PLENARY

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INTEGRATION OF GENOMICS AND PHENOMICS FOR IMPROVEMENT OF PLANT DROUGHT ADAPTATION

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Abstract: The global attempt to meet the needs of extending food demands requires the continuous increase of crop productivity, even under suboptimal conditions. Since plant cultivation is primarily dependent on water availability and the water use efficiency of plant cultivars, breeding for drought tolerance is one of the central objectives in efforts to attain yield stability. The improvement of water productivity can be achieved by establishing genetic potential for increased transpiration of water in limited supply, more efficient exchange of transpired water for CO_2 in producing biomass, and conversion of more of the biomass into grain or other harvestable products.

Nowadays plant breeding relies on the combination of traditional methods, such as crossing, selection and molecular tools, including the use of DNA markers, furthermore the production of transgenic genotypes. In addition to the use of high technological background to optimize the gene pool, there is a requirement for high-throughput quantification of phenotypic traits. Therefore the prime target for the recent development of automated growth phenotyping infrastructures is to provide complex technologies for screening genotypes under limited water supply.

Phenotyping facilities in the greenhouse allow the control of the severity of drought stress and the testing of different watering protocols. In accordance with this trend in Szeged we developed a semi-automated phenotyping platform called "*Complex Stress Diagnostic System*". Morphological, physiological and agronomic parameters are monitored by digital photography, chlorophyll-fluorescence and thermal imaging. The *figure 1.* below presents the major components of this facility.

Barley genotypes grown in soil with 20% water content showed reduction in green pixel-based biomass ranged from 0% to 80%. Thermal images revealed cooler canopy temperature in the case of tolerant genotypes.

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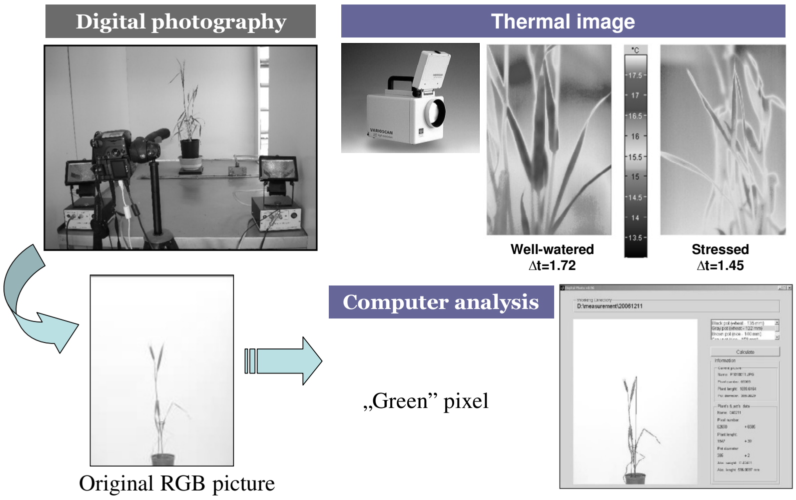

Figure 1. Complex Stress Diagnostic System as phenotyping platform in greenhouse

Allele mining was conducted on drought-related genes in the analyzed barley genotypes using EcoTILLING technology. In the Dehydration-Responsive Factor-1 and NHX1-Sodium/proton Antiporter genes characteristic haplotypes could be identified in the tolerant genotypes. Transgenic wheat genotypes overproducing alfalfa aldo-keto reductase detoxification enzyme showed significant drought tolerance as detected by the phenotyping platform. The recent progress in high-tech methodology provides a more efficient way for breeding of genetic stocks with improved drought adaptation. The adaptive cultivars in combination with optimized soil and water management can be essential contributors to ensure the sufficient food production for the increasing world population.

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APPLICATION OF THE OPTIMIZATION MULTIALGORITHM IN THE SOIL WATER REGIME DIAGNOSTIC PROCESS

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Abstract: Exact knowledge of the soil water storage and dynamics generates the basic hydrological aspect of agriculture, flood protection, waste management and many others. Amount of information obtained from the direct monitoring is usually insufficient for complex soil water diagnostic issues. Therefore mathematical models of the soil water regime are extensively used despite the problematical identification of the representative soil-plant-atmosphere system characteristics. In the proposed study we present the potential of the inverse modeling approach when applied on the sparse soil water content monitoring data reproduced in the HYDRUS 1D model. The objectives of this study are to shed some light on inverse identification of the soil hydrophysical parameters from the in situ information and to assembly the missing soil water data (daily values) on the deterministic, fully physical basis.

Keywords: soil water regime, HYDRUS, AMALGAM

Introduction

Until the fully automatic soil water monitoring systems became widely accessible information about the soil water storage and dynamics was gathered in the form of discrete measurements during the field monitoring campaigns. Realization of field monitoring could be characterized by the extreme time and money consumption and therefore campaigns are realized sporadically (e.g. biweekly or monthly) in dependence on the actual problem demand. Amount of obtained information is usually insufficient for complex soil water diagnostic issues especially when number of spatially distributed and highly interrelated transport and biochemical processes need to be analyzed in detail. As a consequence mathematical models of the soil water regime are extensively used mainly for supplementation of the missing data despite the problematical identification of the representative soil-plant-atmosphere system characteristics. Modeling of water movement in unsaturated soils by the Richards equation (Richards, 1931) requires exact knowledge of the soil hydrophysical characteristics, namely the water retention curves and the hydraulic conductivity functions (Štekauerová and Šútor, 2004; Durner, 2008; Fazekašová et al., 2011). The Mualem-van Genuchten model (van Genuchten, 1980) has become the standard choice for continous representation of the unsaturated characteristics in the Richards equation. Obtaining representative values of Mualem-van Genuchten model parameters became one of the central problems in soil hydrology. Recently the global optimization algorithms (GOA) such as shuffled complex evolution (SCE-UA) or ant colony (AC) were presented as a promising tool in the soil-plant-atmosphere system characterization process (Abbaspour et al., 2001; Wöhling et al., 2008). Application of the global optimization techniques is coupled with the so called “inverse modeling approach” in which the parameters of the model are automatically adjusted (optimized) in such a way that the behavior of the model approximates, as closely and consistently as possible, the observed response of the system under study for some historical period of time (Vrugt et al., 2008). In this study we have analyzed the suitability of the self-adaptive multimethod optimization when

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applied on sparse soil water content dataset obtained from the field monitoring realized in the year 2000 at the Báč location. The objectives of presented study are to supplement the missing daily values of the soil water storage of the 0-60 cm soil layer for the years 2000 and 2001 and to shed some light on suitability of proposed multialgorithm for identification of the Mualem-van Genuchten parameters from the sparse in situ information.

Materials and methods

Soil water content data used in this study was measured at the monitoring site Báč located at the Žitný ostrov territory. Measurements were done systematically from the soil surface to the groundwater level at 10 cm intervals using the neutron probe. Soil profile could be defined with the loamy soil texture which gradually turns into sandy-loam and sand downwards (approximately at a depth of 100 cm the sand is passing into sandy gravel subsoil). Level of the groundwater table is fluctuating only in the sandy gravel subsoil and therefore is not influencing the soil water regime of the 0-60 cm soil layer (Štekauerová et al., 2006). The meteorological characteristics have been measured at the Gabčíkovo meteorological station located approximately 20 km from the monitoring site. The recently presented multialgorithm genetically adaptive search method (AMALGAM), (Vrugt and Robinson, 2007) was implemented for the automatic optimization procedure. AMALGAM introduces powerful new approach for solving complex optimization problems and it could be further characterized as a population based global search procedure that merges the strengths of various optimization algorithms. In the optimization process it adaptively changes the preference to individual search algorithms that exhibit the highest reproductive success what makes the method well adaptive to the specific shape and local peculiarities of the fitness landscape. It has been proved that competition between individual algorithms and adaptive offspring creation dramatically improves the efficiency of evolutionary search. (Vrugt and Robinson, 2007; Wöhling et al., 2008; Vrugt et al., 2008). In this study we have combined the proposed self-adaptive multimethod search with the HYDRUS-1D model (Šimůnek et al., 2008) used as a solver simulating the water flow in studied variably saturated soil profile. This combination was focused on the multiobjective search of the Mualem-van Genuchten parameters (θ_r , θ_s , α, n, K_s) representing the soil hydrophysical characteristics of the two distinct soil layers (0-30 and 30-60 cm). Based upon the compromise solution (parameters related to the best average value of both objective functions) from the obtained Pareto set the forward simulations for the years 2000 and 2001 were performed. From the resulting parameters, daily soil water storage of the 0-60 cm soil layer was evaluated. Statistical criterions as the mean relative error (MRE), root mean square error (RMSE), mean error (ME), and the Pearson's correlation coefficient (r) were applied to measure the ability of the model calibrated on the sparse dataset to simulate the monitored soil water storage data.

Results and discussion

Two sets of the Mualem-Van Genuchten parameters were obtained as a compromise solution from the 10 000 model evaluations. As can be seen on the *Figure 1.*, derived parameter sets can reproduce the soil water storage and dynamics equally well for both years 2000 and 2001. Uncertainty obtained in the modeled soil water storage could be explained by the inexact representation of the boundary conditions (in this case mostly the upper boundary) partly caused by the characterization of the vegetation cover and its root system. Distant location of the meteorological station can also play its role. Furthermore it is hypothesized that implementation of the nonequilibrium water flow model instead of the classical van Genuchten could also influence the obtained results.

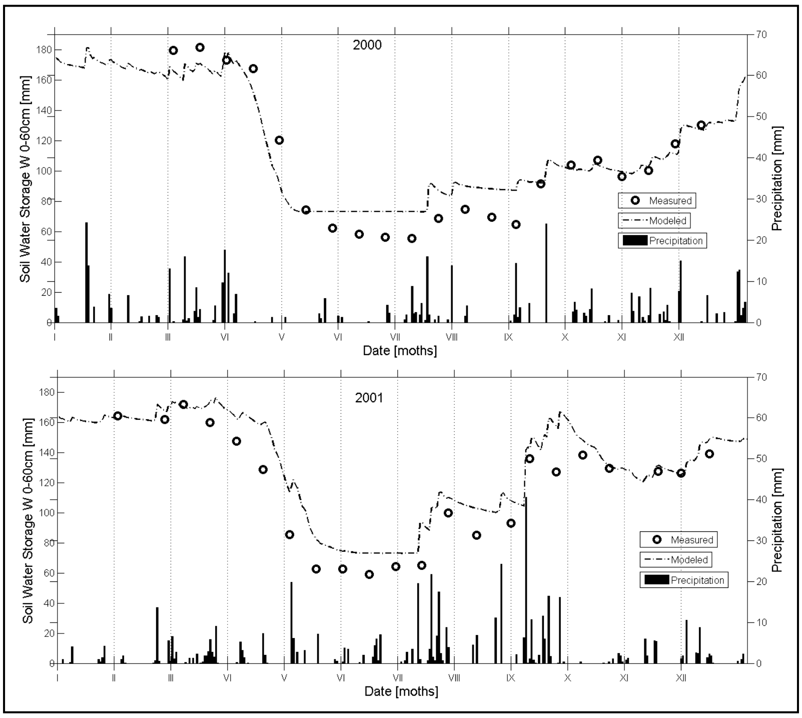

Figure 1. Modeled and measured soil water storage of the 0-60 cm soil layer in years 2000 and 2001

Statistical evaluation of the results is presented in *Table 1*. According to the *Table 1.* the monitoring data inversion experiment could be characterized with high correlation and low values of differences. For both years model slightly overestimates the soil water storage of the 0-60cm soil horizon. Presented values depict the high potential of the AMALGAM self-adaptive search method.

Table 1. Statistical evaluation of the inverse modeling approach

	MRE	RMSE	ME	r
2000	0.134	13.463	2.628	0.965
2001	0.140	15.957	12.565	0.965

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Conclusions

In this study we present an inverse modeling approach based on the sparse field monitoring data. The recently presented multialgorithm genetically adaptive search method and the HYDRUS 1D model were used for automatic search of the Mualem-van Genuchten parameters describing two overlaying topsoil layers. Using the compromise solution of the Pareto set daily values of the soil water storage in 0-60 cm soil layer were computed and statistically evaluated. Results obtained for year 2001 which was not used for calibration clearly demonstrated high efficiency of the proposed approach. The future work will be focused on the effect of quantity and distribution of the monitoring data on the optimization precision and convergence. This could be performed using the synthetic data experiments with exactly defined boundary conditions.

Acknowledgements

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SOIL WATER BALANCE ANALYSES ON THE LEVEL OF BOSNIA & HERZEGOVINA – POSSIBILITIES AND CONTROL OF GREEN AND BLUE WATER REGIME

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Abstract: Results of the soil water balance on the B&H level show that most part of the annual precipitation (51,2%) is used for evapotranspiration, that is for food and biomass production and for sustainability of the ecosystem. This part of the water is called green water which was marginalized in all previous calculations by the planers, managers and politicians.
The remaining, slightly smaller part (48,8%), is called the surplus, potential outflow or blue water. It is the part which is used for the recharge of aquifers, sources, lakes and water currents. This water serves as a supply of not just drinking water, but industrial, recreational, irrigation and hydroelectric as well. Water planers, managers and politicians are focused only on blue water, whereas green water is neglected.

Keywords: water balance, green water, blue water, ecosystem

Introduction

The world's agriculture uses about 70% of the world's water resources for irrigation. Competition between water use in agriculture and the other consumers (drinking, sanitarian, industry, recreation, hydro-energy) already exists. Conflicts between them are increasing in many parts of the world. The water quantity and quality issues are at the top of the world's problems list.
All of our previous efforts concerning water management efforts were aimed at blue water, that is the part of precipitation called runoff. It is the blue waters that constructors use to erect spectacular buildings (canals, dams, cascades, waterfalls, fountains), whereas an interest is taken in green water only when irrigation projects are required to convert blue water into green, or drainage ones to convert green into blue water. It is the blue waters that a special scientific filed called hydrology is based on, as well as the state-level and public administrations' separate administrative water management structure. The affiliated disciplines of hydrology such as hydro-geology, agro-hydrogeology, eco-hydrology, hydro-meteorology, pedo-hydrology, potamology and limnology, have developed only recently.
What situation is in Bosnia and Herzegovina about irrigation water in agriculture?
In this paper we have used the results of the study which was done in three phases during last two years under title "Soil Water Balance of the Bosnia and Herzegovina on the purpose of the erosion, drought and flooding prevention". The water balance was done for seven main watersheds and for B&H as whole country.

Materials and methods

The balance is based on data obtained at 68 meteorogical stations with different lengths of time series (series A) in 7 (seven) large river catchments (Una, Vrbas, Bosna, Drina, Neretva and Trebišnjica, Cetina and Krka, immediate catchment of the Sava).
Three input parameters were used: monthly rainfall (P), monthly potential evapotranspiration (PET) and available soil water holding capacity of 100 mm. This

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way, the following three output parameters were obtained: monthly real evapotranspiration (RET), soil water deficit (D) and soil water surplus (S), drought coefficient or ratio (RET/PET), as well as coefficient of potential runoff (V/P).

All absolute values of these analyses are given in millimeters. The calculation of PET was done by three different methods: Thornthwaite, Turc and Penman-Monteith for the purpose of comparison, but the results used in this paper are presented based on the calculations by Thornthwaite, given that this method provides best results at regional level (Vlahinić et al., 2004).

Based on the three input parameters for each month and year, the following output parameters were calculated:

a) real evapotranspiration (SET or green water),
b) water deficit (M-water deficit),
c) water surplus (V – outflow or blue water),
d) surplus/precipitation ratio (V/P or runoff coefficient), and
e) ratio between real and potential evapotranspiration (SET/PET or drought coefficient).

Results and discussion

RET or real evapotranspiration is actually the amount of green water a plant is capable to uptake from soil and deliver to the evaporating leaf surface in a time unit, to include direct evaporation from the soil. It is limited by available quantity of the soil green water, as well as depth and size of the plant's root system. In a way, it is what a plant is capable of taking up from the soil and offering to the atmosphere, therefore it is often referred to as the offer.

PET or potential evapotranspiration, also called demand, is the amount of water that could be evaporated into the atmosphere in a unit of time through the action of energy available in the atmosphere provided that appropriate offer is ensured. It could be called a potential requirement for green water. The demand is determined by energy available in the atmosphere, hence it is said that atmosphere of the environment imposes demand. There is no way that the amount of evaporated water can exceed the quantity of available energy in the atmosphere. This is why the majority of scientists base their calculation of PET on the amount of energy available in the environment's atmosphere.

The rate of soil's discharge of green water through evapotranspiration processes depends on atmospheric conditions, plants' development stage and successive rate of renewal of the soil's water reserves (green water) through rainfall. The term green water is quite adequate since without this soil water (moisture) there would be no green color in ploughlands, grasslands and forests, and the entire ecosystem would collapse. The green water is essential to food production and sustainability and stability of the entire ecosystem. It deserves credit for the most part of the world's production of food and biomass. In some countries even the total food production and sustainability of ecosystems depend on green water, and this is almost the case in Bosnia and Herzegovina. This is why Falkenmark et al. (2005) points out that the tunnel vision of the stereotype of managing only blue waters should be forsaken for a better management of green water, since green water is the crucial factor of the food production sustainability and ecological stability.

Blue water is a part of rainfall (precipitation) soil can not retain above its normal retention capacity, so it outflows partly on surface and partly underground thus feeding the watercourses (springs and rivers), lakes, water sources and underground aquifers.

Accordingly, the current requirement of a plant for green water will be met depending on whether the offer (SET) has reached the level of demand (PET).

The water balances for the BiH state level (total area of 5.1 million ha) are based on data obtained from 68 meteo stations with various duration of time series in 7 (seven) large catchments (Una, Vrbas, Bosna, Drina, Neretva and Trebišnjica, Cetina and Krka, immediate catchment of the Sava), and show the following average state:

- Mean annual precipitation (P) - 1120 mm or 57,3 billion m^3
- Mean annual potential evapotranspiration (PET) - 660 mm or 33,7 billion m^3
- Mean annual real ET (SET – green water) - 573 mm or 29,3 billion m^3
- Mean annual water deficits (M) - 87 mm or 4,4 billion m^3
- Mean annual water surpluses (V – blue water) - 547 mm or 28,0 billion m^3
- Mean annual ratio SET/PET - 0,87
- Mean annual ratio V/P - 0,49

What do the results of these analyses indicate in respect of the new terminology of green and blue waters?

This analysis shows that the balance state in BiH is relatively favorable, as it would be possible to meet total requirement for green water and establish a balance on the entire area of BiH ecosystem.

However, these are theoretical considerations of the most adverse situation with regard to settling the green water deficits by irrigating the entire surface of the ecosystem, which in practice is very unlikely to happen. Forests and grasslands are practically never irrigated, and when it comes to ploughland, only the areas used for extensive agriculture are irrigated. Currently in BiH there are about 10,000 ha of forests. Therefore, at the level of BiH only 0.07% of the total blue water resources is used for irrigation, which means that there is a large possibility to increase irrigation from the resources of blue water. In a distant future, about 300,000 ha could possibly be irrigated, which is only around 6.7% of total BiH territory, i.e. 2.14 % of the mean annual resources of blue water.

Yet, on the global level, this ratio between green and blue water is not as optimistic as in BiH (Falkenmark and Rockstroem, 2005).

Conclusions

Water and land are the main challenges of the 21st century; a primary base for human life and production of food on the Earth; the key factors of ecological stability and sustainability of biodiversity. Any change in the method and structure of land use reflects on the state of and changes in water balance. This is why an integrated land and water resources management is required (ILRWM).

Soil is an extremely important and powerful storage space for green water, the largest natural water accumulation that is fed by rainfall and discharged by evapotranspiration.

In previous water management, green water in the hydrologic medium of soil was neglected, if not completely ignored, as the entire public and national attention was focused on „blue water“.

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Precipitation is the main water resource, therefore the future water supply of the increasingly growing population, human and natural ecosystem, will totally depend on rational management of precipitation.

Green water is essential to the survival of human and natural ecosystem, particularly to the production of food. On average, green water provides around 86.8% of the total ecosystem requirements for water at the level of BiH. The green water deficit of 13.2% can be settled by a better management of green water and usage of blue water for irrigation, since the level of use of blue water for irrigation is currently rather low (0.07%), while at the global level its usage is much higher (70%), even close to reaching the maximum possible level of utilization.

Blue water is the running water of watercourses and aquifers, which thus far has been in the focus of public and national attention, whereas green water, so vitally important and essential to food production, has been neglected.

Further usage of blue water for irrigation in agriculture at BiH level is possible to cover from the existing resources of blue water, but when it comes to the global levels, this statement is rather questionable. Therefore, it can be concluded that BiH is in a privileged geographic situation given the abundance of precipitation, green and blue water, unlike the global level where a sustainable water future is rather problematic. It is high time that we started thinking about the methods for supplying green water to food production, as there would not be enough blue water for irrigation required for resolving the issues of human nutrition.

The future conflicts of interest at global level, according to Falkenmark and Rockstroem (2005), will occur in the sphere of land use/water use, water quantity/water quality, upstream/downstream water availability and human ecosystems. A reliable supply of food and water for the increasingly growing world population must not be called into question. Therefore, the philosophy of sustainable development, despite controversies and conflicts, has to become a world paradigm and global ideology.

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DROUGHT INDICES ON DIFFERENT TEMPORAL SCALE AND THEIR USE FOR DIFFERENT APPLIED PURPOSES

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Abstract: Hundreds of drought indices are used for different applied purposes. Recently, the more versatile indices are dominant. The first such an index was the Standard Precipitation Index (SPI). This index became very popular despite of its problems. Newer indices can be taken as improved versions of SPI.
SPI is widely distributed partly because its simple input data. This is one of the obstacles of its use in some applied calculations. Development of SPI is the SPEI, the Standard Precipitation-Evaporation Index created in Spain. It has the benefit dealing with temperature as well. In the same time, when SPI cannot differ the winter and summer precipitation (no difference in the precipitation type, no temperature data), SPEI can do that. SPEI is statistically robust and easily calculated, and has a clear and comprehensive calculation procedure. However, a crucial advantage of the SPEI over other widely used drought indices that consider the effect of PET on drought severity is that its multi-scalar characteristics enable identification of different drought types and impacts in the context of global warming.
Therefore, it has interest to use SPEI in the tasks for SPI (which is the mostly advised drought index) and compare the results with other drought indices as well. The investigation of the characteristics of different catchment areas and comparison of the results serves good examples about the usefulness of SPEI. Well-known, that SPI has transformation problems, it does not give appropriate results at any climate condition. SPEI should be checked for the same conditions to give an overview about the conditions of its use.

Keywords: drought, versatility, standardized indices

Introduction

Drought is a complex natural phenomenon with no generally accepted definition. Drought indices have been developed to measure the individual events. The impact of the event can be detected on almost all area of our life, but the time of development is different for different processes. The basic origin of the drought is the less than average precipitation, but the spatial distribution and the development velocity can depend on several other variables (Szalai et al., 2000). Therefore, many drought indices have been developed. According to the connection with the less than average precipitation, these indices used to include precipitation in different form. It follows, that the indices with the least number of input data are that ones containing precipitation.
From the other side, drought events have different features from the other natural extremes. Such features are the slow set up (creeping phenomenon) and the different characteristic tine for the different processes (NCDC, homepage). For example, groundwater table has a much larger inertia, than the upper soil layer, therefore, drought can develop faster in the surface soil layer than at the groundwater table level. That is the reason, why versatile drought indices have been developed recently. Indices with fixed time step could have different temporal resolution. For example, the Palmer Drought Severity Index (PDSI) has a monthly step, while Palfai Aridity Index (PAI) describes one year with one number.
The first and mostly used versatile index is the Standard Precipitation Index, SPI (McKee, 1993), which fulfills the other requirement for low number of input parameters, because needs only precipitation data. SPI is widely distributed and mostly recommended drought index, although has some disadvantages as well. Such a problem

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is with the basic time period. The basic period is used for fitting a gamma (or Pearson) distribution to the empirical distribution of measured data. Of course, different basic periods result different curves and as consequence, different SPI values. If we investigate long series, than the difference is not very large, but if we research the most interesting interval of the SPI values, i.e. the less than -1 value and/or the extreme situations, the difference can be significant.

The other problem of SPI is in the climate of the region where SPI is applied. The area of development is implicitly included into the index mainly via the threshold values, like at PDSI as for Iowa, for PAI for the Great Hungarian Plain. It does not mean that they are not applicable in other regions, but needs special attention by their use. The climatological effect can be detected at SPI as well, but it is much more hidden than in the case of PDSI or PAI, and can be recognized only at the detailed investigation of transformation in the SPI calculation. Therefore, this problem can cause larger problems because of the latent feature, than the commonly detected ones at other indices.

The other problem of the simply drought indices, that they do not differ the rain and snow. Practically, they calculate only with precipitation in general, although well-known, that snow has quite other effects in the surface water balance than rain. Implicitly, it means, that we assume to have the climatologically established rain/snow ratio in each year. According to the large climate variability of the precipitation, this assumption could be very far from reality in some years. Therefore, the temperature should be taken as well. This problem is planned to solve by the Standard Precipitation-Evaporation Index (SPEI).

Materials and methods

Precipitation-based drought indices including the SPI rely on two assumptions: i) the variability of precipitation is much higher than that of other variables, such as temperature and potential evapotranspiration (PET), and ii) the other variables are stationary. The SPEI index is a standardised monthly climatic balance computed as the difference between the cumulative precipitation and the potential evapotranspiration (Vicente-Serrano et al., 2010).

In the case of SPI the empirical distribution of precipitation values according to the temporal resolution is approximated by a Pearson or gamma distribution and transformed into the standard normal distribution. Originally, the procedure was developed for monthly resolution (1-, 2-, etc. up to 72 months), but later smaller time-scales were investigated as well.

The difference between the SPEI and SPI is, that the empirical distribution of water surplus or deficit is investigated, i.e. the difference of precipitation and potential evapotranspiration. In the original form, the potential evapotranspiration was calculated by the Thornthwaite formula (Thornthwaite, 1948). The difference calculation makes the negative values possible (which were not at the empirical distribution of precipitation) therefore, the detailed research of the applied theoretical distribution form was requested. Finally, the log-logistic distribution was used for the description of the difference distribution.

Results and discussion

The difference between the individual indexes is presented. *Figure 1* shows the time series of SPI-3, SPI-12 and PDSI for Szarvas, 1981-1985. It is clearly seen, that the index with the smaller inertia (SPI-3) follows much better the monthly precipitation amounts, while the indices with larger memory (SPI-12 and PDSI, which could be compared with the SPI for 7-9 months) are smoother. As a consequency, SPI-3 can show much faster dry conditions (for example in the second half of 1982) than the other indices, but recover faster from drought (like in 1983 or first half of 1984). *Fig 1.* shows, that processes with different characteristic time can have different drought status (Szalai et al, 2000).

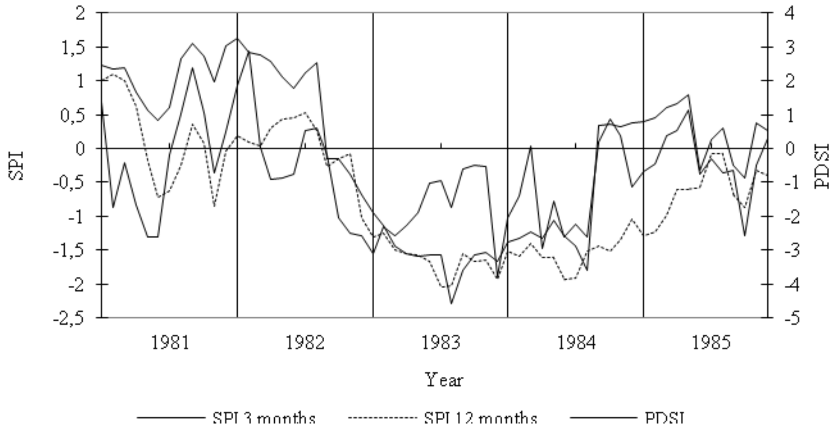

Figure 1. Temporal development of different drought indices in Szarvas, Hungary

Figure 2 presents the difference between SPI and SPEI. SPI-18 and SPEI-18 are used (Vicente-Serrano et al., 2010). According to Figure1, the one-and-half year basic period show a quite large inertia.

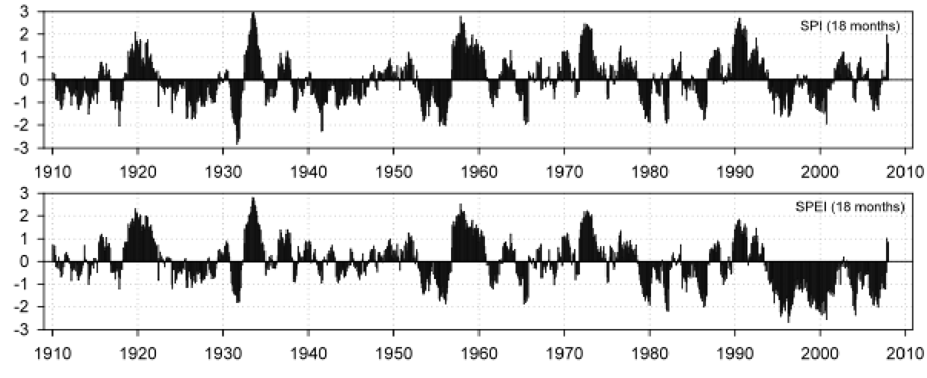

Figure 2. Comparison of SPI-18 and SPEI-18 in Valencia, Spain (SPEI homepage)

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As it seen on the *Figure 2*, the two indices have similar run, but in some cases could have large differences, like in the first half of 40s or the second half of 90s. These results show, that SPEI could have more detailed information in the warm periods paying attention to the temperature tendencies, which are missing in SPI. *Figure 2* shows clearly, that the differences are not for one side, in some cases SPI values are higher, in others SPEI. It shows the effect of temperature, which could play an even larger role in the next future.

Conclusions

It is well-known, that no one climate indices can describe this event universally. Different indices have to be used for different purposes, but the multiindex systems seem to be the best for the applications. Simple input and versatile indices are distributed recently fitting the data best to the drought impacts. The paper discuss two versatile drought indices, the first developed SPI and one of the newest, the SPEI. The SPEI and the SPI show similar features, but SPEI seems to be more sensitive to the temperature changes, and as it follows, could discuss the temperature tendency, the warming. According to this consequence, SPEI could be better used under the climate change conditions than SPI, but this result has to be controlled by much more scientific works.

Acknowledgements

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BLUE WATER – BROWN WATER – GREEN WATER

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Abstract: The sweet water resources of our Globe are limited and show extremely high spatial and temporal variability. Blue water resources are visible surface water bodies and consumed waters. Green water resources are accumulated in the biomass of various ecosystems. The unavailable subsurface waters (groundwater, soil moisture) can be classified as "brown waters" and the used and polluted waters as "grey waters". Water resources have a strong (sometimes determining) influence on soils (including soil formation and soil degradation processes) and various ecosystems. Consequently, the control of the field water cycle and soil moisture regime is an important element of sustainable biomass production and environment protection.

Keywords: water resources; green water; blue water; soil degradation

Introduction

The geological strata – soil – water – biota – plant – near surface atmosphere continuum represents a considerable part of the *natural resources.* Consequently, the rational utilization, management, conservation and quality control of the interactive spheres (lithosphere, atmosphere, hydrosphere, biosphere and pedosphere) and the maintenance of their favourable multifunctionality is the most important element of *sustainability* (Lal, 2002; Várallyay, 2005).

Water resources

Water, as solvent, reactant and transporting agent plays a significant, sometimes decisive role in the life and metabolism of living organisms (biota, natural vegetation, cultivated crops); in the mass and energy regimes and biogeochemical cycles of the global Earth system; in the physical and chemical weathering, soil formation and soil degradation processes, in the resilience, fertility, productivity and environmental sensitivity of soils and various ecosystems (Várallyay, 2011a).
Water exists in/on/around our Globe in liquid, solid (ice) and gaseous state (vapor or steam). Water covers more than two-thirds (71% of the Earth's surface and its total quantity is about 1400 million km³ (~ 1% of the total mass of the Globe) (Somlyódy, 2011b). Most of this huge amount (97.5%) is salty water in oceans. Only 2.5% are "sweet water" resources: ice caps and glaciers, partly or periodically frozen groundwater and deep subsurface waters. Only 0.14% (!) of these sweet waters are in surface waters (rivers, lakes), in soil moisture (stored in the unsaturated soil horizons), in the biomass and (a relatively negligible amount) as the vapour phase of the atmosphere (*Figure 1*) (Water in the Blue Planet, 2010).
Water resources (with very few exceptions) are not pure H_2O, but contain various soluble or suspendable liquid, solid or gaseous materials, and so can be characterized by various concentrations and ion (or molecule) compositions.

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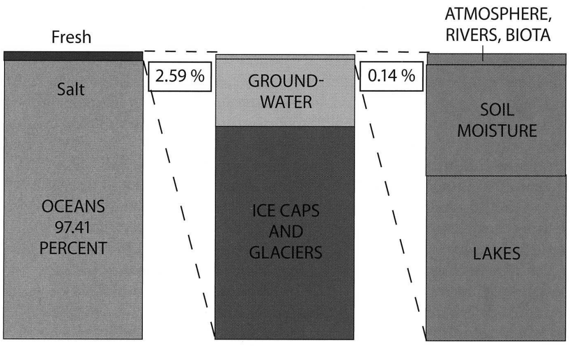

Figure 1. Global water resources

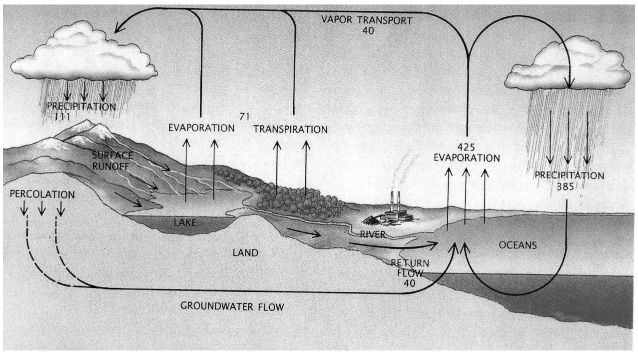

Figure 2. Global water flows

The greatest part of water resources is not static, but exist in a dynamic equilibrium of various transport and transformation processes. The most important elements of the global water cycle are schematically summarized in *Figure 2* (Várallyay, 2010; 2011a). The geographical distribution of various water resources shows extremely high (mosaic and/or caleodoscopic) spatial and temporal variability (Lal, 2002). The same is true for the water requirement of natural ecosystems and for human consumption for various purposes (various direct human consumptions, households; social services; industry, mining, infrastructure, etc.). The limited sweet water resources have become more and more valuable strategic elements and the serious "territorial asynchrone" between resources and requirements have created many internal and international conflicts (Somlyódy, 2011a; Várallyay, 2010).

Blue water – brown water – green water

Blue water resources are directly visible *surface water bodies* (oceans, seas, lakes, rivers, waterways; ice caps, glaciers) and *waters consumed* by individuals or communities for drinking, producing goods and various other services. [In many cases only these resources are taken into consideration in hydrological studies, planning, calculations, statistics, etc.] The "status" of *groundwaters* is rather questionable. Hydro-geologists classify them as "blue water".

Green water resources are – primarily – the waters which are accumulated in the biomass of the living organisms of various ecosystems: microbes, plants, animals and human beings; secondly the waters which are the direct source of the "biomass greenwater": available moisture range (AMR) of the unsaturated zone (field capacity (FC) – wilting percentage (WP); a certain part of the surface and subsurface waters, which can be taken up ("available") for various living organisms (Šútor et al., 2006; Várallyay, 2011b).

The unavailable part of soil moisture in the saturated and unsaturated soil layers and groundwaters can be classified as *"brown water"*. These waters represent the connection between blue and green waters. The used and – consequently (at least to a certain extent) polluted water is *"grey water",* irrespective of its primary origin.

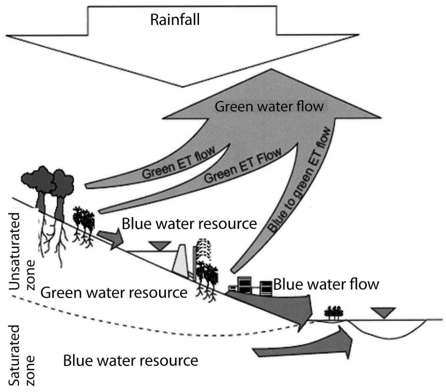

Figure 3. Consumptive water use for agriculture products

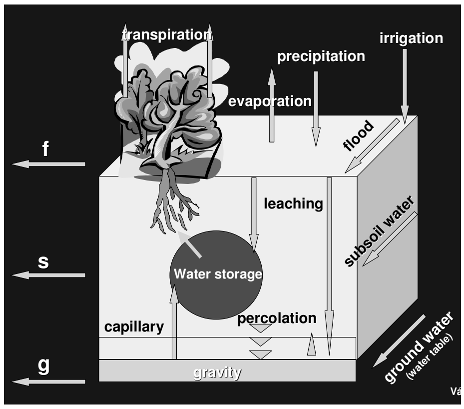

Figure 4. Elements of the field water cycle and soil moisture regime

The blue water – green water relationships are illustrated by *Figs. 3 and 4*.

In Fig. 3 the green water flow "pathways" are indicated from rainfall and from the "available moisture range" of the unsaturated soil layers (real green water) and from the groundwater-saturated layers ("brown water") or directly from the groundwater. In Fig. 4 the most important elements of the field water cycle and soil moisture regime are summarized, showing the possibilities of blue water (flood, irrigation) → brown water (seepage in the unsaturated zone, groundwater flow) → green water (available soil moisture content, capillary transport, water uptake by plants, transpiration) water transfer (Várallyay, 2010; 2011b).

Green water – soil relationships

In spite of the fact that green water is a small faction of the Earth's water balance, it has great significance in the mass and energy regime of the biosphere, in soil formation and degradation processes, in primary biomass production and water management. Two examples (Várallyay, 2011a):

All major factors limit the agro-ecological potential (drought, nutrient stress/deficiency or toxicity, shallow humus layer, excess water, permafrost);

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The main soil degradaton processes of Europe (erosion by water or wind, acidification, salinisation/sodification, aggregate destruction and/or compaction, extreme moisture regime, decrease of organic matter, decline in biodiversity, contamination/pollution) are related to, are reasons or consequences of the field water cycle and soil moisture regime. Consequently, their efficient control is the primary task of sustainable multipurpose biomass production and efficient environment protection.

Conclusions and tasks

The conversion of blue water (and brown water) to green water (water in the biomass) is the main task of agronomy, crop production and agricultural water management (Birkás, 2008; Várallyay, 2005; 2010). All efforts have to be taken:

- -to help the available moisture content of soil (increase infiltration rate, water storage capacity; decrease evaporation evaporation, surface runoff and filtration losses and non-available moisture fraction);
- -to improve the water use efficiency of cultivated crops;
- -to diminish pollution/contamination of waters (mainly by *preventive* measures);
- -to improve the healthy green water flow in the soil–plant–animal–human food chain.

For the fulfillment of these tasks, multidisciplinary cooperation is needed among agronomists, meteorologists, hydrologists, soil scientists, plant and animal physiologists, plant protectionists, plant breeders, biotechnologists and many other scientists and practical specialists.

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HYDROCULTURAL GROWING OF ZANTEDESCHIA

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Abstract: Hydroculture was established in the early 40's. This technology became wide-spread in 60's. Because of economic considerations it played little role in Hungarian ornamental plant growing. The forthcoming joining of the EEC as well as the strict enviroment protection regulations, this technology is likely to spread in our country and like in most of the West European countries, cut flowers will be grown in hydroculture. Closed systems match the moststrict environmental regulations. Zantedeschia can be well adopted to this technology because of its origin and water demand.
We have studied three growing methods: PUR-agrofoam, container and soil-heated, of which soil- heated proved to be the best significantly.

Keywords: hydroculture, Zantedeschia, PUR-aggrofoam, container, soil-heated

Introduction

We have been growing cut flowers (carnation, Zantedeschia, Rose) at the Department of Ornamental Plant Production and Gardening of the Collage Faculty of the University of Horticulture and Food Industry since 1988.
Importance of hydroponics increases day by day. Due to the increasing urbanization growing sites are decreasing and rapid industrial production may exhaust the peat supply, too. The contamination of water supply is a real problem and hydroculture is possibly one of the solutions. Closed circulation systems match even the strictest environmental regulations. No soil is needed, so the expensive sterilization as well as change of soil is not needed.
Due to its origin and water demand, Zantedeschia fits well with this growing technology.
The basic aim of the research was to compare the effect of three different growing technologies (plastic foam, non-heated containers, sub-heated containers) to the plant growth and development as well as to the yield per plant.
Eight species of Zantedeschia live in tropic areas and in South Africa, wide spread, in so called, Zantedeschia swamp. Place of its origin is essential to the rhythm of vegetation. When swamp is under water, in the rainy season, plants start to gorw leaves.
Zantedeschia aethiopica is the oldest known species. From the floriculture point of view, it is the most important variety of white cut flower (Röber et. al., 1994).
Zantedeschia is neutral to the length of photoperiod. It is a facultative long-day plant, but may bloom also in short-days (Nagy, 1986).
This plant demands moderate-temperature, 12-14 °C at blooming (Nessmann, 1993).Temperature affects blooming considerably, the temperature of 8-10 °C can retard it (Röber et. al., 1994).
Zantedeschia has an extremely high water demand, because of its swamp origin. It is important to supply water according to its stage of development (Domokos, 1967). Water application should be considered as "little and often". Water should be given little at once but often. If the soil is not freely drained, tubers or the root system will quickly rot (Andrew, 1998). Irrigation ought to be started right after plantation, once a week at the beginning, then can even be kept under water (Gugenhan, 1991).

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This plant has a low demand for soil, makes do with almost all kinds of soil, if the soil has a good drainage ability (Miessner, 1968).
Zantedeschia likes slightly acidic pH, with an optimum of 5.5-7.0 and has a very high demand for nutrients (Nagy, 1972).
According to Andrew (1998), Zantedeschia is grown well at pH 5.0-7.5, but to avoid bacterial rot caused by *Erwinia*, a pH of 6.0-7.0 is most satisfactory. Zantedeschia is very susceptible to virus, bacterial, and fungal diseases. To avoid virus, clean material should be used (Andrew, 1998).
Meristems meant a new era in the propagation of Zantedeschia. Tubers produced by tissue culture are free from infections, and one of the most dangerous diseases, *Erwinia*, can be eliminated (James, 1997).
Growing in glass houses is the most widespread with a plantation at the end of August and beginning of September. Vigorous varieties are planted at the density of 6-8 tubers per sq. metre, while less vigorous ones are at 8-10 tubers per sq. meter (Nagy, 1986). The yield of this plant varies between 2-4 flowers per stock (Diener, 1997), while, according to Nagy (1986), vigorous stocks can produce as much as 12-16 cut flowers, what means, 60-80 flowers per sq. meter.
In Belgium, in the recent 10 years, researches have been focused on the development of environmental substrates. Recycled Polyurethane- (PUR)-substrate is very easy to handle and can certainly be re-used for 10 years (Benoit-Coustermans, 1995).

Materials and methods

Zantedeschia is grown in two houses. The French Filclair house was established in 1993-94, sponsored by PHARE. Hydroculture was established in two of the blocks.
Climate is computerized in the house. Isolation and shading is assured by energy-courtain. The concrete floor has a 1,5% slope. The mineral solution is circulated by a BCPO-40-1/3 pump in a closed system. Mineral nutrients are fed from a container of concentrate. Feeding tubes pass the solution to the flower beds, while the unused solution is gathered in a 3 m^3 basin.
The second part of the research is located in the previously East-German Primeur-1 type of house with temperature-saving heating and soil-heating operating systems.
We have chosen Zantedeschia aethiopica "Perle von Stuttgart" variety. Rhizomes were planted in containers and polyurethane plastic foams respectively in the second decade of July. A short period of dormancy was dated at the end of August. Growing technology in the houses coincides with each other.
We examined the effect of the three growing methods in the entire growing period (from sprouting to dormancy).
- in polyurethane plastic foam
- normal containers
- soil heated containers

on to the growth and flower yield of the population.
Height of plants and the yield per plant was measured regularly in the vegetation period.

Results and discussion

Evaluation was planned in a random block multivariate analysis of variance.

Table 1. The hydroculture of Zantedeschia 2006-2008 Study of height and yield of plants

Methods	2006-2007.		2007-2008.	
	Average height of plants	Average yield per plant	Average height of plants	Average yield per plant
agrofoam	57,60	5,23	59,23	5,30
container	58,03	11,72	62,96	12,00
soil-heated	86,45	8,40	87,12	8,78
SD 5 %	**11,845**	**3,380**	**20,261**	**3,40**

The plants grown in container, soil mixture produced higher growth. It can be explained by the fact that the plantation media gets warmer sooner and it has got a positive effect on the development of the plants.

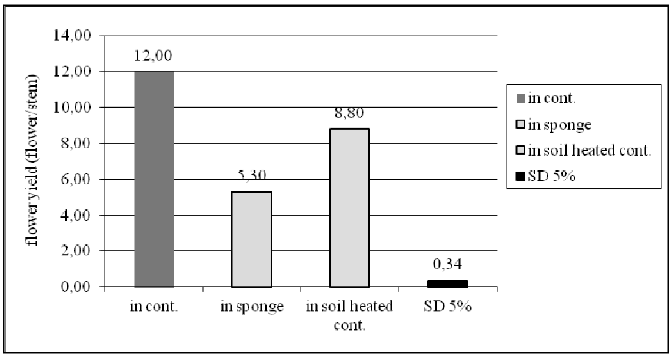

Figure 1. The effect of the growing methods on the yearly flower yield of Zantedeschia (Kecskemét, 2007-2008.)

The soil mixture used as a plantation media that gets warmer much sooner, resulted in a significantly higher yield than the sponge during both years of the experiment. In case of the stock planted in sponge it would be expedient to use soil heating or to solve the warming up of the nourishing solution.

Neither of the media of the experiments (sponge, soil mixture) had a significant effect on the length of the flower but in case of the sponge media there were a bit larger flowers that is sponge is more adequate for the hydro-cultural growing of Zantedeschia.

The effect of the plantation media on the length of the stem was very similar that is both plantation media are adequate for the hydro-cultural growing of Zantedeschia.

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During the period of experiments the height of the stock in container, planted in Primőr-1 greenhouse increased by leaps in the period following November; it can be explained by the effect of starting the soil heating and its effect on the development of the plants.
Concerning the two years of experiments the smallest yield was reached in case of the stock planted in sponge in Filclair greenhouse, followed by the container stock equipped with soil heating in Primőr-1 and the most flowers were given by the container stock planted in Filclair house.
The underfulfilment of the stock in sponge can be explained by the lack of soil heating since the sponge gets warmer much harder than the soil mixture that is it is advisable to install soil heating in Filclair greenhouse.
In the period of the experiment neither Primőr-1 nor Filclair had significant effect on the length of the flower, concerning the length of the flower both growing establishments are adequate for the hydro-cultural growing of Zantedeschia.
The length of the flower stem in Primőr-1 greenhouse increased significantly from December on that can be explained by starting soil heating; the quality of the picked flowers was extra till the end of the survey period. Taking all the above into consideration it is advisable to install soil heating in order to have better flower quality.

Conclusions

We recommend PU sponge as a plantation media for the hydro-cultural growing of Zantedeschia but it is necessary to have soil heating in the growing establishment from the point of adequate development, high flower yield and long stem as well as extra quality flower since the sponge gets warmer harder than the soil mixture.
Zantedeschia grown in hydro-culture lasts longer due to the better supply of nourishing material characteristic of hydro-cultural growing.

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THE EFFECT OF SOWING TIME OF MAIZE HARVEST GRAIN MOISTURE CONTENT AND WATER-LOSS DYNAMICS

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Abstract: The general price increase of the near past has also had an effect on the different kinds of power source, which results in the usage of modern variety-specific technologies in order to get good economic results. One of the most important condition is to determine the sowing time of a hybrid adapted to the character of the farm, landscape. One of the agritechniques, which can provide better efficiency, is the right sowing time. This can influence the moisture level of seed at harvest. In the trials, besides three sowing time were main treatment. With the sowing times above, we tried to analyse the effect of an earlier and a later sowing time than the usual (about 20. April) in Hungary. The analysis of drying down dynamics was carried out each year on several hybrids. Between the analyses, during August and October, we measured the seed moisture level seven-eight times. We can say that we found significant difference among all hybrids even at the first measure. This difference was especially big between early and late sowing. The difference between the first and the second sowing time was significantly smaller at the majority of hybrids. According to the statistical evaluation, there was provable significant difference between seed moisture levels at each time. The difference of moisture level between hybrids was persistent till harvest, the values just got closer to each other at harvest time, however, they never became equal. There was 5-10 % moisture level difference between sowing times at harvest.

Keywords: maize, drying down dynamic, sowing time, seed moisture

Introduction

Many authors, both in Hungary and abroad, have reported on experiments carried out to determine the role of sowing time in maize, but the results are often contradictory. This is hardly surprising, since the maize plant exhibits enormous genetic variability and the hybrids created through selection and inbreeding may have very specific requirements as to sowing date. The year effect, too, often complicates the efforts of scientists to provide clear guidance to farmers on the optimal sowing date for each hybrid (Rácz et al., 2003)

(Futó and Sárvári, 2003) examined the effect of sowing date and the vegetation period of the hybrids on the grain yield of maize and the moisture content (%) at harvest was studied in a two-factor experiment in a small plots design, based on the data for 2001-2002. As the results of the sowing date, the moisture content (%) of the yield at harvest was lowest in the early and optimum sowing date treatments, rising significantly after late sowing. A positive, moderately close correlation was found between the sowing date and the seed moisture content at harvest (R Square were in 2001 0.545 – 0.818 and in 2002 0.630 – 0.891).

This yield increase can be attributed to genetic gain, agronomic innovation and the genetic x agronomic interaction (Berzsenyi and Győrffy, 1995). According to Sárvári and Futó (2001a, b) for some hybrids early sowing leads to an outstanding increase in yield and to lower grain moisture content at harvest, thus improving production efficiency. They thus recommend a variety-specific technology which adapts the sowing date to the hybrids in coordination with other production factors.

Beiragi Ashofteh M. et al. (2011) studied 18 maize hybrids and were evaluated at two sowing date (5 and 20 June) at Iran on 2009. This study has shown that planting date

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has significant effects on maize hybrids yield and its components (kernel weight, kernel No./row,). EXP1 and OSSK617 hybrids were the best hybrids under early planting (5 June) condition, and EXP1 and KDC370 showed the best behavior under late planting (20 June) condition.

The responses of Hungarian-bred maize hybrids with different vegetation periods to sowing date, N fertiliser and plant density were studied in small-plot field experiments between 2002 and 2004. The maize grain yield was highest in the early and optimum sowing date treatments (8.563 and 8.325 t ha^{-1}) and significantly less in the late and very late treatments (7.908 and 7.279 t ha^{-1}). The year had a substantial effect on both the yield and grain moisture content (Berzsenyi and Lap, 2005).

Marton et al. (1977) also found that different maize genotypes had different cold tolerance levels. When six genetically different inbred lines were tested at 10 ^{o}C, a significant difference was found in their seedling cold tolerance, two variants of which could be distinguished.

Materials and methods

We followed the effect of sowing time in an individual trial. Therefore, in Kompolt, in 2010 and in 2011 we also started a sowing time trial for maize, in which besides yield analysis. In the trials, three sowing time were the main treatment. The first sowing time; in the first ten days of April in each year, (~ 5 April), the second sowing time took place in the second ten days of April in each year (~ 20 April) and the third sowing time took place either at the end of the first ten days of May, or at the beginning of the second ten days (~10 - 15 May). In the trials, in 2 years (2010, 2011) we analyzed the 3 different maize hybrids for yield capacity, reaction to sowing time, drying down capacity, dynamics of drying down and maize quality.

Table 1. Rainfall data in 2010-2011.

Rainfall data 2010. Jan. - 2010. Sept, Kompolt										
Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Sum.
Rainfall (mm)	53	60.3	18.8	70.7	158	91	161	76	98	786.8
Average of 30 years	30.6	31.4	28.9	41.9	62.9	71.4	74.4	59.6	42.8	443.9
Rainfall data 2011. Jan. - 2011. Sept, Kompolt										
Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Sum.
Rainfall (mm)	10.7	7	34.5	12	51.8	51.6	73.9	41.1	0.6	283.2
Average of 30 years	30.6	31.4	28.9	41.9	62.9	71.4	74.4	59.6	42.8	443.9

In 2010, between January and September there was average 342.9 mm more precipitation than the average of 30 years, however, its distribution was really unfavorable. There was more rainfall in May (158 mm) and July (161 mm), that there was too much for maize. This airless soil conditions caused, which prevented the root respiration. Despite this, the year 2010 was favorable for maize. In the 2011 year was very arid. In 2011, during the growth of maize (IV-IX. months) there was 231 mm precipitation in total, while average value of 30 years is 353 mm. But the high temperature and soil water due to the yields were high in 2011.

The experimental site soil was brown forest soil. Soil characteristics of the *Table 2*.

Table 2. Main characteristics of the soil

Level	Depth (cm)	KA	pH (H_2O)	pH (KCl)	$CaCO_3$ %	y_1	y_2	Humus %
A_{sz}	0-30	42	6.27	4.59	0	8.71	0.40	2.69
A_2	30-45	58	6.13	4.42	0	8.30	0.61	1.90
B_1	45-60	67	6.22	4.52	0.12	6.28	0.81	1.47
B_2	60-80	68	6.41	4.64	0	4.25	0.30	1.14
C_1	80-135	71	6.74	4.93	0	3.85	0.30	0.79

Results and discussion

The analysis of drying down dynamics was carried out each year on several hybrids. Between the analyses, during August and October, we measured the seed moisture level seven-eight times. We can say that we found significant difference among all hybrids even at the first measure. This difference was especially big between early and late sowing. The difference between the first and the second sowing time was significantly smaller at the majority of hybrids. According to the statistical evaluation, there was provable significant difference between seed moisture levels at each time. The data of SzD5% in each time of 2010: Aug. 27., SzD5% 5,11; Sept. 04., SzD5% 4,08; Sept. 18., SzD5% 3,70; Sept. 25., SzD5% 3,41; Okt. 02., SzD5% 3,67; Okt. 09., SzD5% 3,53; Okt. 16., SzD5% 2,33.

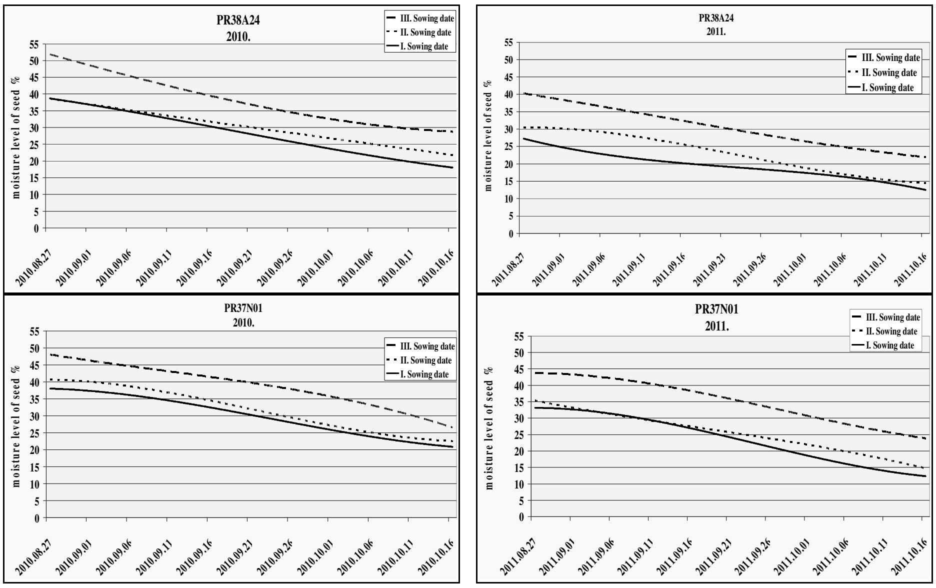

Figure 1. Seed moisture content in different sowing date treatment 2010-2011.

The difference of moisture level between hybrids was persistent till harvest, the values just got closer to each other at harvest time, however, they never became equal. There was 5-10 % moisture level difference between sowing times at harvest *(Figure 1.)*.
The difference in moisture content was significant. In the wet year of 2010 seed moisture content at harvest was higher than in the 2011 dry year. Examined the various

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sowing date achieved yields of maize. In 2010 and 2011, we found significant difference between each sowing time. In 2010 the yield of the first sowing time was 6.247 t ha^{-1} in the average of the hybrids, second sowing time resulted in 6.891 t ha^{-1}, third sowing time had 7.652 t ha^{-1}. Each of them is significant, value of significant difference was 0.61 between sowing times in 2010.

Table 3. Yields, and moisture content of harvest of maize hybrids in 2010 and 2011.

	2010.						2011.					
Hybrids	Yields t/ha			Moisture content at harvest %			Yields t/ha			Moisture content at harvest %		
Sowig time	I.	II.	III.	I.	II.	III.	I.	II.	III.	I.	II.	III.
PR37M34	5.87	6.42	6.99	17	18	28	7.02	5.95	5.54	13	15	23
PR38A24	5.95	6.52	7.19	18	22	29	7.19	5.94	5.63	13	14	23
PR37N01	6.92	7.74	8.78	21	23	27	8.67	6.86	6.45	13	15	24
Average	6.25	6.89	7.65	18.7	21.0	28.0	7.62	6.25	5.87	13.0	14.7	23.3
SzD5%	0.61			2.33			0.49			2.14		

In 2011 the yield of the first sowing time was 7.627 t ha^{-1} in the average of the hybrids, second sowing time resulted in 6.249 t ha^{-1}, third sowing time had 5.872 t ha^{-1}. Each of them is significant, value of significant difference was 0.49 between sowing times in 2011. In two different years the yields were formed differently, but in early sowing date is always lower seed moisture content was obtained.

Conclusions

There was a significant difference in the drying down capacity of hybrids sowed at different times for we received each time significantly lower seed moisture level at early sowing. Earlier sowing results in earlier maturing, faster drying down and 6-10% less seed moisture level at harvest. Therefore, earlier harvest and more efficient maize production becomes possible. The knowledge of specific reaction of maize hybrids at different sowing times is the basis of the creation of hybrid-specific technologies. Hybrids with wide flexibility to different sowing times should have an advantage in use.

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EVALUATION OF STRESS SUSCEPTIBILITY IN WINTER WHEAT VARIETIES USING DROUGHT TOLERANCE INDICES

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Abstract: Commercial winter wheat varieties were tested in a 4-year field experiment for their yielding ability under optimal and drought-stressed conditions. The grain yield reduction caused by insufficient moisture varied yearly from 45% to 81%. Different drought indexes based on varietal performance under drought compared to moisture optimum were calculated and applied for identification of stress susceptible/tolerant varieties. The relationship between indices and relative yield was analyzed by correlation analysis and principal component analysis (PCA). Using PCA, which explained 95% of the total variance, tested varieties were discriminated according to their yield potential and response to drought stress. According to the results, several varieties can be recommended to farmers for drought-prone environments as more stress tolerant.

Keywords: *Triticum aestivum*, cultivars, drought, stress tolerance

Introduction

Drought is the most important environmental stress in agriculture worldwide and even in Central Europe region insufficient precipitation in some years can cause significant reduction in crop production and consequently economical losses. Winter wheat is a preferred crop in drought-prone areas in the Czech Republic, therefore information about drought tolerance/susceptibility of commercial varieties are valuable for farmers. In order to identify drought tolerant genotypes, several selection indices have been recommended on the basis of grain yield under stress and non stress conditions (Geravandi et al., 2011). Fernandez (1992) suggested cultivars classification into four groups according to their yield performance in optimal/stress conditions.

Materials and methods

Winter wheat field experiments with 29 commercial varieties were performed during four growing seasons (2006-2009) simultaneously at two sites with different water availability (optimal/dry conditions). The average grain yield reduction reached 45%; 68%; 67% an 81%, consequently. The yield data were used for calculation of relative yields, a measure of stress tolerance (TOL) as the yield difference between stress and non-stress envirnonments (Rosielle and Hamblin, 1981), Drought Resistance Index (DRI), which is related to yield stability (Fisher and Maurer, 1978; Mohammadi et al., 2010), Stress Tolerance Index (STI) estimated drought tolerance (Fernandez, 1992) and Superiority Measure (SPM) related to the stability of genotypes in different environments (Lin and Binns, 1988). The data were standardized in order to lower the impact of high yielding environments (Clarke et al., 1992). Principal component analysis (PCA) (Statistica 8.0, StatSoft) was applied for a classification of varieties according to their response to stress conditions.

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Results and discussion

The tested varieties showed significant differences in grain yield both in stress and non stress conditions. The average relative yields and calculated stress tolerance indices together with correlation coefficients are given in *Table 1*. Higher values of TOL are associated with larger yield reduction and thus higher sensitivity to stress (Sio-Se Mardeh et al., 2006). However, this index did not favor the best yielding varieties. From this point of view is more effective STI, which identifies high yielding varieties in dry conditions with respect to their performance in normal conditions. On the other hand high values of DRI are associated with above average yields under stress and low yields in normal conditions.

Table 1. Relative yields and drought tolerance indices calculated for 29 wheat varieties grown on optimal and dry site in 2006-2009

Variety	RYh	RYs	TOL	STI	DRI	SPM
Akteur	101	90	1,13	0,91	0,88	2,89
Alacris	88	113	0,75	1,01	1,27	4,00
Arida	91	100	0,86	0,92	1,11	4,35
Axis	98	121	0,92	1,19	1,25	1,26
Balada	94	118	0,86	1,14	1,26	1,69
Bardotka	97	113	0,92	1,12	1,18	1,30
Barryton	100	93	1,00	0,94	0,93	1,53
Biscay	105	107	1,06	1,11	1,01	0,94
Bohemia	98	91	1,01	0,92	0,93	2,11
BonaDea	96	89	1,02	0,89	0,94	3,61
Bosorka	97	83	1,00	0,81	0,85	2,34
Buteo	103	99	1,10	0,98	0,93	1,33
Cubus	103	96	1,04	0,97	0,90	1,61
Darwin	101	102	1,06	1,00	0,97	1,22
Dromos	106	111	1,08	1,17	1,03	0,66
Etela	104	88	1,14	0,91	0,84	2,37
Eurofit	103	97	1,10	1,00	0,92	1,63
Florett	104	104	1,08	1,04	0,96	0,94
Globus	101	107	1,04	1,03	1,03	1,44
Hedvika	107	82	1,26	0,88	0,77	3,14
Kerubino	105	109	1,05	1,18	1,06	0,67
Ludwig	96	99	1,03	0,96	1,02	3,02
Meritto	109	115	1,16	1,27	1,05	0,74
Mulan	108	95	1,12	1,03	0,88	0,88
Rapsodia	102	85	1,11	0,85	0,80	2,58
Sakura	101	118	0,97	1,23	1,19	0,73
Samanta	102	108	1,01	1,06	1,02	0,87
Simila	101	97	1,09	0,94	0,92	1,50
Venistar	97	103	0,92	1,00	1,05	2,25

Correlation coefficients (* P<0,05; ** P<0,01)

	TOL	STI	DRI	SPM
RYh	0,86**	0,26	-0,52**	-0,66**
RYs	-0,52**	0,90**	0,90**	-0,45*

RYh - mean relative yield in high yielding environment
RYs - mean relative yield in drought stress environment
TOL - Tolerance; STI - Stress Tolerance Index
DRI - Drought Resistance Index; SPM - Superiority Measure

The SPM compares the productivity of genotypes across environments using the highest yielding variety as a reference and the varieties with the largest difference have the highest SPM values. Therefore the varieties with low SMP were superior in both conditions.

Different correlation coefficients between yields and indexes (*Table 1*) suggested that evaluation based on a combination of indices may provide a more complex estimation of varietal response to stress. Using principal component analysis (PCA) tested varieties were roughly divided into four groups according to their yield potential and response to drought stress. The PCA explained 57.6% and 37.7% of total variation (*Fig. 1*). Group A included the most suitable varieties for both high yielding and stress environments. Varieties in group B were superior in normal conditions and showed higher sensitivity to stress, and varieties in group C had superior yield in dry condition and low yield in optimal condition. Group D varieties produced low yields in both stress and non-stress environments.

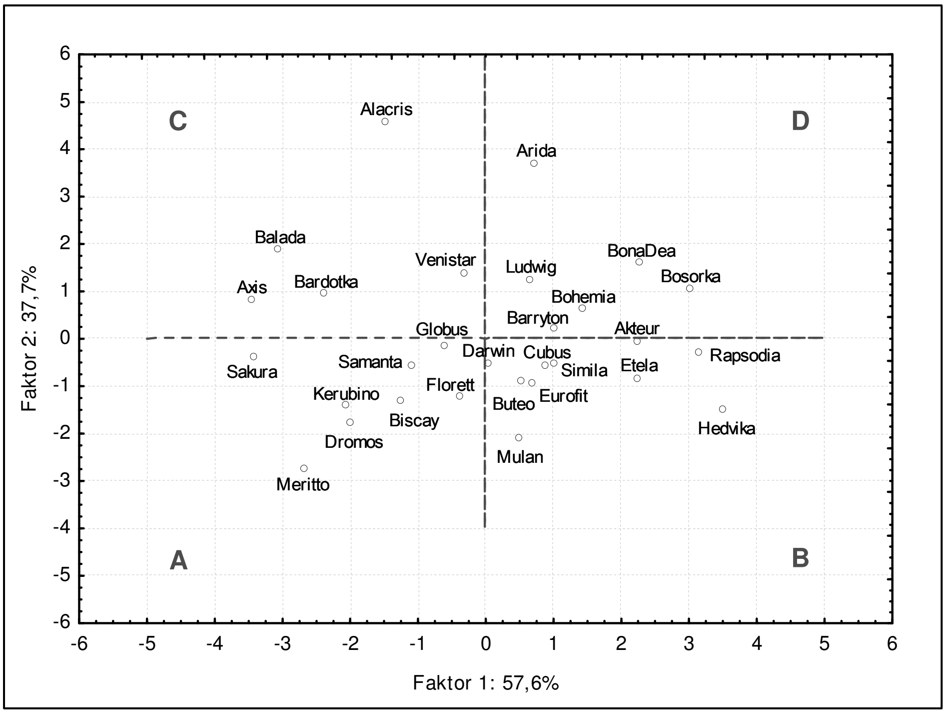

Figure 1. PCA of yield and drought tolerance indices of 29 varieties

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Conclusions

In this study, 29 commerical varieties were tested for their performance in water limited environment. Drought stress reduced significantly the yield of all varieties, but there were different patterns in their productivity under stress and some varieties with better response were identified. Although in Central Europe the shortages of precipitation occur very irregularly, in drought-prone areas farmers should prefer varieties that produce high yields when water is not limiting, and show a certain level of drought tolerance.

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IRRIGATION AND NITROGEN FERTILIZATION NEEDS FOR MAIZE IN OSIJEK-BARANYA COUNTY

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Abstract: Global climatic changes have considerably impacts on field crops growing, mainly by increasing trend of temperature and more frequency of drought stress in the critical stages of growth. Irrigation is direct measure for improvement of water status in soil and alleviation of drought stress effects. Stationary field experiment with irrigation and nitrogen fertilization was started on Agricultural Institute Osijek in spring 2006. Soil moisture was maintained by irrigation in range from 60% to 100% (A2) and 80% to 100% (A3) of field water capacity (FWC) and no irrigation treatment (A1, control). Three rates of nitrogen were used: B1=control (non-fertilized), B2=100 kg N ha^{-1}, B3=200 kg N ha^{-1}. Aim of this paper is analyse variation of maize grain yields in the period 2006-2011 with rainfall and temperature regime in connection with set treatments. In the 3-month June-August period precipitation in Osijek were in range from 105 to 377 mm and mean air-temperature from 21.0 to 22.8 degree. In accordance with these parameters status, need for irrigation was in range from 40 to 160 mm and from 80 to 280 mm, for maintenances of soil water in ranges 60-100% and 80-100% of FWC, respectively. Maize yield increases as affected by irrigation (means of two irrigation treatments) were as follows: 11% (2006), 18% (2007), 11% (2008), 8% (2009), 0% (2010) and 30% (2011). Nitrogen fertilization resulted also by yield increases of maize for 21% (B2) and 36% (B3).

Keywords: maize, irrigation, nitrogen fertilization, grain yield, water

Introduction

Global climatic changes have considerably impacts on field crops growing, mainly by growing trend of temperature and more frequency of drought stress in the critical growth stages. Jolánkai et al. (2005) found in Carpathian basin ascending levels of temperature with a magnitude of 1 ^{o}C and decreasing trend-line of annual precipitation for 83 mm during one century. Maize (*Zea mays* L.) is the most important field crop in Croatia with average cropped area 302512 ha (mean 2000 - 2010: the State Bureau for Statistics 2011). Precipitation shortage, especially during July and August is mainly in close connection with low yields and grain quality of maize (Shaw, 1988; Josipovic et al., 2005; Sostaric and Josipovic, 2006; Kovacevic et al., 2007; Hegyi et al., 2008; Kovacevic et al., 2009; Maklenovic et al., 2009). Aim of this study was testing need for irrigation and nitrogen (N) fertilization of maize under field experiment conditions for 6-year period on Osijek eutric cambisol. Some results of this experiment were shown in the previous studies (Plavsic et al., 2007; Josipovic et al., 2010; Marković et al., 2011).

Materials and methods

The field experiment

The long-term stationary field experiment with irrigation and nitrogen (N) fertilization was set on the experimental field of Agricultural Institute Osijek. Soil type of the experiment site is characterized as eutric cambisol (Soil Survey Division Staff, 1993) on calcareous loess substrate (silt clay loam texture, shallow clay), neutral reaction (pH in

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KCl 6.7), adequate supplied with plant available phosphorus and potassium (AL method: 24.6 mg P_2O_5 and 33.4 mg K_2O 100 g^{-1}).

Impact of irrigation rates (IR), N fertilization and genotype on maize grain yield were tested under field conditions (six growing seasons, 2006-2011). The experiment was set by split-split plot method according to randomized block design. Soil moisture maintained by irrigation (factor A) from 60-100% (A2) and 80-100% (A3) of FWC and no irrigation treatment (A1) was the control. Soil water content measured by Watermark soil moisture instrument and irrigation by self-moving sprinkler was performed.

N fertilization (sub-factor B) treatments were as follows: B1=control (non-fertilized), B2=100 kg N ha^{-1}, B3=200 kg N ha^{-1}. Two third of planned N quantities were added in autumn and pre-sowing (urea: 46% N) and the rest by two top-dressings at early growth stages (calcium ammonium nitrate: 27% N). Phosphorus on the 100 kg P_2O_5 ha^{-1} and potassium 150 kg ha^{-1} K_2O basis were applied. Four maize hybrids (sub-sub factor C) were tested, but at this point yield effects showed on irrigation and N fertilization levels. Harvesting area of basic experimental plots were 14 m^2 (genotype), 56 m^2 (N fertilization) and 112 m^2 (irrigation), respectively. Maize was sown at end of April beginning May. Planned plant density of maize was 58309 plants ha^{-1}.

Collection of weather data, grain yield calculation and statistical analysis

Source of the weather data (precipitation and mean air-temperatures) was the State Hydro meteorological Institute in Zagreb (Osijek Weather Bureau: distance from the experiment 3 km in E direction). Grain yields calculated on 13% grain moisture basis on irrigation and N-fertilization levels. Statistical analysis of the data performed according SAS GLM, split-plot model procedure (SAS, 1998).

Results and discussion

Weather characteristics and water quantities added by irrigation

Precipitation in Osijek for the 3-months (June – August) of 2006 – 2011 period were in two years in 100-130 mm range (105 mm and 129 mm, for 2007 and 2011, respectively), in two years in 150 -200 mm range (187 mm and 167 mm, for 2008 and 2009, respectively) and in two years above 200 mm (240 mm and 377 mm, for 2006 and 2010, respectively). At the same period, mean air-temperature was from 21.0 to 22.8 ^{o}C. In general, the growing seasons 2006 and 2010 were more favourable for maize in comparison with remaining four tested years, while 2007 and 2011 were considerably unfavourable for maize growing because of drought stress. For example, precipitation in June-August period was 50% lower in 2007 and 39% lower in 2011 compared to 30-year mean. Maize on the control treatment was exposed by drought stress in the periods July 2006 and 2009, June-July 2007, August 2008 and 2011 as well. Water deficit was mainly accompanied with the higher air-temperatures (*Table 1*).

In accordance with weather characteristics (*Table 1*) water quantities added by irrigation were, depending on the growing season, in ranges from 40 mm to 160 mm and from 80 to 280 mm, for the treatment A2 and A3, respectively (*Table 2*). Depending on the growing season, total water supplies for maize were from 331 to 776 mm (A1 treatment), from 422 to 816 mm (A2) and from 571 to 856 mm (A3, *Table 2*.)

Table 1. Weather data for Osijek 2006-2011 and long-term mean 1961-1990

Osijek Weather Bureau									
Year	Precipitation (mm) and mean air-temp. (°C) in June, July and August								
	June		July		August		Sum	Mean
	mm	°C	mm	°C	mm	°C	mm	°C
2006	91	20.1	15	23.5	134	19.3	240	21.0
2007	33	22.3	27	23.9	45	22.2	105	22.8
2008	89	22.0	70	22.8	28	23.1	187	22.6
2009	74	19.7	31	23.6	62	23.5	167	22.3
2010	234	20.4	32	23.2	111	21.7	377	21.8
2011	50	20.8	74	22.2	5	23.1	129	22.0
1961-1990	84	19.5	67	21.1	60	20.3	211	20.3

Table 2. Number of irrigation, watering amount (mm) and total water supplies

Year	Number of irrigations (n) and watering amount (mm)				Total water supply (mm) = Precipitation (mm) + soil reserve water (100 mm) + water added by irrigation (mm)		
	A2		A3				
	n	mm	n	mm	A1	A2	A3
2006	2	80	3	120	513.9	593.9	633.9
2007	3	120	5	200	401.7	421.7	601.7
2008	2	80	3	120	537.3	617.3	737.3
2009	4	160	6	240	330.8	490.8	570.8
2010	1	40	2	80	776.2	816.2	856.2
2011	4	160	7	280	347.0	507.0	627.0
Mean	2.7	107.7	4.3	173.3	384.5	574.5	671.2

<u>Maize yields</u>

Maize yield increases as affected by irrigation (means of two irrigation treatments) were significantly increased in five years and in 2010 non-significant differences of irrigated treatments compared to the control were found.

In general, by the first step of irrigation, yields of maize were increased for 9% and by the second step, for 14% (6-years means). The highest effects of irrigation on maize yields were found in 2011 because of yield increases for 29% and 31% by A2 and A3 treatments, respectively. However, these effects in remaining five years were from 0 to 9% for the A2 and from 0 to 28% for the A3, respectively (*Table 3*).

By the first step of N fertilization maize yield was increased for 21% and by the second step for 36% compared to unfertilized treatment (6-years means). Degree of added N utilization for maize yield increases were the highest under conditions of the 2010 growing seasons because yield increases for even 49% and 103%, for A2 and A3 treatment, respectively (*Table 3*). In the remaining five years these effects were depending on year from 4 to 49% (B2) and from 13 to 68% (B3).

During June-August period the smallest precipitation was in year 2007 (105 mm), but its distribution was almost convenient for maize growing and good yield (9456 kg ha^{-1}). In the year 2011 was 129 mm precipitation (June-August period), but in August fall 5 mm, only, and that was probably main reason for achieving the lowest yield (8465 kg ha^{-1}, in six year period). Our results are in accordance with Shaw (1988), Josipovic et al. (2005), Kovačević et al. (2007), Plavšić et al. (2007), Hegyi et al. (2008), Kovačević et al. (2009) and Maklenović et al. (2009).

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Table 3. Influences of irrigation, N fertilization on grain yield of maize

Treatment	Grain yield (t ha^{-1}) of maize (FWC = field water capacity)						
	2006	2007	2008	2009	2010	2011	Mean
	Irrigation effects						
A1 (non-irrigated)	8.54	8.43	8.21	10.34	9.01	7.05	8.59
A2 (60-100% FWC)	9.26	9.17	8.96	10.57	9.26	9.12	9.39
A3 (80-100% FWC)	9.62	10.78	9.24	11.66	8.25	9.23	9.80
LSD A 5%	0.16	0.18	0.16	0.13	0.61	0.26	
LSD A 1%	0.21	0.24	0.21	0.17	0.80	0.35	
	Nitrogen fertilization effects						
B1 (non-fertilized)	8.33	8.94	7.70	9.82	5.85	6.04	7.79
B2 (100 kg N ha^{-1})	9.13	9.29	9.23	10.93	8.73	9.22	9.42
B3 (200 kg N ha^{-1})	9.96	10.14	9.47	11.82	11.93	10.17	10.59
LSD B 5%	0.16	0.18	0.16	0.13	0.56	0.32	
LSD B 1%	0.21	0.24	0.21	0.17	0.74	0.42	
	Year effects						
	9.14	9.46	8.80	10.86	8.84	8.48	

Conclusion

In our study very different effects of irrigation and N fertilization among different growing seasons were found. In general, irrigation was useful crop management practices for maize yield increases especially under drought conditions. Also, adequate N fertilization in amount of 200 kg N ha^{-1} was considerably factor of yield increases.

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VARIABILITY OF TRAIT OF SPIKE IN TWO WHEAT CULTIVARS (*TRITICUM AESTIVUM* L.)

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Abstract: The effect of irrigation to spike traits of two different genotypes (G-10 and G-25) was investigated in experiment designed in 5 reps on the plots of 1 m^2 with 5 variants of irrigation water. Watering was carried out from tillering stage to maturity stage of each seventh on the amount of 5 l/m^2 of water with different degrees of purity. Used the water from the pool in which lived a) ichthyofauna of contaminated water, b) ichthyofauna of half polluted water, c) ichthyofauna of clean water, d) tap water and then the option is) without watering as a control. Effect of water was analyzed on the base of reaction of investigated genotypes under treatments by different degree of water purity. For this purpose were estimated values of spike traits (lenght of spike, number of spikelets per spike and number of kernels per spike) in examined genotypes. For the analysis were taken from the plant root (10 plants/replication ie. 50 plants for one variant of irrigation and 250 plants / line). The highest values of anayzed traits of spike were expreessed at the variant of irrigation by water in which lived ichthyofauna of contaminated water for lenght of spike was 9.6cm (G-10) and 9.0cm (G-25) was abaut 1cm was larger than in other variant. Also, higher number of spikelets per spike 21.2 (G-10) 19.8(G-25) was than i other variant and significantly higher values of number of kernels per spike 48.8 (G-10), 43.1(G-25) than in other variant.

Keywords: wheat, irrigation, spike, grain

Introduction

Optimum soil, climate conditions and growing technology adopted to specific cultivar is necessary provide for achievement of high yield of wheat (Jolánkai and Németh, 2002). Irrigation regime is one the most important factor for scientific farming of crops. During the booting phase of wheat development, the leaf area increase for five or more times compared to the surface in full tillering as well actively absorbing root surfaces. At the same time increases transpiration areas, particularly in relation to the absorptive surface of the active root system, and therefore this stage is considered critical in terms of the need for water absorption (Pesic et al., 2005). Because of that plants at this stage of wheat irrigation applied, unless there is sufficient rainfall and favorable schedule.

In spring time root systems of winter wheat are deep and capable for efficient absorption of water. After developing underground vegetative part the requirement of wheat plant for water mainly for the most cultivars need to be on the level of evaporation. In order to achieve high yield of wheat is necessary favorable nutrition and soil moisture regime. So, environmental and management factors have influence to variation of yield and yield components (Birkás et al., 2007; Paunovic et al., 2007; Petrović et al., 2008; Pepó, 2010). In terms of drought and moisture deficit, the irrigation is necessary. The sources of irrigation are the most common rivers with different degrees of purity or pollution, depending on the time of year, climate type, region etc. The water from these rivers is used for irrigation. It is important to know the effect of various degrees of water purity on the yield, quality and health of crops. For this investigation we used water from aquarium in which lived fish with adaptation to specific level of contamination. Aquarium water is the most key component of the environmental factor for fish. In aquarium water is often deficit of some environmental

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factor and over time the algal content, bacterial colonies varies which contributing to water contamination. In aquarium water are occure cycles of different element what have influence on quality of water.

The aim of the study presented here was to test the influence of watering by water poured from aquarium pool where lived fish adapted on different digre of purity on wheat wheat yield component after harvesting.

The research question was as follows: does watering with wather from pool in which lived fishes with specific adaptability on water purity have influence to wheat productive traits in comparation to drinking water and variant without watering. The second question was does equal safely irigate wheat crops with rivers water with diferent level of polution.

Materials and methods

Two genotypes of wheat G-10 and G-25 were investigated, on soil type smonitza with humus content 2.31%, in field experiment on 1 m^{-2} plots and 5 repetitions under 5 different variants of watering. Watering was carried out from tillering stage to maturity stage of each seventh days on the amount of 5 *l* m^{-2} of water with different degrees of purity. In experiment were analyzed yield components (lenght of spike, number of spikelets per spike and number of kernels per spike) of wheat lines which watered each 7th days from tillering stage to maturity stage with 5 *l* m^{-2} of water with different degrees of purity originated from the pool in which lived a) ichthyofauna of contaminated water, b) ichthyofauna of half poluted water, c) ichthyofauna of clean water, d) tap water and then the option is e) without watering as a control. For the analysis were taken from the plant root (10 plants/replication i.e. 50 plants for one variant of irrigation and 250 plants/line). A total of 500 plants were analyzed for the two cultivars tested for all reps and variant of watering. The analysis of variance was calculated by using ANOVA (MSTAT-C program, 1989) and significant differences among the means were estimated according to least significant difference (LSD).

Results and discussion

The spike traits of investigated wheat genotypes expressed different values in dependence of applied water (*Table 1*.). The length of spike in both wheat genotypes (G-10 and G-25) was the highest on the variant of watering from the pool in which lived ichthyofauna of contaminated water. The average length of spike lenght of spike 9.6 cm in G-10 and 9.0 cm in G-25 was significantly higher than on remain four variant of watereng. Also, the highest number of spikelets per spike had G-10 (21.2) which is significant different than value in G-25 (19.8) as well in comparation to other variant of watering. The number of kernels per spike was the highest on the variant of watering from the pool in which lived ichthyofauna of contaminated water in both analyzed genotype G-10 (48.8) and G-25 (43.1). The values of average number of kernels per spike on five variant of watering were significantly different for both genotypes and between analyed wheat genotypes (*Table 1*. and *2*.). Genotype G-10 had higher average value of number of kernels/spike than G-25 on all variant of watering what could indicate that their different root sensitivity or efficient reaction on entered flora with

watering. However, in both genotypes the increase values of analyzed spike traits were an response to the same variant of watering (*Table 1.*).
The longer period from booting to heading is a prerequisite for the realization of a higher number of kernels per spike. For the normal passage of this phase requires good moisture, mineral nutrition and optimum temperature at least 15 ^{0}C. Because of different climatic condition is neccasary improve genetic control of flovering phase and extend life cycle in the aim of increase yield of components (Pesic et al., 2005; Sikder and Paul, 2010). Although the reduced number of spikelets increased the fertility of spikelets which compensated number of kernels per spike. Developing grains largely depends on environmental conditions (Stone and Nicolas, 1994). Genotypes, environmental conditions, farming system and their interaction contribute to formation yield components (Al-Doss et al., 2010; Barošova and Kristiansen, 2010; Kovacevic et al., 2006; Macak et al., 2009). It mean that used variant of watering is not decisive for yield, but it coul use in modification of practice farming for stability wheat yield in dried condition.

Table 1. Spike traits of two wheat genotypes irrigated by water of different purity from the tillering stage to maturity stage of development

Geno type	Characteristics	Source of water for watring				
		Pool with fishes adapted on polluted water	Pool with fishes adapted on half-polluted water	Pool with fishes adapted on pure water	Drinking water	Control (without watering)
G-10	Length of spike /cm/	9.6	8.5	8.4	8.5	8.4
G-25	Length of spike (cm)	9.0	8.3	8.7	8.4	8.1
G-10	N. of spikelets/spike	21.2	19.8	18.4	19.2	19.7
G-25	No. of spikelets/spike	19.8	19.5	19.4	19.3	19.1
G-10	No. of kernels /spike	48.8	39.1	40.1	41.6	33.9
G-25	No. of kernels /spike	43.1	40.6	39.9	41.8	36.4

Table 2. Mean and analysis of variance for values legth of spike and No.of spikelets/spike of whear

Source	DF	Legth of spike				No.of spikelets/spike				No.of kernels/spike			
		MS	F	LSD 0.05	LSD 0.01	MS	F	LSD 0.05	LSD 0.01	MS	F	LSD 0.05	LSD 0.01
Reps	4	.12	2.47	.27	.44	.72	10.2	.32	.51	3.2	20.8	.48	.81
Cultivr-A	1	.40	8.53	-	-	.69	9.9	-	-	1.4	9.3	-	-
Water-B	4	1.7	35.6	.27	.45	3.6	51.2	.33	.51	151	973.7	.49	.81
AxB	4	.27	5.63	.38	.63	1.9	27.7	.46	.77	25.3	163.1	.69	1.2
Error	36	.05				.07				.16			

Analysis of variance showed highly significant differences among genotypes (A) for all analyzed traits. Differences between investigated genotype (A) and water type (B) were also high significant for all analyzed traits. The strong particular influence to lenght of spike, number of spikelets/spike and number of kernels per spike had watering and genotype as well their interaction.

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Conclusions

The variability of values of analyzed spike traits were established and due to genotypes, environment and their interaction. Interactions between genotypes and applied watering were highly significant, that indicate specific reaction of wheat genotypes to watering with different purity of water. The best values length of spike, number of spikelets per spike number of kernels per spike were expressed on plots watered by water from pool where live fishes adapted on polluted water. This value is significantly different in comparation to remain variant of watering in which values were similar. This study has shown an indication of genotype response to the addition of water contaminated by varying degrees and opened a number of questions to estimate the optimum method of supplying amounts and sources of water for irrigation, which would have a positive effect to increasing yield and yield components, more efficient enrichment of rhizosphere and translocation of mineral elements from the soil of grain of wheat.

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QUALITY-QUANTITY-WATER USE RELATIONSHIPS IN WINTER WHEAT PRODUCTION

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Abstract: In Hungary, winter wheat is one of the most important crops and in last years the negative effects of environmental factors (drought, inland inundations), decaying circumstances resulted significant decrease in the quality and quantity of the wheat yield. To decrease the negative effect of these elements we have to analyze the yield and quality stability of winter wheat, how quality and yield stability is influenced by the different cropyears and genotypes. We examined the effect of fertilization on yield and quality of different winter wheat genotypes in a long-term small-plot experiment on chernozem soil from 2001 to 2011 years. In the last decade the water supply varied from unfavorable weather conditions, long drought periods with weaker vegetative developments and low yields to nearly optimum weather conditions with excellent yields. The results were evaluated with analysis of variance, linear regression analysis, Kang's method for stability analysis and Pearson's correlation analysis. Analyzing the yield stability, fertilizer response and quality parameters we found significant differences between the varieties. Nutrient supply by using of variety-specific fertilization could increase not only the yield quantity, but the yield quality too, which is significantly modified by the genotypes and the character of the actual cropyear in each type of quality parameter.

Keywords: winter wheat, quality, yield, water use

Introduction

The environmental adaptability of crop production is basically determined by the selection of biological background suitable for the region and the site to increase the yield and decrease the yield fluctuation caused natural effects. (Balogh and Pepó, 2006). In the last years the negative effects of environmental factors (drought, inland inundations), decaying circumstances resulted significant decrease in the quality and quantity of the wheat yield. Plant reproduction is sensitive to water deficits (Boyer-Westgate, 2004), and nutrient supply (Fernandez et al., 1996) and varieties can adapt themselves differently to environmental conditions. In general, varieties that give relatively good yields under unfavorable conditions will utilize improving environmental conditions to a lesser extent. (Pepó and Győri, 2005).

The nutrient supply has different but very reasonable effect on the quality and quantity of yield in the case of differing genotypes because there are variety specific reactions among dissimilar wheat varieties (Balogh and Pepó, 2008). Under fairly good environmental conditions appropriate and optimum fertilizer application are very effective, but under unfavorable conditions only retrained, moderate fertilizer doses are recommended. (Csajbók et al., 2003; Pepó and Győri, 2005). In the case of a given crop field the best method to moderate the unfavorable effects of different cropyears is the proper choice of varieties show great adaptability to the local ecological conditions and the application of the adequate cultivation method suitable for the chosen genotypes. This procedure demands much more agronomical competence than economic cost. Our most valuable wheat varieties are capable of producing yield with excellent quality and great volume under different cultivation circumstances due to their good adaptation capacity (Kutasy et al., 2004).

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The objectives of our research were to determine the effects of water and nutrient supply to the yield quality and quantity stability of wheat varieties in different crop years.

Materials and methods

The observations were carried out in the University of Debrecen Látókép Research Site between 2001-2011 years. The soil of the experiment is calcareous chernozem soil, it has favorable water management and water holding capacity. The ground water table is in 8-10 m depth. The pH value (KCl) of the topsoil ranges between 6.3-6.5, the N-supply of the soil is moderate. K supply of the soil is good and the phosphorus supply is medium-good.
The long-term experiment was set in the autumn of 1983. The small-plot experiments were set up in strip arrangement with four repetitions in split-plot design. We applied the same fertilizer doses in every experimental year (*Table 1.*).
The forecrop was sweet corn in each year and the gross area of a parcel was 18 m^2.

Table 1. Fertilizer treatments in the experiment

Treatment	N	P_2O_5	K_2O
	kg/ha		
0	0	0	0
1	30	22,5	26,5
2	60	45	53
3	90	67,5	79,5
4	120	90	106
5	150	112,5	132,5

The examined varieties were GK Öthalom and Lupus (2001-2011).
The values of wetness, wet gluten contents, farinograph index and the Hagberg Falling Number were determined according to the Hungarian standards.
We analyzed and evaluate the data of experimental results with the SPSS 13.0 statistical software. The results were evaluated with analysis of variance, linear regression analysis, Kang's method for stability analysis and Pearson's correlation analysis.

Results and discussion

In order to analyze the yield stability of winter wheat varieties Kang's stability analysis was used, during which the interaction between the environment (cropyear) and the different genotypes was revealed. This is confirmed by the R values except the control treatment, where we didn't use any fertilizer, therefore the yield stability could have been accurately evaluated. It is proved that the yield stability of those varieties is best, of which the regression coefficient is smallest.
Analyzing the yield stability of varieties we found, that Lupus was more stable, it means that under weaker environmental conditions its average yield was higher than the yield of GK Öthalom, but the maximum yield of this variety was considerably lower in the case of fairly good environmental conditions. The yield of Lupus was very good in the control treatments, which shows the good natural nutrient utilization capacity of this

variety. GK Öthalom is very instable and sensitive. Under weaker environmental conditions its yield was lower than environmental average, but with the improvement of the environmental conditions their yield was outstandingly high.

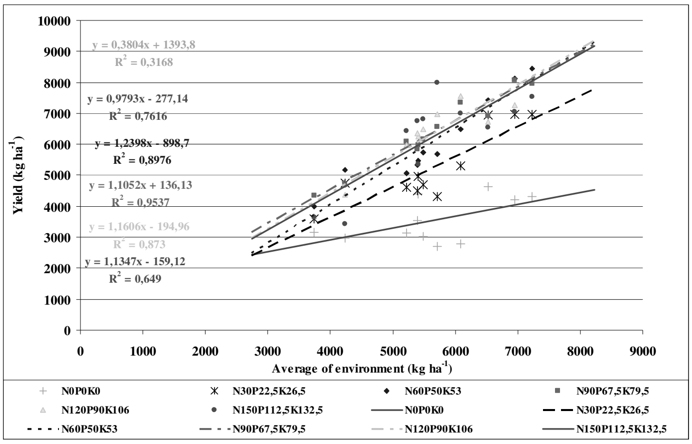

Figure 1. Yield stability of GK Öthalom variety (2001-2011)

In the years of 2001-2011 we studied the yield stability of GK Öthalom (*Figure 1.*) winter wheat variety. The results of the Kang's yield stability analysis of the fertilizer treatments proved that the most stable but lowest yield was obtained in the control treatment without any fertilizer. The greatest increase of the yield was observed in the N60P50K53 treatments under improving environmental conditions, while the N90+PK treatment resulted the largest yield increment in the case of less favorable environmental conditions.

Table 2. Correlations between the potential and actual evapotranspiration, the yield and the quality parameters of wheat (2001-2011, Debrecen)

		PET	AET	PET-AET	Yield	WGC		Fall		GEV	Farin
						N_{30}+PK	Av.	N_{30}+PK	Av.		
PET		1	0,05	0,70*	-0,15	-0,62	-0,36	-0,77*	-0,26	-0,05	-0,33
AET			1	-0,68*	0,23	0,32	0,17	0,38	0,30	-0,20	-0,40
PET-AET				1	-0,27	-0,71*	-0,41	-0,87*	-0,41	0,11	0,05
Yield					1	-0,06	-0,03	0,31	-0,48	-0,62	0,22
WGC	N_{30}+PK					1	0,91*	0,84*	0,79*	0,52	0,15
	Av.						1	0,72*	0,80*	0,67	-0,01
Fall	N_{30}+PK							1	0,87*	0,29	0,09
	Av.								1	0,60	0,09

Pearson- correlation coefficients, * Correlation is significant at the 0.05 level (2-tailed).

WGC: wet gluten contents, GEV: gluten elasticity values, Farin: farinograph index, Fall: Hagberg Falling Number, PET: potential evapotranspiration, AET: actual evapotranspiration, Av: average of nutrient levels

We have analysed the quality stability of varieties too. Comparing the regression coefficients it can be stated, that quality values were most stable but unfavorable at control treatment without any fertilization.

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The quality parameters were determined markedly by the nutrient supply. Analyzing the quality parameters of the examined varieties we observed that the quality parameters of the varieties improved continuously as a result of fertilization until it had reached the N150+PK fertilizer level. Without fertilization the Hagberg Falling Number was almost the same in the different cropyears.
There are no significant differences between water supply parameters and the yield, the farinograph index and gluten elasticity value.
We found the closest correlations between water supply and quality parameters at N30+PK nutrient level. PET-AET has significant effect on the wet gluten content (r=-0.71) and also the Hagberg Falling Number (r=-0.87).
Our measurements show strong connections (r=0.72-0.84) between the wet gluten content and the Hagberg Falling Number of winter wheat (*Table 2*).

Conclusions

The Kang's yield stability analysis proved to be efficient evaluation method for the analysis of the varieties adaptation to the favorable and unfavorable environmental conditions. The most stable but lowest yield was obtained in the control treatment. The greatest increase of the yield was observed in the N60+PK treatments under improving environmental conditions, while the N90+PK treatment resulted the largest yield increment in the case of less favorable environmental conditions. Among of the examined varieties the Lupus proved to be the most stable. The variety of GK Öthalom can be considered as the most instable and sensitive.
Appropriate nutrient supply by using of variety-specific fertilization could increase not only the yield quantity, but the yield quality too, which is significantly modified by the genotypes and the character of the actual cropyear in each type of quality parameter. In the case of examined quality parameters the stability of quality were various under different fertilization treatments. Supposedly these parameters are influenced by other environmental and agrotechnical factors considerably.
From the examined quality parameters the wet gluten content and Hagberg Falling Number were determined markedly by water supply.

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YIELD, RESISTANCE PARAMETERS AND TECHNICAL QUALITY OF WINTER WHEAT CULTIVAR MIXTURES IN DIFFERENT GROWING AREAS

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Abstract: Many experiments have already demonstrated the efficiency of the cultivar mixtures (CMs) to increase the yield stability of the different varieties by numerous mechanisms. To optimize the composition of the mixtures with enhancing the mixture effect we have to follow the breeders' steps. Similarly to the traditional crossing procedure and variety development, studious assemblage of the CMs and complex selection work in multi-location and multi-year experiences need to create successful CMs. This paper demonstrates an important step of this work. On the basis of our data of former experiments, selected winter wheat mixtures and multi-lines with predetermined mixing ratios were planted in two field plot trials in Szeged and Kiszombor. The yield, TKW, resistance levels to powdery mildew, red rust and leaf spot diseases and some technical quality parameters (wet gluten, falling number, Zeleny-index, pharinograph, hardness, and ICC values) were determined of each trait. The results confirmed our previous data. The mixing effects proved to be negative on the powdery mildew and leaf spot diseases while that on the leaf rust showed various results. Considering the great epidemic similarity of this and last years, the incompatibility among the pathogens had been greatly enhanced by the coexistence of the different host varieties yielding ground to the competitor leaf rust. The selected mixtures mostly over yielded the weighted average of pure lines in both growing conditions. Positive mixing effect appeared at the majority of the quality parameters except the ICC values. Our results are conducive to establish an optimization-selection system similar to that of the traditional breeding system leading to develop flexible, efficient and popular CMs.

Keywords: wheat, cultivar mixture

Introduction

Earlier studies have demonstrated an enhancement effect of inter-genotypic competition on yield of wheat cultivars grown in mixed planting system (Jokinen, 1991; Juskiw et al., 2000). Numerous mixture effects like those of the soil borne diseases, weeds and insects, soil fertility, lodging and better over wintering survival of plants are commonly cited but little information is available on how to select components and mixing ratios for establish them in mixtures. The overall performance of a mixture cannot be derived from the simple accumulation of performances of the components, nor can individual contributions to the performance of the mixture be deduced accurately from measurements in pure lines (Finckh and Mundt, 1992). Mille et al. (2006) tested 2-way CMs to exclude incompatible lines to perform more complex CMs on the basis their performances.

Our preliminary results (Fónad, 2011) suggested that the mixing ratio had equal importance in forming the mixing efficacy like the compounds themselves. Our ratio-specific development of CMs was predicated on the assumption in which we can exploit the untapped advantages from the ratio diversity even of its own.

Materials and methods

Considering the one-year and one-location character of the experiment we repeated the trials at two locations. The CMs A with the highest mixture efficiency were selected for planting in the field trials and new two-cultivar mixtures completed them. A three-way winter wheat mixtures in 4 mixing ratios (A) and four more 2 and 3-way cultivar

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mixtures were planted in a common field trial in four replications. The components of the A mixtures were similar to those in the last year trial (Fónad, 2011). The mixing ratios were chosen on the basis of their over-yielding capacity after which the mixing ratio 4:1:2 of CM A was the highest. Also, to specify and confirm this result we apply ratios 4:1:1, 4:1:3 and 4:1:4.

CMs "C" consisted of popular wheat cultivars. The component *GK Fény* with high yielding was moderately resistant to leaf rust and moderately susceptible to powdery mildew and leaf spots. The resistance parameters of cv. *GK Kalász* was similar to those of, its productiveness was lower, the quality parameters were better than those of *GK Fény*. The third component was the cv. *GK Körös*. 4 CMs were set in equal ratios from these pure lines: *Körös-Fény (C-KsF), Körös-Kalász (C-KsK)*, *Fény-Kalász (C-FK)* and a three-way mixture *Körös-Fény-Kalász (C-KsFK).*

The pure lines of all CMs were also planted in the same field trial as standards. The area of the plots was 6.5 m^2, the trial was Latinized. Neither of the plots has been treated by fungicide. The trials were set in two locations. The field in Szeged (S) identical to that of the yesteryear mixture trial had loose alluvial clay soil with good nutrient supply close to a natural water surface. The experimental field in Kiszombor (K) had compact cernoziom with low input.

Yield and 1000-kernel mass (TKM) of seed samples of each plot were determined. Data of disease symptoms caused by powdery mildew, leaf rust and leaf spot diseases in terms of the percentage of leaf area covered with the pathogens. The following technical quality parameters were measured and evaluated on the basis of the whole milling products: extraction rates (E), wet gluten (G), farinograph value (FV), dough forming time (T), stability (ICC), falling number (FN) and Zeleny-number (Z). One factor variance analysis and correlation assay was applied for data evaluation.

Results and discussion

Yield and yield components. The yield levels of the CMs A positively selected last year were dispersed between 104 and 118.5% in the weighted average as per the mixing ratios (*Figure 1.*). The over-yield of A412 in Kiszombor and that of A413, A414 CMs in both locations were significant. These results perfectly correspond with our former experimental data (Fónad, 2011). The mixture effects of the CMs C were also positive (100.6-110.5%, not significant). The level of the mixture effect strongly depended on the mixing ratio and the compounds of the CMs.

The mixture effects on TKW of CMs A 411, A412 and A413 were leak positive (102.5-107.7%) in Szeged, those in Kiszombor and other CMs in both locations were leak negative (81.5-96.4%). Only one trait was significant (*C-KsF*, Szeged: 81,5%, *Figure 1.*). The lack or inverse trend of the correlation between yield and TKW data verified former experiences in which other yield components first had become instrumental in forming the main cultivar-specific compensation/competition mechanism (Julian BT et al., 1993; Fónad, 2011). On the basis of the yield the CMs *A413, A414*, C-*KsK* and C-*KsFK* proved to be the most exploitable regarding the mixing ability their pure lines.

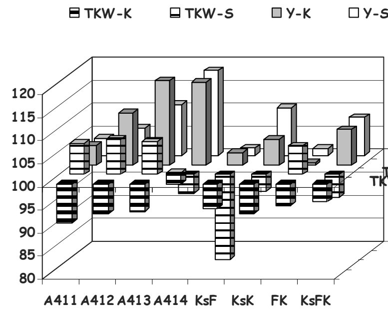

Figure 1. Yield (Y) and TKW of the CMs in the weighted average of the pure lines. C mixtures: KsF, KsK, FK, KsFK K-Kiszombor, S-Szeged. 2012.

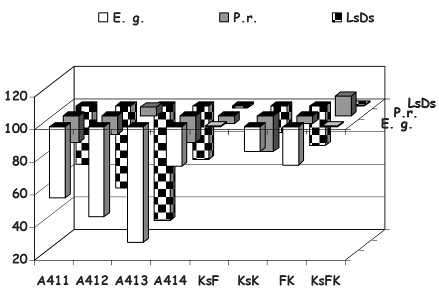

Figure 2. Mixture effect on the foliar diseases powdery mildew (E.g), leaf rust (P.r.) and leaf spot diseases (LsDs) in the weighted average of the pure lines. Szeged, 2012.

Foliar diseases. Important climatic difference was observed between the two growing locations. The late spring was more humid in Szeged than in Kiszombor, consequently, almost as high pathogen pressure had formed here as last year. No diseases have occurred in Kiszombor despite of lack of fungicide, due to the late spring drought. The average severity of leaf rust, powdery mildew and leaf spot diseases were 36, 59 and 12%, respectively. The pressure of *E.g.* was six times higher than in 2010, the abundance of other fungi was similar. The mixture effect on powdery mildew and leaf spots was clearly negative and mostly significant. The decrease of *E.g.* disease on CMs A varied between 24.7-70.9% and between 0-23.6 in case of C mixtures. The leaf spot disease reduction on CMs A varied between 32.6-69.8% and between 0-24.2% at the C mixtures (*Figure 2*.).

The reduction of the leaf rust severity was reflected in a higher percentage of experiments on CMs A the pure lines of which were less resistant. However the mixture effect on leaf rust disease was no significant. Converse mixing effects also occurred (*Figure 2*.). A competition mechanism between the pathogen species can explain the weak enhancement of rust disease of CM A413 (Fónad, 2011) but the cause of another positive mixing effect on CM KsFK was completely different, regarding the lack of any mixing effect on other pathogen species (*Figure 2.*) The mixture efficacy of CMs A413 and A414 were the highest.

Technical quality. The levels of all quality features of CMs A were higher than the weighted averages of their pure lines (*Figure 3*.). Significant positive mixture effect was on FV at several mixing ratios in Kiszombor (121.7-135.2%) and on FN, Ze in both locations (116.7-152.2%). In contrast, the quality parameters of another mixtures C showed mainly not significant losses in comparison to their pure lines (76.9-99.6%). Only G and FN indicated positive mixture effect in the case some two-way mixture C in Szeged (108.5-121.6%). The 3-way mixture C-*KsFK* showed negative effect at all parameters and locations (*Figure 3*). This finding correspond to the former result referring mixing advantages at low or no input production sites (Sarandón and Sarandón, 1995). Regarding to the mixing influence on seed quality data CMs A412, A413, A414 can be selected as the mixtures bringing an enhanced quality. Important finding is the effectiveness of the synergism by mixing rather depended on the types

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and proportion of the pure lines than the location. The mixture effects on the quality of CMs A were similarly great at both locations despite of extremely different quality level between the seed samples (*Table 1.*).

Table 1. Means of the quality parameters of the seed samples from Szeged and Kiszombor.

Location	Wet gluten	Farinograph value	Stability (ICC)	Falling number	Zeleny
Szeged	34.5	88.0	11.9	340	52.1
Kiszombor	18.0	43.7	1.8	323	22.8

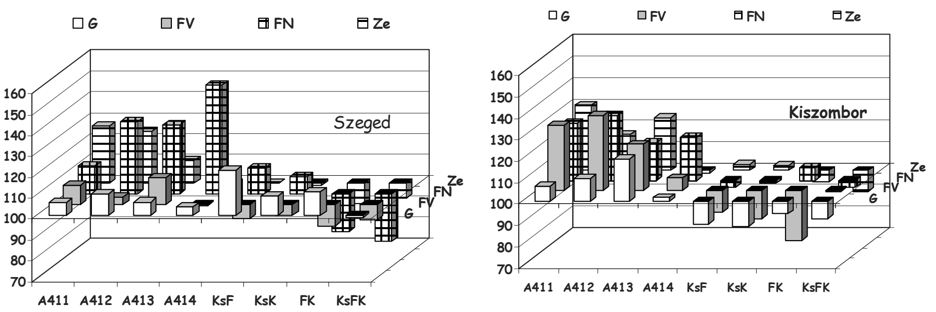

Figure 3. Effect of mixture use on some quality parameters of the seed samples of trials in Szeged and Kiszombor, 2011. Mixtures C: KsF, KsK, FK, KsFK. Data in relative % of the weighted averages of the pure lines.

Conclusions

The intra-specific and inter-specific plant mixtures in the agriculture can become intrinsic elements of the sustainable agriculture in the future. Disease reduction, increasing yield stability along with the pesticide reduction could emerge one of the most important reasons of use cultivar mixtures. Again, in this work we showed a beneficial mixture efficiency for reducing disease levels and increasing yield and technical quality. In addition we designed a possible strategy to develop a CMs selection system similarly to the traditional breeding procedure. In fact, we followed the traditional breeders' steps: the sound assemblage of the CMs can be considered analogous to the crossing procedure as their complex selection process in multi-location and multi-year trials are similar to that of the wheat lines.

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IMPACT OF WATER AVAILABILITY ON THE PERFORMANCE OF MAIZE (*ZEA MAYS* L.)

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Abstract: Yield samples of maize *Zea mays* L. taken from consecutive series of crop years at the Nagygombos experimental field of the Szent István University have been evaluated. Impact of precipitation on yield quantity and quality was studied. In case of maize crop protein, starch, and grain alcohol production was examined.

Yield performance has been highly variable regarding crop years. Yields were affected by precipitation in general, however extremely high precipitation as well as drought caused yield depression. Yield quality was highly influenced by different crop years. Yield quantity of maize crop proved to be more variable than quality parameters. Protein values were smaller, and starch values higher in rainy years. Ethanol processing values were closely related to yield figures. The amount of annual precipitation had a significant impact on ethanol yield.

Keywords: water availability, maize, performance, yield, ethanol

Introduction

Life is based on water fluxes within the habitat as well as that of the specific organism. Water availability profoundly influences all physiological processes of plant life. Water transport of individual plants as well as water budget of the crop site determine growth and development and ultimately quality.

Crop water use, consumptive use and evapotranspiration, are terms used interchangeably to describe the water consumed by a crop. This water is mainly used for physiological processes; a negligible amount is retained by the crop for growth. Water requirements for crops depend mainly on environmental conditions. Plants use water for cooling purposes and the driving force of this process is prevailing weather conditions. Different crops have different water use requirements, under the same weather conditions (Várallyay, 2008; Pepó, 2010). Crops will transpire water at the maximum rate when the soil water is at field capacity. When soil moisture decreases, crops have to exert greater forces (energy) to extract water from the soil. Usually, the transpiration rate doesn't decrease significantly until the soil moisture falls below 50 percent of available water capacity. Information regarding seasonal crop water requirements are crucial for planning crop species planting especially during drought years. In Hungary, the seasonal water use of maize crop is 550 mm while cereal grain crops use some 400. These water requirements are net crop water use (the amount a crop will use not counting water losses such as deep percolation and runoff) in an average year, given soil moisture levels don't fall below critical levels. Under ideal conditions, this net water requirement is reduced by the effective rain (Muchová-Fazekašová, 2010; Führer et al., 2011; Pásztorová et al., 2011).

Maize provides a basic staple for mankind as well as a most widely used feed for animals. This crop is one of the most important ones in Hungary, and has a high economic value. Utility, market and alimentation value of the crop is highly affected by climatic conditions, specifically annual weather performances, as well as soil moisture conditions (Ács et al., 2008; Koltai et al, 2008; Pepó et al, 2000; Várallyay, 2008). The aim of maize production is twofold; to provide quantity and quality. Maize is a major

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source of protein and carbohydrates for human and animal nutrition. At the same time maize is a valuable industrial raw material providing bases for biofuels, sugar, oil etc. Maize performance is mainly determined by the genetic basis, however it can be influenced by management techniques (Nagy et al., 1997). The aim of this study was to determine the role of water availability impacts on maize production.

Materials and methods

In long term field trials high starch maize (*Zea mays* L.) hybrids were tested in a 9 year perod of 2002-2010. The small plot trials were run at the Nagygombos experimental field of the Szent István University, Crop Production Institute, Hungary. The soil type of the experimental field is chernozem (calciustoll). Annual precipitation of the experimental site is in the 550-600 mm belt of the Northern edges of the Great Plain (*Figure 1.*), while the average depth of groundwater varies between 2 to 3 metres.

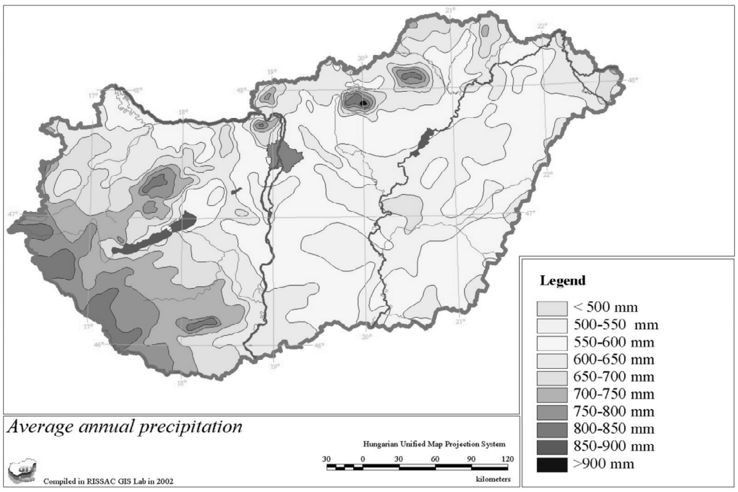

Figure 1. Average annual precipitation spatial distribution in Hungary
Source: RISSAC, 2002

Experiments were conducted in split-plot design with four replications. The size of each plot was 10 m^2. Plots were sown and harvested by plot machines (Standard Wintersteiger maize specific experimental plot machinery series). Various identical agronomic treatments were applied to plots. All plots were sown with identical series of maize hybrids for studying their performance in relation with agronomic impacts.
Regarding water availability impacts, experimental mean values of respective treatments and homogenized bulk yield samples were used only. Precipitation records have been evaluated in relation with yield quantity and quality. Quality tests were done at the Research Laboratory of the SIU Crop Production Institute, according to Hungarian standards (MSZ 1998). Grain yield samples and quality figures were correlated with water availability parameters. Analyses were performed using Microsoft Office 2003 statistical programmes.

Results and discussion

Annual amounts of precipitation and maize yields have been examined in a 9 year period at the Nagygombos experimental field of the Szent István University, Gödöllő. *Table 1.* and *2*. illustrate annual changes of yield and precipitation mean values. Yields, protein and starch content, as well as ethanol processing values have been correlated with water availability.

Table 1. Annual precipitation, grain yield and alcohol production figures of a maize trial (Nagygombos, 2002-2010).

Year	Precipitation, mm	Yield, t ha^{-1}	Protein, %	Starch, %	Ethanol, l ha^{-1}
2002	426	5,44	9,2	63,5	2245,4
2003	442	4,12	7,63	72,2	1933,5
2004	463	5,60	8,43	68,8	2504,3
2005	705	5,22	7,1	74,5	2527,8
2006	593	7,40	6,7	74,1	3564,2
2007	545	8,24	8,5	65,8	3524,3
2008	612	6,28	7,9	64,3	2624,7
2009	623	7,34	6,8	63,3	3020,0
2010	847	4,09	8,2	70,5	1874,2

Maize yields and annual precipitation were in a close non-linear correlation. Yields were smaller in drought years (2002, 2003 and 2004) and extremely moist years (2005 and 2010). The highest yields were obtained in crop years with average precipitation (2006, 2007, 2008 and 2009).

Table 2. Correlation figures of a maize trial (Nagygombos, 2002-2010).

r	Precipitation, mm	Yield, t ha^{-1}	Protein, %	Starch, %	Ethanol, l ha^{-1}
Precipitation, mm	1				
Yield, t ha^{-1}	0,76210	1			
Protein, %	-0,50219	-0,22311	1		
Starch, %	0,22297	-0,36296	-0,46314	1	
Ethanol, l ha^{-1}	0,80224	0,58342	-0,36783	0,48741	1

The protein content of grain samples showed slight negative correlation with the amount of annual precipitation. Starch figures have not been affected by water availability. Protein content was smaller, and starch values were higher in moist years in, however neither of the correlation was strong enough to provide a basis to formulate a general statement. Alcohol production exhibited strong correlation with yield figures and with the amount of annual precipitation as well. The highest ethanol yields were obtained in average precipitation years.

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Conclusions

Water availability is a basic factor related to yield quality and quantity performance of grain crops. In an agronomic long term trial run at the Szent István University's Nagygombos experimental site impact of water availability on maize crop has been evaluated. Various crop years have had different impacts on crop yield quantity. Yield figures were in correlation with annual precipitation in general. However two years of extremely high precipitation resulted in lowest yields. Moisture availability had diverse influence on quality manifestation. Drought stress reducing the amount of yield has induced non-significant quality improvement in a few cases. Protein values were smaller, and starch values higher in rainy years. Ethanol processing values were in strong correlation with yield figures. The amount of annual precipitation had a significant impact on ethanol yield.

There have been two parameters in this study with less chance to observe; once the soil impacts on water availability, since the trials were designed in a *ceteris paribus* agronomic layout. The other is the varietal differences between maize hybrids. These fields are to be evaluated in further studies.

Acknowledgements

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OPTRX^{TM} SENSOR SUPPORTED TOP DRESSING OF WHEAT

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Abstract: The aim of our experiments was to improve the nitrogen nutrition of winter wheat. For the calculation of the doses of N topdressing we used vegetation map prepared on the basis of measuring NDVI index. The NDVI index was measured by a GPS-connected sensor (OPTRx). The applied doses of N fertilizer were 50, 200 and 300 kg ha^{-1} on the high, medium and low supplied parts of the field respectively. There was a significant relationship between the treatments and the gluten content of wheat and a negative correlation was proved between the NDVI index and the wet gluten content.

Keywords: OPTRx sensor, NDVI index, N top dressing, gluten content

Introduction

One of the basic pre-conditions of successful crop growing includes a reasonable nutrient supply that is able to adapt to the arable site and to the plants' needs. Our experiments aimed to variable-rate N supply of winter wheat. Among the present conditions instead of "soil fertilization" we should aim at assuring a harmonized supply of plant nutrients in the given year (Csathó et al., 2007). Variable-rate N supply could mean one of the most promising applications of precision farming, which may contribute to optimizing the efficiency of nitrogen utilization and to reducing the environmental impact of farming (Zillmann et al., 2006).

Materials and methods

Our experiments were launched on the fields of Farkas Mezőgazdasági Kft. in Zimány in the years 2010 and 2011. Before the experiments we carried out soil analyses (*Table 1.*).

Table 1. Soil analyses results

Analysed parameters			
pH	6.77	Total salts	0.02
Liquid limit	42	Mg ppm	210.2
Humus content %	1.89	Mn ppm	200
NO_3,NO_2N	3.79	Na ppm	14.2
P_2O_5 ppm	2213	Zn ppm	1.4
K_2O ppm	198.9	Cu ppm	3.81
$CaCO_3$ %	3.68	SO_4-S ppm	15.02

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After the primary fertilization in autumn, spring topdressing was applied at the time of wheat tillering. Before the spring topdressing we drew a vegetation map of the field and determined the value of NDVI index. To plan the variable-rate fertilization we carried out measures with the use of a GPS-linked OptRx™ sensor. The vegetation index, NDVI (Normalized Difference Vegetation Index) is a dimensionless parameter, which means the vegetation activity of a given field. It is widely used in remote sensing to test crop development, to estimate LAI (Ganguly et al., 2008; Xiao et al., 2005; Wulder et al., 1998) and to measure N supply of plants indirectly (Víg et al., 2011). Its value is delivered by the quotient (URL5) of the difference and the sum of the radiation intensity reflected by the vegetation in the NIR and RED range of radiation.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

On a field of 30 ha well, medium and poorly supplied parts distributed at a rate of ⅓. Therefore we marked 10-10 sample taking points on the three field parts and we marked their coordinates by GPS and collected leaf-samples at the marked points. Leaf-samples were used to analyse the total N-content, and the results were compared with the NDVI values determined by the OptRx™ sensor later. Field parts showing the highest N-supply were given 50 kg ha^{-1}, mid-supplied parts 200 kg ha^{-1} and low supplied parts were given 300 kg ha^{-1} doses.

Gluten content was determined according to the prescriptions of the Hungarian standard MSZ 6369/5-87. Evaluation of the test results were done with the use of the SMS applications of Excel, Statistica, and Ag Leader Technology. Groups were compared and the mean values were tested on significance with variance analysis (ANOVA). We used the Bartlett test to prove the homogeneity of the groups.

Results and discussion

On the test-field of 30 ha the differently supplied parts distributed at a rate of ⅓ based on the first recording before the fertilization (*Figure 1.*).

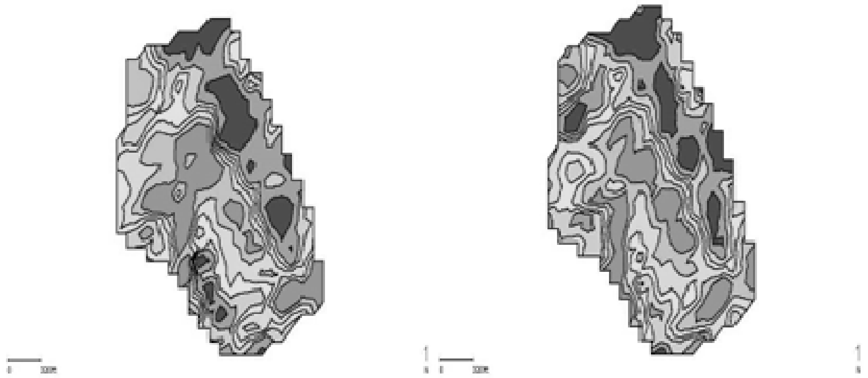

Figure 1. Vegetation map before variable-rate fertilization and thereafter

Low supplied parts included 9.7ha, where we measured NDVI values of 0.23-0.28, and on the 10.61 ha medium-supplied part 0.28-0.31 and on the 10.72 ha highly supplied field-parts we measured values of 0.31-0.36. After the application of variable-rate fertilization the NDVI values showed on average 0.24-0.34 on the low supplied parts, while these values changed on the highly supplied parts between 0.36-0.42. We marked 30 sample taking points on the field, where we collected leaf samples. During the plant analysis we determined the total nitrogen content of the leaves, which correlated with the NDVI values measured by the OptRx ™ sensor.
The measured nitrogen content of the leaf-samples on the low supplied field-parts amounted on average 3.9 m m%$^{-1}$ in dry matter, but the same value measured in the leaf-samples collected on the high supplied parts was 4.7 m m%$^{-1}$.
Our results on NDVI index and gluten content met most of the published values, e.g. Song (2009) who says that the protein and gluten contents have been in negative correlation with the value of NDVI index.

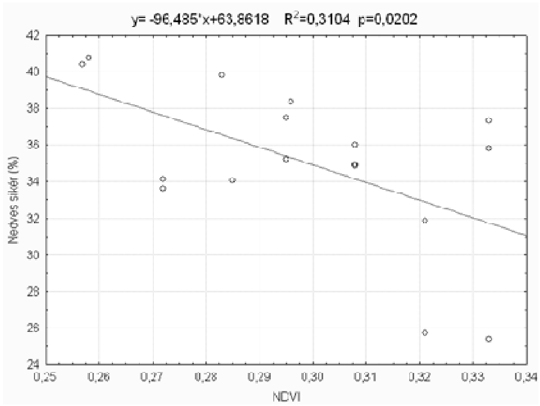

Figure 2. Correlation between the wet gluten and the NDVI-values

We carried out the regression analysis of the correlation of NDVI index values and the wet gluten content. According to the statistical analysis there was not a very close correlation, but it proved to be significant, and confirmed those proved above as well as the results of publications (*Figure 2.*).

Conclusions

Following the variable-rate fertilization and based on the NDVI values the rate of low supplied parts reduced initially, while the rate of the highest supplied parts was quite similar to the initial values. NDVI values scattered a bit, while the values of the measured total nitrogen content of the leaves showed a normal distribution. The trend of the total nitrogen content correlated with the NDVI-values measured by the OptRx™ sensor and we could prove significant regression correlation among them. Wet gluten content had the highest values on the low supplied field-parts: 37.5%, compared to the high supplied areas where this value was 31.22%. We could prove significant

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differences with the method of variance analysis between the gluten values measured on the low and high and medium and high supplied areas respectively. As a result of variable-rate fertilization we can say that there is a close negative correlation between the wet gluten content of wheat and the NDVI index.

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THE EFFECT OF PLANT DENSITY ON THE YIELD AND PHYTOPATHOLOGICAL PROPERTIES OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN CROP YEARS WITH DIFFERENT WATER-SUPPLY

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Abstract: The response of the sunflower hybrid PR64H42 to different plant densities in crop years with different water-supply (2010 and 2011) has been investigated on a chernozem soil type. Our research work focused on the factors mostly affected by the amount of precipitation (stalk breaking, infection by phytopathogens, and yield). We found significant stalk breaking in 2010 (33.8%) due to the high amount of precipitation and the heavy Sclerotinia infection. In 2011 the rate of lodging was lower, but still significant (20.7%) due to the high amount of rainfall in July. Parallel to the higher plant densities the infection rate increased in case of all four investigated phytopathogens, because the higher plant densities ensured better microclimatic conditions for the expansion of phytopathogens. We found differences between the two investigated crop years. The crop year of 2010 was extremely wet, therefore the infection rate was high in case of all four phytopathogens (*Scelortinia*: 23.9%, *Phoma:* 71.4%, *Alternaria*: 51.8%, *Diaporthe*: 70.3% - in the average of different plant densities). In 2011 mainly *Alternaria* and *Diaporthe* caused the highest infection of the plant (87.3%, 81%). As a result of our experiments it can be stated that from the aspect of yield amount (2010: 3018 kg ha^{-1}, 2011: 3596 kg ha^{-1}) the optimal plant density in the crop year of both 2010 and 2011 was 45 000 plants ha^{-1}.

Keywords: sunflower, water-supply, genotype, plant density, yield

Introduction

According to Pepó (2010a) sunflower is a very sensitive plant to crop year. Even in case of an average crop year the occurrence of stalk, leaf and head diseases and the yield decrement caused by them can be of significant extent. In a dry crop year the infection rate is rather lower and higher yield amounts can be produced therefore. According to Borbélyné et al. (2007) the precipitation in the vegetation period has the main role in the development of plant diseases. The safety of sunflower production is determined by the occurrence of some fungi diseases (*Sclerotinia sclerotiorum, Diaporthe helianthi, Phoma macdonaldii*, *Botrytis cinera, Plasmopara halstedii*) (Fisch, 2011). Szabó (2011), Pepó (2010b), as et al. (2003) found, that the decreasement of plant density lead to the fail of stalk stability parameters and the increment of infection by phytopathogens. The determination of plant density is essential and possible under given production circumstances (Frank, 1999). According to Pepó (2001) agro-ecological, biological and agro-technical factors all play important roles in the determination of the density of sunflower populations. In the average of different crop years and genotypes the most favourable yield amount on a chernozem soil could be produced in case of a plant number of 40 000 ha^{-1}. Szabó (2011) found the highest yield amounts in his research work in the case of dry, drought-affected crop years and average planting time (April) at higher plant densities, that are 55 000 – 65 000 plants ha^{-1}, while in case of wet crop years – when stalk and head diseases occur more frequently – at lower plant density, that is 45 000 plants ha^{-1} and late planting time (May). On a sandy soil the highest seed and oil yield was produced at a plant density of

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50 000 plants ha^{-1}, while the highest oil content at 60 000 plants ha^{-1}. The effect of plant density was more expressed in a wet crop year, than in a drought one (Harmati, 1990).

Materials and methods

The field experiments were conducted at the experimental station in Debrecen – Látókép on a calcareous chernozem soil. The plant density was adjusted in the interval between 35 000 and 65 000 plants ha^{-1} at an increasing scale by 10 000 plants ha^{-1}. The hybrid PR64H42 was studied in the experiment. The crop year of 2010 was an extreme wet one, because the amount of precipitation was over 80 mm in each month, which means an extraordinary deviation from the average values. In the vegetation period of 2011 almost the same amount of precipitation fell as the 30-years average (307.6 mm). On the other hand, the distribution of the precipitation was rather uneven (*Table 1.*).

Table 1. Main meteorological data in the investigated crop years (Debrecen, 2009-2011)

	April	May	June	July	August	Total/Avarage
Precipitation (mm) 2010	83,9	111,4	100,9	97,2	98,3	491,7
Precipitation (mm) 2011	15,6	52,3	22,0	175,0	42,7	307,6
30 year's average	42,4	58,8	79,5	65,7	60,7	307,1
Temperature (°C) 2010	11,6	16,6	19,7	22,0	19,0	17,8
Temperature (°C) 2011	12,2	16,4	20,5	20,4	21,4	18,2
30 year's average	10,7	15,8	18,8	20,3	19,6	17,0

Results and discussion

The extent of stalk lodging has a strong effect on the yield amount and quality of sunflower. This extent is determined by crop year, production technology factors, just as genetic properties. The effect of precipitation is the most expressed among weather factors that is manifested in the promotion of the development of stalk and head diseases. The extreme high amount of precipitation in the crop year of 2010 has resulted in increased stalk lodging through the high occurrence and infection rate of plant diseases. The extent of stalk lodging increased parallel to the increasing plant densities from 19.3% to 51.8% in 2010. The stalk lodging values stayed significantly lower in the drier crop year of 2011 (10.2 – 28.9%). The highest difference (22.9%) between the two crop years was measured in case of the plant density of 65 000 plants ha^{-1}. The extent of stalk lodging was 13.1 absolute% lower in the average of different plant densities in 2011. In 2010 the effect of plant density on *Sclerotinia* infection was more expressed due to the high amount of precipitation. The infection rate varied between 13.4 and 36.2% depending on the plant density. This infection rate varied in a significant lower interval (2.1-4.2%) in 2011. In both crop years the lowest infection rate was detected in case of the plant density of 35 000 plants ha^{-1} (2010: 13.4%, 2011: 2.1%), while the highest values were registered in case of the density of 65 000 plants ha^{-1} (2010: 36.2%, 2011: 3.1%). In the average of different plant densities the *Sclerotinia* infection rate of 2011 was 20.8 absolute% lower, than in the previous year. Regarding the infection by *Phoma* a difference of smaller extent was detected between the two investigated crop years. The infection rates varied between 61.0% and 82.6% in 2010, while in 2011 between 52.3% and 74.2%. Higher plant densities increased the infection rate of this pathogen in both investigated years. In the average of the plant densities the infection rate was 9.7 absolute% lower in the dry crop year of 2011, than in the wet 2010. *Alternaria helianthi* can cause serious infection in the population under warm and humid conditions. The crop year of 2011 was warmer than the average, and because of that the infection rate was extreme high (depending on the plant density: 74.4–95.8%). We have found in our experiment that the highest infection rate of 2010 (68.0%) was lower than the lowest one (74.4%) of 2011. In the average of the plant densities the infection rate was 35.5 absolute% higher in contrast to the vegetation of 2010. The infection rate by *Diaporthe* was extreme high in both crop years. Depending on the plant densities the infection rate varied between 54% and 86% in 2010, while in 2011 this rate was even higher and varied between 68% and 93%. In the average of the plant densities the infection rate of 2011 was 10.8 absolute% higher than that of the previous year; however the infection occurred later in the population in contrast to its early occurrence in 2010. (*Table 2.*).

Table 2. The effect of the crop year and plant density on the stalk breaking, infection rate and yield of sunflower (Debrecen, 2010-2011)

Year	Plant density (plants ha^{-1})	Stalk lodging (%)	*Sclerotinia* (on the stalk) (%)	*Phoma* (%)	*Alternaria* (%)	*Diaporthe* (%)	Yield (kg ha^{-1})
2010	35.000	19,3	13,4	61,0	36,3	54,0	2796
	45.000	26,9	19,6	67,1	47,8	62,0	3018
	55.000	37,0	26,4	74,8	55,2	79,0	2697
	65.000	51,8	36,2	82,6	68,0	86,0	2591
Avarage		33,8	23,9	71,4	51,8	70,3	2776
$LSD_{5\%}$		8,1	4,3	7,5	8,3	11,7	387,6
2011	35.000	10,2	2,1	52,3	74,4	68	2567
	45.000	16,7	2,4	59,5	86,7	73	3596
	55.000	26,8	3,7	67,8	92,2	90	3481
	65.000	28,9	4,2	74,2	95,8	93	3220
Avarage		20,7	3,1	63,5	87,3	81,0	3216
$LSD_{5\%}$		6,6	0,9	7,1	8,4	8,5	502,4

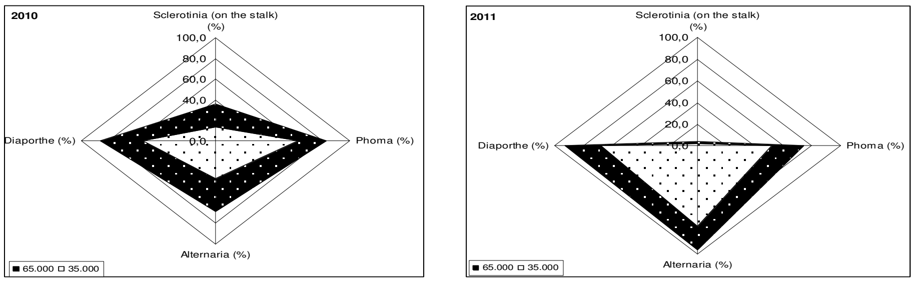

Figure 1. Infection rate in the investigated crop years (Debrecen, 2010-2011)

Figure 1. shows the total extent of the studied infections. Due to the high amount of precipitation in 2010 the infection rates of all four studied pathogens were high. In contrast, the crop year of 2011 was characterized by lower *Sclerotinia* infection and – compared to 2010 – lower *Phoma* infection. On the other hand the weather conditions of 2011 were more favourable from the aspect of development and infection of the diseases *Diaporthe* and *Alternaria*. The increasing plant densities increased the stress by the phytopathogens, however not in the same extent. In the crop year of 2010 with extreme high amount of precipitation the effect of plant density was more expressed, because the by the infections affected area in case of a plant density of 35 000 plants ha^{-1} was 2585 units and in case of the plant density of 65 000 plants ha^{-1} more than three times larger (8784 units). In contrast in the crop year of 2011 in case of the plant density

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of 35 000 plants ha^{-1} this area was 4601 units, while in case of 65 000 plants ha^{-1} almost two times as much (8360 units). The yield amount of the investigated hybrid (PR64H42) in 2010 varied between 2591 and 3018 kg ha^{-1}, depending on the plant density. A bit higher interval was shown by the yield amounts of 2011 (2567 – 3596 kg ha^{-1}), also depending on the density of the population. This means that the heavier infection of disease *Sclerotinia* in 2010 decreased the yield amount more, than the higher *Alternaria* infection (in 2011), so *Sclerotinia* is a more dangerous phytopathogene. Regarding the yield amounts, the plant density of 45 000 plants ha^{-1} proved to be optimal in both crop years (*Table 2.*).

Conclusions

According to our results it can be stated that the crop year affected the stalk breaking, the extent of the infection by phytopathogens and the yield amounts significantly. The amount of precipitation was different in 2010 and 2011, but due to the difference in its distribution (175 mm in July 2011) the yield-decreasing effect of plant diseases was of almost similar extent. According to this it can be stated that beside the total amount of the fallen precipitation its distribution is of great importance too. In the crop year of 2010 we have detected an extreme high rate of stalk lodging (33.8%) that was due to the high amount of precipitation and the therefore occurring heavy *Sclerotinia* infection. In 2011 the lodging rate was lower, but still of significant extent (20.7%) because of the high amount of precipitation in July. Parallel to the higher plant densities the infection rate increased in case of all four investigated phytopathogens, because the higher plant density ensured better microclimatic conditions for the expansion of phytopathogens. 2010 was extreme wet, therefore the extent of the infection of all four phytopathogenes was rather great (*Scelortinia*: 23.9%, *Phoma*: 71.4%, *Alternaria*: 51.8%, *Diaporthe*: 70.3% in the average of the different plant densities). In 2011 *Alternaria* and *Diaporthe* infected the population utmost (87.3% and 81% resp.) among the investigated phytopathogenes. As a result of the experiments it can be stated that in the crop year of both 2010 and 2011 the optimal plant density was 45 000 plants ha^{-1} regarding the yield amount (2010: 3018 kg ha^{-1}, 2011: 3596 kg ha^{-1}).

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IMPACT OF MICROBIAL PREPARATIONS ON A CALCAREOUS CHERNOZEM SOIL PARAMETERS AND ON BIOMASS OF RYEGRASS (*LOLIUM PERENNE*, L.)

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Abstract: In pot experiment the effect of different microbial preparations on some soil properties and on the biomass of ryegrass (*Lolium perenne,* L.) were studied. The experiment was set up in 2011 at the UD Institute of Agricultural Chemistry and Soil Science. The studied soil type was calcareous chernozem soil, from the Debrecen-Látókép area. The soil had the following parameters: upper limit of plasticity according to Arany (K_A): 40; clay and silt content: 51%; pH_{KCl}: 5.5; pH_{H2O}: 6.6; humus %: 2.8; AL-P_2O_5: 312 mg kg^{-1}; AL-K_2O: 360 mg kg^{-1}, showing that the soil was mildly acidic, of loam texture, with good supplies of N and very good supplies of P and K. The basic treatments in the experiment were control, NPK fertilizer and wheat straw treatment, while in some combinations these were combined with three different microbial preparations (Bactofil A, EM-1 and Microbion UNC). The 12 treatments in the experiment were arranged in a random block design with three replications. In our laboratory the moisture content of soil, the NO_3-N, the AL-soluble P_2O_5 and K_2O content of soil, the total number of bacteria and microscopical fungi, and the urease enzyme activity of soil were determined. We were defined the green mass and dry weight of ryegrass. The assessment of data was performed with variance and correlation analysis. The work/publication is supported by the TÁMOP-4.2.2/B-10/1-2010-0024 project. The project is co-financed by the European Union and the European Social Fund.

Keywords: bacterial fertilizers, NPK fertilization, wheat straw, soil characteristics, ryegrass biomass.

Introduction

In Hungary the use of microbiological preparations has spread in agriculture since 1960 (Manninger-Szegi, 1963). The use of inoculants has not spread in agriculture to such a great extent of their less spectacular effect compared to the fast and conspicuous impact of fertilizers (Biró, 2003). Fertilizer and pesticide usage is questionable in ecological farming (Soltész and Szabó, 1997). Nowadays the use of environment-friendly ways of production is one of the most important aims that include the application of microbial inoculants (Biró, 2005). By using „first generation" preparations a lot of microorganisms and a lot of important materials (for example vitamins, hormones and soil conditioners) are allocated into the soil (Biró, 2002). The microbial inoculants‘positive impact was certified in agriculture by Biró and Anton (2003). The advantageous effects of inoculants were shown in the studies of Makádi et al. (2007) and Biró et al. (2010).

We investigated in a pot experiment the effect of different biofertilizers (Bactofil A, M-1 and Microbion UNC) that are available in commerce, together with the use of fertilizers and straw. We examined the effects of bacterial preparations on the soluble nutrient content of soil, the number of bacteria and fungi in the soil, urease enzyme activity and plant biomass.

Materials and methods

The pot experiment was set up in the greenhouse of the Institute of Agricultural Chemistry and Soil Science (15. April 2011). The soil applied was a calcareorus

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chernozem soil from Debrecen-Látókép with a good nitrogen and very good phosphorus and potassium content. The physical and chemical properties determined were the following: K_A: 37,5; silt and clay fraction: 51%; pH_{KCl}: 5,5; pH_{H2O}: 6,6; Hu%: 2,8; AL-P_2O_5: 312 mg kg^{-1}; AL-K_2O: 360 mg kg^{-1}. The test plant was ryegrass (*Lolium perenne,* L). In perforated pots 1-1 kg air-dried soil was measured. In the surface of soil 0,6-0,6 g perennial seed was sown. The pots were held under roof at night and on rainy days. Weight supplement irrigation of the vessels was performed every day for 60% of field water capacity. The applied treatments were the following: 1-Control, 2-NPK fertilizer, 3-Wheat straw, 4-Bactofil A bacterial fertilizer, 5-NPK+Bactofil A, 6-Straw+Bactofil A, 7-EM-1, 8-NPK+EM-1, 9-Straw+EM-1, 10-Microbion UNC, 11-NPK+Microbion UNC, 12-Straw+Microbion UNC. In fertilization (20 cm^3 pot^{-1}) nitrogen was injected as NH_4NO_3, phosphorus as KH_2PO_4, potassium as KH_2PO_4 and K_2SO_4. In the straw treatment 7 t ha^{-1} cut wheat straw pot^{-1} was stirred in. The applied quantity of biofertilizers was the double of the recommended dosis for field application, in 1:2000 dilution. We expounded the parameters of biofertilizers in Jakab et al. (2011). The soil samples were collected and the moisture content of soil (Buzás, 1993) was measured after eight weeks (15. June 2011). The analysis of NO_3-N content of soil was based on Felföldy's (1987) natrium-salicilate method, and the AL-soluble phosphorus and potassium content of the soil was established based on Egnér et al. (1960). The total number of bacteria (on Bouillon soup agar) and the total number of microscopic fungi (on peptone glucose agar) was determined from soil-water suspension using the plate dilution method based on Szegi (1979). The urease enzyme activity was determined based on Szegi (1979). We measured the green mass and the dry weight of ryegrass dried at 50°C, where mass stability is set. The 12 treatments in the experiment were arranged in a random block design with three replications, giving a total of 36 pots. For the examination of the statistically justifiable differences between the average values of the results we applied Tolner et al.'s (2008) factor analysis of variance on statistical data, which showed 5% significant difference values and SPSS13.0 Pearson-correlation in correlation analysis.

Results and discussion

The parameters of soil examined are illustrated in *Table 1*, and the biomass of plant is demonstrated in *Figure 1*.

The *NPK fertilization* increased the soil nutrient content and promoted the fast nutrient uptake and supported the multiplication of bacteria. The AL-soluble phosphorus content of soil, the urease enzyme activity of soil, the total number of bacteria, and the green mass and dry weight of ryegrass increased significantly in these treatments. *The stirred straw* increased the amount of nitrate-nitrogen and also urease enzyme activity. The *bacterial fertilization* had positive effect on enzyme activity, the total number of bacteria and in certain cases - EM-1 - the ryegrass' biomass significantly. In case of the *NPK+bacterial fertilizer combined treatments* significant positive changes were experienced in the amount of NO_3-N, enzyme activity and in certain cases the total number of bacteria, and plant biomass. The *straw+bacterial fertilizer treatments* caused an increase in the AL-soluble phosphorus content, the enzyme activity, the amount of bacteria and fungi. In certain cases - Bactofil A, EM-1 – it also increased the plant biomass. The quantitative *average ratio* of bacteria-fungi was 36%.

Table 1. The measured parameters of soil (Pot experiment, Debrecen, 2011)

Treatments	NO_3^--N (mg kg^{-1})	AL-P_2O_5 (mg kg^{-1})	AL-K_2O (mg kg^{-1})	Moisture content of soil (%)	The total number of bacteria (10^6 g soil^{-1})	The number of microscopic fungi (10^3 g soil^{-1})	Bacteria-Fungi Ratio	Urease enzyme activity NH_4^+ (mg 100g^{-1})
Control	3,72	312,0	360	15,34	10,59	59,36	17,84	9,04
NPK	**3,05**	326,7	340	**13,66**	**15,42**	**46,25**	33,34	13,47
Straw	**4,59**	**267,2**	352,5	15,65	**6,39**	**23,64**	27,04	**28,11**
Bactofil A	3,00	**236,2**	**318**	15,81	**14,79**	**31,50**	46,96	**24,37**
NPK+Bactofil A	3,39	**276,7**	350	15,11	**11,31**	**30,52**	37,05	**42,90**
Straw+Bactofil A	**2,94**	283,7	350	15,27	**14,35**	**49,20**	29,16	**51,60**
EM-1	**2,34**	305,2	**323**	**13,45**	**14,53**	54,78	26,52	**29,28**
NPK+EM-1	3,35	329,2	**310,5**	**12,09**	15,33	52,15	29,39	**38,62**
Straw+EM-1	**2,58**	**309,7**	330,5	**12,73**	**12,92**	**35,44**	36,45	**23,58**
Microbion UNC	4,31	**253,2**	367,5	15,14	9,88	**38,39**	25,73	**52,24**
NPK+M. UNC	**4,70**	**279,2**	352,5	14,60	13,77	**38,06**	36,17	**34,19**
Straw+M. UNC	5,01	268,7	374,5	15,94	**12,56**	**42,32**	29,68	**7,14**
Average values	**3,58**	**287,28**	**344,1**	**14,57**	12,65	**41,80**	**31,28**	**29,55**
CV%	**12**	**7**	**4,1**	**6**	**9,7**	**10**	**-**	**21,7**
$LSD_{5\%}$	**0,73**	**33,8**	**23,15**	**1,47**	**2,6**	**7,06**	**-**	**10,78**

* Changes **significant** compared to the control treatments (control, NPK, straw) are marked in typed bold.

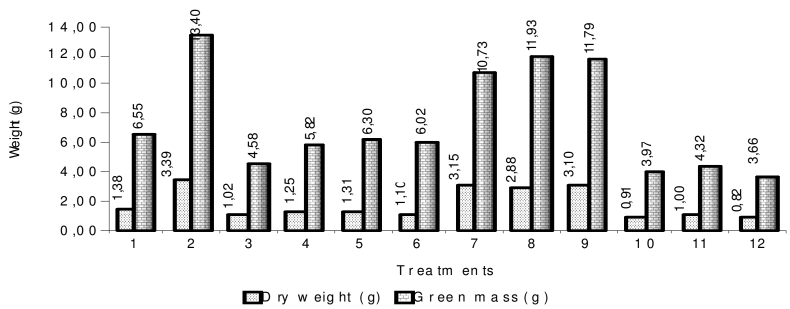

Figure 1. The green mass and dry weight of ryegrass ($LSD_{5\%Dry}$ 0,28; $LSD_{5\%Green}$ 1,56)

We studied the connection between treatments using *Pearson-correlation analysis. Close negative relations* could be observed between the green mass and the amount of NO_3-N and AL-K_2O, between the dry weight and the amount of NO_3-N and AL-K_2O, and between the amount of AL-P_2O_5 and moisture content of soil. *Medium negative relation* was there between the moisture content of soil and the total number of bacteria. *Medium positive relation* was there between treatments and urease enzyme activity. *Positive close relation*s were present between the amount of AL-P_2O_5 and the number of bacteria and fungi. *Very close positive relation* was experienced between the green mass and dry weight of ryegrass.

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Conclusions

Finally, we established the microbiological preparations' significant positive effects on the soil and plant parameters studied, in every treatment - in it and in NPK+bacterial fertilizer and straw+bacterial fertilizer combinations. On the basis of our results the following can be concluded:

The amount of NO_3-N and AL-K_2O of soil increased in Microbion UNC combined treatments. The EM-1 treatments enhanced the AL-soluble phosphorus content of soil.

Bacterial fertilization - Bactofil A, EM-1, Microbion UNC applied in itself - increased the urease enzyme activity of soil. The bacterial fertilization and straw+bacterial fertilizer combinations increased the green mass and dry weight of ryegrass. We established the presence of close and very close relations between treatments with Pearson-correlation analysis.

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EFFECT OF CROPYEAR AND SOME AGROTECHNICAL FACTORS IN RAINFED AND IRRIGATED MAIZE (*ZEA MAYS* L.) PRODUCTION

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Abstract: Maize has high productivity and produces hudge vegetative and generative phytomass, but maize is very sensitive to agroecological (mainly to climatic, partly to pedological conditions) and agrotechnical circumstances. In Hungary maize is grown on 1,1-1,2 million hectars, the national average yields vary between 4-7 t ha^{-1} depending on the year and the intensity of production technology. The crop rotation, fertilization and plant density on the yields of maize were investigated in dry and wet cropyears in a long-term experiments on chernozem soil. The water-supplies were rainfed and irrigated. In dry cropyear the yield-surpluses of irrigation were 2.8-4.2t ha^{-1}, in the cropyear characterized by average-good water supply the yield increasements of irrigation varied between 0.7-2.1 t ha^{-1}, respectively. The yield-increasements of irrigation were mainly modified by crop rotation and fertilization. The optimum plant density of maize was different in the rainfed and irrigated crop technology on chernozem soil.

Keywords: maize, water supply, agrotechnical elements, yield

Introduction

Maize has high productivity and produces hudge vegetative and generative biomass, but maize is very sensitive to agroecological (mainly to climatic, partly to pedological conditions) and agrotechnical circumstances. In Hungary maize is grown on 1,1-1,2 million hectars, the national average yield varies between 4 and 7 t ha^{-1} depending on the year and the intensity of production technology (Pepó et al., 2006). According to Szász (2002) the frequency of dry cropyears increased from 22.5% to 52.6% in Hungary in the last 150 years. The results of Birkás et al. (2006), Várallyay (2007) showed that as a results of global climatic change the yield of crops have dropped and yield fluctuation has increased. The effect of agrotechnical elements is exerted in a complex way in the soil-plant system (Németh, 2006). The effects of plant nutrition supply (Kovačevic et al., 2006; Izsáki, 2007), plant density (Berzsenyi and Lap, 2006) and irrigation (Ruzsányi, 1992; Berényi et al., 2007) on the yield and yield stability are especially important in rainfed and irrigated production. These agrotechnical factors exert their effect via interactions and not individually (Pepó et al., 2007).

Materials and methods

The long-term experiment was set up in 1983 on chernozem soil in the Hajdúság. The structure of the multifactorial experiment is as follows:

- crop rotation: monoculture (maize), biculture (wheat-maize), triculture (peas-wheat-maize)
- fertilization: control, one-, two-, three- and fourfold amounts of the basic dosage of N=60 kg ha^{-1}, P_2O_5=45 kg ha^{-1}, K_2O=45 kg ha^{-1}
- plant density: 40 thousand plants ha^{-1}, 60 thousand plants ha^{-1}, 80 thousand plants ha^{-1},
- water supply: R=rainfed, I=irrigated

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From our long-term experimental data two different cropyears were choosed which could be characterized by different water supply and heat-units (*Table 1*). The 2004 cropyear was favourable for the vegetative and generative growth of maize just almost during all vegetation period (irrigation was 2x50 mm=100 mm). The 2007 cropyear was mainly dry from April to July so 4x50 mm=200 mm irrigation norm was applied.

Table 1. Some important meteorological data (Debrecen)

Meteorological parameter/year	Apr	March	May	June	July	August	Total Average
Rainfall (mm) 2004	40.1	17.0	61.7	142.2	50.2	31.3	342.5
2007	3.6	54.0	22.8	39.7	77.	86.1	283.8
Average of 30 years	42.4	58.8	79.5	65.7	60.	38.0	345.1
Temperature (°C) 2004	11.4	14.8	19.3	21.1	20.4	15.3	17.05
2007	12.6	18.4	22.2	23.3	22.	14.0	18.80
Average of 30 years	10.7	15.8	18.7	20.3	19.	15.8	16.82

Results and discussion

Maize is a crop sensitive to ecological factors, mainly to optimum water supply. Optimum water supply is especially important in critical periods for the growth, development and yield formation of maize. The effect of water supply on the yield of maize many different agroecological (soil) and agrotechnical (croprotation, fertilization, plant density etc.) factors could modified. Two different cropyear (2004 = good water supply, 2007 = dry cropyear) were choosed to demonstrate the irrigation effects and effectiveness in maize production. In 2004 cropyear the control yields varied between 6500-7300 kg ha^{-1} in mono-, 9200-11700 kg ha^{-1} in bi- and 10500-11200 kg ha^{-1} in triculture croprotation, respectively. So in the cropyear characterized by fairly good water supply the maize could well utilized the natural nutrient resources of chernozem soil and we obtained high control yields in different croprotation. We can state that even in good water supply there were differences in the yields of different croprotation. In control treatment the yields were by 3.7-4.3 t ha^{-1} (biculture) and 3.9-4.0 t ha^{-1} (triculture) higher than in monoculture. The effect of irrigation on the yield was minimum because of good quantity and distribution of rainfall in control treatment. The other reason was the lock of nutrient supply in the control. The yield surpluses of irrigation were 0-1200 kg ha^{-1} in different croprotation in control treatment. In 2004 year the maximum yields varied between 12900-14500 kg ha^{-1} in mono-, 12300-14900 kg ha^{-1} in bi- and 12700-14300 kg ha^{-1} in triculture croprotation depending on plant density (*Table 2*). Because of favourable cropyear in 2004 we obtained high yields in N_{opt}+PK fertilizer treatments. There were very moderated differences among the different croprotations. The maximum yields were 13.4 t ha^{-1} (rainfed) and 14.2 t ha^{-1} (irrigated) in monoculture, 12.4 t ha^{-1} and 14.5 t ha^{-1} in biculture, 13.5 t ha^{-1} and 14.1 t ha^{-1} in triculture in the average of plant density, respectively. The yield surpluses of irrigation in N_{opt}+PK treatments were little bit higher than in control (800 kg ha^{-1} in mono-, 2100 kg ha^{-1} in bi- and 700 kg ha^{-1} in triculture, respectively). We obtained different experimental results in a dry and warm cropyear (2007). The effects of croprotation on the yields of maize were very strong especially in the control treatments.

In 2007 cropyear the yields of control varied between 2600-5600 kg ha^{-1} in mono-, 6000-8400 kg ha^{-1} in bi-, 6500-8200 kg ha^{-1} in triculture croprotation depending on water supply and plant density, respectively. In the N_{opt}+PK treatments the yields were the followings (depending on irrigation and plant density): in mono 3900-10242 kg ha^{-1}, in bi 7200-11000 kg ha^{-1}, in tri 7200-11100 kg ha^{-1}, respectively. The yield surpluses of irrigation were much high in dry cropyear (2007) comparing with a good water supply year (2004). Our scientific results proved that the yield increasements of irrigation were much less in control treatments (in mono 2300 kg ha^{-1}, in bi 1900 kg ha^{-1}, in tri 1000 kg ha^{-1}, respectively in average of plant density) than in N_{opt}+PK treatments (in mono 4200 kg ha^{-1}, in bi 3000 kg ha^{-1}, in tri 2800 kg ha^{-1}, respectively) because of special interaction between better nutrient and water supply in N_{opt}+PK treatment (*Table 3*).

Table 2. Effect of agrotechnical elements on the yield (kg ha^{-1}) of maize in a good water supplied cropyear (Debrecen, 2004)

Crop rotation	Water supply	Nutrient supply	40 000 ha^{-1}	60 000 ha^{-1}	80 000 ha^{-1}	Average
Monoculture	R	Ø	6624	7139	6542	6092
	R	N_{opt}+PK	12926 $_{(180)}$	12926 $_{(240)}$	13850 $_{(240)}$	13391
	I	Ø	7165	7157	7310	7211
	I	N_{opt}+PK	13674 $_{(240)}$	14347 $_{(240)}$	14453 $_{(240)}$	14158
Biculture	R	Ø	9163	9740	10567	9823
	R	N_{opt}+PK	12364 $_{(240)}$	12260 $_{(180)}$	12521 $_{(180)}$	12382
	I	Ø	10036	10426	11745	10736
	I	N_{opt}+PK	14056 $_{(240)}$	14502 $_{(240)}$	14925 $_{(240)}$	14494
Triculture	R	Ø	10969	10489	11162	10873
	R	N_{opt}+PK	12710 $_{(60)}$	13829 $_{(180)}$	13895 $_{(120)}$	13478
	I	Ø	10705	10483	11136	10775
	I	N_{opt}+PK	13837 $_{(180)}$	14152 $_{(240)}$	14322 $_{(240)}$	
$LSD_{5\%}$ mono			786			
$LSD_{5\%}$ bi			903			
$LSD_{5\%}$ tri			872			

Table 3. Effect of agrotechnical elements on the yield (kg ha^{-1}) of maize in a drought cropyear (Debrecen, 2007)

Crop rotation	Water supply	Nutrient supply	40 000 ha^{-1}	60 000 ha^{-1}	80 000 ha^{-1}	Average
Monoculture	R	Ø	3679	2685	2573	2979
	R	N_{opt}+PK	5681 $_{(180)}$	4316 $_{(120)}$	3874 $_{(60)}$	4624
	I	Ø	5570	5210	4946	5242
	I	N_{opt}+PK	10242 $_{(240)}$	8586 $_{(180)}$	7690 $_{(180)}$	8839
Biculture	R	Ø	6742	6258	6032	6344
	R	N_{opt}+PK	7929 $_{(120)}$	7706 $_{(120)}$	7156 $_{(120)}$	7597
	I	Ø	8202	8413	8175	8263
	I	N_{opt}+PK	10523 $_{(120)}$	10970 $_{(120)}$	10205 $_{(120)}$	10566
Triculture	R	Ø	7938	6716	6526	7060
	R	N_{opt}+PK	8192 $_{(60)}$	7998 $_{(60)}$	7214 $_{(60)}$	7801
	I	Ø	7964	8152	8069	8062
	I	N_{opt}+PK	10135 $_{(120)}$	10679 $_{(120)}$	11080 $_{(120)}$	10631
$LSD_{5\%}$ mono			582			
$LSD_{5\%}$ bi			540			
$LSD_{5\%}$ tri			647			

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Conclusions

Maize is a sensitive crop to climatic conditions, mainly to water supply (quantity and distribution of rainfall). Our long-term experiment data proved that there were strong interactions between the cropyear and agrotechnical elements (irrigation, croprotation, fertilization, plant density) even on chernozem soil characterized by excellent physical and chemical properties. In a good water supplied cropyear (2004) we obtained high control yields (mono=6100-7200 kg ha^{-1}, bi=9800-10700 kg ha^{-1}, tri=10800-10900 kg ha^{-1}, respectively in average of plant density) and very excellent yields in N_{opt}+PK treatments (mono=13400-14200 kg ha^{-1}, bi=12400-14500 kg ha^{-1}, tri=13500-14100 kg ha^{-1}, respectively). In good cropyear there was moderated croprotation effect in N_{opt}+PK treatments. In a dry and warm cropyear (2007) our scientific results proved that the croprotation had high modification effects on the yields of maize both in control and N_{opt}+PK treatments. In 2007 year the yields (in average of plant density) were in monoculture 3000-5200 kg ha^{-1} (control) and 4600-8800 kg ha^{-1} (N_{opt}+PK), in biculture 6300-8300 kg ha^{-1} and 7600-10600 kg ha^{-1}, in triculture 7100-8100 kg ha^{-1} and 7800-10600 kg ha^{-1}, respectively. The effect of irrigation depended on the water supply of cropyear and modified by fertilization, croprotation and plant density. In a dry and warm cropyear (2007) the yield surpluses of irrigation varied 1000-2300 kg ha^{-1} in control and 2800-4200 kg ha^{-1} in N_{opt}+PK treatment depending on croprotation and in a good water supplied cropyear (2004) the yield surpluses were 0-1200 kg ha^{-1} and 700-2100 kg ha^{-1}, respectively. Our research results proved that there were special interactions between the water and nutrient supply in maize production. The optimum plant densities were 80000 ha^{-1} in a year (2004) characterized by good water supply and it varied between 40-80000 ha^{-1} in a drought cropyear (2007). Our long-term experimental data proved that we have to harmonize the agroecological and agrotechnical elements to get high yields and good yield stability in maize production

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AGRONOMICAL AND ECONOMIC ASPECTS OF THE OPTIMIZATION OF WINTER WHEAT CROP MANAGEMENT PRACTICES

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Abstract: Under the current price relations of inputs and outputs in plant production, there is a need to modify crop management with the aim of obtaining higher efficiency of the applied inputs. This contribution analyzes modification possibilities in crop management practices and their economic results using the example of international comparison of winter wheat crop management practices at the DLG Field Days 2010 in Germany (http://www.dlg-feldtage.de). A total of 12 institutions took part in the comparison (5 from Germany, and 7 others – the Czech Republic, Denmark, France, Great Britain, Poland, Sweden and Switzerland) each with two variants of crop management and variety options. Crop management practices were compared in field trials where each variant consisted of four replications in 12 m^2 plots. Final assessment was carried out using gross margin – the difference between revenue for the produced grain and direct (variable) costs. The best results were obtained with the Czech variant of crop management oriented to cultivation of elite bred wheat under rather humid conditions. The variety Akteur (E) has been used with the assumption that increased costs for crop protection will be compensated by higher revenues for elite grain.

Keywords: winter wheat, grain yield, grain quality, comparison of crop management practices, DLG-Feldtage 2010

Introduction

International comparison of winter wheat crop management practices is a part of the DLG-Feldtage agricultural exhibition (http://www.dlg-feldtage.de), which is organized every two years by the German Agricultural Society (Deutsche Landwirtschafts-Gesellschaft). About 25 thousand visitors, mostly agricultural specialists from Germany and neighbouring countries, visit the three-day event. The aim of the experiments was the comparison of winter wheat crop management practices used in different regions of Germany and in neighbouring countries. Another aim was economic assessment of crop management practices based on costs, grain yields obtained, and grain quality.

Materials and methods

The DLG-Feldtage'2010 (DLG e.V., 2010) exhibition was held in June 15-17, 2010 in a farm Rittergut Bockerode near Hannover (Niedersachsen). The average annual temperature at the locality is 10.5 ^{o}C, and the average sum of annual precipitations is 720 mm. The soil is loamy, degraded chernozem on loess, with pH 6.5 (Bodenzahl 85). Nutrient contents (mg.kg^{-1} of soil) were 121 K_2O, 137 P_2O_5 and 116 MgO. Forecrops in the preceding three years were winter wheat (2007, 2009) and potatoes (2008). A total of 12 institutions took part in the International Comparison, each with two technologies (see *Table 1*). The first group of technologies was characterized as competitive (Wettbewerb) and the second as experimental (Experiment). A choice of variety was in both technologies. The Czech Republic was as usually represented by the Agricultural Research Institute Ltd. with a team led by Prof. Křen. Before starting the field trials, all

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participants engaged in the comparisons have to present for each variant an objective and a strategy how to obtain it for publication in the "Guide of Field Days" (Veranstaltungsführer) and presentation on the internet. In the final comparisons, both variants were assessed and classified according to gross margin. The objective of the Czech competitive variant (CZ-W) was to obtain substantial yield of high quality grain using an adequate level of nitrogen fertilizers and pesticides according to stand condition of the variety Potenzial (A) which has a balanced combination of agricultural characteristics. The experimental variant (CZ-E) was oriented to growing of elite bred wheat under rather humid conditions. The variety Akteur (E) was used with the assumption that the increased costs for crop protection will be compensated by higher revenues for high quality grain. Each variant was composed of four random plots of 12 m^2. Seed bed preparation was carried out after uniform ploughing and basic fertilizing for all crop management practices (August 17, 2009 – 200 $kg.ha^{-1}$ KornKali, i.e. 80 kg $K_2O.ha^{-1}$, 12.8 kg $MgO.ha^{-1}$).

Table 1. List of participants in comparisons of crop management practices in winter wheat at the DLG-Feldetage´2010

Institution	Country	Abbre-viation	Variant/Variety	
			Econo-mic-W	Experi-mental-E
Hanse Agrarforschung e. V.	D	HAF	Tommi	Tabasco
Institut für Bodenkultur und Pflanzenbau e.V.	D	IB	JB Asano	Akteur
Nicholas Forman Arable Services	GB	GB	Genius	Tommi
Rittergut Bockerode	D	RB	JB Asano	Adler
Strickhof Beratungsdienst	CH	CH	Smaragd	Claro
Hochschule Anhalt, Bernburg	D	HA	Genius	Smaragd
Agricultural Research Institute Kromeriz, Ltd.	CZ	CZ	Potenzial	Akteur
Landwirtschaftskammer Niedersachsen	D	LWK	Julius	Tabasco
ARVALIS – Institut du Végétal	F	F	Barok	Altigo
MODR – Oddział "Poświętne" w Płońsku	PL	PL	Muszelka	Bamberka
Patriotisk Selskab	DK	DK	Potenzial	Hereford
HIR Malmöhus	S	S	Chevalier	Inspiration

Results and discussion

Seeding on the experimental plots started on October 6, 2009. The average emergence rate was low (82%, ranging from 67 to 98%) due to excessive soil moisture and crust formation on soil surface. The stands started overwintering in the stage BBCH 21-22 with average density 200-250 plants per m^2. It was a hard winter with a lot of snow lasting till March, which together with a cold May delayed earing by two weeks. The limiting factor during the whole vegetative period was the lack of soil aeration which persisted from sowing. Dry and hot weather in July accelerated ripening and impaired grain filling. The crop was harvrsted on August 10, 2010.

The strategy of crop management practices varied widely with individual participants (Roßberg et al., 2010). Already the selection of varieties formed a wide diversity. Sowing rates ranged from 240 to 350 germinating seeds per m^2. Nitrogen fertilization differed markedly with individual technologies. The total nitrogen dose ranged from 100 to 249 kg $N.ha^{-1}$. Growth regulators, predominantly CCC, were mostly used once or twice during the growing season; in April to promote tillering, and then in May against lodging when more preparations were used in combinations (e.g. Moddus, Medax Top). Stand density offering standard productivity at harvest was in the range 296 to 528 ears per m^2. The yields were generally lower, ranging between 5.6 and 8.6 $t.ha^{-1}$. Final assessment (*Table 2*) was significantly influenced by grain quality obtained and the corresponding price.

Table 2. List of crop management practices in winter wheat based on the assessed characteristics (DLG-Feldtage 2010- crop management practices are indicated in abbreviations)

Var. No.	Abbreviation	Protein content (%)	Price ($EUR.t^{-1}$)	Yield ($t.ha^{-1}$)	Revenues ($EUR.ha^{-1}$)	Direct costs ($EUR.ha^{-1}$)	Gross margin ($EUR.ha^{-1}$)	Profitability (%)*
1	HAF-W	12.1	185	7.32	1683.83	660.16	1023.67	155.1
2	HAF-E	10.3	205	7.31	1829.17	598.71	1230.46	205.5
3	IB-W	12.1	190	8.15	1879.07	789.80	1089.27	137.9
4	IB-E	13.4	220	7.47	1973.84	758.11	1215.73	160.4
5	GB-W	13.0	195	5.07	1318.46	610.48	707.98	116.0
6	GB-E	12.2	180	5.56	1330.98	582.82	748.16	128.4
7	RB-W	12.0	190	8.12	1873.18	711.71	1161.47	163.2
8	RB-E	13.8	160	7.92	1597.20	746.58	850.62	113.9
9	CH-W	11.8	185	7.38	1694.93	734.42	960.51	130.8
10	CH-E	13.2	200	5.63	1456.20	560.39	895.81	159.9
11	HA-W	14.0	240	7.12	2037.60	784.53	1253.07	159.7
12	HA-E	12.5	160	7.47	1525.04	735.65	789.39	107.3
13	CZ-W	12.5	190	7.58	1770.96	673.71	1097.25	162.9
14	**CZ-E**	**14.6**	**240**	**6.79**	**1959.12**	**698.60**	**1260.52**	**180.4**
15	LWK-W	13.5	220	6.88	1843.38	712.64	1130.74	158.7
16	LWK-E	12.3	160	7.68	1559.28	672.96	886.32	131.7
17	F-W	12.3	180	8.44	1848.30	692.67	1155.63	166.8
18	F-E	11.2	172	7.51	1621.38	641.97	979.41	152.6
19	PL-W	11.8	180	7.79	1732.74	718.12	1014.62	141.3
20	PL-E	12.6	195	8.18	1924.13	719.81	1204.32	167.3
21	DK-W	12.8	200	7.62	1854.00	671.87	1182.13	175.9
22	DK-E	10.6	172	8.60	1808.86	622.60	1186.26	190.5
23	S-W	12.4	195	8.00	1890.00	691.81	1198.19	173.2
24	S-E	10.1	180	7.96	1762.44	650.98	1111.46	170.7

**Profitability = (Gross margin /Direct costs) * 100 (%)*

Variant CZ-W - variety Potenzial obtained the 7th position among the competitive variants, and the 13th position in a total assessment of all variants. The obtained yield was good, however the redemption price was lower (190 $€.t^{-1}$).

Variant CZ-E – variety Akteur (*Table 3*) had the second lowest yield (6.97 $t.ha^{-1}$), but the high quality of grain assessed as 240 $€.t^{-1}$ resulted in the **1st position among all the compared technologies** as assessed using the gross margin.

The experiment confirmed that obtaining good economic results depends on goal selection and the strategy used in obtaining it. In 2010, the most important factor for setting a goal was market evaluation (in Germany) and orientation to the highest grain quality possible. Selection of variety and modifications of crop management practices are parts of the strategy. It is also necessary to combine intensity (costs) with weather

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conditions, which affects efficiency of inputs. Determination of input intensity under given soil and weather conditions in relation to produce commercialization has a key role. In 2010, the strategy oriented to medium yield of good quality grain at reasonable costs was more successful than intensification oriented to maximum yields.

Table 3. Crop management practices for winter wheat Akteur (CZ-E) at the DLG-Feldtage´2010

Date	Treatment
6.10.2009	Sowing – sowing rate 300 plants.m^{-2}, 145.9 kg of seeds.ha^{-1}, seed treatment Celest Extra 050 FS 150 ml per 100 kg of seeds
5.3.2010	Regeneration fertilization - ammonium nitrate with limestone 200 kg.ha^{-1} (54 kgN.ha^{-1})
8.4.2010	N and S application 151.5 kg.ha^{-1} Piamon (50 kgN.ha^{-1} + 18.2 kgS.ha^{-1})
10.4.2010	Tankmix – liquid fertilizer AHL28% 83 l.ha^{-1} (30 kgN.ha^{-1}) + CCC 720 1.2 l.ha^{-1}+ Monitor 13 g.ha^{-1} + water, the total of 400 l.ha^{-1}
5.5.2010	Tankmix - liquid fertilizer AHL 28% 83 l.ha^{-1} (30 kgN.ha^{-1}) + 0.7 l.ha^{-1} CCC 720 + Bravo 1 l.ha^{-1} + Flamenco FS 1,5 l.ha^{-1} + water, the total of 300 l.ha^{-1}
1.6.2010	N application LAV 222 kg.ha^{-1} (60 kgN.ha^{-1})
4.6.2010	Tankmix – fungicides Taspa 0.5 l.ha^{-1} + Folicur 0.3 l.ha^{-1} + water, the toal of 300 l.ha^{-1}

Conclusions

It is always very difficult to succeed at the DLG-Feldtage by comparing the European crop management practices of winter wheat. Foreign participants are usually hindered by the necessity to make decisions concerning cropping measures at a distance of more than 500 km. Moreover, in 2010 the decision was harder due to atypical weather conditions at the region. Nevertheless, it was confirmed that adaptation of crop management practices to the local and weather conditions in a particular year is a correct way.

The results of international comparisons showed that based on research outputs in the field of wheat growing in the Czech Republic and Hungary, it is possible to create crop management practices which are comparable and competitive with wheat crop management practices in other agrarian developed countries of Western Europe.

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MAIZE YIELDS VARIATION AMONG YEARS AS FUNCTION OF WEATHER REGIMES AND FERTILIZATION

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Abstract: The field experiment with P and K fertilization was conducted in spring 2004 (a = ordinary fertilization, b = a + P1, c = a + P2, d = a + P3 , e = a + K1, f = a + K2, g = a + K3 , h = a + P2K2). The amounts of added either/or phosphorus (P_2O_5) and potassium (K_2O) were (kg ha^{-1}) 500, 1000 and 1500, for the step 1, 2 and 3, respectively. The triplephoshate enriched with sulphur and zinc (45% P_2O_5 + 1-2% S + 0.06% Zn) was used for P fertilization. Potassium salt (KCl containing 60% K_2O) was source of K. The experiment was conducted in four replicates. The measured experimental plot was 77 m^2. In the next years the experiment was fertilized uniformly in level of usual fertilization. Crop rotation since 2004 has been as follows: maize (2004) - soybean (2005) - maize (2006) - wheat (2007) - maize (2008) - maize (2009) - soybean (2010) - maize (2011). Mean maize yield in the experiment (t ha^{-1}) was 12.78 (2004), 10.73 (2006), 11.70 (2008), 10.27 (2009) and 8.34 (2011). Mean of precipitation and air-temperature in the May-September period (Daruvar Weather Bureau) were as follows: 384 mm and 17.7 ºC (2004), 407 mm and 18.4 ºC (2006), 430 mm and 18.6 ºC (2008), 231 mm and 19.5 ºC (2009), 269 mm and 19.6 ºC (2011), while long-term means (1961-1990) were 427 mm and 18.2 ºC. Mean maize yield (the hybrids of the early maturity FAO group 200-300: t ha^{-1}) in the experiment were in close connection with water supplies by precipitation and air-temperatures: 12.78 (2004), 10.73 (2006), 11.37 (2008), 9.78 (2009) and 8.34 (2011). In general, application of both P and K fertilizer in ameliorative amounts (the P2K2 treatment) resulted with significant increase of maize yields in level from 7% to 16%, compared to the control. Under drought stress conditions in 2009 and 2011 growing seasons their effect were 14% and 16%, respectively.

Key words: maize yield, weather conditions, precipitation, air-temperature, fertilization

Introduction

The weather characteristics are important factor in yield variation of field crops among years (Liovic et al., 2006; Kovacevic et al., 2010b; Paunovic et al., 2010; Pepo and Kovacevic, 2011). In general, in this regard very high yield variation of maize was found (Jelic et al., 2009; Kovacevic et al., 2009b, 2009c; Markulj et al., 2010). For example, in decade-period 1998-2007 maize yield variation in Croatia (State Bureau for Statistics, 2008) was in range from 3.86 t ha^{-1} (2007) to 6.92 t ha^{-1} (2005). Luvisol and planosol are dominant soil types in Western and Central Pannonian Subregions of Croatia. Acid or very acid reaction, high potential acidity, low cation exchange capacity and base saturation as well as low humus and available nutrient contents are main characteristics of luvisol (Kovacevic and Basic, 1997). By adequate soil management practice is possible to increase soil fertility of these soils and to alleviate effects of less favorable weather conditions. Aim of this study was testing effects of ameliorative fertilization with phosphorus and potassium on yield and yield variation among years in stationary field experiment situating in Bjelovar-Bilogora County.

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Material and methods

The field experiment

The field experiment of P and K fertilization was conducted in April 23, 2004 in Pavlovac (Veliki Grdjevac municipality, Bjelovar-Bilogora County) acid soil (a = ordinary fertilization, b = a + P1, c = a + P2, d = a + P3 , e = a + K1, f = a + K2, g = a + K3 , h = a + P2K2. The amounts of added either/or phosphorus (P_2O_5) and potassium (K_2O) were (kg ha^{-1}) 500, 1000 and 1500, for the step 1, 2 and 3, respectively. The triplephoshate enriched with sulphur and zinc (45% P_2O_5 + 1. 2% S + 0.06% Zn) was used for P fertilization. Nitrogen amount was equalized for all treatments by adequate quantities of CAN (calcium ammonium nitrate: 27% N). The experiment was conducted in four replicates. The measured experimental plot was 77 m^2. In the next years the experiment was fertilized uniformly in level of usual fertilization (for maize kg ha^{-1}: 160 N + 60 P_2O_5 + 80 K_2O). Crop rotation since 2004 has been as follows: maize (2004) - soybean (2005) - maize (2006) - wheat (2007) - maize (2008) - maize (2009) - soybean (2010) - maize (2011). In this study maize yields and weather characteristics in each growing season, with emphasis on precipitation and temperature regime effects were shown. Impacts of the ameliorative fertilization on field crop yields, and soil characteristics for the first 4-years of testing (2004-2007) were elaborated in detail by Kovacevic et al., (2007, 2009a, 2010a, 2011) and Seput et al., (2008).

Collection of the weather data and statistical analysis

For this study, the data from State Hydrometeorological Institute (precipitation and air-temperature: Daruvar Weather Bureau - 20 km distance from the experiment site in SE direction) were shown. Data were statistically analyzed by ANOVA and treatment means were compared using t-test and LSD at 0.05 probability level.

Soil properties

The choice of experiment site was based on general soil characteristics in the Bjelovar-Bilogora County and by previous soil test (0-30 cm depth). Acid reaction (pH in KCl 4.10), low levels of plant available phosphorus (9.7 mg P_2O_5 100 g^{-1} according to AL-method), humus content (2.08%) and high hydrolitical acidity (5.60 cmol kg^{-1}) are main soil chemical characteristics.

Results and discussion

Maize was grown since 2004 through five growing seasons in the stationary field experiment. Mean maize yields were from 8.34 to 12.78 t ha^{-1}. The lowest yield was 35% lower compared to the highest annual yield (*Table 1.*). This difference is mainly result of specific weather conditions in each growing season.

In three growing seasons precipitation for 5-month (May-September) period were close to long-term mean (LTM: 1961-1990), while in two observed years they were considerably below LTM, 46% in 2009 and 37% in 2011. At the same period, only in 2004, air-temperatures were 0.5 ^oC lower and in remaining four years they were higher compared to the LTM. In this regard, two years have air-temperatures close to LTM and two years have considerably higher air-temperatures compared to LTM (for 1.3^oC in 2009 and for 1.4 ^oC in 2011).

Water shortage accompanied by higher air-temperatures resulted with stress conditions in 2009 and 2011 maize growing seasons (*Table 2.*). Therefore, grain yields in the experiment were bellow 10 t ha^{-1} (9.78 and 8.34 t ha^{-1}, for 2009 and 2011, respectively). However, under more favorable precipitation and temperature regimes of the remaining three tested growing seasons maize yields were above 10 t ha^{-1} (3-y mean: 11.63 t ha^{-1}).
In two summer months - July and August - weather conditions have important effects on maize yield. According to USA Corn Belt experiences (Shaw, 1988) they found that low maize yields are in connection with water deficit and with higher air-temperatures in July and August. However, in case of adequate precipitation maize is more tolerant to high temperatures. Our data (*Tables 2.* and *3.*) confirming these findings.
Fertilization with P and K had positive effects on alleviation of maize stress induced by unfavorable weather conditions. In this regard, application of both nutrients (P2K2 treatment) had better effects compared to individual application either P or K (*Table 2*).

Table 1. Grain yields of maize

Response of maize (2004-2011) to ameliorative fertilization (April 2004)								
Fertilization (2004)			Year					Mean
	P_2O_5	K_2O	2004	2006	2008	2009	2011	
			Grain yield of maize (t ha^{-1})					
STD	0	0	12.28	10.37	10.93	9.00	7.58	10.03
P-1	500	0	12.67	10.55	11.10	9.20	8.00	10.30
P-2	1000	0	12.62	10.84	11.30	9.74	8.42	10.58
P-3	1500	0	12.65	10.45	11.91	10.15	8.62	10.76
K-1	0	500	12.58	10.90	11.25	9.85	8.07	10.53
K-2	0	1000	12.73	10.58	11.36	9.78	8.42	10.57
K-3	0	1500	12.95	10.97	11.44	10.22	8.76	10.87
P2K2	1000	1000	13.75	11.17	11.70	10.27	8.83	11.14
		LSD 5%	0.52	0.64	0.50	0.49	1.02	
		LSD 1%	0.71	ns	ns	0.66	ns	
Mean of the experiment			12.78	10.73	11.37	9.78	8.34	10.76

Table 2. Precipitation and air-temperature regimes during maize growing seasons (Daruvar Weather Bureau)

Daruvar Weather Bureau (20 km from the experiment site in SE direction)												
Year	May	June	July			August			September			
	1-30	1-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30	
	Precipitation (mm)											Sum
2004	56	97	29	0	36	7	23	33	7	30	66	384
2006	106	95	12	6	1	68	24	69	0	27	0	407
2008	21	163	27	9	66	30	7	11	14	62	19	429
2009	57	72	37	10	0	7	40	3	0	4	0	230
2011	55	44	9	17	96	33	7	0	3	22	3	289
	Mean air-temperature (°C)											Mean
2004	14.2	18.7	21.3	20.0	20.0	21.0	21.6	18.1	16.0	15.7	13.0	17.7
2006	15.2	19.1	20.6	21.7	25.0	18.8	20.5	16.7	17.5	16.8	15.4	18.4
2008	16.7	20.7	22.6	21.1	19.5	21.9	21.3	18.6	20.4	12.0	10.6	18.7
2009	17.5	19.0	20.4	21.5	23.1	22.5	21.8	20.8	18.3	18.6	16.2	19.5
2011	15.6	20.3	22.6	24.5	18.2	20.8	21.1	22.9	21.2	19.6	15.4	19.6
	The long-term mean (LTM) 1961-1990											
mm	86	99	86			91			65			427
°C	15.7	18.9	20.6			19.7			16.1			18.2

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Conclusions

The lower maize yields, up to 35% in comparison with normal weather characteristics, are in close connection with water deficit and higher air-temperatures. Phosphorus and potassium fertilization alleviated up to 16% maize stress caused by unfavorable weather conditions.

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STUDY OF THE EFFECT OF FERTILIZATION OF MAIZE (*ZEA MAYS* L.) IN CROP YEARS WITH DIFFERENT WATER-SUPPLY

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Abstract: We examined nutrient reaction of maize hybrid SY Flovita on chernozem soil in 2010, 2011 in a long-term experiment. We studied the crop yield on six different nutrient levels (control, N_{30}+PK, N_{60}+PK, N_{90}+PK, N_{120}+PK, N_{150}+PK). We determined that in 2010 the average yield values were between 9053 kg ha^{-1}–11642 kg ha^{-1}, while in 2011 they were between 10746 kg ha^{-1}–15296 kg ha^{-1}. In 2010, which was a year with beneficial water supply and less heat units we experienced maximum yield on N_{90}+PK nutrient level, while in 2011, a year with average water supply and more heat units, on the N_{120}+PK nutrient level. The study of extra yield per 1kg NPK fertilizer showed that largest yield increases were realized on N_{30}+PK nutrient level the control treatment in both years (21.3 kg in 2010 and 45.4 kg in 2011). The yield increases decreased with the increase of nutrient levels (on N_{60}+PK nutrient level, 7.4kg in 2010, 4.8 kg in 2011). From the examination of the hybrid's water utilization it can be concluded that in the different fertilizer treatments the water utilization in 2010 was worse than in 2011. The smallest crop yields per 1mm rainfall were experienced in the control treatment (15.3 kg mm^{-1} in 2010, 34.2 kg mm^{-1} in 2011), while the maximum yield (19.7 kg mm^{-1}) was obtained on N_{90}+PK level in 2010 and on N_{120}+PK level in 2011 (48.7 kg mm^{-1}). In both years water utilization of maize was better in Nopt.+PK treatment compared to the control treatment.

Keywords: maize, crop year, fertilization, yield

Introduction

Evaluating the effect of production factors in maize production, most researchers consider that fertilization is one of the most important factors (Nagy et al., 2003). The determination of the optimum fertilizer dosage is one of the hardest tasks, because in this process the nutrient utilization capacity of the produced hybrid and its reaction towards mineral fertilization, just as the effect of the crop year shall all be taken into account (Nagy, 2007). From the aspect of the effect and utilization of mineral fertilizers the amount of precipitation can not be neglected (Pummer et al., 1995). This statement has been confirmed by the research results of Lente and Pepó (2009). They have stated that the water-supply of the vegetation period had a significant influence on the utilization both of the natural nutrients in the soil and the active substances of mineral fertilizers. The vegetative growth depends on the amount of precipitation until flowering, while water supply determined the nutrient utilization (Dobos and Nagy, 1998). According to Nagy (2006) the high variability of the climate conditions is one of the main risk factors in crop production. In a long-term experiment Pepó (2009) has revealed a close relationship between water- and nutrient-supply. Sárvári and Boros (2009) also reflected to the close relationship between crop year effect, mineral fertilization and the yield of maize hybrids.

Materials and methods

We executed our study at the experimental station in Debrecen - Látókép. The investigated maize hybrid was the SY Flovita. The treatments consisted of six nutrient-supply levels. The basic mineral fertilizer dosage was 30 kg ha^{-1} nitrogen, 22.5 kg ha^{-1}

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and 26.5 kg ha^{-1} potassium active substance. The other treatments were two-, three-, four- and five-times dosages of it. The nitrogen has been applied divided in 50-50% in the autumn and spring period. 100% of the phosphorous and potassium fertilizer dosages were applied in the autumn period.
In the investigated period of 2010 fell altogether 924 mm precipitation, in contrast in the crop year of 2011 only 564 mm. According to this it can be stated that regarding the amount of fallen precipitation the crop year of 2010 was much more favourable than that of 2011, still, the distribution of the first year wasn't optimal for the yield development of maize.
Comparing the temperature values of the crop years 2010 and 2011 it can be stated that 2011 was warmer for maize production than the previous year. For the crop maize with high demand on warm the crop year of 2011 had 164 heat units better heat supply *Table 1*.

Table 1. The main weather parameters during the vegetation period of maize (Debrecen, 2010-2011)

Precipitation (mm)	Oct. – Marc.	Apr.	May	Jun.	Jul.	Aug.	Sept.
2009-2010 years	334,3	83,9	111,4	100,9	97,2	98,3	98,4
2010-2011 years	251,0	15,6	52,3	22,0	175,0	42,7	6,2
30 year's average	220,2	42,4	58,8	79,5	65,7	60,7	38,0
Temperature (°C)	Oct. – Marc.	Apr.	May	Jun.	Jul.	Aug.	Sept.
2009-2010 years	28,3	11,6	16,6	19,7	22,0	19,0	14,1
2010-2011 years	14,2	12,2	16,4	20,5	20,4	21,4	18,0
30 year's average	17,2	10,7	15,8	18,7	20,3	19,6	15,8

Results and discussion

Comparing the yield data of both crop years it can be stated that yields varied between 9053 kg ha^{-1} and 11642 kg ha^{-1} in 2010, while in 2011 between 10742 kg ha^{-1} and 15296 kg ha^{-1}. In the crop year of 2010 the nutrient supply level of N_{90} + PK proved to be optimal, whereas the investigated hybrid produced the highest yield (11642 kg ha^{-1}). In contrast, the highest yield of 2011 was measured in case of the nutrient treatment of N_{120} + PK (15296 kg ha^{-1}), *Figure 1*.
Figure 2 shows the water utilization of the hybrid SY Flovita in 2010 and 2011 on the different nutrient-supply levels. In the average of the fertilizer treatments the water utilization was 18.4 kg mm^{-1} in 2010, while in 2011 44.7 kg mm^{-1}. We have measured different water utilization values of the hybrid SY Flovita in case of the different nurient supply levels. In 2010 the yield growth against 1 mm precipitation varies between 18.2 kg mm^{-1} and 19.7 kg mm^{-1}, while these values laid between 34.2 kg mm^{-1} and 48.7 kg mm^{-1} in 2011.

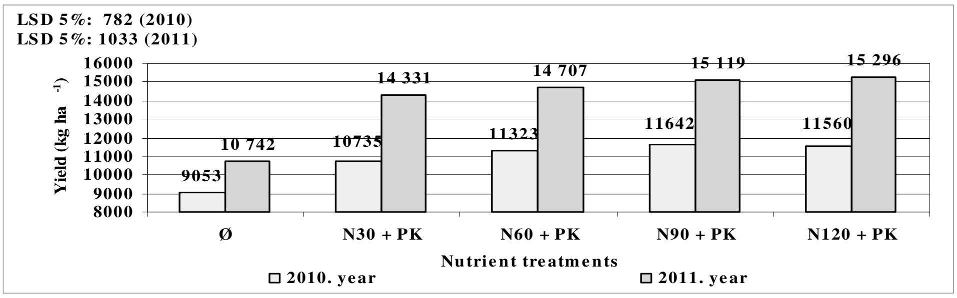

Figure 1. Yield development of the hybrid SY Flovita in case of different nutrient treatments (Debrecen 2010-2011)

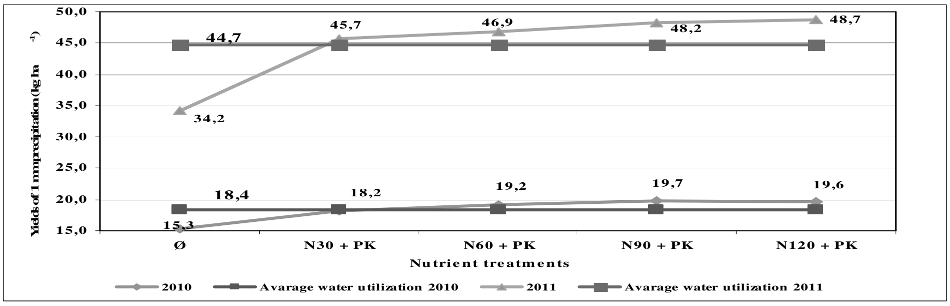

Figure 2. Comparison of the water utilization of the hybrid SY Flovita in case of different crop years and nutrient-supply levels (Debrecen, 2010-2011)

Studying the yield growth against 1 kg NPK fertilizer active substance we have stated that in contrast to the control treatment the highest yield growth was measured in the treatment of N_{30} +PK. The hybrid SY Flovita has produced 21.3 kg ha^{-1}, while in 2011 45.4 kg ha^{-1} yield per 1 kg NPK mineral fertilizer. In case of the nutrient supply level of N_{60} + PK we have found that the efficiency of the applied fertilizer decreased in contrast to the nutrient supply level of N_{30} + PK. It can be stated that the yield growth per 1 kg NPK mineral fertilizer active substance was lower in the too wet and colder crop year of 2010, than in the warmer crop year of 2011 with average water-supply *Figure 3*.

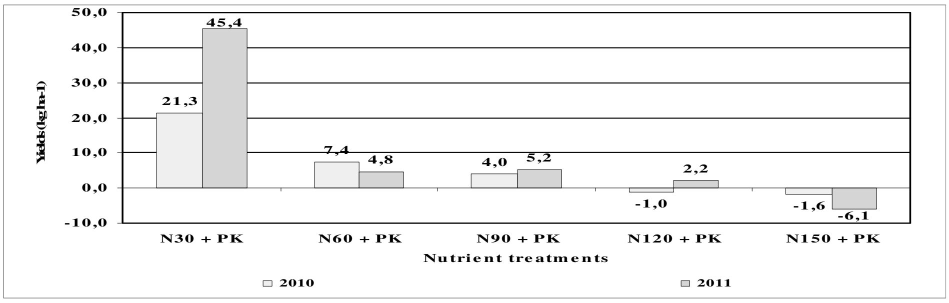

Figure 3. Development of the yield growth per each kg applied NPK fertilizer active substance in the different fertilizer treatments (Debrecen, 2010-2011)

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Conclusions

As a result of the research work it has been stated that the yield amounts of the investigated hybrid were lower in the crop year of 2010 (9053 kg ha^{-1} – 11642 kg ha^{-1}) than those of the crop year 2011 (10742 kg ha^{-1} – 15296 kg ha^{-1}). The positive effect of mineral fertilization has been confirmed by increasing the fertilizer dosages. The considerable difference in yield amounts can be attributed the high amount of fallen precipitation in 2010, the less aerated soil volume and the lower heat sum (1315 ^{o}C). The higher yield of the crop year 2011 is produced due to the higher heat sum (1479 ^{o}C), the higher amount of soil water reservoir and the optimal amount of precipitation in July. The water utilization of the hybrid in case of different nutrient-supply levels has been compared in both years. The water utilization of the hybrid SY Flovita was lower in 2010 than in 2011. Less dry matter was incorporated with the utilization of 1 mm precipitation than in the drier crop year of 2011. The lowest yield per each mm precipitation was measured in the control treatment (in 2010 15.3 kg mm^{-1}, in 2011 34.2 kg mm^{-1}). The highest yield per 1 mm precipitation (19.7 kg mm^{-1}) was measured at the nutrient-supply level of N_{90} + PK in 2010. In contrast, the same parameter showed the highest value (48.7 kg mm^{-1}) at the nutrient-supply level of N_{120} + PK in the crop year of 2011. From the analysis of the yield growth data per 1 kg applied NPK mineral fertilizer active substance it has been revealed that in contrast to the control treatment the highest yield growth was produced at the nutrient-supply level of N_{30} + PK in both crop years (21.3 kg $kgNPK^{-1}$ in 2010, while 45.4 kg $kgNPK^{-1}$ in 2011). The yield per each kg NPK fertilizer active substance showed a decreasing tendency parallel to the increasing nutrient-supply levels. In case of the nutrient-supply level of N_{60} + PK the efficiency of fertilizer application was 7.4 kg ha^{-1} in 2010 and 4.8 kg ha-^{1} in 2011.

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THE EFFECT OF ACID RAIN AND HEAVY METAL ON GARDEN CRESS (*LEPIDIUM SATIVUM*)

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Abstract: Nowadays, environmental loads of acid rain and heavy metals are accountable for various damages. The main source of these pollutions originates from anthropogenic activity. Heavy metals can pass into the nature by waste dumping, mining, metallurgy and transportation. Acid rain is caused by atmospheric emission of acid gasses, such as SO_2, CO_2, NO_x, primarily originated from traffic and industrial activities. The object of our study was to test the effects of these pollutants on garden cress (*Lepidium sativum*) under laboratory condition.

We examined the changes in the plant physical parameters and vitamin C content inducted by different treatments (1 mg kg^{-1} Cd for dry matter content, nitric acid and their combination) during the 6 day long growing season. Additionally the Cd content accumulated in plant was measured by Inductive-coupled Plasma Atomic-Emission Spectrometer (ICP-AES, Jobin-Yvon 24). It can be stated that the acid rain and heavy metal have impact on the plant. The length of roots and stems are significantly shorter compared to the control plants meanwhile the leaf surface area is increased. The vitamin C content is increased, although the highest vitamin C content was measured in the case of control samples, in which the plants were sprinkled with distilled water (29.3 ±2.9 mg 100 g^{-1} for fresh matter). Among the treated samples, the highest vitamin C content was measured in plants grown in acid rain polluted soil. This can be explained by behaviour of nitric acid in soil, as plants are able to utilize the nitrogen originated from nitric acid transformation.

Keywords: heavy metals, Cd accumulation, acid rain, garden cress

Introduction

The demages of acid rains were studied for a long time. Their effects for plants have been studied in pot experiments (Wyrwicka and Skłodowska, 2005).

The Cd^{2+}-ion (Máthéné et al., 2004), the other applied contaminant in the frame of this experiment, can be accumulated by plants resulting damages. The combined effects of acid rain and heavy metals on plants have not been studied fully (Bo-han et al., 2006).

Materials and methods

1.) Soil preparation

Heavy metal and acid rain treatment in the soil: 130 g “Hahóti” garden soil (Nr. 02.5/2138/2/2009) was used for each pot. The humus content was 15% and plasticity index was <10% (MSZ 124043-2:2006). The soil was contaminated either with 1 mg kg^{-1} cadmium-ion (in form of $CdCl_2$) or 1 mg kg^{-1} Cd-ion (from $CdCl_2$) and 20 cm^3 nitric acid (from 1 M HNO_3 solution). Nitric acid rain (pH=4.5) was prepared according to Sing and Agrawal (1996).

2.) Plant preparation

After 30 minutes of seed soaking in distilled water 5 g garden cress (*Lepidium sativum*) seeds (Biorganik Online Kft.) were sown in each soil pot and then they were kept in dark for the first 24 hours. The plants were nursed in fitotron, in which the lighting was regulated providing 12 hours exposure time (CRI:93+, full spectrum, 1350 lumen) per

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day and the temperature was 22± 3 °C. Furthermore 20 cm^3 distilled water was used for irrigation.

The rain simulations: On the 6th day after sowing the plants were sprayed with 20 cm^3 nitric acid rain or 20 cm^3 bidistilled water.

After these, samples with different treatment were named as it is followed: 1. Control; 2. Control2 (sprayed with distilled water); 3. Cd (the soil treated with cadmium); 4. AR (the soil treated with acid rain); 5. CdAR (the soil treated with cadmium and acid rain) and 6. CdAAR (the soil treated with cadmium and the plants spayed with acid rain). All treatments were performed in three replicates (6x3=18).

3.) Measurement of different soil and plant parameters

Determination of dry weight and pH: Determination of dry weight content was made according to standards no. MSz-08-0205-1978; and pH of soil by MSz-08-0206/2-1987.

The physical parameters of plants: The plants were removed on the 6th day after sowing and 6 hours after spraying. Each removed plant was separated into root, stem, and leaf to measure the length of the root and stem and the surface of leaf by graph paper.

The vitamin C content of plants: Sample preparation was according to the modified method of Lásztity and Törley (1987). The vitamin C was separated on a BST C18 HS RUTIN column (120 x 4 mm ID; 10 μm) and BST C18 HS RUTIN (50 x 4 mm ID; 10 μm) precolumn (BST, Hungary) at a flow rate of 1 ml min^{-1}; solvent was 2% acetic acid (isocratic system). Detection (Jasco UV-2077 multichannel detector) was performed at 243 nm. The chromatographic data processing software was Chrom Pass Chromatography Data System v.1.7.403.

Plant preparation and heavy metal determination:

The stems and leaves of the removed plants were prepared for total cadmium determination*:* after a 72 hour long drying process at 70 °C the separated plant tissues were crushed and sifted through 0.2 mm sieve. 6 cm^3 65% HNO_3, 1 cm^3 30 % H_2O_2 were used for extraction (Gyarmati et al., 2010; Bernvalner et al., 2011). The total Cd concentration was measured in every sample of cresses by ICP-AES (Jobin-Yvon 24).

4.) Statistical analysis

The statistic is based on ANOVA randomized block analysis (SPSS v.14.0).

Results and discussion

1.) The effect of acid rain on soil pH

The soil pH was measured on the 6th day after seeding. The *Table 1.* shows the results.

Table 1. The soil pH

Samples	The pH of the soil samples			
	pH_{H_2O}	±SD	pH_{KCl}	±SD
Control	6.72	0.01	6.58	0.01
Control2	6.72	0.01	6.56	0.01
Cd	6.67	0.01	6.37	0.02
AR	6.47	0.02	6.15	0.04
CdAR	6.46	0.01	6.17	0.03
CdAAR	6.59	0.02	6.31	0.01

Due to the results acid rain reduces significantly the soil pH ($LSD_{5\%}$=0.04). The pH of the soil treated with acid rain before sowing (AR and CdAR) was lower than in the spayed sample (CdAAR), since less acid rain gets to the soil at the time of the spraying. The measurement of the soil pH is important because the lower the pH the higher the rate of mobilization of toxic metals (Reddy et al., 1995).

2.) The results of the dry weight

The *Table 2.* contains the results of dry weight of garden cress. Significantly the highest dry matter content was measured in the sample of AR ($LSD_{5\%}$=2.34).

It should be noted that the dry matter content in Control2 was higher than in Control, which can be explained by the extra water supply, since it is ensured the optimal condition for plant growth.

3.) Analysis of physical parameters of garden cress

The *Table 2.* includes the results of the effects of acid rain and cadmium on the plants physical parameters.

Table 2. The physical parameters and dry weight of garden cress

Treatments	Physical parameters of plants						The dry weight of the samples	
	Root [mm]	±SD	Stem [mm]	±SD	Leaf [mm^2]	±SD	%	±SD
Control	14.4	2.3	22.4	2.8	29.8	3.0	21.62	1.7
Control2	13.6	4.6	22.4	2.5	29.5	3.6	24.75	1.9
Cd	10.9	4.2	21.0	2.7	29.6	2.5	22.55	0.6
AR	8.3	2.5	17.5	2.8	32.6	4.7	27.17	0.2
CdAR	10.5	2.7	21.1	3.0	30.1	2.5	20.81	0.0
CdAAR	11.2	3.3	20.9	3.1	29.8	2.1	27.13	1.1

According our results, the length of the roots of the treated plants was shorter compared to the control group ($LSD_{5\%}$=3.32). The shortest root lengths were measured in the case of the plants treated by nitric acid rain. The highest plants based on their stem length were found in control samples. The plants grown in the soil treated only nitric acid (AR) were significantly shorter ($LSD_{5\%}$=1.97). The same changes were not provable, if the two contaminans were presented simultaneously in the experiment. Although the present of the acid in soil has inhibitory effect on the growth of root and stem, the highest leaf surface area values were measured in these samples. This effect is explicable due to the microbiological nitric acid transformation in soil, which resulted in nitrogen source for the plants. Based on the research of Mácsai (2004) 100 cm^3 65% HNO_3 is equal to 43 -53 g NH_4NO_3.

4.) Effect of acid rain and cadmium on vitamin C

The vitamin C content (see on *Figure 1.* – left) is increased, although the highest vitamin C content was measured in the case of control samples, in which the plants were sprinkled only with distilled water (29.3 ± 2.9 mg 100 g^{-1} for fresh matter). The Control, which did not receive water, had significant lower vitamin C content ($LSD_{5\%}$=2.73). The acid rain presented in soil may have positive effect on the vitamin C content of plants. There is no significant difference between the sample Cd and CdAAR, which shows that the acid rain spray has no effect on vitamin C content under the 6 hours of drying time.

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5.) The total cadmium content of garden cress

According to the data (*Figure 1.* – right) Cd accumulation is significantly higher in stem ($LSD_{5\%}$=4.76), however the standard deviation of the concentration values is high, which is explicable by the short vegetation period of the plants. The significantly

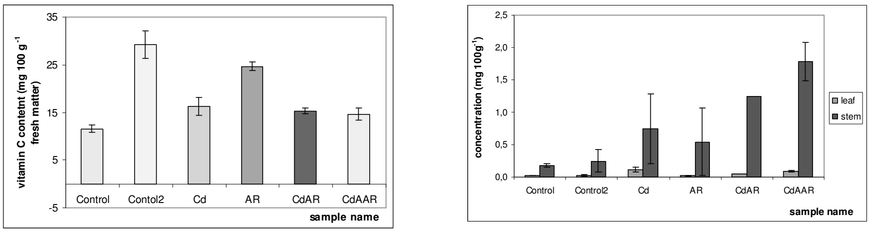

Figure 1. The effect of pollutans on vitamin C content (left) and the tolal Cd of tissues (right)

highest Cd accumulation was measured in sample CdAAR ($LSD_{5\%}$=0.73). Based on the comparison of the samples Cd and CdAAR it can be stated that the acid rain treatment on leaves actuated the heavy metal accumulation in plant.

Conclusions

Nitric acid pollution before germination can provide nitrogen source for the plants due to the microbiological transformation in soil. Acid rain has a positive effect on the dry matter and vitamin C content of the plants. In addition it affects the leaf surface area, since the measured values were higher compared to the control samples.

In case of acid rain treatment *Lepidium sativum* accumulates averagely more Cd during the 6 day long vegetation period.

Acknowledgements

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THE EFFECT OF DIFFERENT COMPOST RATES ON THE WATER BALANCE OF RYEGRASS (*LOLIUM PERENNE* L.)

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Abstract: Greenhouse pot experiment was set up in four replications to study the effects of three composts blended with acidic sandy soil in five (0%, 5%, 10%, 25% and 50%) rates. The experimental plant was perennial ryegrass (*Lolium perenne* L.). After the shooting of ryegrass the water supply of the 2.5kg pots was carried out at 60 per cent of field water capacity of soil. During the growing season the plant water consumptions were measured and registered. After the harvest of ryegrass the fresh and dry weight of harvested plants were measured. Our aim was to study the relations between plant dry matter content, composts and the compost:soil ratio, and we evaluated the effects of compost treatments on the water use efficiency. Significant relations were found between the compost utilization, dry matter production and WUE.

Keywords: compost, mixing ratio, biomass production, water balance

Introduction

Protection and sustainable management of natural resources are essential to ensure the survival of humanity. The growth of world population associated with increasing water and food consumption raises several problems.

Water is a limited resource therefore we should economize the water use including field water management. The use of compost increases the water retention capacity of soil (Zougmoré et al., 2004; Aggelides and Londra, 2000), in addition, the amount of waste materials formed in the public spaces of cities and during the processing of agricultural row materials can be decreased by the recycling of them (Simándi, 2008).

Organic waste materials could be collected selectively, mixed and completed with suitable additives. If we use the appropriate treating technology, compost will have a good quality and will be capable to supply horticultural plants with nutrients. Scientific research on the positive effect of compost on soil parameters and yield has been published widely both in Hungarian and international literature (Gigliotti et al., 1966; Kádár-Morvai, 2007; Keserű, 2007).

We hypothesized that compost utilization improve the water use efficiency of plant. Therefore, we studied the relations between the dry matter productions of plant, the plant water use and compost: soil ratio.

Materials and methods

Compost utilization experiment with 3 different composts under controlled conditions was set up in the glasshouse of the Institute of Agricultural Chemistry and Soil Science. We received the 3 composts from one of the partners of University of Debrecen in 2009. Composts were sieved (< 2 mm), because degradation of the large particles in the pots is a slow process.

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Composts were mixed with acidic sandy soil in four proportions (volumetric ratios: 5%, 10%, 25% and 50%), in four repetition. The pots were set up randomised. The water supply of the pots was controlled. The pots were placed on cars, by which they could be easily moved under a roof.
After one week maturation of compost-soil mixture we sowed perennial ryegrass *(Lolium perenne* L.*)*. The advantage of ryegrass is that it grows quite fast, tolerates the glasshouse conditions well and it indicates the effect of treatments well. After the shooting of ryegrass the water supply of the 2.5 kg pots was carried out at 60 per cent of field water capacity of soil. The pots were weighted and irrigated two times a day. The water consumptions (evapotransporations) of pots were registered during the three week. In our department previous researches (Loch et al., 1992) confirmed that irrigation at 60 per cent of field water capacity is optimal in sandy soils.
After the harvest the fresh and dry weight of ryegrass were measured. Water use efficiency (WUE g kg^{-1}) was calculated from the quotient of total dry mass (TDM) divided by total water used (TWU).

Statistical analyses:
All statistical analyses were performed by a Microsoft Excel Macro developed by L. Tolner (Aydinalp et al., 2008; Tolner et al., 2008; Vágó et al., 2008) according to Sváb (1981). The processing of the data was conducted by variance analyses. The significance level of the treatment effect and significant differences were determined at $P \leq 0.05$.

Results and discussion

The effects of treatments on the fresh and dry weight of ryegrass were evaluated in our earlier study (Szabó et al., 2010). The compost:soil ratio and the different composts modified significantly (P = 0.1%) the yield of ryegrass. We found the most positive effect in the case of the 1st compost. If a 25% compost dose were applied, the dry weight increasing effect of 1st compost would reach a value of 45 g pot^{-1}. The 50% compost rate did not cause higher yields. The optimal compost:soil ratio was 25:75%. The 25 and 50% rates of 3rd compost increased significantly the yield. The yield increasing effect of 50% compost was nearly 10 g pot^{-1}.
The 2nd compost had a moderate effect, but the 10% compost dose increased significantly the dry and fresh weight of ryegrass. The recommended compost doses were different for each of the composts.
The daily water consumption of the pots in the aforementioned treatments is represented in *Figure 1, 2 and 3*. The water consumption was related to the biomass production of the ryegrass. It increases during the vegetation period. The most significant differences were observable in the case of 1st compost. Two peak of water consumption were observable on the 15th and 20th of July. The increased water consumption could be explained by the high temperature (35-40 °C at peak) of this period.

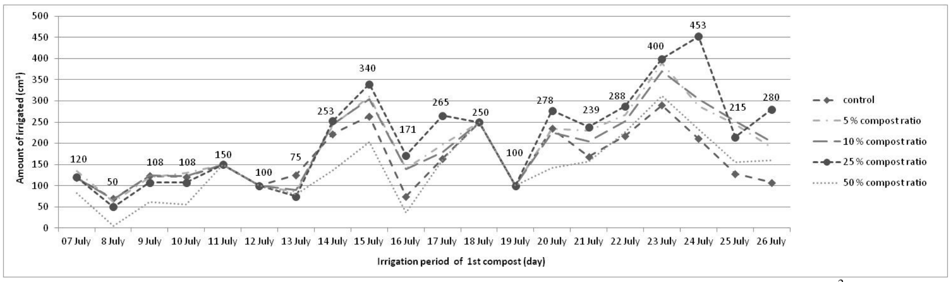

Figure 1. The average daily water consumption of each treatment of first compost (cm^3)

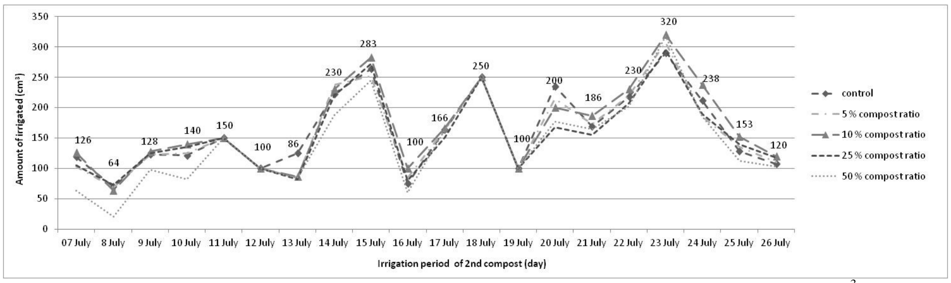

Figure 2. The average daily water consumption of each treatment of second compost (cm^3)

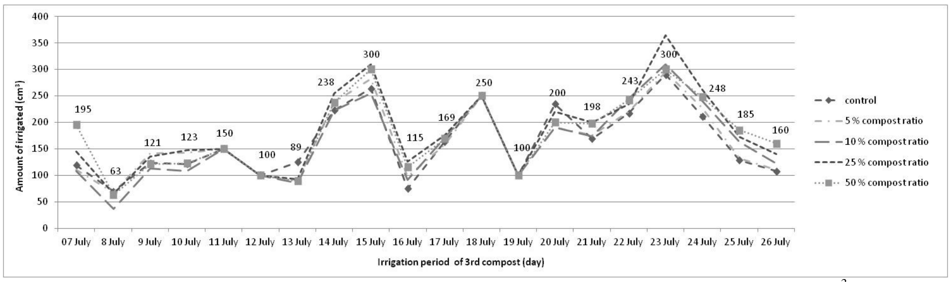

Figure 3. The average daily water consumption of each treatment of third compost (cm^3)

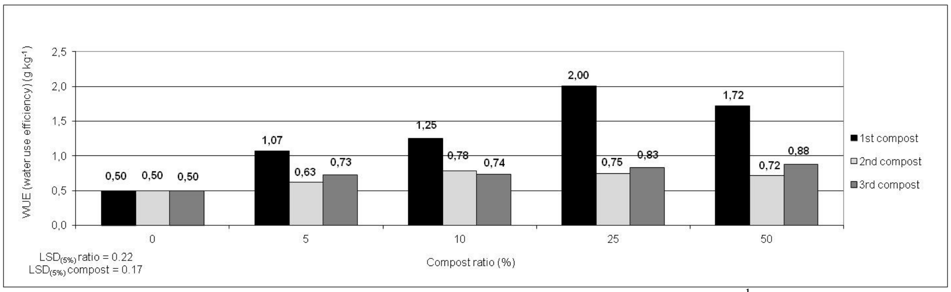

Figure 4. The three compost of water use efficiency (WUE g kg^{-1})

WUE = TDM/TWU

WUE: water use efficiency (g kg^{-1}), TDM: total dry mass (g), TWU: total water used (kg)

Water use efficiency (WUE) was also evaluated in the experiment (*Figure 4*). Compost utilization increased significantly the water use efficiency (P = 0.1%). As the data show

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in the case of 1st compost the WUE of the 25% compost treatment was 4 times higher than that of control treatment. The 2nd and 3rd composts had a moderate effect on WUE.

Conclusions

Our results are concluded as follows:
- Compost utilization increases the yield of ryegrass.
- The WUE increased significantly as an effect of composts. It can be explained by the better nutrient supply of the plant and by the improved water management of soil.

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EFFECT OF WATER SUPPLY AND TEMPERATURE ON MAIN FRUIT COMPONENTS OF RED SWEET PEPPER

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Abstract: Special tomato shaped or capia type red sweet pepper varieties are consumed fresh or processed in fully ripened stage in the Hungarian diet. They have one of the highest colour components among the red sweet peppers. These colour components have high antioxidant capacity, which are important in human health preservation. A two year experiment was conducted in 2009-2010 to evaluate the effect of water supply on the ingredients of red sweet pepper capia type cultivar Kárpia F_1 and tomato shaped pepper variety Pasa F_1. Fruits showed significantly different chemical composition during the two different seasons in open-field cultivation. In the two experimental years there was nearly four times more precipitation in 2010 a total of 580 mm, compared to 150 mm in 2009, in growing seasons. This study aims to investigate the effect of different precipitation and temperature on red capia pepper's colour components. There was significant difference in the total carotenoid content between the two experimental years. The capia fruits consisted 20.7, and 49.3 mg/100g total carotenoid content in 2009 and 2010 respectively.

Keywords: red sweet pepper, capia carotenoid content, water supply

Introduction

Capsicum annuum L. is the main cultivated Capsicum species, which has wide range of variability in quantitative and qualitative character of fruits (Bosland and Votava, 1996). Hungarian sweet pepper, classified as *Capsicum annuum* L. var. *grossum* highly diversified in types had been declared as having high antioxidant content (Remenyik et al., 2008). Special type of red sweet peppers such as tomato-shaped and capia, traditionally consumed in fully ripened stage are usable for processing as paprika paste. The capia varieties are the best-known type in the Balkans and have become popular in recent years in Western Europe (Csilléry, 2006).

Varieties of this type due to their excellent flavour are processed by cannery food industry, as well as being sold for fresh consumption (Fruitveb, 2011).

Red pepper fruit is a good source of natural colours and bioactive compounds such as carotenoids, tocopherols, and ascorbic acid (Daood et al., 1996). In association with their bioactive constituents red pepper products have significant cancer preventive activity (Maoka et al., 2001). Factors most likely to affect the content and composition of bioactive compounds in red pepper possibly include ripeness, genotype, processing and environment (Daood et al., 1996; Márkus et al., 1999; Pérez-Gálvez and Mínguez-Mosquera 2001).

The aim of this study was to compare tomato shape and capia type red sweet pepper fruit components and the effect of temperature and precipitation on these parameters.

Materials and methods

Open field experiment was carried out in the test sites of Szent István University, Gödöllő in 2009 and 2010. A determined conventional tomato shaped pepper variety Pasa F_1 and capia type red, sweet pepper cultivar Kárpia F_1 were investigated in this study. The experimental field, with a size of 150 m^2, was a brown forest soil, with

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mechanical composition of sand, sandy-clay, in both years. The subsoil water is below 5 m, therefore it cannot influence the water turnover.
Seeds were sown on the 2nd of April 2009 and 3rd of April 2010 in greenhouse and transplanted to field on the 30th of April 2009 and on the 4th of May 2010, respectively. The pepper seedlings were planted out in twin rows, with 0.3 m spacing inside the row and 1.2 m between adjacent twin rows, the space between the plants in the row was 0.25 m. Drip irrigated water was given out according to weather forecast estimates of mean daily temperatures divided by 5, but it was ended at the beginning of ripening process. Basic nutrition supply was given out when plants were transplanted with Agroblen 18-8-16+ 2 MgO (nitrogene-phosphorus-potassium-magnesium), with 0.1 kg/m² volumes.
Red ripened fruits were measured at harvesting on the 11th of August in 2009 and 26th of August and 30th in September in 2010.
Brix° value was measured using a refractometer (AST 1230, Tokyo, Japan). Ascorbic acid content was measured via high performance liquid chromatography (HPLC) (Dong and Pace 1996). Total polyphenols were analyzed with the Folin-Denis method according to the AOAC official protocol 952.03 (AOAC 1990).
A Waters model Alliance liquid chromatographic aparatus consisting of a Waters 2695 Separations Module and a Waters 2696 photodiode array detector was used. The operation and data processing was performed by using Waters Empower software. A Nucleosil 100, C-18, 3 µm, 240 mm x 4.6 mm i.d. column was used with gradient elution as described (Daood and Biacs, 2005) for the separation and quantitative determination of carotenoids.
All samples were measured in three repetitions. The data were analysed by two-factor analysis of variance (ANOVA) with repetitions and the means separated using the Student's test at p=0.05.

Results and discussion

Seasonal effect on yield quality significantly depends on the weather, especially on temperature and precipitation conditions during the growing season. The two examined years were similar in temperature regime, but totally different in precipitation amount and distribution (*Figure 1*).
The evaluated Brix°, ascorbic acid content, total polyphenols and total carotenoids depended on fruit type and seasonal effect in 2009 and 2010 (*Table 1*). We did not detect varietal effect in Brix° in 2009, but seasonal effect was significant in case of capia type pepper fruits. We tested the ascorbic acid and polyphenol contents of the fruits, but they did not show significant differences.
We tried to find correlation between ecological parameters and the most important quality factor, carotenoid content. Accumulated precipitation of 40 days preceding fruit harvest did not show any correlation with carotenoid content of pepper fruits. But, accumulated temperature of 40 days preceding fruit harvest had strong positive (R^2=0.89) effect on total carotenoid content during two years. Linear regression showed, that 12.5 °C more accumulated temperature caused 1 mg/100g more carotenoid content in the fruits. These results are demonstrated in *Figure 2*. calculated from two years data.

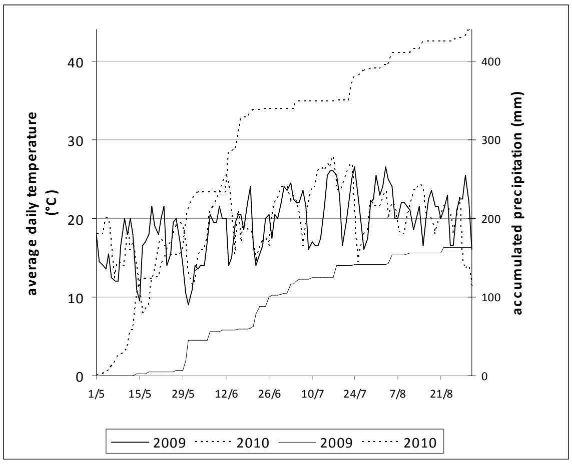

Figure 1. Average daily temperature and accumulated precipitation during the vegetation season in 2009-10.

Table 1. Average value of some fruit components in different types of sweet pepper fruit, in 2009 (n=4; ±SD)

	Brix°	Ascorbic acid [mg/100g]	Total polyphenol [mg/100g]	Total carotenoids [mg/100g]
Pritamin 2009	10.06±0.74a	156.1±6.4a	205.0±11.9a	25.9±8.5a
Kárpia 2009	10.46±1.09a	152.8±15.1a	181.9±16.8a	20.7±2.34a
Kárpia 2010	12.36±0.38b	164.7±15.9a	162.8+15.68a	49.3±7.6b

Data in the same column bearing the same superscript letter are not significant at P=0.05.

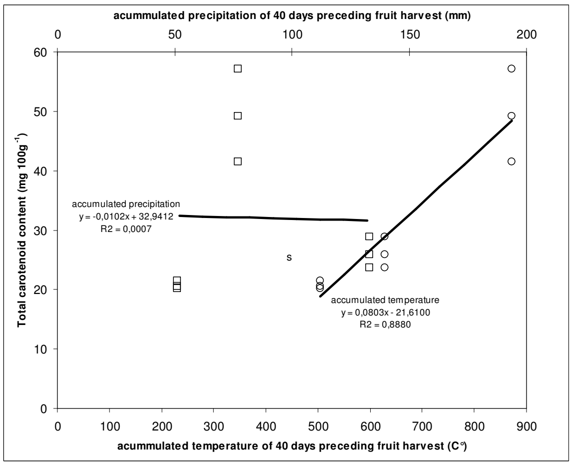

Figure 2. Total carotenoid content of capia and tomato shaped type red pepper fruits in relation of accumulated temperature and precipitation of 40 days preceding fruit harvest in 2009-2010 (n=9).

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Conclusions

We can conclude that Hungarian red sweet peppers produced for processing consist of high amounts of antioxidants and red carotenoids, but these are mainly influenced by temperature, not by precipitation.

Acknowledgements

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EFFECT OF TWO DIFFERENT CROPYEARS WITH DIFFERENT WATER SUPPLY AND THE AGROTECHNOLOGICAL FACTORS ON THE AGRONOMIC CHARACTERISTIC AND THE YIELD OF MAIZE (*ZEA MAYS* L.)

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Abstract: The experiments were carried out at the Látókép experimental station of the University of Debrecen on chernozem soil in a long term maize experiment in 2010 (extremely rainy) and 2011 (average weather) in mono-and biculture crop rotation on 2 nutrient levels (control, N_{180}+PK) with 2 treatments of water supply (no irrigation and irrigation) and 3 plant density values (40 thousand plant ha^{-1}, 60 thousand plants ha^{-1} and 80 thousand plant ha^{-1}).We examined how the extent of corn smut- and fusarium infection and yield changes as a result of crop rotation, nutrient treatment and irrigation and plant number in 2010 and 2011.

Keywords: maize, irrigation, diseases, fertilization, yield

Introduction

In maize production, rational crop rotation and harmonized NPK fertilization are of major importance (Nagy and Huzsvai, 2005). According to Berzsenyi et al. (2011), fertilization, hybrid selection and plant density as agrotechnical elements have a 30.6%, 32.6% and 20.2% share, respectively, in maize yields. Szalókiné and Szalóki (2002) found that water and nutrient supply had a slight yield-increasing effect independently, but yields were doubled or tripled as a result of their combined effect. Polyfactorial long-term experiments proved that fertilization had the largest yield-increasing effect in maize in years with average precipitation (Győrffy and Berzsenyi, 1994; Nagy, 1995). Zembery et al. (2011) found a significant correlation between fertilization and maize yield. According to the combined analysis of variance by Berzsenyi and Lap (2002), the year, primarily the amount of precipitation, had the greatest impact on yields. Precipitation is the most variable element of our climate, its uncertainty is shown by the fact that the amount of precipitation in the most humid years is three times higher than in the dry years (Bocz, 1996).

The agrotechnical, economic and ecological benefits of crop rotation have been proven in numerous long-term experiments worldwide (Debreczeni and Debreczeni B.né, 1994). Although maize endures partial monoculture, the yields of monoculture maize are 1.3 t ha^{-1} lower in an average year as compared to maize in crop rotation. Győrffy and Berzsenyi (1992) found that proper crop rotation is an efficient and cost-effective tool in pest management as the largest yield reduction in monoculture is caused by fungal diseases (Kurowski and Adamiak, 2007). *Fusarium sp.* Significantly reduce maize yields (Pepó et al., 2006). Increasing nitrogen doses significantly increased the severity of *Fusarium spp*. and corn smut infection (Szulc, 2011). From among the maize diseases, *Fusarium spp.* can have a significant effect on yields (Clements et al., 2003).

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Materials and methods

The study was carried out at the experimental site of the University of Debrecen Centre for Agricultural and Applied Economic Sciences at Látókép in the long-term maize experiment on chernozem soil in the seasons of 2010 and 2011 in monoculture and biculture (wheat-maize) at two fertilization levels (control, $N_{180}P_{135}K_{135}$) in two irrigation treatments (non-irrigated and irrigated to optimum water supply) applying three different plant density values (40 thousand plants ha^{-1}, 60 thousand plants ha^{-1}, 80 thousand plants ha^{-1}). The experiment was set up in a randomized block design in four repetitions. The tested hybrid was Reseda (PR37M81).
In the seasons of 2010 and 2011, the effect of crop rotation, fertilization, irrigation and plant density on the disease severity of *Fusarium spp.* and corn smut and on maize yields. The meteorological factors of the two years are presented in *Figure 1.*

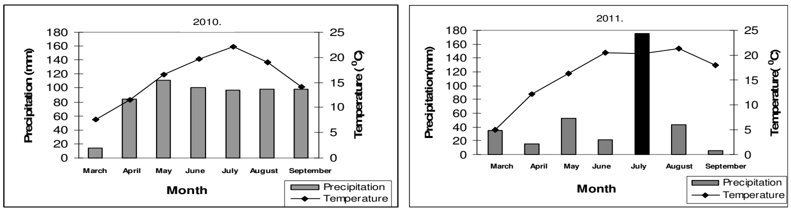

Figure 1. Meteorological parameters in the vegetation period of maize (precipitation, mean monthly temperature, Debrecen, 2010., 2011.)

Results and discussion

Table 1. Effect of plant density, fertilisation and irrigation on the corn smut infection of the maize in two different cropyears with different water supply (Debrecen, 2010., 2011.)

Crop density (B)	Fertiliser doses (A)	2010.		2011.			
		non-irrigated		non-irrigated		irrigated	
		Mono-culture	Biculture	Mono-culture	Biculture	Mono-culture	Biculture
40000 ha^{-1}	control	2.1	1.8	1.4	0.9	1.6	1.2
	N_{180}+PK	4.3	3.6	2.6	1.6	3.4	1.9
60000 ha^{-1}	control	1.9	1.6	1.3	1.1	1.8	1.4
	N_{180}+PK $_{135}$	4.8	3.1	2.9	1.8	3.0	2.4
80000 ha^{-1}	control	1.9	1.5	1.7	1.2	1.7	1.6
	N_{180}+PK N_{180}+PK $_{35}$	4.6	3.7	3.2	2.1	3.2	2.2
LSD $_{5\%}$ (A)		**2.2**	**1.8**	**1.1**	**1.3**	**1.0**	**0.7**
LSD $_{5\%}$ (B)		**0.9**	**0.5**	**0.7**	**0.6**	**0.4**	**0.5**

The severity of corn smut (0.9%-2.1%) and *Fusarium spp.* (0.8%-2.4%) infections was minimal in both crop rotations in both irrigation treatments in 2010 and 2011. The fertilization treatment N_{180}+PK significantly increased the infection by corn smut (1.6-4.8%) and *Fusarium spp.* (1.4-4.7 %), however, plant density did not have a significant effect on either of the diseases (*Tables 1* and *2*). After wheat as a forecrop, disease severity was lower in all variations than in monoculture. Infection by corn smut and *Fusarium spp*. was stronger in the wet year (2010) than in the average year (2011) under irrigated conditions. The dry warm weather of 2011 was not beneficial for the occurrence and spreading of diseases in maize stands. In 2011, the infection was higher as a result of irrigation. Depending on the crop rotation and the fertilization treatment, corn smut infection was 0.9-3.2% and *Fusarium spp*. infection was 0.8-2.9% in the non-irrigated plots. Under irrigated conditions, the level of infection was 1.2-3.4% for corn smut and 1.0-3.1% for *Fusarium spp*.

Table 2. Effect of plant density, fertilisation and irrigation on *Fusarium spp.* infection of the maize in two different cropyears with different water supply (Debrecen, 2010., 2011.)

Crop density (B)	Fertiliser doses (A)	2010.		2011.			
		non-irrigated		non-irrigated		irrigated	
		Monoculture	Biculture	Mono-culture	Biculture	Mono-culture	Biculture
40000 ha^{-1}	control	2.0	2.1	1.6	0.9	1.7	1.0
	N_{180}+PK	4.1	4.6	2.1	1.6	2.3	1.4
60000 ha^{-1}	control	1.7	2.4	1.5	0.8	1.7	1.1
	N_{180}+PK	4.3	4.7	2.4	1.7	2.4	1.9
80000 ha^{-1}	control	2.4	2.1	1.9	1.1	2.0	1.3
	N_{180}+PK	3.9	4.7	2.9	2.0	3.1	2.2
$LSD_{5\%}$ (A)		**1.9**	**1.9**	**0.9**	**1.4**	**0.6**	**0.7**
$LSD_{5\%}$ (B)		**1.2**	**0.9**	**0.6**	**0.4**	**0.4**	**0.4**

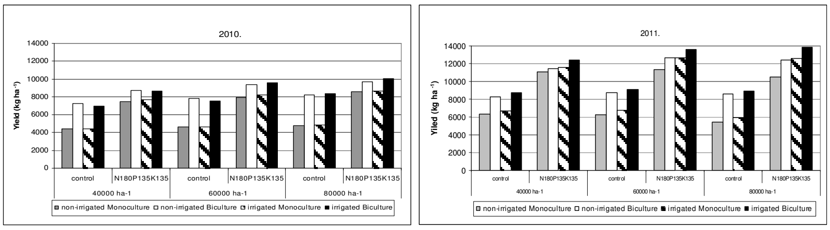

Figure 2. Effect of fertilisation, plant density and irrigation on the yield of the maize in mono- and biculture (Debrecen, 2010., 2011.)

For both mono- and biculture, higher yields were obtained in 2011 than in 2010 (*Figure 2*). The abundant precipitation in 2010 filled up the water stock of the chernozem soil to field capacity (FC) and the weather of 2011 was favourable for the vegetative and generative development and yield formation of maize except for short periods. In 2011, yields were 1011-1941 kg ha^{-1} higher in the control plots in monoculture and 836-1032 kg ha^{-1} higher after wheat than in 2010 depending upon irrigation and plant density. When the yields of the fertilized plots were compared, the differences were even higher. In 2011, the yields were 1082-2198 kg ha^{-1} higher in monoculture in the N_{180}+PK treatment and 964-2432 kg ha^{-1} higher in biculture depending upon irrigation and plant density. Fertilization had a significant yield-increasing effect. Yields increased with increasing plant density up to 80 thousand plants ha^{-1} in 2010, however, the differences were not significant in all cases. In 2011, the yields increased up to 60 thousand plants ha^{-1}, the plant density of 80 thousand plants ha^{-1} resulted in a yield reduction (except for the irrigated and fertilized plot in biculture).

Irrigation resulted in a yield increment of 512-1342 kg ha^{-1} in monoculture and of 473-1202 kg ha^{-1} in biculture depending upon fertilization and plant density, that is the

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yield-increasing effect of irrigation was only moderate in 2011 due to the favourable water supply and soil moisture content.

Conclusions

Infection by corn smut and *Fusarium spp*. was stronger in the wet year of 2010. The N_{180}+PK fertilization treatment significantly increased, while plant density did not have a significant effect on the studied disease parameters. The level of infection was always smaller after wheat as a forecrop than in monoculture and irrigation increased the level of corn smut and *Fusarium spp*. infection in maize.

In the extremely rainy year, the weather parameters were not appropriate for the vegetative and generative development of maize, therefore, lower yields were obtained. According to our results, higher yields were obtained as a result of the combined effect of the year, the crop rotation, the plant density, fertilization and irrigation. The highest yield was achieved in 2011 under irrigated conditions in the N_{180}+PK fertilization treatment with 80 thousand plants ha^{-1} after wheat as a forecrop (13872 kg ha^{-1}).

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CORRELATIONS BETWEEN YIELD AND WATER SUPPLY ON DRY AND MESIC PASTURES

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Abstract: The yield of pastures will be impaired by the climate change as a result of reduced winter and spring precipitation and the increasing number of hot days as well as the rise in temperature. Species composition is also due to change, however, this change will be more difficult to establish as the increasing concentration of glasshouse gases has different impacts on the various components. Pasture is a water demanding culture; droughts reduce yield significantly and these losses should be compensated by an adaptive agricultural technology. On protected and Nature 2000 pastures, giving 50% of Hungarian pastures – strict regulations prevent the application of yield boosting techniques, such as irrigation fertilisation or oversowing. The impacts of the weather may only be compensated to a certain extent by the utilisation technology.
We investigated the effects of 3 utilisation technologies and seasonal changes with special regard to water supply on dry and mesic pastures in the years 2006-2010. This is why we recommend modifying the specifications on pasture utilization in nature conservation areas, by having the first cutting earlier and increasing utilization frequency wherever possible. On dry pastures, yield is affected most significantly by precipitation in winter and the vegetative period; the latter showing the second strongest correlation with yield. On mesic pastures, temperature and radiation have the strongest influence. Here, the significance level in the case of total annual precipitation was lower, whereas the correlation was not significant for precipitation in the vegetative period.

Keywords: dry and fresh grass, precipitation of vegetation period, precipitation of the winter half-year, dry matter yield

Introduction

Having read several scientific papers and analyzed trends we may conclude the fact that the climate (or in shorter terms, the weather) is changing cannot be denied any more (Jolánkai and Birkás, 2010; Láng et al., 2007; Harnos, 2005).
In Hungary, the risks regarding food supply may be reduced by enhancing the adaptability of national plant production, animal production and pasture management (Láng et al., 2007). Within the sector of agriculture, pasture management has a significant share, 11% of the area of Hungary being covered by pastures. The impacts of the climate change should also be examined for pastures, considering these not only as habitats but also as a production sector. Pasture management is affected by the trends of temperature and frequency of hot days increasing as well as decreasing precipitation. The latter mainly refers to decreasing winter and spring precipitation. Precipitation extremities – extremely heavy rains, hailstorms – damage pastures less than arable cultures. Pastures do not suffer significant damage from floods, excess inland water, windstorms or early and late frosts either, they even benefit from short floods. The climatic factor having the most significant adverse impact of pastures is *drought*, caused by the combined effects of heat, strong radiation (global radiation) and the lack of precipitation. (Láng et al., 2007).
Pasture is a water demanding culture, having a shallow root system, a large evaporating surface and being forced to regenerate continuously (Tasi, 2011; Fekete and Molnár, 2005; Barcsák, 2004; Vinczeffy, 1993). Pastures need 500-800 liters of water to produce 1 kg of dry matter. The evaporation coefficient may be reduced by a demand-driven supply of nitrogen (Barcsák, 2004; Tasi, 2011).

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In the case of protected pastures, fertilization and irrigation are not allowed, thus a pasture management technology should be developed that allows the vegetation under the given ecological conditions to utilize water stored in the winter and from precipitation in the vegetative period in the most efficient way. Modifying pasture management technologies is extremely important as half of the Hungarian pastures are located in nature conservation areas or in NATURA 2000 sites. According to the newest data of the Hungarian Central Statistical Office (KSH), the ratio of protected areas exceeds 50% in the case of utilized pastures. (KSH, 2010).

Materials and methods

In this paper, results of a 2006 experiment set up at 2 sites with different pasture types are given. The effect of 3 pasture utilization systems (*Table 1.*), simulated by cutting, on dry matter yield, nutrient and mineral contents of the feed coming from the pastures and the vegetation itself was analyzed. Drought sensitivity and the effect of the season were also considered. Our project was supported by the National Development Agency. (Contract No. Tech 08-A4/2-2008-0140). Our partner, the Hungarian Meteorological Service supplied important data from its measuring stations positioned in the vicinity of the two sites. Daily data of precipitation, mean temperature, global radiation, relative humidity and wind were processed. Dry matter contents were established by cutting plots as a whole, weighing the yield and drying it until a stable weight. Plot size was 16 m^2; treatments were repeated 3 times in space. The software SPSS was used for statistical analysis. To calculate significant differences and present results, the method of Sváb (1984) was also applied, combined with ones given by Pajor, 2011 in the case of the presentation of data.

Table 1. Sampling dates in the 3 pasture utilization systems at the 2 sites from 2006 to 2010

Utilization system	Cut	Dry pasture	Mesic pasture
Utilization in protected areas, delayed first cut (2x/year)	1.	16 June	17 June
	2.	6 October	7 October
Regular meadow utilization (3x/year)	1.	12 May	13 May
	2.	14 July	15 July
	3.	6 October	7 October
Regular strip grazing (4x/year)	1.	5 May	6 May
	2.	9 June	10 June
	3.	28 July	29 July
	4.	6 October	7 October

Note: a long regeneration period was allowed before the last cut, as the vegetation was killed by the heat in August.

Pasture 1 (Bösztör) is a dry goat pasture with a saline undersoil dominated by small Festuca species. It is located in a nature conservation area. Pasture 2 (Mende) is a sown pasture utilized as a meadow. It is located in the region Gödöllői-dombság. It was established at the end of the 1990s and it is dominated by *Festuca arundinacea*. The

Mende pasture is located in a valley and characterized by mesic conditions. It is not protected but it is part of an ecologically managed site.

Results and discussion

The dependence of the drought sensitivity of the pastures on the 3 utilization systems was analyzed (*Table 2.*). In the case of the utilization system for protected areas (2x/year), the highest yield loss caused by lack of precipitation and the lowest increase in yield when receiving extra precipitation were recorded for both pasture types. This utilization system has the highest sensitivity for droughts; we recommend limiting its application to the smallest area possible. Wherever possible, nature conservation specifications related to the scheduling of the first cut and other aspects of pasture management should be modified.

Table 2. Yield (t/ha) and % of yield compared to the year of average precipitation (2006-2009)

Dry pasture			Mesic pasture	
Utilization system	Annual dry matter yield (t/ha)	%	Annual dry matter yield (t/ha)	%
2006 (average precipitation)				
2x /year	3.12	100.0	8.28	100.0
3x /year	2.51	100.0	7.86	100.0
4x /year	2.48	100.0	6.93	100.0
2007 (drought)				
2x /year	1.09	35.0	5.73	69.2
3x /year	1.04	41.3	6.55	83.4
4x /year	1.15	46.3	5.80	83.7
2008 (wet)				
2x /year	2.37	76.0	10.52	127.1
3x /year	2.92	116.3	11.32	144.0
4x /year	3.18	128.2	12.77	184.3
2009 (dry)				
2x /year	1.16	37.2	10.27	124.0
3x /year	1.4	55.8	11.01	140.1
4x /year	1.56	62.9	9.45	136.4

In extensive production systems where dry matter yield is not influenced by agricultural technologies, yields will mainly depend on the weather. In our experiments, only utilization technologies were applied that differed in the frequency of utilization and the length of the regeneration periods. Measurable effects of the weather were analyzed by liner regression. Correlation coefficients representing the strength of the relationship are given in *Table 2*. Levels of significance are marked by asterisks.

Precipitation in the winter season as well as in the vegetative period had a significant effect on yields in the case of the dry pasture. According to data from 4 years, precipitation stored during the winter and falling in the vegetative period, when combined, has a stronger correlation with dry matter yields than precipitation in the vegetative period alone. Radiation and wind both had a positive correlation with dry mater yields.

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Table 3. Utilization and weather factors having an effect of nutrient contents, together with correlation coefficients, at the dry pasture

n=36		Precipitation		With winter precipitation		Humidity		Temperature		Global radiation		Wind	
Dry matter yield	dry pasture	.563	**	.808	**	.109		.148		.396	*	.374	*
	mesic pasture	.293		.353	*	-.093		.540	**	.610	**	-.052	

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

From weather factors, temperature and global radiation had the strongest effect on yields in the case of the mesic pasture. Cumulated precipitation correlated with dry matter yields at the 95% level, while the correlation coefficient for precipitation in the vegetative period was only 0.29; the relationship in this case was not significant.

Conclusions

While the highest dry matter yields were given by a utilization frequency of 2x/year on the examined pastures in the 5-year experiment period, the difference of absolute values between utilization systems was not significant. However, the utilization frequency of 2x/year showed the highest yield loss caused by lack of precipitation and the lowest increase in yield when receiving extra precipitation, even on the mesic pasture. Thy we recommend modifying the specifications on pasture utilization in nature conservation areas, by having the first cutting earlier and increasing utilization frequency wherever possible.

The effect of weather factors also depend on the water supply of pastures. On dry pastures, yield is affected most significantly by precipitation in winter and the vegetative period whereas on mesic pastures, temperature and radiation have the strongest influence.

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STUDY OF CROPYEAR EFFECT ON THE YIELD AND PATHOLOGICAL INFECTIONS OF DIFFERENT WINTER WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES

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Abstract: Different winter wheat genotypes (Lupus, Antonius, Pannonikus, Genius) were tested in an extremely wet (2010) and in an average year (2011). According to our results, the year had a significant effect on the yields of the varieties and on the severity of fungal diseases. Due to their different fertilizer response and resistance, the varieties gave different results though of similar tendency both regarding the yields and the level of infection. In the extremely rainy year, the maximum yields were obtained at lower fertilizer doses (N_{30-60}+PK), while in the average year, the higher fertilizer doses resulted in the maximum yield. The severity of fungal diseases in winter wheat varieties were strongly influenced by the year and the fertilizer doses. The level of infection was minimal in the control and in the fertilizer treatments of lower doses for all the four studied diseases, while maximum infection values were recorded in the $N_{120-150}$+PK treatment in both years. The rainy year was favourable for the spread of ear- and leaf diseases, the level of infection was two-three times higher than that of the average year.

Keywords: winter wheat, cropyear, fertilization, fungal diseases, yield

Introduction

According to Harnos and Erdélyi (2011), the yields are greatly determined by the temperature and the precipitation. The average temperature of the April-June period and the amount of precipitation from March until June have a great effect on the yield of winter wheat. L-Baeckstrom et al. (2006) claim that the yield of wheat is determined by the year (precipitation and temperature), the agrotechnique and the nitrogen doses, while fungal disease severity is influenced mainly by the weather, the phenophase and the nitrogen doses. The severity and spread of fungal diseases in winter wheat were greatly influenced by the temperature and precipitation of the season (Weber and Kita, 2010; Nierobca and Horoszkiewicz-Janka, 2006). Wiik és Ewaldz (2009) concluded that a mild winter and spring and a rainy summer season promote the spread of fungal diseases in winter wheat. Pepó (2004) found that the severity of ear- and leaf diseases is determined by the nature of the year. If the amount of precipitation varied between 200-250 mm in the spring and early summer months (April, May, June), the diseases occurred at a significant level.

Materials and methods

The field experiment was set up at the experimental site of the Institute of Crop Science, University of Debrecen Centre for Agricultural and Applied Economic Sciences at Látókép. The soil of the experiment was calcareous chernozem. The study contains the data of the seasons of 2010 and 2011. The small-plot field experiment was set up in four repetitions in a strip-plot design. In the experiment, the fertilizer response of 4 winter wheat varieties was tested. In the treatments, six fertilization levels were applied. In addition to the control, the base dose of N=30 kg ha^{-1}, P_2O_5=22.5 kg ha^{-1} and K_2O=26.5 kg ha^{-1} and its double, triple, quadruple and quintuple doses were applied. The 100%

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doses of P and K were applied in the autumn, while N doses were divided as 50% in the autumn and 50% in the spring. The forecrop of the experiment was sweet corn.

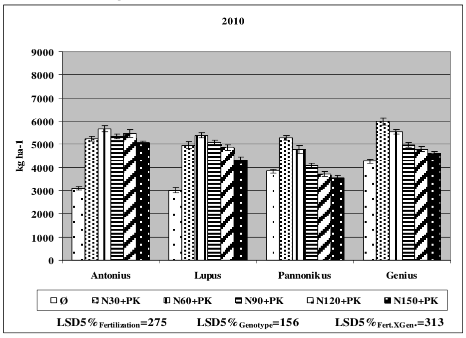
Table 1. Main meteorological data of vegetation period (Debrecen, 2010-2011)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total/ Average
Precipitation (mm) 2010	79.3	78.3	54.9	48.8	58.6	14.4	83.9	111.4	100.9	630.5
30 year's average	30.8	45.2	43.5	37	30.2	33.5	42.4	58.8	79.5	400.9
Difference	*48.5*	*33.1*	*11.4*	*11.8*	*28.4*	*-19.1*	*41.5*	*52.6*	*21.4*	*229.6*
Precipitation (mm) 2011	22.8	52.9	104.2	19.2	16.8	35.1	15.6	52.3	22	340.9
30 year's average	30.8	45.2	43.5	37	30.2	33.5	42.4	58.8	79.5	400.9
Difference	*-8*	*7.7*	*60.7*	*-17.8*	*-13.4*	*1.6*	*-26.8*	*-6.5*	*-57.5*	*-60*
Temperature (°C) 2010	11.4	7.6	2.3	-1.1	0.5	7.6	11.6	16.6	19.7	8.47
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5	10.7	15.8	18.8	6.94
Difference	*1.1*	*3.1*	*2.5*	*1.5*	*0.3*	*2.6*	*0.9*	*0.8*	*0.9*	*1.53*
Temperature (°C) 2011	6.9	7.7	-1.7	-1.2	-2.5	5	12.2	16.4	20.5	7.03
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5	10.7	15.8	18.8	6.94
Difference	*-3.4*	*3.2*	*-1.5*	*1.4*	*-2.7*	*0*	*1.5*	*0.6*	*1.7*	*0.09*

The season of 2010 was extremely rainy. while 2011 was an average season (*Table 1*). We used SPSS 17.0 statistical software for data processing. and the $LSD_{5\%}$ values were calculated by the Sváb (1981) method.

Results and discussion

In the experiment the modifying effects of the year and fertilization on the yields and the severity of fungal diseases in winter wheat (leaf rust. powdery mildew. HTR [helminthosporiosis] and head blight) were studied. When studying the yields. it can be concluded that the fertilizer doses applied in the extremely rainy year were better utilized. therefore. the maximum yields were obtained at smaller fertilizer doses (N_{30-60}+PK) (*Figure 1*).



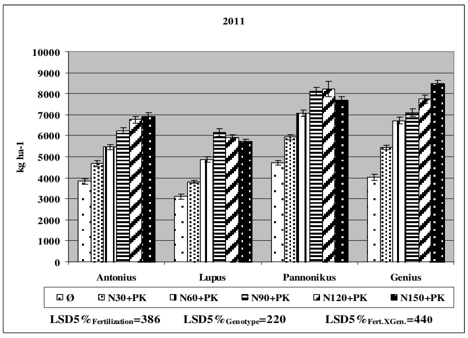


Figure 1. Yields of the tested winter wheat varieties in the different years. (Debrecen. 2010-2011)

The highest yields (5986 kg ha^{-1}) were measured in the variety Genius at the fertilizer dose N_{30}+PK and by the variety Antonius (5675 kg ha^{-1}) at the dose of N_{60}+PK. The yields of Lupus (5386 kg ha^{-1}) and Pannonikus (5271 kg ha^{-1}) were lower than that of the other two varieties. Due to the weaker nutrient release in the average year because of the lower amount of precipitation. higher fertilizer doses were necessary for the winter wheat varieties to achieve the maximum yield. The highest yield was measured in the variety Genius (8462 kg ha^{-1}) also in 2011. while the variety Pannonikus also gave a high yield (8224 kg ha^{-1}) at the $N_{120-150}$+PK fertilization level. The lowest maximum yield was obtained in the case of Lupus (6150 kg ha^{-1}) in the N_{90}+PK fertilizer treatment. When studying the phytopathological characteristics. it can be concluded that the fungal infection increased with increasing fertilizer doses in both years. the highest infection was observed at the $N_{120-150}$+PK fertilizer doses. while in the control treatments. The infection was minimal.

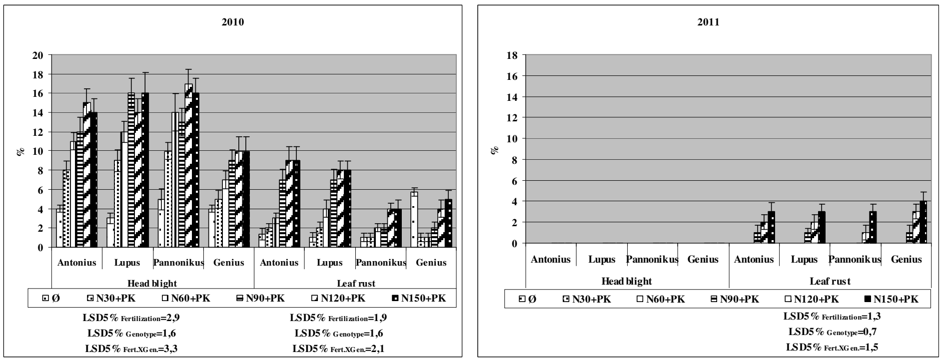


Figure 2. Levels of head blight and leaf rust infection in two different years. (Debrecen. 2010-2011)

In the rainy year of 2010. the head blight infection was high (14-16%) in the case of the varieties Antonius. Lupus and Pannonikus. while the infection was lower in the case of Genius (9-10%). Leaf rust infection was twice as high in the varieties Antonius and Lupus (7-9%) than in the varieties Pannonikus and Genius (2-5%). In the average year of 2011 (*Figure 2*). no head blight infection was observed.

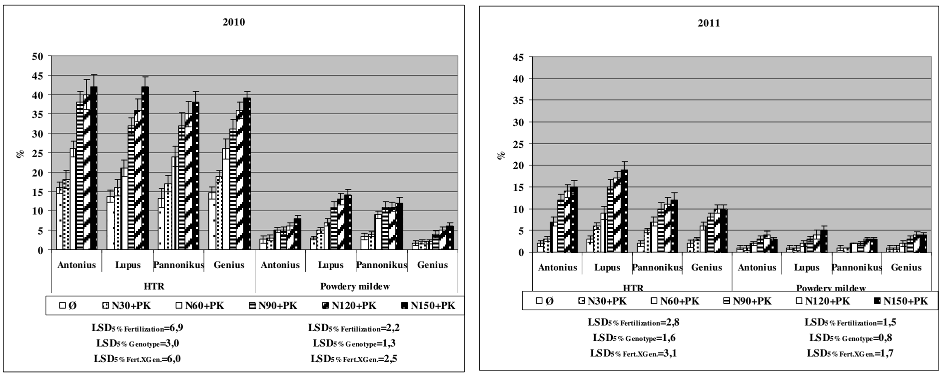


Figure 3. Levels of HTR and powdery mildew infection in two different years. (Debrecen. 2010-2011)

The level of infection by leaf rust (2-4%) was also minimal. it occurred in all four varieties only at higher fertilizer doses of N_{90-150}+PK.
The extremely rainy year of 2010 was favourable for the spread of HTR infection; it was high in all four winter wheat varieties (35-42%) (*Figure 3*). In the average year of

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2011. the level of HTR infection was half of that in the previous year. The infection was higher in the varieties Antonius (14-15%) and Lupus (17-19%). while it was lower in the case of Pannonikus (11-12%) and Genius (10-10%). As a result of the rainy year. the level of powdery mildew infection was also higher. especially in the varieties Lupus (13-14%) and Pannonikus (11-12%). while the infection was much lower in the case of Antonius (6-8%) and Genius (5-6%). In the average year. the powdery mildew infection was moderate (3-4%) in all the tested varieties.

Conclusions

Based on our results. it can be stated that the year significantly influenced the yields of the varieties and the level of fungal infection. Due to their different fertilizer responses and resistance. the varieties gave different results though of similar trend both regarding the yield and the level of infection. In the extremely wet year. the yields were significantly lower and the maximum yields (5271-5986 kg ha^{-1}) were obtained at the fertilizer doses of N_{30-60}+PK. It was a result of the better nutrient release due to the higher amount of precipitation and of the yield reduction caused by the stronger infection at higher fertilization levels and by lodging. In the average year. higher yields (6150-8462 kg ha^{-1}) were achieved at the doses of $N_{120-150}$+PK due to the lower nutrient release and the lower level of ear- and leaf diseases. The level of fungal diseases in winter wheat varieties was strongly influenced by the year and the fertilizer doses. The level of infection was minimal in the control and at smaller fertilizer doses for all four diseases. while the maximum infection was observed at the doses of $N_{120-150}$+PK in both years. The rainy year was favourable for the spread of ear- and leaf diseases. the level of infection was two to three times higher than that in the average year. The variety Lupus gave lower yields and showed higher infection than the other three tested winter wheat varieties in both years. On the contrary. the highest yields and lowest infection values were measured for the variety Genius in both years.

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RESPONSE OF SOYBEAN TO PHOSPHORUS FERTILIZATION UNDER DROUGHT STRESS CONDITIONS

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Abstract: The field experiment was conducted on clay soil with five phosphorus (P) fertilization rates (a = 75, b = 225; c = 375; d = 525; e = 975 kg P_2O_5 ha^{-1}) on March 12, 2011 in Prud (Posavian Canton, Federation B&H, Bosnia and Herzegovina). The choice of experimental plots was based on previous soil test. The source of P was monoammonium phosphate or MAP (13% N + 53 % P_2O_5). The experiment was conducted in four replicates (basic plot 60 m^2). The type of experimental soil was calcareous alluvial, low in plant available P and rich in K. Soybean (cultivar *Lucija*, originating from Agricultural Institute Osijek, Croatia) was sown on April 30, 2011 and harvested on September 14, 2011. The 2011 growing season was less favorable for soybean because of water shortage and higher air-temperatures. For example, precipitation quantity in August (Gradiste: about 20 km distance from the experiment) was only 4 mm (mean 1971-1990: 66 mm) accompanied by mean air-temperature 23.4 °C (mean 1971-1990: 20.7 °C). Moreover, in the second 10-day period of July mean air-temperature was 25.5 °C and without precipitation. Under these conditions achieved soybean yields were low (mean 2111 kg ha^{-1}). However, P fertilization alleviated this type of abiotic stress. Increase P fertilization from 75 to 375 kg P_2O_5 ha^{-1}, soybean yield was increased up to 20%, whereas further increase of P rates resulted with lower yield to the control level.

Keywords: soybean yield, oil, protein, phosphorus fertilization, drought stress

Introduction

Drought is main abiotic constraint responsible for heavy production losses because soil drying have a serious influence on plant growth, development and crop yield. The climatic–change models predict that in many regions of Europe drought losses and yield variability of field crops will increase (Pogson et al., 2011). Soil drought inhibits plant nutrient uptake and decrease mineralization of soil organic matter (Buljovicic and Engels, 2001). On the other hand, nodulation and nitrogen fixation in soybean are sensitive to water deficit, which can have negative effects on soybean yield. Serraj and Sinclair (1998) reported that it is important to develop drought–tolerant cultivars to improve yield stability and N_2 fixation (inoculated with *Bradyrhizobium japonicum*).

Phosphorus is a major plant essential nutrient which cannot be replaced by another element to sustain plant life and phosphorus fertilization is important component for high yield achievement (Lott et al., 2011.).

The aim of this study was to observe influence of phosphorus fertilitation on soybean yield and grain quality in drought stress conditions.

Materials and methods

The field experiment and soil characteristics

The field experiment was started on March 12, 2011 in Prud (Posavian Canton, Bosnia and Herzegovina) on clay soil with five phosphorus (P) fertilization rates (a = 75, b = 225; c = 375; d = 525; e = 975 kg P_2O_5 ha^{-1}). The selection of the experimental plot was

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based on previous soil test (sampling 0-30 cm in February 22, 2011): pH_{H2O} = 8.03, pH_{KCl} = 7.06; Humus = 4.17; $CaCO_3$ = 3.79%; available P and K determined by the AL-method = 5.4 mg P_2O_5 and 25.65 mg K_2O/100 g. The source of P was monoammonium phosphate or MAP (13% N + 53 % P_2O_5). Nitrogen added by MAP was equalized to level of 110 kg N ha^{-1} for the a–c tretaments by using CAN (calcium ammonium nitrate: 27% N). The experiment was conducted in four replicates (basic plot 60 m^2). The highest P rate of 220 kg N ha^{-1} was added with MAP. The experimental soil was calcareous alluvial soil type, low in plant available P and rich in K. Furthermore, it is dark coloured and in drought period incline to form cracks. Soybean (cultivar *Lucija*, originating from Agricultural Institute Osijek, Croatia) was sown on 30 April 2011 and harvested on 14 Sept. 2011. From each basic plot area of 3.0 m^2 was manually harvested. Soybean plants were enumerated, pods were separated and harvested by special combine. Soybean yield was calculated on 13% basis grain moisture.

Chemical and statistical analysis

Oil content in the grain was determined by nuclear magnetic resonance (NMR) spectroscopy method. Protein and starch content in grain was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer"). The data were statistically analyzed by ANOVA and treatment means were compared using t-test and LSD at 0.05 and 0.01 probability levels.

Collection of the weather data

The State Hydrometeorological Institute in Zagreb was the source for weather data (precipitation and mean air-temperatures): Gradiste (close to Zupanja; Croatia Weather Bureau), distancing about 20 km in NE direction from the experiment.

Results and discussion

The growing season 2011 was less favorable for soybean because of water shortage and higher air–temperatures, especially in August. For example, precipitation quantity in August (Gradiste: about 20 km distance from the experiment) was only 4 mm (mean 1971–1990: 66 mm) accompanied by mean air–temperature 23.4 ^{o}C (mean 1971–1990: 20.7 ^{o}C). Also, in the second 10–day period of July mean air–temperature was 25.5 ^{o}C and without precipitation.

Under these environmental conditions acieved soybean yield was low (mean 2111 kg ha^{-1}). Worldwide measurements prove that atmosphere warming up with precipitation decreasing tendency, but producers mainly meet its harmful consequences (Köles et al., 2011). Based on a 3–year study of 132 genotypes from Agricultural Institute in Osijek (Croatia), Vratarić et al. (2005) determined that average soybean yield was about 3 t ha^{-1}, grain protein content about 38% and oil about 22%.

Table 1. Weather characteristics for Gradiste Weather Bureau (close to Zupanja, Croatia) in 2011 growing season (Meteorological and Hydrological Service, 2011).

The period	Gradiste (close to Zupanja, Croatia) Weather Bureau The growing season 2011 and (LTM = long-term mean 1971-1990)									
	May	June	July			August			Sept.	
			1-10	11-20	21-31	1-10	11-20	21-31		
	Precipitation (mm)									Total
2011	48	37	38	0	46	4	0	0	16	189
LTM	66	81	72			66			56	341
	Mean air–temperature (°C)									Mean
2011	20.3	21.1	22.9	25.5	19.2	22.2	22.9	25.1	20.7	21.6
LTM	16.7	19.6	21.2			20.7			16.6	19.0

The growing season 2011 was less favorable for soybean because of water shortage and the higher air–temperatures, especially in August. For example, precipitation quantity in August (Gradiste: about 20 km distance from the experiment) was only 4 mm (long–term mean or LTM: 1971–1990 = 66 mm) and it was accompanied with mean air–temperature 23.4 °C (mean 1971–1990: 20.7 °C). In the second 10–day period of July mean air–temperature was 25.5 °C and without precipitation. Also, in the 5–month period May–September, precipitation quantities were 189 mm or 45% lower and air–temperatures were 2.6 °C higher compared to LTM.

However, under these conditions P fertilization had considerable effects on increase soybean yield. With P fertilization (375 kg P_2O_5 ha^{-1}) soybean yield was increased up to 20% and further increase of P rates resulted with lower yield to the control level (*Table 2*).

Table 2. Effect of phosphorus fertilization on soybean yield and grain quality

Response of soybean (cultivar *Lucija*) to phosphorus fertilization – location Prud (PDR = plant density realization; TGW = 1000 grains weight)						
Fertilization (12. 03. 2011.)		Yield	PDR	TGW	Percent in grain	
	kg P_2O_5 ha^{-1}*	kg ha^{-1}**	plants ha^{-1}	(g)	Proteins	Oil
a/ Control	75	2111	373330	155.8	37.56	23.18
b/ P-1	225	2445	363330	154.5	38.58	22.68
c/ P-2	375	2527	366663	153.9	37.80	23.00
d/ P-3	525	2356	356666	153.0	37.05	23.65
e/ P-4	975	2367	360000	156.9	40.12	21.99
LSD 5%		240	–	ns	1.23	0.79
LSD 1%		ns			1.72	1.11
Average		2361	363997	154.8	38.22	22.90

* source of P: MAP (13% N + 53% P_2O_5) – N equalized to 110 kg N ha^{-1} for the a–c treatments by CAN (calcium–ammonium nitrate 27% N);

** grain yield calculation on 13% moisture and PDR 364000 plants ha^{-1}

Kovacevic et al. (2007) reported that soybean yield of 3,60 t ha^{-1} increased by 21% with P ameliorative fertilization (1500 kg ha^{-1}) on acid soil (pH_{KCL}=3.7) and that P and K fertilization did not have influence on protein and oil content in grain.

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In our study (neutral soil pH_{KCL}=7.06) increase in P dose had no significant effect on 1000 grains weight, whereas 975 kg of P significantly increased protein content (from 37.56% to 40.12%) and reduced oil content in grain (from 23.18% to 21.99%) compared to the control and other fertilization variants (*Table 2*).

Conclusions

Based on one year research, on neutral pH soil, poor in available P and in unfavorable weather conditions (high air-temperatures and lack of precipitation) increase P fertilization from 75 to 375 kg P_2O_5 ha^{-1} increased soybean yield for 20% compared to control level. Further P fertilization increase up to 975 kg P_2O_5 ha^{-1} did not increase grain yield, but it have influence to grain quality, increase protein content and reduced oil content. In the next years we expecting residual effects of ameliorative fertilization on the field crops in crop rotation.

Acknowledgements

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THE EFFECT OF NATURAL WATER SUPPLY AND IRRIGATION ON THE MOISTURE CONTENT OF THE SOIL AND MAIZE YIELD

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Abstract: Nitrogen (N) fertilisation is a critical point in maize production and the reduction of environmental load; therefore, it is especially important to determine the optimal fertiliser doses and treatment combinations under irrigated conditions.
Six different N doses (0-150 kg ha^{-1}) were applied in a 2-year-long field trial in Hungary (47° 33' N, 21° 26' E, 111 m above sea level) in non-irrigated and irrigated treatments with the aim to examine the effect of irrigation and N fertilisation on the moisture content of the soil and the grain yield of maize.
In the drought year of 2007, increasing moisture profiles were detected from the surface (8.5–9.5 v/v%) to the deeper layers (15–20 v/v%) in both irrigation treatments. There was a totally contrasting moisture profile in the extremely rainy year of 2008. In 2008, yield was significantly reduced by the excessive water supply, while the lack of moisture caused stress in 2007. The obtained results show that natural water supply greatly differentiates maize yield; therefore, it is important to consider the water balance of the preceding period, the initial accessible water stock of the soil, the depth of the groundwater and the dynamics of the water need of maize besides the actual amount of rainfall, when calculating natural water supply.

Keywords: irrigation, fertilisation, soil water content, grain yield

Introduction

Intensive plant nutrition is necessary in order to increase maize yield. On most soils, nitrogen is the most significant yield increasing fertiliser of the three macroelements (NPK) (Shaahan et al., 1999; Fabrizzi et al., 2005), while is also plays a key role in several physiological processes of the plant.
Favourable water supply is indispensable to perform successful nutrient replenishment and achieve high yields. Irrigation is an important element in the case of insufficient natural water supply, as it is the most efficient intervention into the vital process of the plant if there is drought (Bharati et al., 2007). In addition to its yield-increasing effect, irrigation also reduces yearly yield fluctuation and the risk of crop production (Pandey et al., 2000; Zwart and Bastiaanssen, 2004). As a result of irrigation, the accessible water stock of the soil will increase and it will have a beneficial effect on dissolution processes and it will improve the biological activity of the soil.

Material and methods

Production site description
We performed our examinations at the Látókép Experiment Site of the University of Debrecen (47° 33' N, 21° 26' E, 111 m above sea level), on loess-based lowland mid-heavy pseudomyceliar chernozem (pH_{KCl}: 6.6, Arany plasticity number: 39) in a multifactoral small plot field experiment with four replications and a strip-plot design under natural water supply and irrigated conditions in the growing seasons of 2007 and 2008.
The temperature and precipitation of the two examined crop years were entirely different. In comparison with the average of several years, 2007 was drier and an

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especially drought year, while in 2008 the weather was optimal from the aspect of maize production.
Six fertiliser treatments (0, 30, 60, 90, 120, 150 kg N ha^{-1}) were applied in the field trial in both years. The short season Mv 277 SC maize hybrid (FAO 310) was used in the experiment. In 2007, the amount of irrigation water applied in the growing season was 110 mm in 4 cases (25 mm on 27th April, 30-30 mm on 16th May and 10th June and 25 mm on 26th June). In 2008, 25 mm was applied on one occasion (11th May). Irrigation was done by using a Valmont linear irrigation system. The moisture content of the harvested grain yield was 14 m/m%.
The changes in the moisture cycle of the soil were tracked with soil moisture probes that function on the basis Time Domain Reflectometry (CS 615 Water Content Reflectometer, Campbell Scientific, Inc.). The moisture probes were placed in the 0–15, 15–30, 30–45, 45–60, 60–90, 90–120 cm layers in parallel with the soil surface. The probes were connected to a Campbell Scientific CR10X data logger. The change of the moisture content (v/v%) was measured daily in the 0-120 cm soil profile from sowing to harvesting.
A general linear model (GLM) was used to describe the effect of treatments on the soil moisture content and maize yield. In order to compare the mean values of the treatment, the 5% significant difference ($LSD_{5\%}$) was determined. During the multiple comparison, the confidence intervals were corrected with the Duncan's method in order to avoid the accumulation of alpha error. There was no difference between the quality parameters within the homogeneous group and yield at the 5% level of significance. Evaluation was done with SPSS for Windows 13.0.

Results

Soil moisture content

In 2007 under non-irrigated conditions, there was severe water shortage in the soil layer surrounding the seedling as a result of the dry spring period. The moisture content of the upper 0.15 m of the soil reduced to 17–18 v/v% at the time of sowing and that of the 0.07 m layer decreased to 8.5–9.5 v/v%. On the contrary, the deeper soil layers of the 1.2 m soil profile had lower water supply until the 40th day from sowing (*Figure 1*). After flowering, the soil moisture content reached the value of slack water and became permanent at this level for one month. Water shortage struck the crop stand at the period of intensive grain filling, causing significant yield decrease. There was severe/moderately severe water shortage in nearly 50% of the growing season. In 2008, the 1.2 m soil profile had optimal water supply for the crop population in around 75% of the growing season. From the 6/7-leaf growth stage of maize, the upper 0.5 m layer of the soil were saturated with moisture to above 300 mm to a greater extent than the field water capacity (*Figure 1*). The favourable moisture conditions characteristics of the vegetative phase were maintained also after maize flowering. The soil moisture stock continuously decreased as a result of intensive grain filling in the remaining part of the growing season. However, this phenomenon did not affect yield directly.

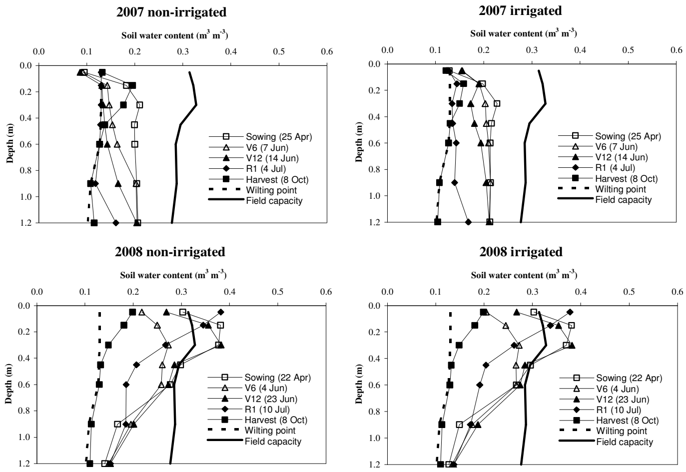

Figure 1. Soil water profiles under rainfed and irrigated conditions over the 2007 and 2008 crop seasons

In 2007, the initial moisture content of the irrigated soil profile was 15-20 mm higher than the natural water supply and the difference was significant ($p<0.05$). The applied irrigation water further increased the moisture surplus (20-50 mm) significantly ($p<0.05$) until the 47th day after sowing. After flowering, there was water shortage in the irrigated treatment, too. From the 117th day after sowing until the end of the growing season, 7-13 mm lower moisture content was measured in the upper 0.5 m of the irrigated soil profile (*Figure 1*) and the difference was significant ($p<0.05$). In 2008, there was significantly lower ($p<0.05$) moisture content (12.5 mm) in the irrigated soil profile until the 19th day from sowing. As a result of the applied 25 mm irrigation water, the difference between the two treatments disappeared, no significant difference was shown. In the remaining part of the growing season, 8.5-9.7 mm lower significant difference ($p<0.05$) was measured the moisture content in the irrigated treatment.

When evaluating the moisture profiles of the 1.2 m soil layer, contrasting tendencies were observed in the two growing seasons in both irrigation treatments (*Figure 1*). In the dry growing season of 2007, the lowest moisture contents were measured in the 0-0.15 m layer of the soil (8.5–9.5 v/v%) in both treatments. Moisture increased to the deeper layers. The significant ($p<0.05$) difference in moisture (10-12 v/v%) measured at the 11/12-leaf stage of maize continuously decreased as the moisture stock of the soil reduced until the end of the growing season. In 2008, the moisture content of the soil profile was the highest in the 0.12-0.30 m layer (36-38 v/v%) and it continuously decreased towards the deeper layers (12–15 v/v%). The typical "bulge" of the moisture curve of the 0.15-0.30 m soil layer is the consequence of the soil compaction and volume mass increase caused by autumn basic cultivation and spring seedbed preparation.

Grain yield

Under natural precipitation supply conditions, yield linearly increased until applying 60

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kg ha^{-1} N in both years (5.3 t ha^{-1} in 2007, 11.2 t ha^{-1} in 2008). Applying further fertiliser doses did not result in higher yield. The obtained results show that increasing N doses do not always result in yield increase if the water needed for nutrient uptake is available only to a limited extent. In 2007, as a result of irrigation, the statistically highest yield was observed in the 120 kg ha^{-1} N treatment. The yield increasing effect of irrigation was significant (3.8 t ha^{-1}) ($P<0.001$). However, irrigation caused significant yield decrease (-1.9 t ha^{-1}) in the average of fertiliser treatments with a 0.1% confidence. The amount of yield decrease as a result of irrigation was the highest (2.6–2.7 t ha^{-1}) on the plot which had natural nutrient supply and in the case of the lowest N dose (30 kg ha^{-1}) and this amount continuously decreased with the increase of nutrient dose.

Discussion

The environment of the seedling suffered from severe water shortage under non-irrigated, dry, rainless conditions, but there was favourable water supply in the deeper layers of the soil. Starting from the flowering and especially during the grain filling period, there was water shortage in the whole soil profile which significantly reduced yield. In the wet crop year, optimal water supply was detected in the examined profile. Under irrigated conditions in the drought year, the effect of irrigation water could only be shown until the beginning of the grain filling period, but the yield surplus achieved as a result of irrigation seems to contradict this phenomenon. The explanation is provided by the moisture content measured after the 3rd third of the grain filling period in the uppermost layers of the soil, as it was lower than that of the non-irrigated treatment and it shows the increased water uptake of the maize population. Similarly to the end of the preceding year, the irrigated soil profile had lower moisture content from sowing to harvesting in the wet year. Both too much water (much rainfall, over-irrigation) and water shortage (lack of rainfall and irrigation) caused stress to the maize plant and they significantly reduced yield.

Acknowledgement

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WATER CONTENT AND BIOMASS PRODUCTION OF WEEDS IN MAIZE

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Abstract: Maize is the third most important cultivated crop in the world, following wheat and rice. The effects of the competition among different weed and cultivated plant species need to be known for the secure and sustainable crop production. Plants are facing the strongest competition for water from each other. The cold-tolerant maize hybrids have appeared on markets in recent years, and taking them into cultivation. These hybrids can be sown a month earlier - in late March or early April - than the conventional ones. Although, with special regard to weeds some unanswered questions remained in their growing.
In this experiment competitive abilities of a cold-tolerant (MT Milo) and a conventional (Kamelias) corn hybrid were tested against weeds in field conditions. The experimental year (2010) was extremely wet both in terms of the quantity and the distribution of precipitation.
Studies were conducted on the biomass production and the water content of maize hybrids and weeds.
Experimental results proved that maize hybrids and weeds were in strong competition. The difference in water content was higher than that which was found in dry biomass between the hybrids grown in weedy and weed-free conditions. The grain yield of MT Milo decreased by 79.4%, and in the case of Kamelias it was less by 51.2% due to the weed competition.

Keywords: maize hybrids, cold tolerant, green water, competition, weeds

Introduction

The effects of the competition among different weed and cultivated plant species need to be known for the secure and sustainable crop production. Significant weed competition was reported in corn by Lehoczky et al. (2009, 2010) and it has been proved that weeds were able to uptake large quantities of nutrients caused considerable yield losses. From the viewpoint of weediness, many factors of agricultural technics – such as cultivation, fertilization etc. – have great importance (Lehoczky and Kismányoky, 2008; 2010; Lehoczky et al. 2011, Márton et al., 2011).
Maize is the third most important cultivated crop in the world, following wheat and rice. The competition for water between crops and weeds is very important. In Hungary the amount and particularly the distribution of precipitation caused difficulties for corn growers in last years, mainly due to the lack of rainfalls after the sowing period.
The cold-tolerant maize hybrids have appeared on markets in recent years, and taking them into cultivation could bring solution to the above mentioned problem too. These hybrids can be sown a month earlier - in late March or early April - than the conventional ones. Although, with special regard to weeds some unanswered questions remained in their growing.
In this experiment competitive abilities of a cold-tolerant (MT Milo) and a conventional (Kamelias) corn hybrid were tested against weeds in field conditions. The experimental year (2010) was extremely wet both in terms of the quantity and the distribution of precipitation.
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Materials and methods

The field experiment was carried out under cropping conditions on Eutric cambisol soil near Keszthely in Zala County. The annual precipitation and daily mean temperature data in 2010 are shown in *Table 1* and *Table 2* contains the experimental setting data.

Table 1. Preicipitation data, Keszthely 2010

Month	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Precipitation(mm)	37.3	41.4	20.7	50.2	166.7	91.9	51.3	179.7	140.8	36.6

Table 2. Experimental setting data

Maize hybrid	MT Milo	Kamelias
Sowing time	02/04/2010	28/04/2010
Plot area	0.1 ha	0.1 ha
Replications	4	4
Weed control	10/05/2010	10/06/2010
Applied herbicides	Ordax [Clio (a.i. topramezon) 0,15 l·ha^{-1} + Stomp 330 (a.i. pendimetalin) 3,3 l·ha^{-1}]	
Sampling date	23/06/2010 (weeds and maize)	
Harvest	22/09/2010	19/10/2010

MT Milo (Dow AgroSciences) is a very short-season (FAO 220), cold-tolerant maize hybrid. This belongs to the very early ripening and fixed-type hybrids, has a high initial vigor and it is tolerant of cold spring weather. Kamelias (KWS) is an early maturing (FAO 340) hybrid. It has excellent drought tolerance and is characterized by rapid initial growth. Each of the hybrids within the experimental area was sowed on 4 plots with size of 0.1 hectare. During the herbicide treatment, covering method was applied using plastic foil on a 4 m^2 plot area in order to study the weed-corn competition.
Maize samples were taken two times, on 23 June from both hybrids and at the time of full ripening, on 22 September from MT Milo and on 19 October from Kamelias hybrid. Sampling was performed on 1 m^2 areas in all experimental plots, and all of the weeds and 7-7 maize plants were collected from each one. After the measuring of fresh weight of shoots, samples were dried at 40°C, and then the dry weight was also measured.
At the time of and after the harvest fresh and dry weight of maize seeds were measured as well. For the statistical evaluation of the experimental data variance analysis was used by MS Excel.

Results and discussion

The rate of biomass production of MT Milo and Kamelias hybrids were different according to their characters. At the time of sampling (23 June) the shoot mass of MT Milo was 1.89 times higher than that of Kamelias on the herbicide treated plots. However, the latter was sown a month later. In the weedy plots, the dry weight of shoots was similar in the case of the two hybrids (*Table 3.*), but there was a significant 4.72-fold difference in the dry weight of weed biomass. In the culture of MT Milo nearly five times more weed biomass was measured than in Kamelias. The one month longer period of growth of MT Milo resulted significantly higher differences in weed biomass than in the shoot weight of weedy and weed free maize hybrids.

Table 3. Dry biomass weight of maize hybrids and weeds, g·m^{-2}

MT MILO			Kamelias			Weeds	
23 June 2010							
weed free	weedy	$LSD_{5\%}$	weed free	weedy	$LSD_{5\%}$	in MT MILO	in Kamelias
328.8	109.3	*74.2*	174.1	100.4	*23.5*	716.3	151.9
grain yield 22 September 2010			grain yield 19 October 2010				
1020.3	210.3	*85.4*	1399.8	673.0	*223.5*	1192.0	633.0

The water content of plants, the green water also showed notable differences. However, its values represented less difference between the two hybrids than that was observable in dry biomass. Its rate was 1.3-fold. In the weedy plots, similar difference was observed in the water content of maize shoots (*Figure 1*).

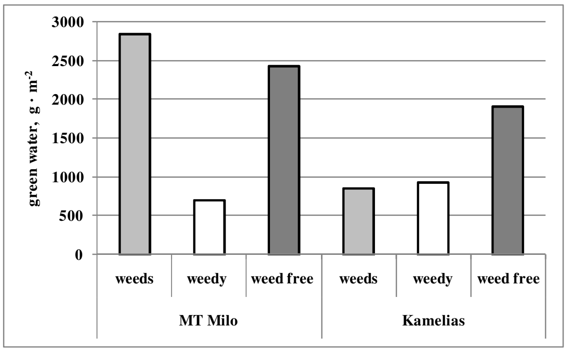

Figure 1. The green water content of maize hybrids and weeds, g·m^{-2}

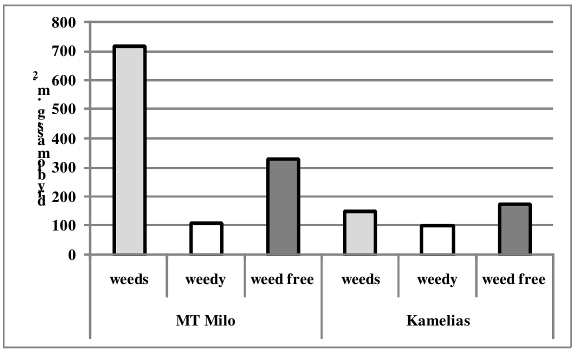

Figure 2. The dry biomass weight of maize hybrids and weeds, g·m^{-2}

On 23 June – compared to that plots which were free of weeds – the competition was manifested by shoot weight reduction in the rate of 66.7% in MT Milo and 42.3% in Kamelias (*Figure 2*).

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The weeds grown with MT Milo contain 3.3 times more green water than in those plots, which were sown with Kamelias. This difference was smaller than that which was shown up in dry biomass.
The relative distribution of total biomass (maize + weed = 100%) on $1m^2$ was 13.2% of maize and 86.8% of weed in MT Milo, 60.2% of maize and 39.8% of weed in Kamelias. It meant 19.5% green water in MT Milo and 80.5% in weeds, and 52.2% in Kamelias and 47.8% in its weeds. These results indicated that MT Milo was in notably disadvantageous conditions compared with the competing weeds. Later, this was well reflected in grain yield. The dry grain weight of MT Milo decreased by 79.4%, and it was less by 51.2% in Kamelias due to the weed competition.
In weed free conditions and independently of the mentioned interspecific competition, difference was also observed between the two hybrids. The grain yield of Kamelias was 1.3 times higher than that of MT Milo.

Conclusions

Experimental results proved that maize hybrids and weeds were in strong competition. The difference in water content was higher than that which was found in dry biomass between the hybrids grown in weedy and weed-free conditions.
On the weedy plots was the grain yield of the traditional Kamelias 3.1 times more than that of the cold-tolerant, early ripening MT Milo hybrid. The grain yield of MT Milo decreased by 79.4%, and in the case of Kamelias it was less by 51.2% due to the weed competition.
In MT Milo sown on 2 April, weeds appeared in masse and very strong competition was formed among them. Comparing with the weed free treatment, the dry shoot weight of maize was less by 66.7% and the water content of shoots decreased by 71.6% on the 12^{th} week after sowing. The competition caused 79.4% reduction in grain yield of the cold-tolerant Milo MT and 51.9% decrease in the case of the conventional Kamelias.
Based on our results, it can be stated that high priority has to be given for weeds both in the growing of the conventional and the cold-tolerant, early maturing maize hybrids. Consequently, weed control should be undertaken in time to prevent the early weed-crop competition.

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EFFECT OF RAINFALL AMOUNTS ON FORAGE YIELD AND WATER CONTENT IN RED CLOVER (*TRIFOLIUM PRATENSE* L.) GROWN FOR COMBINED FORAGE AND SEED PRODUCTION

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Abstract: The impact of rainfall amounts on forage yield, hay yield and water content in the green forage of red clover *(Trifolium pratense* L.*)* was examined in field trials. The crop was grown for combined forage and seed production. The experiment was established on alluvium soil in a randomized block design. Four red clover cultivars (K-39, K-17, Una, and Viola) were analyzed for first cut in their second year. Significant differences between cultivars were observed for green forage yield, hay yield, and water content in the green forage, regardless of rainfall amounts in the production year. A significantly higher green forage yield in K-39 and K-17 and a larger water proportion in the green forage of all varieties were found in the first year as compared to the second year. Hay yield was not significantly different over years. Green forage yield was positively correlated with both hay yield and the water content of green forage.

Keywords: red clover, forage yield, water content.

Introduction

In order to reduce energy consumption and environmental pollution, intensify sustainable agricultural systems and conserve biodiversity, Rochon et al. (2003) proposed increases in forage legume acreage. Being nitrogen fixers, these plants are minimally treated with nitrogen fertilizers, whose residues easily leach from the soil, causing contamination of ground waters, local streams and ponds (Janzen and McGinn, 1991). One such plant is red clover *(Trifolium pratense* L.*)* which due to its high stable yields, varied use, relatively modest growing requirements and good forage quality plays an important part in the production of protein-rich livestock feed. Red clover has a high ability to regenerate; therefore, depending on growing conditions, it can produce up to even three cuttings per year. Under natural water supply conditions, with adequate cultural practices used, green forage yields of up to 147.7 t ha^{-1} can be achieved during the utilization period (mostly three years) (Vasiljevic et al., 2010). Green forage yields of red clover (containing up to 85% of green water) vary widely depending on weather conditions, most notably the amount and distribution of rainfall during the year. In the Republic of Serbia, the combined production of red clover for both forage and seed has proved to be the most cost-effective production method (Lugić et al., 1996), with the first and second cuttings in the second year stand being used to produce forage and seed, respectively (Duronić, 2010). This manner of production involves harvesting the first-cut material at the stage of budding or at the beginning of flowering. The objective of this study was to determine green forage yield, dry matter yield, water content of green forage as well as their interdependence, in the combined forage-and-seed production of red clover cultivars.

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Materials and methods

The experiment was established in 2009 and 2010 in Čačak (43°54'39.06" N, 20°19'10.21" E, 246m a.s.l.), on alluvial soil, pH_{H2O} 4.8, poor in nutrients and low in organic matter. Along with tillage, 300 kg ha^{-1} $N_{15}P_{15}K_{15}$ was incorporated into the soil. The experiment was set up in a completely randomized block design with four replications, with a plot size of $5m^2$ (5x1m). Red clover cultivars, including K-17, K-39 (Institute of Forage Crops Krusevac), Una (Institute of Field and Vegetable Crops Novi Sad) and Viola (a Polish cultivar) were planted at a 20cm row spacing, at a rate of 18 kg seed ha^{-1} Mechanical weed control was performed on two occasions. The crop was grown without irrigation. The test cultivars were cut at the same time (budding phase), on May 13, 2010 and May 14, 2011.

The total rainfall during the pre-growing season and early growing season until the first cutting (November 2010 - May 2011) was 284.6 mm, which was 174.7mm lower as compared to the same period of the previous year (*Table 1*).

Table 1. The amount and distribution of rainfall by month (mm) for the period 2009 - 2011

Month	I	II	III	VI	V	VI	VII	VIII	XI	X	XII	XII	$\bar{x}$ i $\sum$
2009	50	32	42.5	12.5	43	98.4	41.0	35.5	30	91.5	**72**	**97**	645.4
2010	**33**	**52**	**54.5**	**52**	**98.8**	81	90.0	28.5	25	63	**54.6**	**37**	669.4
2011	**22**	**29**	**31**	**15.5**	**95.5**	47	30.5	9.5	42	21	2.5	29	374.5

First-cut green forage (GF) yield in the second year of cultivation was determined by measuring the total weight of the plot immediately after cutting and recalculated to GF yield in t ha^{-1}. After drying at 65 ° C, the measured sample (500g) was used to calculate hay yield (t ha^{-1}) and the water content of the green forage.

The results were subjected to a single-factor analysis of variance (ANOVA) using the SPSS 4.5 software. Significant differences between mean values were tested by the LSD test. The interdependence of green forage yield, hay yield and water content in the green forage was evaluated by calculating the simple correlation coefficient.

Results and discussion

Cultivar Una, regardless of year and rainfall, had a significantly higher GF yield (49.3t ha^{-1}) as compared to cv. Viola (40.3 t ha^{-1}) (*Table 2*). Vasiljevic et al. (2010) report differences in the first-cut green forage yield of red clover in its second year, ranging from 22.4 t ha^{-1} (Nike) to 40.0 t ha^{-1} (Una). The same authors obtained significantly lower forage yields in foreign cultivars and observed intense thinning in their stands until the end of the growing season in the second year, as compared to domestic cultivars. According to (Radovic et al., 2004), red clover cultivars show better performance under the agroenvironmental conditions in which they were selected. The same authors highlight the advantage of domestic red clover cultivars over foreign cultivars due to their better adaptation to the existing agroenvironmental conditions. The increased rainfall in 2010 resulted in a significant increase in green forage yield only in cvs. K-39 and K-17 (cultivar/year interaction). This suggests that these cultivars responded somewhat more favorably to better soil water supply conditions. Hanson (1991) observed a reduction in alfalfa forage yield at inadequate soil moisture. Bosnjak (1993) reported an average 56-61% increase in green forage yield of alfalfa in dry years under irrigated conditions, with the effect of irrigation early in the season being somewhat more modest.

Hay yield was highest in cv. Una, being significantly higher than that of cvs. Viola and K-39. Different rainfall amounts across years did not significantly affect hay yield in any cultivar, regardless of differences in GF yield. This was due to the fact that increased rainfall amounts induced a significant increase in the water content of the forage at the time of cutting in all cultivars. Regardless of the amount of rainfall, significantly higher moisture of the green forage at the time of cutting was recorded in cv. K-17 as compared to cvs. Una and K-39. Given the same cutting date for all cultivars, this may be due to late maturity of cv. K-17. Seguin et al. (2002) report that soil moisture deficiency induced changes in the dry matter quality of red clover, including an increasing content of acid detergent fiber (ADF) and neutral detergent insoluble protein, a decreasing content of acid detergent lignin (ADL) and reduced dry matter digestibility.

Table 2. Green forage (GF) yield (t ha^{-1}), hay yield (t ha^{-1}) and water content of green forage (GW) at the time of cutting in red clover cultivars in 2010-2011

		GF yield (t ha^{-1})	Hay yield (t ha^{-1})	GW (%)
Cultivar	K-39	41,3ab	6,6b	82.64 b
	K-17	46,5ab	7,29ab	84.25 a
	Una	49,3a	8,62a	82.31 b
	Viola	40,3b	6,75b	83.07 ab
Year	2010	48,8a	7,9	85.29 a
	2011	39,9b	7,62	80.85 b
K-39	2010	48.0abc	6.91	85.53
	2011	34.6 d	7.01	79.74
K-17	2010	52.5 a	7.58	85.74
	2011	40.5 bcd	7.00	82.77
Una	2010	52.2 ab	8.00	84.67
	2011	46.3 abcd	9.24	79.94
Viola	2010	42.5 abcd	2.28	85.20
	2011	38.0 cd	7.22	80.29
ANOVA	Cultivar	*	*	*
	Year	*	ns	*
	Cultivar x Year	*	ns	ns

The values denoted with different small letters within columns are significantly different at ($P<0.05$) in accordance with the LSD test; * - F test significant at $p<0.05$; ns - F test non-significant.

Green forage yield was positively correlated with hay yield ($r = 0.76$), as well as with the water content in the green forage ($r = 0.40$). According to Duncan and Woodmansee (1975), the correlation between rainfall amounts and green forage yield of grasses and legumes was significant at the stage of their intensive growth, which was accompanied with soil moisture deficiency. Bosnjak et al. (1995) observed complete correlation ($r = 0.99$) between GF yield and annual rainfall in alfalfa.

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Conclusions

Regardless of the amount of rainfall and year, the test cultivars showed significant differences in green forage yield, dry matter yield, and water content of green forage. Cultivars K-39 and K-17 responded more favorably to better soil water supply conditions. This suggests that different behaviors at different soil water supply levels should also be considered when choosing cultivars for stand establishment under particular agroenvironmental conditions. During high rainfall years, the water content of the green forage was significantly higher in all cultivars, with cvs. K-39 and K-17 giving a significantly higher green forage yield as compared to the other cultivars. Green forage yield was significantly positively correlated with both hay yield and the water content of green forage.

Acknowledgments

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IMPROVEMENT OF GROWTH OF ZN DEFICIENT PLANTS BY BIOFERTILIZER AS A PART OF GREEN WATER CONCEPT

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Abstract: Many soils are Zn-deficient worldwide, which also determine the effectiveness of agricultural production and the quality of the yields. The Zn contents of soils are medium or rather low in Hungary. The most Zn deficient areas are in Békés, Fejér and Tolna County in Hungary, although, the organic matter contents are high.
As it is known, the microorganisms have particularly important role is the nutrient uptake. Nowadays, use of biofertilizer is one of the important components of nutrient management due to cost efficiency, as well as they are renewable source of plant nutrients to supplement the mineral fertilizers for "green water concept" reducing the pollution of water by chemicals, what uptake by the plants determine the quality of crops in the food chain.
In this study, the effect of Zn deficiency and a living bacteria containing biofertiliser were examined on some physiological parameters of maize seedlings, such as dry matter of shoots and roots and their ratio, intensity of root growth in rhizobox experiments. The seedlings were cultivated in Zn deficient soils originated from three different hungarian counties. It was observed that the Zn deficiency reduced the intensity of root growth. In case of the biofertilizer treated plants the dry matter production and the intensity of root growth were higher than the control. It is supposed that the bacteria could solve Zn bound strongly by clay mineral crystals, which can be uptaken.

Keywords: Zn deficiency, biofertilizer, maize, rhizobox experiment

Introduction

Zn deficiency in agricultural soils is a major global problem affecting both crop yield and quality. Kádár (1987) emphasizes in his study entitled the mineral nutrition of maize the importance of Zn-supply. It was reported that the application of phosphate fertilisers in high-concentration reduces the Zn availability (Turán, 2003), as well as the high doses of liming, the shallow root caused by soil compaction, the hardly degradation of soil organic matter are the most frequent reasons causing Zn deficiency in maize (Bergmann, 1979; Bergmann and Neubert, 1976; Kádár and Turán, 2002). Zn is absorbed strongly in the upper layer of the soil. The critical Zn deficiency level of soils are 0.6 to 2.0 mg kg^{-1} depending on the extraction method (Bhupinder et al., 2005). The critical Zn deficiency level of soil was determined at 1.5 mg kg^{-1} by MÉM NAK in Hungary using KCl-EDTA extractant (MÉM NAK, 1979). Kremper et al. (2008) published the calculation factors among KCl-EDTA, LE (Lakanen Erviö) and DTPA extractants, with this possible to determine the Zn deficiency in soil. According to the calculated factors 1 mg KCl-EDTA extracted Zn kg^{-1} soil equal with 0.51 mg $CaCl_2$-DTPA extracted Zn kg extracted and with 1.28 mg LE extracted Zn kg^{-1} soil.
There are a number of physiological impairments in Zn-deficient plant cells with causing retardation of the growth, differentiation and development of plants (Cakmak, 2000), because the Zn is an essential micronutrient for the plant via important enzyme-constituent and influence enzyme-activator.
Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. To apply bacteria (PGPB – Plant Growth Promoting

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Bacteria) as biofertilizer is getting become conspicuous, because the level of animal husbrandy and the utilization of organic fertilizers are dropping, thus the soil is getting poor in useful bacteria.

Materials and methods

In this study maize (*Zea mays* L. – Dekalb DKC 4490) was used as experimental plant, because it is one of the most sensitive crop plant to the Zn deficiency. It was proposed to examine the effect of latent Zn deficiency on the growth of the maize seedlings and the effect of a biofertilizer on the mobilization of Zn bound in mineral chrystals, because it is supposed that the applied biofertilizer can improve the Zn availability in Zn deficient soils. Low Zn containing topsoils (*Table 1.*) were used in this experiment taken from Szabolcs-Szatmár-Bereg, Hajdú-Bihar and Békés Counties with different physical and chemical properties. The soil samples were taken according to the Hungarien Soil Information and Monitoring System (TIM). It was also tested a carcareous chernozem soil originated from the Reseach Station Látókép of the University of Debrecen. The Zn contents of the soil were determined by Lakanen Erviö (LE) extractant. The examined soils were under the Zn deficiency level, which is 1.92 mg LE extracted Zn kg^{-1} soil determined by Kremper et al.'s (2008) calculation factors.

Table 1. Origin and properties (pH and Zn contents) of hungarien Zn deficient soils from Szabolcs-Szatmár-Bereg (SZ-SZ-B), Hajdú-Bihar (H-B) and Békés counties.

Number and origin of the soils		pH $CaCl_2$	pH H_2O	Zn µg kg^{-1} soil extracted by LE
1	SZ-SZ-B	4.56±0.01	4.71±0.06	0.32±0.01
2	SZ-SZ-B	4.37±0.01	4.49±0.03	0.14±0.01
3	SZ-SZ-B	5.24±0.01	5.57±0.06	0.35±0.02
4	SZ-SZ-B	4.95±0.01	5.04±0.01	0.08±0.00
5	SZ-SZ-B	4.75±0.08	4.80±0.03	0.14±0.01
6	SZ-SZ-B	4.75±0.00	4.93±0.03	0.12±0.02
7	SZ-SZ-B	4.56±0.16	4.57±0.08	0.07±0.01
8	H-B	7.42±0.04	7.69±0.05	0.21±0.01
9	H-B	5.95±0.01	6.05±0.07	0.21±0.00
10	H-B	7.72±0.04	8.29±0.50	0.23±0.07
11	H-B	6.07±0.03	6.36±0.13	0.28±0.13
12	H-B	7.42±0.01	7.49±0.08	0.20±0.08
13	H-B	6.05±0.21	6.21±0.07	0.15±0.01
14	Békés	7.65±0.01	8.17±0.53	0.16±0.05
15	Békés	7.54±0.01	7.83±0.08	0.21±0.03
16	Békés	7.67±0.01	7.92±0.05	0.27±0.16
17	Békés	7.47±0.01	7.80±0.03	0.33±0.08
18	Békés	7.67±0.01	8.00±0.04	0.25±0.03
19	Békés	7.67±0.02	7.96±0.11	0.21±0.03
20	Látókép	5.70±0.08	5.99±0.03	0.32±0.00

Living bacteria containing biofertilizer was applied, which contents two bacteria stain: *Bacillus megatherium var. phosphoricum* (1-2x10^8 pieces/cm^3) and *Azotobacter chroococcum* (1-2x10^9 pieces/cm^3). The soils were incubated with the biofertilizer in the concentration of 1ml L^{-1} two weeks before the experiment started to be sure that the bacteria will be alive for the start of the experiment. The biofertilizer was added to the water used to moist the soils to the 50% water-holding-capacity (WHC). During the experiment the soils were daily watered.

The seeds were germinated in moist filter paper then the seedlings (3 seedlings rhizobox^{-1}) were transfer to the rhizoboxes and grown under controlled environmental conditions (light/dark regime 16/8 h at 20-25 ^{o}C, 65–75% relative humidity and a photosynthetic photon flux density 300 µmol m^{-2}s^{-1}). Rectangle shape, 1 cm deep, (one side clear) plastic plant-growth boxes (255 cm^3 rhizoboxes) were used, which make the rhizosphere examintaion possible. The seedlings were harvested on the 4th day, when the roots reached the bottom of the rhizobox. The treatments were set up in 3 replicates. The dry matter of shoots and roots were measured by Ohaus (Switzerland) analitical balance. Microsoft® Excel 2007 and SigmaPlot 11.0 (One Way ANOVA) were used for the statistical evaluation of the data.

Results and discussion

The effect of Zn deficiency of soils and a biofertilizer were investigated on dry matter production of maize (*Table 2.*). Significant differences were observed on the shoot dry weight among the treatments. It was measured significantly higher shoot dry weight among the soil from Látókép (treatment 20), the sand (treatments 1, 3, 7) and clay (treatments 8 and 14) soils as well. The biofertilizer treatment resulted higher shoot dry matter production in case of 1, 7, 8, 11, 12, 14 and 18 treatments, but not significantly.

Table 2. Effect of Zn deficiency and the added biofertilizer on the dry weight of shoots and roots of 4-day-old maize seedlings cultivated on Zn-deficient hungarien soils. (n=9±s.e., P: biofertilizer).

Tr.	shoot µg plant^{-1}	root µg plant^{-1}	shoot/root ratio	Tr.	shoot µg plant^{-1}	root µg plant^{-1}	shoot/root ratio
1	26466±0.01 abc	126166±0.07	209775	11	22744±0.01 bc	44344±0.03	512904
1P	32225±0.01 a	148655±0.08	216776	11P	27400±0.00 abc	42655±0.02	642355
2	26866±0.01 abc	81800±0.07	328443	12	19850±0.01 c	38800±0.02	511598
2P	25588±0.00 abc	77255±0.09	331224	12P	22400±0.01 bc	44811±0.02	499876
3	32666±0.01 a	148544±0.14	219912	13	26977±0.01 abc	110377±0.04	244413
3P	32011±0.01 a	122833±0.14	260606	13P	26955±0.01 abc	97700±0.02	275901
4	32355±0.01 a	94666±0.09	341784	14	23544±0.01 a	36233±0.02	649801
4P	29777±0.00 ab	115533±0.07	257742	14P	31700±0.01 ab	41277±0.02	767968
5	30533±0.00 ab	125277±0.08	243725	15	31066±0.00 ab	40211±0.01	772589
5P	29000±0.01 ab	90533±0.03	320324	15P	23322±0.01 abc	36355±0.01	641504
6	26800±0.00 abc	75922±0.01	352993	16	20218±0.01 c	21388±0.02	945299
6P	26633±0.00 abc	68622±0.04	388115	16P	20762±0.01 bc	33144±0.02	626425
7	21700±0.01 b	102433±0.05	211845	17	28066±0.01 abc	33983±0.04	825895
7P	22444±0.01 b	102822±0.10	218284	17P	23800±0.00 abc	25533±0.00	932115
8	22633±0.01 b	37288±0.02	606973	18	24916±0.00 abc	140883±0.51	176860
8P	24800±0.00 abc	29833±0.02	831285	18P	26962±0.01 abc	24033±0.02	1121879
9	34244±0.01 a	49322±0.02	694301	19	29412±0.01 ab	30000±0.01	980417
9P	25200±0.00 abc	35277±0.02	714331	19P	27222±0.00 abc	28200±0.01	965327
10	29033±0.00 ab	39366±0.03	737511	20	17288±0.01 c	24822±0.02	696509
10P	24200±0.00 abc	38588±0.01	627124	20P	17711±0.01 c	23577±0.02	751178

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One of the visible symptoms of Zn deficiency are shorter internodes and dwarf plants, therefore the effect of Zn deficiency and the applied biofertilizer were examined on the shoot and root growth of maize (*Figure 1*).

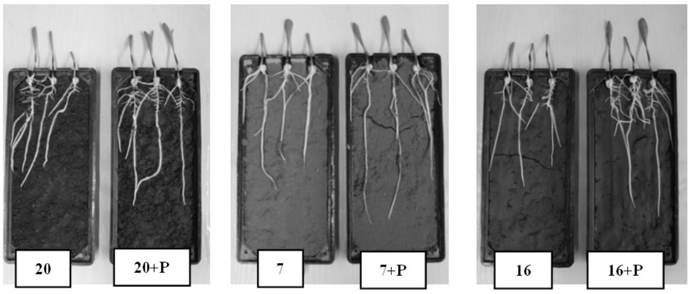

Figure 1. Effect of Zn deficiency and biofertilizer treament on the growth of shoots and roots of maize seedlings cultived Zn-deficient soils. (20: chernozem soil, 7:sand soil, 16: clay soil, P: biofertilizer).

The soil application of biofertilizer in 1 ml L^{-1} concentration increased the growth of the shoots and roots of maize seedlings in comparison to the untreated seedlings.

Conclusions

The dry weight of the shoots were higher in several cases than in case of the treatment with the soil from Látókép, what showes the differences of the soil properties. It was observed positive effect of the biofertilizer. The applied biofertilizer stimulated the shoot and root growth in case of early development of maize, which may indicate the positive effect of bacteria on micronutrient avalivability in soil. It is supposed that the microorganism could solve and improve the availability of Zn bound strongly in clay mineral chrystals via exudated organic acids.

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DETERMINING THE BRIX CONTENT IN SWEET SORGHUM STALK

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Abstract: The present work was undertaken to determine the Brix content in the sweet sorghum internodes and to compare it with the whole plant mean Brix content. The filed study was conducted at the Biomass Utilization and Crop Production Demonstration Centre of Szent István University in 2010. The trial included 4 cultivation treatments (ploughing, disc harrow, cultivating and direct seeding) and 7 different fertilisation treatments. Two plant samples were taken from each replication of each treatment. The leaves were stripped from the stalk and the stalk was cut up into internodes. Brix content measurements were carried out on each internode. The juice samples were measured using a digital hand refractometer type ATAGO PR-201 (0-60% Brix). However we couldn't find an exact internode which would be suitable for measuring, it is advisable to take the juicy samples from the upper half of the plant.

Keywords: sweet sorghum, stalk, Brix

Introduction

Sweet sorghum (*Sorghum bicolor* L. Moench) a member of the sorghum family, is a warm-weather crop highly tolerant of drought and high temperatures primarily used for fodder and the production of sorghum syrup (Mask and Morris, 1991; Linton at al., 2011) and it is also a high biomass yielding crop (Bryan, 1990). It can be harvested within 4-6 months after sowing even in temperate areas and it is a promising plant as raw material for fermentation (Tsuchihashi and Goto, 2004). Sugar stalk crops, such as sugarcane and sweet sorghum, offer more advantages than other crops since they produce a solid residue which can be used as fuel to produce energy (Monti and Venturi, 2003), as animal feed (Ratnavathi et al., 2010) or as soil fertilizer after composting with other wastes (Negro et al., 1999). High concentrations of its sugar juice can be extracted from the stem by milling. The juice extracted from fresh stems of this plant contains approximately 16-18% fermentable sugars predominately sucrose, glucose, and fructose (Goshadrou et al., 2011). The fermentable sugars are ideal raw materials for the ever growing bioethanol industry. Ethanol from agricultural crops continues to be of interest because of the renewable nature of the raw materials (Nguyen and Prince, 1996). For fuel use it has high octane value, suitable for use in lead free petrol. It has lower environmental impact than petrol in terms of the combustion by-products and greenhouse gases (Nguyen and Prince, 1991). Most of the existing studies concern the breeding and harvesting of the sorghum plant and recently, its conversion to industrial outlets. Nevertheless, very little is known about the chemical structure of the sorghum components which is critical for the optimization of the different scenarios for industrial exploitation (Billa et al., 1997). Sugar accumulation mechanisms in stems must be elucidated to determine the optimum harvest time because sweet sorghum is used for its stem sugars as a raw material for fermentation (Tsuchihashi and Goto, 2004). The present work was undertaken to determine which internodes sugar content

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are near to the whole plant mean sugar content. The exact measuring of the stalk sugar content is an unsolved problem because; the sugar content between the internodes is not equivalent.

Materials and methods

Study Site

The filed study was conducted at the Biomass Utilization and Crop Production Demonstration Centre of Szent István University in 2010. The site has a continental climate where weather extremes are typical. The mean annual temperature is 9.7 °C. The average annual precipitation is 550 mm. The soil type of the trial area was classified as a rust-brown forest soil, Luvisol (Chromic) according to the WRB soil classification. Main chemical and physical properties at the study site (0-40 cm) were as follows: pH(H_2O) 6.76; organic matter content 1.32%; phosphorus content 371.1 mg kg^{-1} and potassium content 184.0 mg kg^{-1}. Both the humus content and the N-supply of the topsoil were poor. The potassium and phosphorus supply of the soil were sufficient. The upper 40 cm layer of the soil contains 53% sand, 26% loam and 20% clay fractions respectively.

Experiment design and crop cultivation

The experimental filed was designed in three replications with a strip-plot design. The minimum plot size was 10 x 8 meters with a walkway of two meter between the plots. The number of plots was 84 with an individual plot area of 80 m^2. The trial included 4 cultivation treatments (ploughing, disc harrow, cultivating and direct seeding) and 7 different fertilisation treatments. Nitrogen, as ammonium nitrate at 0, 50, 100 kg ha^{-1} and potassium as potassium chloride, was applied at 0, 40, 80 kg ha^{-1}. The fertilization treatment combinations were as follows: N_0K_0 (control), $N_{50}K_0$, $N_{100}K_0$, N_0K_{40}, N_0K_{80}, $N_{50}K_{40}$ and $N_{100}K_{80}$. Nitrogen was applied in two steps, just before sowing and during the germination period. The potassium fertilisation was carried out before primary tillage. The pre-crop was winter wheat in both years. Flail mowing and shallow soil mixing were followed by basic soil cultivation. Mechanical weed control was carried out once with a cultivator. Chemical pest control was not necessary. The seeds were sown at a row spacing of 70 cm and at a plant distance of 10 cm. High-yielding sweet sorghum variety Sucrosorgo was used during the trial.

Sampling and measurements

Sweet sorghum plants from two 5 meter inside rows were cut by hand from each treatment plot to determine biomass. Then the plants were measured on industrial tare scales type Kern De with a scaling of 10 grams. Two plant samples were taken from each replication of each treatment. The leaves were stripped from the stalk and the stalk was cut up into internodes. Brix content measurements were carried out on each internode. The internodes were marked from 1 to 12 in order of altitude. The first marked sample (1.) was the nearest internode to the ground. The internodes then were pressed to get the sugary juice. The juice samples were measured using a digital hand refractometer type ATAGO PR-201 (0-60% Brix). The refractometer was calibrated by distilled water before each series of measurements to ensure authentic and accurate results. We used Brix to determine sugar content because Guigou et al., 2011 found high linear correlation (0.96) between total sugar content and Brix in the sweet sorghum stalk juice.

Calculation and statistics analysis

The influence of the fertiliser levels and the cultivation methods on the Brix-value was analysed using Microsoft Excel Analysis Toolpack.

Results and discussion

Figure 1. shows the Brix content at harvest stage in case of four fertilisation rate. Each tillage treatments mean sugar contents (Brix) are indicated on the figures. The symbols on the tillage treatment lines represent which internode Brix-value is approximately the same as the whole stalk mean Brix-value. With the increase in internode position from bottom (1. internode) to apical (12. internode) in a mature plant, the Brix value fluctuated overly between the internodes.

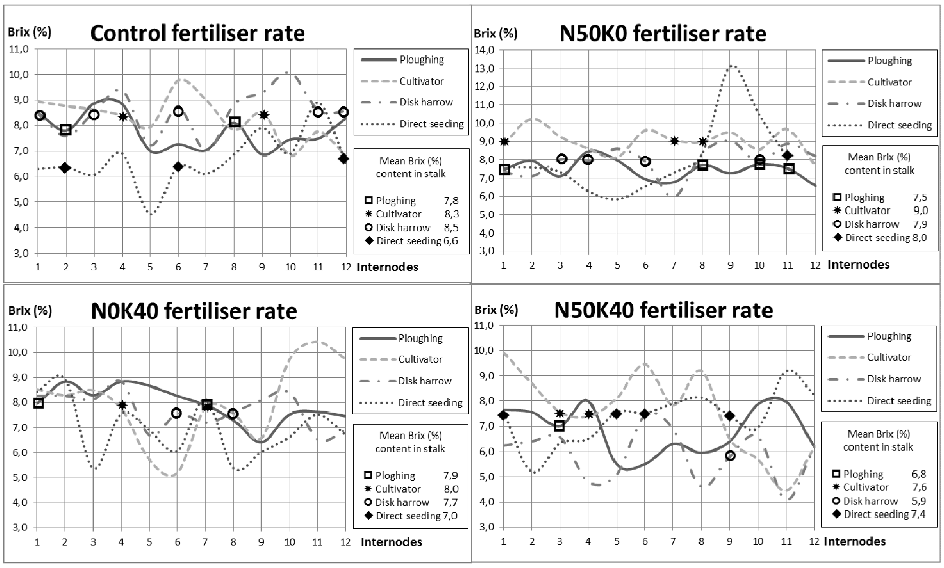

Figure 1. Sweet sorghum stem Brix (%) content at harvest stage (Gödöllő, 2010. 10. 05)

According to the data at control fertilizer rate the second (ploughing and direct seeding), sixth and twelfth (disk harrow and direct seeding) internodes showed matches with the mean Brix value. At N50K0 fertiliser rate we found four matches: at first and eighth internode (ploughing and cultivator), at tenth (ploughing and disk harrow) and eleventh

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(ploughing and direct seeding). In case of N50K40 fertiliser rate we found two matches, at third internode (pluoghing and cultivator) and at the ninth internode (disk harrow and direct seeding). At N0K40 fertiliser rate we found only one match at the seventh internode (ploughing and cultivator).

Conclusions

Investigating only the harvest period results are not enough to get a clear view about the Brix content in the whole plant. However we couldn't find an exact internode which would be suitable for measuring, it is advisable to take the juicy samples from the upper half of the plant. Furthermore, variations in effects of vintage and other plant growth factors must be taken into account in future studies.

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YIELD ABILITY OF MAIZE GENOTYPES UNDER EXTREME HIGH WATER DEFICIENCY

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Abstract: The yield ability and agronomic traits of 12 grain and 7 silage modern maize hybrids of different maturity groups (early, medium, late) with high starch accumulation, or biomass production capacity, were investigated in field trials and by laboratory analyses. Field trials were conducted at the Keszthely-location of Hungary in the growing season of 2011. Maize hybrids were cultivated with optimal fertilization and without any irrigation, set out in a randomized complete block design. The location suffered from extreme drought in 2011, before and during the vegetation period. The actual precipitation data were as follows: January-June 27%, April-September 53% of the long-term (1951-2000) mean precipitation values, which caused high deficiencies. Plant height, grain and stalk weight, harvest index, corn-cob rate, and grain- or total above-ground-yield, were examined. Despite of the extraordinary dry weather the elite maize hybrids performed well because of their excellent genetic basis, the water storage of the deeper soil layer, and the used optimal agrotechnics (water saving tillage and optimal sowing time).

Keywords: field trial, maize for bioenergy, agronomic traits, drought stress

Introduction

Maize crop is one of the most important raw material, which is used as primary energy source in Hungary for bioethanol or biogas production. For the energy production are suitable such genotypes that have high grain and/or stalk yield potential, high carbohydrate content (for biogas watersoluble carbohydrate Hegyi, 2011), excellent ecological stability and good resistance to abiotic stress, first of all good drought resistance. High starch content is very important, but the grain yield potential is more determinant (Boros and Sárvári, 2011). High yield potential can be established with optimal water supply (Dóka, 2011), the water supply effects positively especially in July (Gyenesné-Hegyi et al., 2002). In dry years without irrigation the importance of the soil water storage capacity is highly determinative, as well (Varga-Haszonits et al., 2008). In the drought, hybrids with shorter growing period and earlier sowing times performed better (Nagy, 2009). Good water supply and optimal sowing time positively affects starch content as well (Ványiné Széles et al., 2010).

Materials and methods

Field trials with different maize hybrids were carried out at the Keszthely-location of Hungary on Ramann's brown forest soil (Eutric Cambisol) with originally low organic C and P and medium K contents in the growing season of 2011. Maize hybrids were cultivated with optimal fertilization and without any irrigation, set in randomized complete block design, in three replications. Plot size was 16.8 m^2 (4 rows) with a plant density of 70,000 ha^{-1}. Optimal previous crop (winter barley) and sowing time (25 April) were applied. Long term (1951-2000) annual mean temperature and precipitation are 10.4 °C and 654 mm, respectively. Yield ability and agronomic traits of 12 grain and 7 silage maize hybrids of different maturity groups (early, medium, late) with high starch accumulation or biomass production capacity, were investigated in field trials and by laboratory analyses. The experiment was sown and harvested by

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hand. Twenty plants from each plot were cut and analysed for agronomic traits. Experimental results were statistically evaluated using the statistical software SPSS 13.0 for Windows.

Results and discussion

Meteorological data are presented in *Table 1*. We can see that in the growing season 2010 there was an extraordinary rain surplus over the year and the growing season (April-Sept: +286 mm). However 2011 became very dry (April-Sept.: -185 mm, especially the April–June period was dry) and the temperature was much higher as well. After all maize is able to develop normally, where the deeper soil layer could accumulate enough water because of the water saving soil tillage, and when maize roots could reach this soil layer in time due to the optimal sowing time.

Table 1. Meteorological data of the experimental site

Precipitation (mm)	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	Xl.	Xll.	Total
2010	37.3	41.4	20.7	50.2	166.7	91.9	51.3	179.7	140.8	36.6	85.0	39.1	940.7
2011	5.5	3.7	17.8	17.3	13.9	21.2	66.1	55.1	35.8	56.6	0.5	49.3	337.3
Long-term mean	31.6	32.6	36.6	48.0	62.5	82.0	79.8	65.4	56.8	46.9	62.5	48.2	652.9
Deviation 2011	*-26.1*	*-28.9*	*-18.8*	*-30.7*	*-48.6*	*-6.8*	*-13.7*	*-10.3*	*-21.0*	*9.7*	*-62.0*	*1.1*	*-315.6*
Temperature (°C)	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	Xl.	Xll.	Mean
2010	-2.0	0.2	5.9	10.8	15.0	18.9	22.3	20.0	14.2	8.4	7.6	-1.1	10.0
2011	0.4	-0.2	5.8	12.6	15.6	20.1	20.5	21.5	18.5	9.6	2.2	2.7	10.8
Long-term mean	-0.8	1.1	5.5	10.8	15.7	19.0	20.6	20.1	16.1	10.7	5.1	1.0	10.4
Deviation 2011	*0.4*	*-0.9*	*0.3*	*1.8*	*-0.1*	*1.1*	*-0.1*	*1.4*	*2.4*	*-1.1*	*-2.9*	*1.7*	*0.4*

Experimental results of the maize hybrids for bioethanol production (originating from two different breeding company: A and B) can be seen in *Table 2*. Significant differences are existing in many cases between the single maize hybrids in all the traits under survey. However, taken the different traits by maturity groups into consideration, we could find significant differences only in cases of stalk- and grain yields, and harvest indexes. Highest stalk and grain yields resulted in the late maturity group. This can be explained by the fact that the second part of the growing season, July and August were less dry, and the later flowering time of the hybrids could meet with more favourable conditions. The less harvest index could be detected in the late maturity group as well. We can see that despite of the drought the hybrids performed relatively well.

Table 2. Characteristic results of the maize hybrids in the bioethanol production experiment

Hybrid	FAO group	Height (cm)	Corn-cob rate (%)	Stalk kg ha^{-1} (100% DM)	Grain yield kg ha^{-1} (85.5% DM)	Harvest index (HI)
A/1	310	204	86.4	9,766	11,879	0.51
A/2	320	190	87.9	11,622	12,638	0.48
A/3	380	213	86.0	12,317	12,909	0.47
A/4	420	219	87.2	10,787	12,705	0.50
A/5	450	194	84.0	10,147	11,720	0.50
A/6	460	212	86.8	10,566	12,542	0.50
A/7	510	215	85.7	11,369	13,082	0.50
B/1	380	215	87.1	12,355	12,577	0.47
B/2	390	210	87.7	9,281	12,959	0.54
B/3	410	199	87.7	9,581	13,985	0.56
B/4	410	203	87.0	11,909	12,398	0.47
B/5	520	196	87.0	13,904	13,891	0.47
LSD 5%	-	*4.2*	*1.17*	*856.81*	*929.55*	*0.023*
Early maturity group		206.3	87.0	11,068.3	12,592.5	0.495
Medium maturity group		205.3	86.5	10,598.0	12,670.1	0.506
Late maturity group		205.5	86.4	12,636.6	13,486.7	0.482

Table 3. Characteristic results of the silage maize hybrids in the biogas production experiment

Hybrid	FAO group	Height (cm)	Green yield (kg ha^{-1})	DM content (%)	Total DM yield 100% (kg ha^{-1})	Grain yield 85.5% (kg ha^{-1})
A/1	310	217	53,340	48.1	25,657	12,517
A/2	530(Lfy)	248	63,793	45.5	29,045	14,471
A/3	580	225	55,720	43.8	24,400	13,280
A/4	610(Lfy)	240	55,813	50.5	28,169	11,926
B/1	560	204	56,000	49.5	27,983	12,931
B/2	580	224	54,367	48.1	26,134	12,323
B/3	600	214	57,447	45.2	25,977	12,680
LSD 5%	-	*4.52*	*2114.5*	-	*1004.1*	*n.s.*

The examined silage hybrids originated from two different breeding company as well. Two of them are leafy hibrids with higher leaf number above the ear. In the *Table 3* we can see that the leafy hybrids performed the best with their highest total aboveground mass yield.

The highest grain yield was presented by one of the leafy hybrids as well, but the differences could not be proved statistically. Correlation between the yielding ability of

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the silage hybrids and their growing period could not be shown, too. The yielding ability depended rather on the genetical basis of the hybrids.

Conclusions

Our results referred to several facts. Once, present time on the field for the bioenergy production there are available such maize genotypes which have excellent environmental adaptability, good quality and yielding ability. Second, if we keep our soils in good condition, namely we use optimal tillage, harmonic nutrient supply and suitable crop rotation, we can help our crops to overcome severe abiotic stresses. However the question remains: how long and to what size can be used our fields on the Earth primarily for energy production instead of growing food or fodder?

Acknowledgements

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POTENTIAL APPLICATIONS OF PRECISION TECHNOLOGIES AT EROSION-AFFECTED AREAS

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Abstract: Many soils are exposed to stress and damaging processes caused by these stress factors threaten the soil's renewable capacity thus limit the success of agricultural production. Precision agricultural technologies allow the understanding of the infield soil variability that provides the basis of information for sustainable farming. In case the agricultural site is threatened by erosion, it is important to acknowledge changes taking place there, in order to adapt to the local conditions. In our work, an agricultural site threatened by erosion was examined in the region of Gyöngyöspata (Northern Hungary), where an analysis of digital elevation model maps was performed and, in addition, the erosion model of the area was developed. Furthermore vegetation map was calculated from high resolution aerial hyperspectral images to evaluate the spatial effects of erosion. Based on these results, conclusions and recommendations were made concerning the technology that can be used on this agricultural site.

Keywords: erosion, remote sensing, DEM, precision agriculture, hyperspectral

Introduction

Soil is a conditionally renewable natural resource. Its renewal however can not come off automatically, the sustenance of its undisturbed functional capacity and fertility requires persistently conscious activities including rational land-use, soil prevention and melioration as their most relevant elements. According to several research carried out, the mean annual amount of soil eroded by water from Hungary's slope areas is an estimated 80–110 million m^3 (Várallyay et al., 2005). Contradiction between sustainable development and the non-rational intensive agricultural production is also manifested in accelerated soil erosion (Láng et al., 1995). Recognising the habitat is complicated as soils indicate extremely diversified features even within a given plot. Successful farming can not be conducted on degraded, eroded soils and production carried out on such soils will further aggravate soil and environmental conditions (Jolánkai et al., 1997). By applying one of the most up-to-date type of optical remote sensing, i.e. airborne hyperspectral technology, due to the higher spectral and spatial resolution, compared to conventional airborne survey technologies (RGB-, multispectral images), more detailed information data can be obtained on a range of phenomena, layers and terrains of the Earth's surface. Today, an increasingly wide-spread application of hyperspectral airborne technology is witnessed in precision agriculture (Thenkabail, 2002; Ray et al., 2010) and among them several examples from Hungary are identified (Burai et al., 2009; Milics et al., 2008).

Materials and methods

To this research, a 32.83 ha area at a ploughland located in the outskirts of Gyöngyöspata in Northern Hungary was designated (*Figure 1*).

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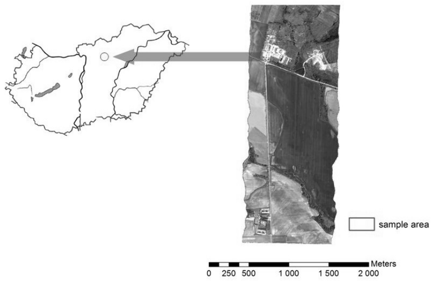

Figure 1. Location of studie site and aerial hyperspectral image (RGB)

Intensive crop production is conducted at the sample area where the soil type is chernozem brown forest soil. In 2010, compared to the year-long average, a high amount of precipitation (866 mm) was experienced of which 248 mm fell between July and October when the land lacked vegetation cover. To the erosion studies carried out in the area, 2 digital elevation models and airborne hyperspectral images were applied. By digitalisation of the 1:10 000 contour topographic map covering the area and by using ArcGIS 10 software, a 10m×10m resolution elevation model was developed. The consequent DEM's elevation precision is ± 0.7-1.5 m (Winkler, 2007) and reflects a state of ca. 30 years ago. From spot elevations (horizontal: 10 mm; vertical precision: 20 mm) measured by high-accuracy field DGPS device, a digital elevation model was developed to evaluate the present status of the sample area. The mean altitude of the 32.83 ha sample area is 180 m (min.: 160 m, max.: 200 m). Only its one fourth is flatland and the majority is located at slope (3 – 9 %) areas. A push-broom typed Aisa Eagle II hyperspectral camera (www.specim.fi) was used at the whole sample area, which is capable of imaging in the visible and near-infrared (VNIR) region. Acquisition was between 10:50-11:00 GMT, on 26th May, 2011. Sensor was set up with 2.5nm spectral sampling in the full spectrum (400-1000nm), so each pixel contains 253 spectral channels. Flight altitude was 1024m that is produced 1m ground resolution hyperspectral image. Image analysis was performed with the ENVI+IDL 4.7 software (http://www.ittvis.com/). At the study area, at 1m^2 sample spots, wet biomass bulk and stalk height were measured and their position was recorded by a sub-meter accuracy GPS device.

Results and discussion

Soil loss image was calculated based on two DEM layers in order to evaluate degree of erosion. Some part of the area showed average 2 m thick soil loss (*Figure 2*).

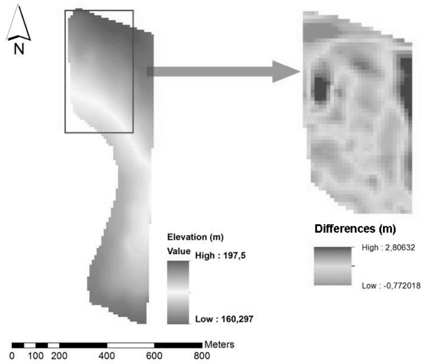

Figure 2. Digital Elevation Model (DEM) (a.) and elevation change map (b.) shows amount of soil mass in the study site

Following the pre-processing the hyperspectral image, Normalised Differential Vegetation Index (NDVI) was calculated from the red (620 nm) and near-infrared (800 nm) channels. The extreme weather era of 2010 caused a significant land mass degradation at some sections of the plot. Several erosion rills 1-5 m in width and 20-250 m were resulted in the sample area. At sections affected by erosion, the vegetation's biomass volume is decreased as well indicated by the NDVI image. For the values of NDVI and field sample data, linear regression was calculated in order to study the relationship between the two variables for which a close correlation (n=9, R^2=0,713, p<0,05) was established. By applying the equation for the entire sample area, a wet biomass bulk map was developed.

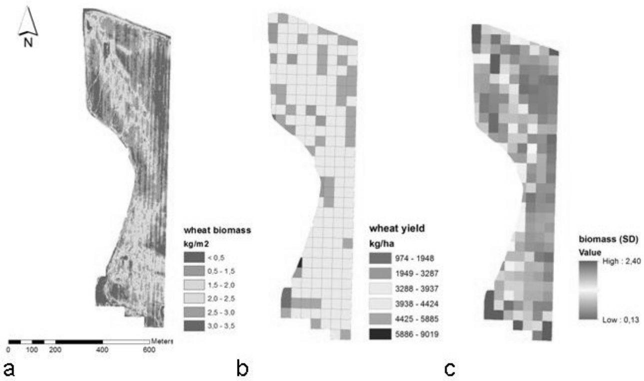

Figure 3. Wheat biomass map of studie site was calculated from HS NDVI image (a.), wheat yield map (b.), and standard deviance (SD) values of biomass (kg/m^2) was derived to 40×40m blockes (c.)

At the area, precision agriculture is conducted and treatments are calculated based on the crop estimation results for the 40×40 m field resolution database. Based on the biomass volume estimated from the NDVI images, the dispersion of vegetation was

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studied in 1600 m^2 blocks (*Figure 3*). Standard deviation was calculated for all cells (min.: 0,13; max.: 2,40). Biomass values show significant differences within a box where the rate of erosion is higher.

Conclusions

Resolution of the available digital elevation models (DEM) is inadequate to provide exact estimations for the amplitude of erosion at the sample area or to identify erosion rills and patches impacting yields. To the chronological study of erosion-induced soil degradation, a calculation of an elevation model by applying the available orthophoto stereo pairs (airborne images were taken by the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) in 2005 and 2010) would be rewarding, thus soil degradation taking place in the area could also be detected through time series. Due to the high heterogeneity within the plot, an improved field resolution for methodologies applied at precision agriculture would be expedient. Precision agricultural technologies facilitate the recognition of soil diversity within the plot and such information could be the basis for sustainable farming.

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ANALYSIS OF PROLIFICATION ON HAILSTORMED MAIZE AND THE BIOTIC STRESS CAUSED BY CORN SMUT FUNGUS

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Abstract: Present examination was motivated by a hailstorm, which damaged the vegetative and generative development of the maize. Although the hailstorm touched the vegetative, assimilating organs sensitively, significant changes have happened in the development of female organs, too. The developing internodia lengths of the hail stormed plants were decreased 5.5%, the longitudinal development regressed 5.8% comparing to not affected plants. Neither plant length, nor number of green and dry leaves indicated statistically significant differences in themselves, the joint effect of these proves a decline in vegetative organs' development. The main consequence of the hailstorm manifested itself in declining of the ear formation, as well as disturbations in incorporation of nutritive matters. The appearance of corn smut fungus [*Ustilago maydis* (DC.) Corda] caused a further 2.5% decrease of cob weight and incorporation disturbations.

Keywords: vegetative-, generative prolification, maize, hailstorm

Introduction

Recent agrometeorological investigations supports unambiguously that the probability of extreme rainfalls is increasing (Bartholy and Pongrácz, 2005). The damage caused by hailstorms became more and more significant even on corn (Lauer, 2009; Zhao et al., 2012). Our examinations were motivated by the changes of maize's vegetative and generative prolification development and habitus after the hailstorm. Furthermore we wondered the degree of damage caused by corn smut fungus [*Ustilago maydis* (DC.) Corda] in the particular climatic conditions too.

Materials and methods

We carried out our examinations in 35 ha monoculture of maize where DK 440 (FAO 320) hybrid of Monsanto ® was sown. The half of this field was damaged by strong hailstorm on 19.06.2007. in 10-11 leafy stage of maize. Three 40x10 m parcels were formed: 1.control (healthy), 2.hail stormed and 3.transition area. The examinations were: 1st: measurement of 10-10 plant's shoot length and width of leaves under the tassel and calculation of full leaf surface values. 2nd: measurement of 10-10 plant's internodium length under and above the ears, and calculation of the internodium quotients. 3rd: total measurement of 10-10 plants after 2.5 month (plant height, internodium length, leaf number, and -surface, tassel length). 4th: measurement of the degree of corn smut fungus infection by means of checking of 600 plants. Besides we measured the ear-, cob-, grain mass and we calculated grain-cob ratio of 10-10 ears infected by corn smut fungus collected randomly. We compared the averages of samples by One-Way Anova ($P \leq 0.05$): grain-, cob- and ear mass of control and hail stormed samples; grain-, cob- and ear mass of control and infected by corn smut fungus samples. According to the Hungarian Standards we got the quality parameters of samples to determine in laboratory (raw protein, raw fat, raw fibre, raw ash, extractable material free from N, starch) and we established the occurring changes.

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Results and discussion

Examinations of vegetative prolification:
In *Table 1* it is clearly visible than the leaf surface values of the not affected control plants are higher than those of the hail stormed and transitional plots, although high dispersion values were observable in all three plots.

Table 1. Leaf surface values (cm^2) of the leaves below the tassels

	control	transition	hail stormed
average	501.95	477.21	464.34
dispersion	50.43	82.16	89.32

The internodia situated above the ear (*Table 2.*) were longer in all three plots than the internodia situated below the ear. The average value of these internodia lengths doesn't showed significant differences in the three samples. The comparison of the internodia quotient above and below the ear merits attention because a decrease of 5.5% of this quotient can be observable in the hail stormed sample, comparing with the control. The length of the internodium situated above the ear is decreasing in the hail stormed plants, showing a possible development disturbance of the juvenile, intensively assimilating sprouts. Beside, the increasing dispersion values from the control to the hail stormed samples supports the heterogeneous plant developments after the hailstorm.

Table 2. Internodium length values collected above and below the ear

	Above ear		Below ear		InQ	
	Average length (cm)	dispersion	Average length (cm)	dispersion	average	dispersion
control	17.24	0.95	16.18	0.91	1.063	0.051
transition	18.05	1.34	17.43	1.64	1.040	0.052
hail stormed	17.97	2.08	17.84	1.79	1.004	0.059

Explanation: InQ (internodium quotient) = internodium length above ear / internodium length below ear.

The results of the sampling effectuated after 2.5 month to the hailstorm are compiled in *Table 3*. It was registered a gradual decrease of plant length from the control to the hail stormed samples. An average decrease of 5.8% in plant length was observable in the hail stormed plants, comparing with the control. The results of leaf surface and tassel length investigations effectuated in the end of the vegetation period showed a small decrease in the hail stormed samples, but the high dispersion of the data doesn't permit us to deduce the disturbation of development of these organs caused by the hailstorm.

Table 3. Full plant (shoot) length and leaf surface values (below tassel)

	Plant length (cm)		Leaf surface (cm^2)	
	Average length (cm)	dispersion	Average length (cm)	dispersion
control	241.00	9.94	490.12	64.82
transition	234.13	16.58	437.10	54.81
hail stormed	227.27	12.08	429.46	46.44

Examinations of generative prolification:
The tassel length showed a small decrease caused by the hailstorm, because of the high dispersion values we can not deduce the disturbation of the tassel development (average tassel length, control plot: 50.5 cm, dispersion: 10.26; average tassel length, transition plot: 50.77 dispersion: 7.78; average tassel length, hail stormed plot: 49.68 dispersion: 5.82). In this way we support the consequences drawn by Berzy et al. (1994) and Berzy and Feher (1995): the crop producing effect of the hail stormed tassels depends primarily from the temperature and precipitation features of the particular year's vegetation period. The ear weight values of the three plots and the smut-infected plants are compiled in *Table 4*. It is clearly observable than the total-, grain- and cob weights of the plants from the control plot are higher than those of the other plots. The difference percentages of the ear components (grain, cob) are varying between wide bounds (12.94-52.2%).

Table 4. Ear weight, grain weight, cob weight values and grain-cob rates

	ear-weight (g)	grain-weight (g)	cob-weight (g)	grain-cob rate
Control sample ears (10)				
average	187.0	143.0	44.4	3.49
dispersion	69.1	37.72	18.32	1.14
Transition sample ears (10)				
average	146.1	124.5	21.3	5.85
dispersion	33.23	33.62	6.57	2.50
absolute average differences	40.9	18.51	23.14	2.36
percentage average differences	21.87	12.94	52.50	67.62
Hail stormed sample ears (10)				
average	136.5	106.5	30	3.99
dispersion	33.19	21.8	11.78	1.44
absolute average differences	50.51	36.53	14.42	0.5
percentage average differences	27.00	25.52	32.72	14.32
Smut infected sample ears (10)				
average	131.8	102.2	29.7	4.07
dispersion	79.24	70.79	19.88	2.07
absolute average differences	55.20	41.84	14.73	0.58
percentage average differences	29.52	29.23	33.40	16.62

The formation of ear and ear component parameters corresponds with the results of Shapiro et al. (1986). The average ear weight decrease caused by hailstorm was 27%. This decrease referring to 1 hectare means a significant crop loss. The weight loss in the transition plot was less than in the hail stormed plot, derived from the less tissue damages of the plants. The corn smut fungus infection caused a further weight loss, increasing the mass degression with 2.5%. According to our investigations this microbial activity caused an average 4.7 g weight loss. The ear weight averages of the control and hail stormed samples differed significantly (P=0.013), in contrast to the averages of control and smut infected samples, where no significant difference was observable (P=0.748). The biggest percentage differences were observable between cob weights, supporting the grain-cob rate shift observed. It is conspicuous the high values in the transition samples. The grain-cob rate of the hail stormed and smut infected samples were higher than the control. The grain-cob rate changes 15% in the favour of

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the grain, caused by the hailstorm. This was modified by another 2% caused by smut fungus infection. Our results supports that in the case of maize the abiotic stress followed by the biotic stress evolves a priority of "full value" grain development over against the cob development. Significant differences were observable only between the control and hail stormed samples based on both grain weight (P=0.014) and cob weight (P= 0.035). These values were P=0.93 between cob weights, P=0.709 between grain weights in the case of control and smut infected samples. The in-kernel air-dry content values of the three samples and the smut infected one is compiled in *Table 5*. It can be observed that parallel with the aggravation of the damage the in-kernel air-dry content values decreases, supporting the investigations of Dwyer et al. (1996). The hailstorm causes disturbance in the incorporation of nutritive matters in the grains, aggravated by the infection of corn smut fungus. Only the disturbance of incorporation of raw fat cannot be proved by the analytical analyses.

Table 5. In-kernel air-dry content values of the grains

	Draw matter%	Moisture %	Raw protein %	Raw fat%	Raw fibre%	Raw ash%	E.m.e.N.	Starch %
control	83.7	16.3	8.5	2.8	1.7	1.4	69.3	59.7
transition	80.5 ▼	19.5 ▲	8.5 ▼	3.1 ▲	1.6 ▼	1.2 ▼	66.1 ▼	57.3 ▼
hail stormed	75.7 ▼	24.3 ▲	6.1 ▼	3.0 ▲	1.6 ▼	1.0 ▼	64.0 ▼	56.9 ▼
Smut inf.	67.3 ▼	32.7 ▲	5.8 ▼	2.8 ▼	1.4 ▼	0.9 ▼	56.4 ▼	50.5 ▼
	-	-	↓	-	↓	↓	↓	↓

Explanation: triangles are showing the decrease, respectively the increase of the particular parameters. Arrows are showing the aggravation of the damage.

Conclusions

Hailstorms can cause serious changes in maize prolification, manifesting mainly in ear weight decrease and can result significant crop loss, aggravated by the higher chance of corn smut fungus infection in the affected maize fields.

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EFFECT OF INTERSPECIFIC COMPETITION ON THE QUALITATIVE AND QUANTITATIVE PARAMETERS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) YIELD

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Abstract: Competition caused by cursed thistles (*Cirsium arvense* L.) was examined in sunflower culture. The results of the experiment suggest, that the effect of interspecific weed competition did not indicate big differences between the hoed control and the various canopy levels of *Cirsium* infected plots. Significant difference had been observed between the hoed control, 15 and 30 pieces of weed plots and the mixed weed plots which means, that specific competition may be successfully controlled.

Keywords: *Cirsium arvense* L., weed competition, sunflower, water availability

Introduction

Regular application of weed control has been increasing recently. The formulation of any weed control system is based on complexity that means integration of several ways of control (chemical, mechanical, agro-technical, etc.). Several experiments have been justified the success of complex control systems.

Results of countrywide weed surveys also support the importance of protection against weed. On our arable lands several weed species with distinguished significance are present and the protection against them is difficult and expensive. The rapid growth of these weeds causes serious problems in agricultural production. Effective protection requires knowledge about the weed relations of each of the cultivated crop species and their competitive capabilities. An analysis from the top 5 cm of soil is the most important, since this layer contains the majority of emerging seeds (Percze, 2003).

Competition among plants was first scientifically defined by Clements in 1907. Competition can be interspecific, intraspecific, intraindividual, intragenotypic or intergenotypic (Pozsgai, 1983).

While examining interspecific competition an important question emerges: how and at what extent the populations within an association share sunlight, water and nutrients that have an essential role in plant development. Measuring the usage of resources is difficult and expensive to be carried out, though it is important for plant production. An others important characteristic of weed species is the identification of the economic damage threshold regarding certain crops (Kazinczi et al., 2007). In arable crop plant production weed propagation is one of the most important yield decreasing factors (Klupács et al., 2011). Crop loss caused by weeds can even be 30% of total loss or more (Solymosi, 1998; Percze, 2002).

Materials and methods

In small plot field experiments competition caused by cursed thistles (*Cirsium arvense* L.) was examined in sunflower culture. The cursed thistle was on the fourth place in the 5th National Weed Survey (Novák et al., 2009). The sunflower was sown on the 4th May 2011. The variety of the sunflower was Paraiso 102 CL and its category was 1st generation hybrid. After sowing the plots the experimental design was arranged. In the experiment the dominant weed species of the weed flora present in the given area was

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chosen as the object. Experiments were arranged in randomized blocks with three replications.
Size of plots was 2m×2m=4m^2 (2 meters wide, 2 meters long, 3 rows of sunflower) with a consistent number of sunflowers; 20 plants in each plot. Half-meter-wide paths were made between the plots, which were free of weeds as a result of permanent hand hoeing. The number of the competitor cursed thistle plants was 15, 30 and 45 pieces per plot in the treatments. These numbers represents the *Cirsium* weed sprouts above the ground. There were an additional 3 plots of mixed weed in the system, which means that the plots did not get any weed control during the experiment. We have applied treatments with *Cirsium* but we have also done direct estimation of weed coverage (%) two times (24.06.2011 and 05.09.2011) in the vegetation season in this case, because of the G_3 life form of this species. After that the phenological examination of sunflowers (height, stem diameter, number of leaves) has been done in every 10-14 days. Treatments in the experiment were compared with hoed control. As a result of the extremely dry cropyear, there was no need to desiccate the sunflower plots before harvest. The time of harvest was on the 16th September 2011. Kernel parameters (moisture, oil, protein content) of sunflowers harvested in each plot were measured with INSTALAB 600 NIR analyzer device at the Laboratory of the Crop Production Institute, Szent István University, Gödöllő, Hungary.

Results and discussion

From our experimental results (*Table 1*) we came to the conclusion that in the plots covered by *Cirsium* the amount of moisture and protein content in the sunflower achenes have decreased while oil content have increased along with the expanding weed coverage.

Table 1. The effect of weediness on the quality parameters of sunflower yield

	Cirsium coverage				Mixed weed
	control	15 weed plants	30 weed plants	45 weed plants	
Moisture content [%]	4.20	4.03	3.67	3.70	3.63
Protein content [%]	15.67	14.47	15.07	13.63	12.67
Oil content [%]	45.67	46.27	46.90	47.17	47.53

The decrease in the amount of moisture is a consequence of the high water consumption of *Cirsium*, hence less amount of eligible water remains in the soil for the crop. Increase in weed number and coverage have caused decrease in crop growth in every plot in the experiment. *Figure 1* shows the quality parameters related to the average.

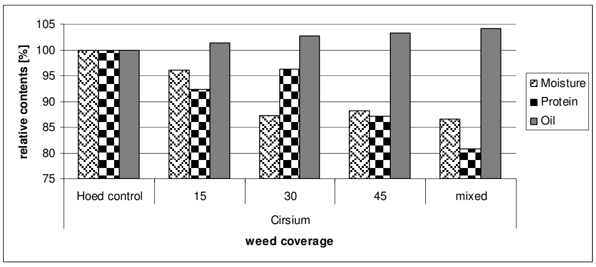

Figure 1. The effect of weed canopy on the quality parameters of sunflower yield related to the average of the hoed control (moisture 4.2%, protein: 15.67%, oil: 45.67%)

As seen in *Table 2* the highest coverage of *Cirsium arvense* was observed in the mixed weed plots. The second highest coverage was that of the barnyard grass (*Echinocloa crus-galli*) which belongs to T_4 life form. The coverage of other weed species did not influence the yield of the sunflower in large extent.

Table 2. Weed coverage in the mixed weed plots [%]

Date of surveys / Weed species	24.06.2011			05.09.2011		
	Repl. 1	Repl. 2	Repl. 3	Repl. 1	Repl. 2	Repl. 3
Amaranthus chlorostachys	-	-	-	-	0.5	1.5
Amaranthus retroflexus	-	-	0.1	-	-	1.4
Avena fatua	-	0.6	-	-	-	-
Chenopodium album	0.3	0.4	0.4	5.2	6.0	11.0
Chenopodium polyspermum	-	-	-	7.5	2.5	2.0
Cirsium arvense	40.0	25.0	21.0	45.0	25.0	19.5
Convolvulus arvensis	0.8	-	1.2	1.5	5.5	5.0
Echinocloa crus-galli	2.5	11.0	10.0	5.0	11.0	5.0
Galinsoga parviflora	-	0.6	-	-	-	-
Hibiscus trionum	-	0.1	-	-	-	-
Lathyrus tuberosus	-	0.2	0.1	-	-	-
Plantago major	-	-	1.2	-	-	-
Setaria viridis	-	0.3	0.3	8.0	21.0	25.0
Sinapis arvensis	-	-	0.2	-	-	-
Stenactis annua	-	-	0.8	-	9.0	6.0
Thlaspi arvense	-	0.1	-	-	-	-
Total	43.6	38.3	35.3	72.2	80.5	76.4

Between the two surveys of *Cirsium* coverage a growing tendency has been observed (*Table 3*). In case of 15 weed plants plots the coverage was 4.67 point higher in the second survey than in the first. The 30 plants of *Cirsium* have risen with 3.67 point and in case of 45 plants plots we have observed the highest coverage of cursed thistle.

Table 3. The average coverage of *Cirsium arvense* in the controlled plots [%]

	Average *Cirsium* coverage [%]	
	24.06.2011	05.09.2011
15 pieces	16.00	20.67
30 pieces	25.00	28.67
45 pieces	28.33	36.67

Figure 2 shows the average weight of the sunflower yield. It was 1357.7 grams in case of the hoed control. The difference of the yield between the hoed control and the 15 weed plants plots was only 33.4 grams, while the difference between the hoed control and the 30 weed plants plots was 48.7 grams. These differences are not significant. A larger deviation was measured (294.7 grams) between the hoed control and the 45 weed plants plots, however this difference was not significant either. Between the mixed plots and the hoed control there was a very high difference detected ($LSD_{0.95}$ 358.26 g). The reason of the rather low values of differences is due to the G_3 life form of *Cirsium arvense*, since the original experimental schedule of number of plants per plot was established by above ground selection only, subsurface root propagation may have contributed to further deviations. The yield loss between the 15 weed plants plots and the hoed control was only 2.4% while between the mixed and the hoed control there was

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36.7% of total loss. We also examined yield loss between the 45 weed plants plots and the hoed control, which was 21.7% and we measured 3.6% yield loss between the 30 weed plants plots and the hoed control. For one unit of weed coverage caused the biggest loss in yield in the case of 45 weed plant plot (weed coverage: 36.67%, loss: 27.1%) that is more than for the mixed weed plot (weed coverage: 76.36%, loss: 36.7%).

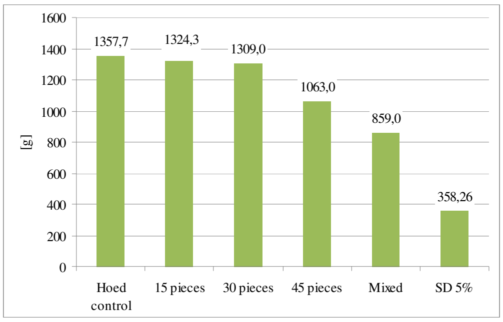

Figure 2. Average amount of the sunflower yield [g]

Conclusion

The results of the experiment suggest, that the effect of interspecific weed competition did not indicate big differences between the hoed control and the 15 and 30 pieces of *Cirsium* plots. The difference between the 45 weed plants plots and the hoed control was large, but not significant. Significant deviation had been observed between the hoed control, 15 and 30 weed plants plots and the mixed plots which show the effect of weed control on the crop yield. Our results were obtained in a drought year (2011). Probably in a crop year with an average or more precipitation these differences can be higher.

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EFFECT OF COPPER CONTAINING ION-EXCHANGED SYNTHESISED ZEOLITE ON THE YIELD AND QUALITY PARAMETERS OF WINTER WHEAT

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Abstract: Copper containing ion-exchanged synthesised zeolite was produced in water medium. Suspension of that kind of zeolite was used as foliar fertilizer in winter wheat. Treatments were carried out at the phenological phases of tillering and flowering of the plant. Zeolites have a porous structure that can bound water which helps copper-ion exchange. As a result of copper-treatments the improvement of yields and of protein contents were observed. Yields increased significantly. Improvement of raw protein content was statistically proved in the case of applying copper-zeolite at tillering stage of winter wheat development.

Keywords: wheat, copper, zeolite, yield, raw protein

Introduction

Winter wheat is one of the most important crops that are grown in Hungary. Weather condition and soil composition in Hungary determine the growing possibilities of high quality wheat.

Besides macro-elements micro-elements also gain in importance in growing winter wheat. Copper being an essential micro-element plays an important role in nitrogen metabolism. If there is not enough copper in the soil it will block nitrogen up-take (Nagy et al., 2011). As a result protein and gluten content of wheat will stagnate at a very low rate. Investigations revealed that about 15% of Hungary's soils show copper deficiency. Soils of high humus content are very suitable for wheat growing but they show copper deficiency as well. Because of blocked transportation we can find the symptoms of copper deficiency even in soils that are well supplied with copper. Copper replacement can be done via the soil or even the leaves. It is well known that the soil is not an ideal intermediary material of plant nutrients. Foliar fertilization has lately gained on importance as a result of economic reasons. Foliar fertilizers are often contains micronutrients. Different copper complexes are used for fertilization to avoid leaf scorching, for the sake of better utilization, to increase yield and quality of crops (Horvat et al., 2010). The structure, the size and the chemical composition of ligandum is very important in respect to nutrient up-take and utilization. The utilization of highly stable complex compounds may be blocked in plants.

Nutrients taken up by the roots quickly spread into different plant parts. Isotope tests were carried out with different ligandums for complex compounds (Lesny et al., 2005). Nutrient up-take via leaves and roots happens similarly: ion-exchange, adsorption, diffusion and mass flow. If metal complexes get into the cells a part of them falls apart metal ions detach and incorporate (Kádár, 2007; Győri et al., 2011).

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Radioactive isotope tests showed that materials put on the leaves quite quickly distribute in the plant.

Copper replacements test have been carried out at the Faculty of Agricultural and Food Sciences of the University of West Hungary for several years. During the past years our experiments have been concentrated on the application of natural and artificial zeolites besides complex compounds. We launched tests with copper ion-exchanged synthesised zeolites in foliar application on winter wheat. It provides long lasting nutrient delivery completed by effective fungicide control utilizing the retarded impact of copper bound by ion-exchange and surface adsorption. Bound and free water in the canals of zeolite ensure the stable ion-transport in the plant.

Materials and methods

Ion-exchange was carried out on synthesised zeolite (P4A) with the use of copper-tetramine-hydroxide complex. Copper-synthesised zeolite was produced by multiple decantation of the suspension with ion-exchanged water. The compound was used in the experiments after gentle drying. Foliar fertilization experiments were launched with copper-ion-exchanged synthesised zeolite on sandy soils with poor copper supply in Győrszentiván in 2011. Experiments were launched in four replications on randomly arranged blocks of 10 m^2-plots. Treatments were carried out at phenological phases of tillering and flowering. Applied copper doses amounted 0.1, 0.3, 0.5 and 1 kg ha^{-1}. Yield and raw protein content of the harvested samples were measured.

Results and discussion

Yield-tests

We applied ion-exchanged synthesised zeolite for copper treatment of winter wheat at the two phenological phases of tillering and flowering. Based on the yields (*Figure 1*) we could detect a little increase in yields due to the application of copper doses at tillering. The most important increase in the yield could have been achieved at a copper dose of 1 kg ha^{-1}, when we got the highest yield increase of 0.4 t ha^{-1} compared to the control. This yield increase could not have been confirmed mathematically. Higher doses might have resulted in further yield increase.

As a result of treatments at flowering stage higher yield increase could be measured. If we increased the copper doses the yield increased too and we achieved the highest yield increase at 0.5 kg copper per ha. That resulted in a significant yield $LSD_{5\%}$. Higher doses (1 kg ha^{-1}) proved to be toxic and reduced the yield.

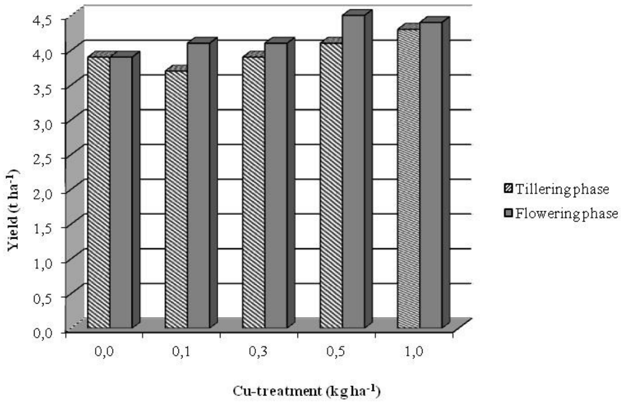

Figure 1. Effect of Cu-treatment on the yield

Raw protein content

We tested the changes in raw protein content as a result of copper treatments (*Figure 2*). Copper-ion-exchanged zeolite applied at tillering positively changed the raw protein content. The raw protein content of the winter wheat seeds increased from the control value of 12.4% to 12.8% if we applied a dose of 1 kg. This produced a significant increase with an LSD value of 0.38. We could expect higher raw protein yields if we increased the doses.
As a result of copper-treatments at flowering we detected a little increase in the raw protein content. As a result of low doses (0.1, 0.3 kg ha^{-1}) raw protein yield increased a little, but it was not significant. Higher doses reduced the raw protein content.

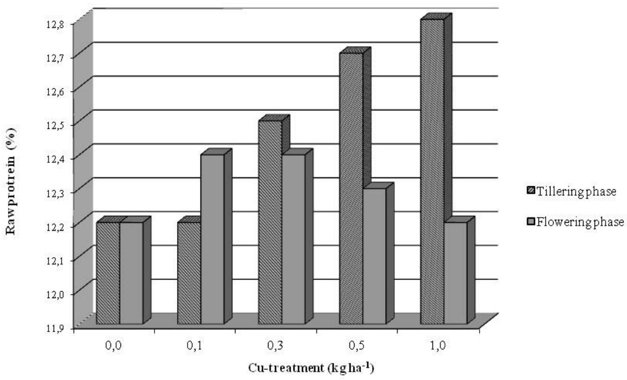

Figure 2. Effect of Cu-treatment on raw protein content

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Conclusions

In our experiments we carried out ion-exchange in synthesised zeolite. The produced copper-ion-exchanged synthesised zeolite included high quantity of physically bound water in there pores. Bound water has a determining role in copper material transport, which improves the plant's nutrient take-up. We applied copper-zeolite in our foliar fertilization experiments. Treatments were done at phenological phases of tillering and at flowering on small plots. As a result of the copper treatments some significant yield increases could have been detected after treatments at flowering, though we could not show any considerable yield increase after treatments at tillering.

Testing the raw material content we found that copper doses applied at tillering increased the raw material content significantly. We were not able to show any considerable increase in raw protein content as a result of copper doses at flowering.

Copper applied as ion-exchanged zeolite foliar fertilizer is able to increase the raw protein content if applied at the phenological phase of tillering. As a result of applications at flowering it can only affect protein synthesis for a short period therefore it has only a little influence on its raw protein content.

Yields increased as a result of copper applications at flowering. Copper or zeolite has a more favourable effect on fruit setting. Yields increased significantly. As a result of applications at tillering yields increased only a little.

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EFFECT OF SOME AGRONOMIC FACTORS ON THE EAR YIELD AND THE LAI OF SWEET CORN HYBRIDS IN DRY AND HUMID CROP-YEAR

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Abstract: The effect of nutrient-supply (control, N_{120}+PK) and two different genotypes on the leaf area index and crop-yield of sweet corn has been investigated in the crop-year of 2009, and 2010. In the experiments we applied two sowing times (end of April, end of May). The two involved hybrids were Jumbo and Enterprise. As regards the requirements of sweet corn production, the crop year of 2009 was dry and warm. The effect of water deficiency was more adverse on the crop yields with the second sowing time. On the contrary, the other examined year (2010) was significantly humid; the precipitation was higher than the 30-year average by 184 mm and the temperature was average. Sweet corn has a shorter growing season, its dynamic water requirements differ from those of maize, the continuity of water supply has a significant effect not only on the quantity but also on the quality of ear yield, therefore, the crop is very sensitive to the year, especially to water supply parameters. I studied the nutrient-supply on the agronomical traits of sweet corn hybrids of different genotypes and their ear yields on chernozem soil in two years. We found that the early sowing time in the crop-year 2009 was most favourable for sweet corn production; the moisture content of the soil was sufficient for the plants. The ear yield of both hybrids was above 24 t ha^{-1}. In the crop-year 2010, there were no significant differences found between the average yields of the two hybrids in the two sowing times.

Keywords: sweet corn, water supply, fertilization, ear yield, LAI

Introduction

Many experimental results prove that there is a close relationship between the yield production and water-supply, just as the water-supply capacity of soil (Szász, 1968; Ruzsányi, 1989). A wide range of bibliography from home and abroad has proven that – even with the application of favourable agronomic measurements – we have to calculate with more or less deviation of the yield results in the different crop-years (Lorenzetti and Pitzalis, 1994; Lopez-Bellindo et al., 2001). According to Sárvári's (2006) results the amount of precipitation has shown a decrement of 55.3 mm in the investigated time interval (1968-2004) compare to the 30-years average. Based upon the results of a precise field experiment that was set up with 82 hybrids in Illinois State Williams and Lindquist (2007) have stated that in case of a late sowing time in June the height of the hybrid plants increased by 22 cm, on the other hand the total biomass amount was 18% as well as the LAI-values 43% lower than in case of a sowing time at the end of May. According to the results of Grindlay (1997) in case the N-supply is not limited, a close relationship can be observed between the N-content of the plant biomass and the leaf area index (LAI).

Materials and methods

The experiments were carried out at the University of Debrecen, Experimental Station of Plant Production at Látókép. The soil was calcareous chernozem soil with a deep humus-layer. The soil of the experiment was of good physical state, medium dense and from soil physics properties is classed among the loam category. It has favourable drainage and water retention capacity and from water-management aspects it is rather

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suitable for sweet corn production. We used two sweet corn hybrids (Jumbo and Enterprise) of the mid-late ripening time were sown. Both hybrids were sown in two sowing time: the first was about 20th of April (early sowing time), while the second a month later, that was about 20th of May (late sowing time). We have executed instrumental measurements in case of two nutrient-supply levels: control treatment (untreated) and N=120 kg ha^{-1} P_2O_5=90 kg ha^{-1}, K_2O=106 kg ha^{-1} and the plant density of 65 000 plants ha^{-1}. For the measurement of the leaf area indexes we have used the equipment LICOR LAI 2000.

Results and discussion

In the crop-year of 2009 the total precipitation in the examined 5 months was 160 mm below the 30-year average (*Table 1.*). The highest moisture deficiency was detected in July, when only 14 % (9.2 mm) of the average amount (65.7 mm) was obtained. June was the only month when the precipitation was (by 17.1 mm) higher than the 30-year average (96.6 mm).

Table 1. Meteorological data of the crop-year (Debrecen)

Month	Monthly precipitation (mm)			Monthly average temperature (°C)		
	Year 2009	Year 2010	30 year average	Year 2009	Year 2010	30 year average
April	9.9	83.3	42.4	14.9	11.6	10.7
May	20.1	111.4	58.8	17.4	16.6	15.8
June	96.6	100.9	79.5	19.8	19.7	18.7
July	9.2	97.2	65.7	23.4	22.0	20.3
August	11.3	98.3	60.7	22.6	19.0	19.6
Total/average	147.1	491.1	307.1	19.6	17.8	17.0

In the crop-year of 2010, the precipitation increased the 30-year average by 184 mm in the vegetation period (from April to August). High amount of precipitation and the extreme temperature values caused yellowing of the plant leaves. In the flowering stage in the first sowing time (beginning of July) the temperature increased the 30-year average by 1.7 °C, while the precipitation was almost 1.5 times higher. The amount of water available for the plants basically determines the success of production. It is influenced on the one hand by the amount of the precipitation in the season and outside of the season and on the other hand by the water-holding capacity and available water stock of the soil. Sweet corn is especially sensitive to proper water supply, the yield is much determined by the amount of water available at the time of flowering. Usually sweet corn requires about 25 mm of water per week during the growing season. Drought stress, as evidenced by slow progress and rolling of leaves during the day, will result in delayed maturity and uneven harvest. In case of the crop-year of 2009 and the early sowing time we harvested the highest ear yields from the fertilized plots in case of both hybrids (*Table 2*). The maximal ear yield was produced by the Jumbo hybrid, it was 26 375 kg ha^{-1}. In the crop-year of 2010 in the case of both the early and the late sowing time higher yields were produced on the fertilized plots. The maximal ear yield was 22 583 kg ha^{-1}, it was measured in the case of the hybrid Enterprise in the early sowing time. In 2009 we have observed a dynamic growth of the leaf area in case of all experimental treatments, that was mainly due to the characteristics of the crop-year. In spite of the fact that from the end of June there fell no – from the aspect of sweet corn production – significant amount of precipitation, the chernozem soil with excellent water supply characteristics was able to ensure the conditions for the intensive vegetative growth.

Table 2. Effect of the agrotechnical factors on the ear yield of sweet corn hybrids (Debrecen)

Sowing time	Crop-year	2009		2010	
	Hybrid / Fertilizer	Ø	N_{120}+PK	Ø	N_{120}+PK
Early sowing time	Jumbo	23158	26375	13439	19630
	Enterprise	22652	25312	16579	22583
Late sowing time	Jumbo	19145	17780	15880	19671
	Enterprise	22097	18647	17286	19910
$LsD_{5\%}$		2534		2071	

This growth was not limited by the development of temperature values, because we have measured almost optimal values from the aspect of sweet corn production. We have used Pearson's correlation tests for analyze the relations and the significance between the nutrient-supply, leaf area and ear yield. In the crop-year of 2009 we have found a very close and very significant relationship between the leaf area and the nutrient-supply, just as the yield only in case of the early sowing time (*Table 3*). The relationship between nutrient-supply and leaf area values can be characterised by the analysis values of 0.629 and 0.845 respectively; while the extent of the correlation between leaf area and yield was 0.751 in the case of the first and 0.724 in the third measurement time. In the case of the late sowing time we haven't found any statistically significant relationship between the leaf area values and fertilization, just as yield data. This can partly be attributed to the unfavourable effects of the weather conditions – that were characteristic of the vegetation period of the late sowing time – on the plant population and the yield.

Table 3. Pearson's correlation of the examined factors in 2009 (Debrecen)

2009.		Yield	LAI 1	LAI 2	LAI 3	LAI 4
Early sowing time	Fertilization	0.787**	0.698**	0.479	0.845**	0.629**
	Yield	1	0.751**	0.501*	0.724**	0.411
Late sowing time	Fertilization	-0.508*	0.385	0.524*	0.398	0.418
	Yield	1	-0.026	-0.219	-0.076	-0.355

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level

In the crop-years of 2010 more moderate increment of the LAI-values was measured in the sweet corn populations. In contrast to 2009 this crop-year was characterized by far more favourable water-supply and better leaf area index values could be measured due to that. Due to the favourable water-supply we haven't found significant difference between the different treatments and genotypes. In the investigated vegetation we have found a very close positive correlation between the nutrient-supply and the ear yield in the early sowing time (0.929), while in the late sowing time this positive correlation was close (0.721) (*Table 4*). In the early sowing time the leaf area index values showed a very close (0.827 and 0.871 resp.) positive correlation with the yield at the 2nd and 4th measurement time, while at the 3rd measurement time this positive correlation was close (0.735). In contrast, in the case of the late sowing time the correlation values proved

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only a loose relationship between the leaf area values and the amounts of the harvested ear yield.

Table 4. Pearson's correlation of the examined factors in 2010 (Debrecen)

2010.		Yield	LAI 1	LAI 2	LAI 3	LAI 4
Early sowing time	Fertilization	0.929**	0.318	0.827**	0.735**	0.871**
	Ear yield	1	0.318	0.753**	0.627**	0.786**
Late sowing time	Fertilization	0.721**	0.603*	0.499*	0.554*	-0.611
	Ear yield	1	0,376	0.450	0.307	-0.331

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level

Conclusions

Sweet corn has a shorter growing season, its dynamic water requirements differ from those of maize, the continuity of water supply has a significant effect not only on the quantity but also on the quality of ear yield, therefore, the crop is very sensitive to the year, especially to water supply parameters. The crop-year of 2009 was rather warm and dry; the precipitation was less than the half of the 30-year average. On the contrary, the crop-year of 2010 was extremely humid and the amount of rainfall was significantly above the 30-year. We found that the early sowing time in the crop-year of 2009 was most favourable for sweet corn production; the water content of the soil was sufficient for the plants. The ear yield of both hybrids was higher than 24 t ha^{-1}. In the crop-year of 2010, no significant differences were found between the average yields of the two hybrids with the two sowing times. We have analysed the relationships between mineral fertilization, yield amount and LAI-values of two rather different crop-years by Pearson's correlation analysis. In the case of the early sowing time we have found close and very close significant correlation between the yield and fertilization, just as between the fertilization and the leaf area values in both crop-years.

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INVESTIGATION OF THE WATER USE EFFICIENCY OF SUMMER BARLEY (*HORDEUM VULGARE* L.) LINES

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Abstract: The main utilization field of summer barley is the brewing industry. Its yield therefore is of high economic value. In order to ensure the production the use of varieties with adequate yield safety is of great importance.
As a consequence of climate change the occurrence of dry, drought crop years is even more frequent. By such circumstances the water use efficiency of the varieties is a determining element in yield safety. Plant breeders therefore shall pay special attention to the water use efficiency of lines in the breeding work.
In the crop years of 2009, 2010 and 2011 we have investigated the water use efficiency of 18 barley lines (with 2 standard varieties) in a random block small-plot filed experiment with four replications. The experiments have been set up with the same agrotechnical conditions in each year.
In the evaluation we have studied the productivity of the lines as a function of the precipitation (amount, and distribution) in the vegetation period. From our results it can be stated that in our breeding programme there are several lines with very good water use efficiency and high productivity even in the drought crop years.

Keywords: summer barley, water use efficiency, lines

Introduction

Among cereals barley production still plays an important role in nowadays' agricultural production system. Due to its use in brewing, summer barley production may be one of the most profitable plant production branch for farmers. But summer barley is the cereal that is the most sensitive for environmental effects (Kádár, 2009). This fact has high significance under nowadays' changing environmental circumstances. So the use of varieties with good quality and high productivity, just as stable production are the main criteria in the selection of varieties of summer barley (Kismányoky, 2005). In case of cereals it has been proven that not in all cases meet the requirement of the highest yields that of the best production stability of varieties (Ágoston and Pepó, 2005).
Among nowadays changing conditions – the probable global climate warming, the decrease of the amount of fallen precipitation, the increment of extreme climatic anomalies (Biacs, 2011) – the water utilization of the varieties and the precipitation in the vegetation period, that is the amount of plant-available water are of great importance from the aspect of yield stability.

Materials and methods

In this paper we have investigated the relationship between the amount of vegetation precipitation and the productivity, and water use efficiency (Szász, 2002) of summer barley lines in the breeding programme of the Károly Róbert College, Fleischmann Rudolf Research Institute in Kompolt in three crop-years (2009-2011). The basis of the study was a small-plot field experiment that was set up with 16 barley lines and 2 standard varieties, under the same agrotechnical conditions and with four replications.
The weather conditions of the three years were significantly different. 2009 was drier than the average. From the aspect of summer barley production it is a rather significant fact that in the vegetative period (from February till July) there has been an almost two month period (March to May) without any precipitation. The crop year of 2010 was

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extreme wet. During the vegetation period of summer barley almost twice as much precipitation had fallen than the 30-year average. The crop year of 2011 was about average. The precipitation of the above mentioned three years are introduced in *Table 1*.

Table 1. Precipitation in the vegetation periods of the investigated crop years (Kompolt Weather Bureau)

Crop year	Kompolt: Precipitation (mm) and average air-temperature (ºC) The growing season (2009-2011)							Total	Average
		February	March	April	May	June	July		
2009	mm	40	43	3	36	97	37	256	43
	ºC	1	5.4	14.8	20.1	22.5	22.5		14.4
2010	mm	55	22	74	160	97	164	572	95
	ºC	0.7	5.2	14.4	17.8	19.5	22.8		13.4
2011	mm	7	34.5	12	51.8	51.6	73.9	304.7	43.5
	ºC	-1.1	5.8	12.9	16.4	20.5	20.9		13.8
	Long-term mean (LTM): 1961-1990*								
LTM	mm	30	34	42	59	80	65	310	52
	ºC	0.2	5.1	10.7	15.8	18.7	20.3		11.8

*national mean

The elements of the production technology were the same in both investigated years. These elements have met the requirements of modern, up-to-date agricultural practise.

Results and discussion

From our results it can be revealed that the yields of different summer barley lines have been significantly affected by the precipitation in different crop years. In the year 2009 the average yield of the investigated lines was 4.57 t ha^{-1}. Contrarily the average yield of the experiment was only 2.28 t ha^{-1} in 2010 and 4.86 t ha^{-1} in 2011. These results show that the far over-average precipitation amount of 2010 and the anaerobic soil circumstances caused by this factor resulted in higher yield decrease of summer barley than the below-average precipitation amount and the almost two month drought period in the previous year.

The close relationship between the yield of the barley lines and the deviation of the in the vegetation period fallen precipitation from the long-term average was confirmed by a linear regression analysis. The R-value in case of each line varied between 0.78 and 0.99. We have found the closest relationship (R = 0.99) in case of the lines '*M-03/27-17', 'M-03/33-9', 'M03/132-12'* and '*Prestige'*. The loosest relationships – that was still a very close one acc. to the analysis (R = 0.78 and R = 0.88) – were found in case of the lines '*M-03/132-7'* and *'M-01/26-74'*. Regarding the whole experiment we have found an average relationship of significance of R = 0.89. These data are interpreted in *Figure 1*.

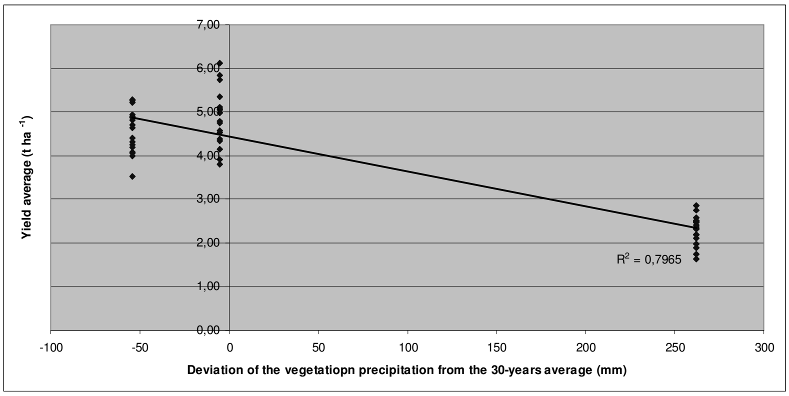

Figure 1. Relationship between the precipitation in the vegetation period and the yield amount

In the analysis of the yield data we have stated that both in the dry crop-year of 2009 and the almost average one of 2011 all lines have produced significantly higher yields than in the wet crop-year of 2010.

In case of the crop-years of 2009 and 2011 we have found significant difference in the yield of only one line. The line named *'M-03/132-7'* produced significantly higher yield in the average crop-year of 2011 than in 2009.

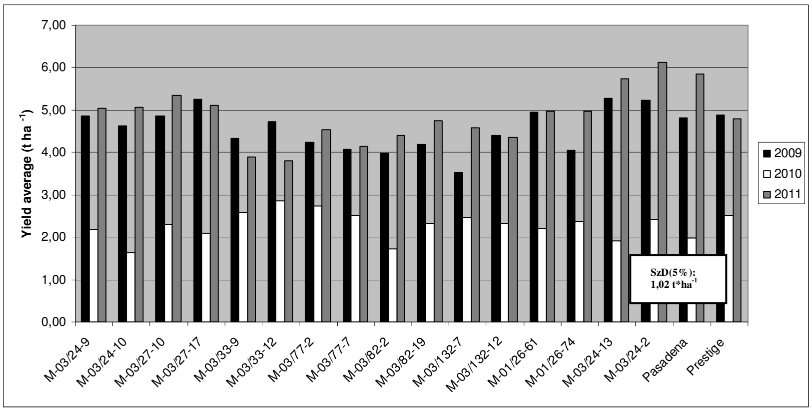

Figure 2. Yield of the investigated lines in the different crop-years

13 lines from the total 18 produced the highest yield in the crop-year with average precipitaion, while 5 lines *('M-03/27-17', 'M-03/33-9', 'M-03/33-12', 'M-03/132-12', 'Prestige')* produced the highest yield in the driest crop-year. Yield data of the different lines are interpreted in *Figure 2*.

In case of four lines (*'M-03/27-17', 'M-03/33-9', 'M03/132-12', 'Prestige')* among the five that have produced the highest yield in the dry crop-year *('M-03/27-17', 'M-03/33-9', 'M-03/33-12', 'M-03/132-12', 'Prestige'),* the linear regression analysis has resulted and confirmed the closest relationship (R = 0.99).

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We have investigated the water use efficiency (WUE) of the lines. The data are introduced in *Table 2*. Based on the data of the two dry years the "M-03/27-17", "M-03/24-13" and "M-03/24-2" have the best WUE (14,39-17,27 kg mm^{-1}).
Based on the yields and the WUE the "M-03/27-17" is the best drought tolerance from aspect of breeding. In the future breeding programme it can be used as crossing partners, gene ressource, it is basic materials of the breeding work.

Table 2. The water use efficiency (WUE) of the investigated lines

Lines	WUE (kg mm^{-1})		
	2009	2010	2011
M-03/24-9	15,90	3,51	14,20
M-03/24-10	15,13	2,63	14,31
M-03/27-10	15,90	3,71	15,07
M-03/27-17	17,19	3,38	14,39
M-03/33-9	14,13	4,14	11,00
M-03/33-12	15,39	4,58	10,71
M-03/77-2	13,87	4,42	12,76
M-03/77-7	13,30	4,05	11,66
M-03/82-2	13,06	2,78	12,38
M-03/82-19	13,71	3,74	13,39
M-03/132-7	11,49	3,96	12,91
M-03/132-12	14,40	3,73	12,25
M-01/26-61	16,14	3,54	14,05
M-01/26-74	13,24	3,80	14,05
M-03/24-13	17,25	3,05	16,14
M-03/24-2	17,08	3,87	17,27
Pasadena	15,75	3,19	16,46
Prestige	15,96	4,02	13,48

Conclusions

The comparison of extreme years (with special regards to the even more often occurring lack-of-water, dry crop-years) with appropriate methods enables plants breeders to select to the season effects most adaptable lines, variety candidates. By the detailed investigation of the adaptability of lines with the best productivity on the one hand we can select variety candidate that can be produced overall in the country with high stability and safe in all kinds of crop years. On the other hand we can breed variety candidates that produce extraordinary high yield or have over-average yield stability under a special weather condition (e.g. in rather dry or even in wet regions).

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THE EFFECTS OF NATURAL AND PROVOKED ARSENIC CONTAMINATION IN SPRINKLING WATER ON THE ARSENIC CONTENT OF SOME PLANT PARTS OF LETTUCE

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Abstract: Horticulture, and mainly vegetable growing, is one of the most important sectors of agriculture in Hungary. The production area of indoor and outdoor vegetable growing exceeds 60 000 ha per year. About 80 percent of this area is located in the southeast region of the country. The average precipitation of this area is 380-450 mm per year, therefore intensive vegetable growing can't avoid irrigation. However, sprinkling water is relatively available in this territory. Underground water for irrigation between 30 and 200 m is obtainable in good quality and quantity for all agricultural production. In some cases higher salt content and iron level appear in underground waters, and beyond these, higher arsenic concentration can be observed probably from geological origin. Main arsenic ion form is arsenate, which was concentrated in living water residues in Pleistocene and Holocene. In these waters arsenic concentration is 20 to 200 µg/L. In Faculty of Horticulture, Kecskemét College, we started our investigations in order to study the arsenic uptake and accumulating properties of different vegetables, grown under the influence of arsenic polluted sprinkling water. Our methods were indoor and outdoor growing, rainfall and trickle irrigation, soil and hydroculture manner as well. This paper summarizes our results on hydroculture lettuce grown with 0-25-50-75-100-200 µg/L (natural As dose) and 400-600-800 µg/L (provoked As dose) arsenic polluted sprinkling water.

Keywords: arsenic pollution, lettuce, greenhouse, hydroculture, hidroponically, ICP-AES

Introduction

Arsenic (As) is a well known toxic element found in Hungarian well waters due to natural geological conditions (Fügedi et al., 2004). In the EU-countries as well as in Hungary government decrees [201/2001 (X.25.)] determine the acceptable concentration of arsenic in drinking water (10µg/L, at most) and food of vegetable origin (vegetables, 200 µg/kg) [17/1999 (IV.16.) EüM]. Serious problems in the water supply of Hungary are caused by wells bored in some parts of the country which yield polluted water of 30-150 µg/L As concentration (Bartha, 2004).

Due to these measures the impact of polluted water on the population can be reduced, but it must not be forgotten, that in the southern and south-eastern parts of the country fresh vegetables irrigated with arsenic water can threat the consumers directly.

It is clearly known from geological research (Bartha, 2004), that underground waters in southern and south-eastern parts of the Great Plain contain arsenic in high concentration. This area represents 80 % of the irrigated vegetables territory.

The inorganic forms of arsenic are dangerous poisons noxious to the whole human body, reducing the activity of the nervous system, kidneys, respiratory organs and the liver, also resulting in reproductive and genetically anomalies and cancer (Fergusson, 1991).

Trial series were started in cooperation between the Ornamental Plant and Vegetable Crops Institute and Soil and Plant Analysis Laboratory of the College for Horticulture (Hungary, Kecskemét) to determine the concentration of this toxic element in some important vegetables irrigated with polluted water. Leaf-vegetables, pepper, tomato,

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carrot and parsley have been tested from 2006 onwards followed by hydropone lettuce in 2009, 2010 and 2011. Lettuce is grown on about 2000 ha, half in the open and half in forcing-house. The water used for irrigation or for nutrient solutions is obtained from wells, 30-100 m deep (Bartha, 2004).
Aim of trials to analyze the effect of water with arsenic content characteristic for the region on lettuce leaves grown in hydroculture, when polluted water is used for the nutrient solution. Arsenic doses of 25, 50, 75, 100, 200, 400, 600, 800 µg/L were tested. The first five doses represent concentrations found in nature, the extreme values (400-600 µg/L) served for scientific observations or modelled extreme conditions.

Materials and methods

Trials included lettuce in hydropone culture in the greenhouse of the Ornamental Plant and Vegetable Crops Institute. There were three tables each containing three nutrient channels made of plastic plates, 4.3 m long, 15 cm high and 30 cm large.
In each channel 25 l standard solution was circulated by a pump controlled by a time switch. An upper container (feeder) and a bottom container (collecting) facilitated the storage of the solution. The slight sloping of the channels furthered the solution flow. In the hydroculture roots developed in the solution and plants were fixed in a neutral agent, rock-wool, and cubes.
The hydroculture started 1st September 2009, 29th March 2010 and 11th April 2011. Two-four leaf lettuce was pricked into rock-wool cubes. The growing period lasted 6 weeks in each year.
At the end of the trial period the lettuce heads were removed from rock-wool cubes. Random samples were taken on the whole length of each channel, fully developed healthy leaves were taken from the middle of the heads in four repetitions.
Root samples were also collected by lifting the rock-wool cubes and disentangling the roots carefully.
The solids content in leaves and roots were determined by drying (70 ^{o}C) and homogenizing samples in a mill up to air dry stage. Samples were digested in a microwave device by means of concentrated nitric acid and hydrogen peroxide. Element contents were evaluated in an ICP-AES spectrometer.

Results and discussion

According to classical analytical methods the arsenic content of samples was determined from the solids content. It must not be forgotten, however, that parts of vegetables (in lettuce the whole foliage) have very high water content. In our solids calculations the solids content of the samples varied between 3.05 and 5.82 m/m% with an average of 4.06 m/m%.
Relevant rules [17/1999 (IV.16.) EüM] allow 0.200 mg/kg arsenic in vegetables for fresh consumption at original water content. The value of arsenic concentration measured in lettuce solids should be divided by 25 to obtain the arsenic concentration of the plant at original water level.
Figures 1-3 represent arsenic concentrations in the three years and average of repetitions.

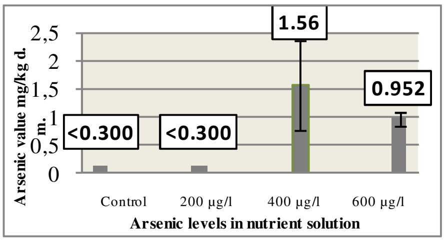

Figure 1. As levels in leaves referring to solids, mg/kg (2009)

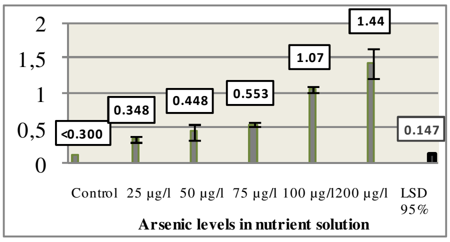

Figure 2. As levels in leaves referring to solids, mg/kg (2010)

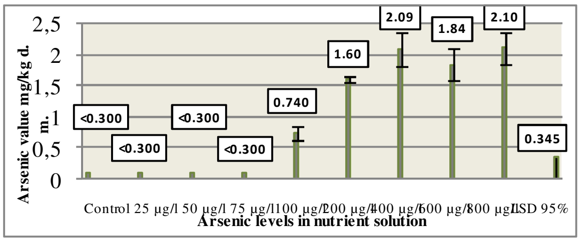

Figure 3. As levels in leaves referring to solids, mg/kg (2011)

As shown by *Figure 2.* the 200 µg/L dose in 2009 did not result in measureable As-content in lettuce leaves. Doses 400 and 600 µg/L increased As-content in leaves referring to control and the 200 µg/L dose. Scattering among repetitions is high. The highest As value – 2.67 mg/kg - was found in the third repetition of the 400 µg/L dose. Repetition averages in 400 and 600 µg/L doses were contradictory as the mean of the 400 µg/L dose surpassed that of the 600 µg/L dose (1.56 and 0.952 mg/kg, respectively).

Figure 3. shows our results in 2010. Repetitions showed much less scattering than in 2009. Trials in 2010 indicated a more precise execution of trials. Between the same doses of the two years (200µg/L) there was considerable difference despite similar conditions. To clear up the situation trial was repeated in 2011 involving all the doses.

The results of our study in 2011 confirmed the experiences of 2010 year. Arsenic content in leaves increased significantly with As doses elevating from 75 to 400 µg/L. in a concentration dependent manner. Arsenic concentration in leaves due to 100 and 200 µg/L concentration were similar. Arsenic doses higher than 400 µg/L did not cause further increase in leaf arsenic concentration, in 2009 and 2011 either.

Analysis of variance showed significant differences in arsenic concentration in leaves after arsenic contamination in sprinkling water in 2010 and 2011. Statistically significant differences (SD<5%) appeared after 75 and 100 µg/L treatments.

Similar trends were observed in the increase of As content in roots in the study years. *Figures 4-6* represent As values in root samples.

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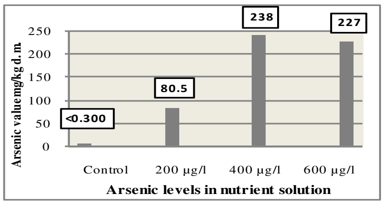

Figure 4. As levels in roots referring to solids (2009)

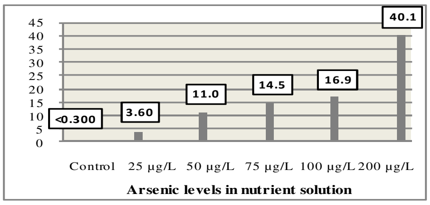

Figure 5. As levels in roots referring to solids (2010)

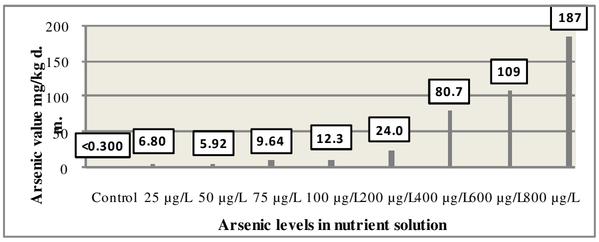

Figure 6. As levels in roots referring to solids (2011)

Increasing As doses increased As concentration in the roots. Low quantities of root samples did not allow repetitions and statistical analysis, yet the physiological filtration effect of the roots is well expressed.

Conclusions

Trials show that the arsenic concentration of the nutrient solution affects the As content in the vegetative parts of lettuce. Even slight doses (200µg/L) increased As level in the test plant.

Increasing As doses increased As concentration in the roots as well but the accumulation was more accentuated. In some doses As content in roots was 16-89 times higher than in leaves. Results are parallel to those of Kádár (1993) who found 30 mg/kg in roots and 1-5 mg/kg in stems and leaves of the test plants, as affected by As doses. Summarizing it can be stated that the arsenic content of lettuce in original moisture content, grown in hydroculture, increases as affected by As application but it does not surpass the 0.2 mg/kg limit. According to our results even three times higher values than 200 µg/L found in natural well water do not increase the As level above the limit in lettuce.

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IMPACTS OF FERTILIZER TREATMENTS ON YIELD AND QUALITY OF WINTER WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract: Only use of nitrogen fertilizer was recommended by RISSAC – RIA HAS fertilization advisory system on the chernozem brown forest soil characterized by poor nitrogen, good phosphorus and moderate potassium supply. Phosphorus and potassium supply of the soil met the phosphorus and potassium demands of wheat plants during the growing season. Quantity and quality of grain yield were improved mainly by nitrogen, but the nitrogen rate (166 kg ha^{-1}), aimed to get the maximum yield could not surpass the effect of balanced nitrogen level (151 kg ha^{-1}). The average yield was almost the same in both treatments. Quality characteristics were better in balanced level treatment, but these were not significant differences. Baking quality wheat grain ("Malmi I") could be produced by use of recommended fertilizes rates of the RISSAC – RIA HAS fertilization advisory system. This good quality could be achieved by using less fertilizer doses, compared to the higher NPK rates that are typically (generally) applied by farmers in the region.

Keywords: wheat, nutrition, fertilizer rates, grain yield, quality

Introduction

The yield and grain quality of winter wheat are influenced by several biological, ecological and crop management factors (Szabó and Véha, 2009). The most important biological factor is the variety that determines the grain quality in 21% (Fodor et al., 2009a). The yield levels and baking quality of wheat are also determined by climatic impacts of the cropyears (temperature, distribution of precipitation etc.) in interaction with other external factors (Smutny, 2010; Szabó, 2010; Szentpéteri et al., 2010). Nutrient inputs make a substantial contribution in wheat yields. Nitrogen fertilization play the most important role in yield formation, but good yields can be achieved by adequate nutrient supply (Hoffmann et al., 2006; Fodor et al., 2009b). Nutrient inputs can affect wheat quality too. Nitrogen fertilizer impacts wheat quality by affecting protein content (Jolánkai et al., 2006). Depending on targets and level of wheat production, farmers can chose recommendations of different fertilization advisory systems in Hungary. For example aims of the intensive fertilization advisory system ("MÉM NAK") are to have maximum yield and to get and maintain a good–very good PK-supply in the soil, while the environment friendly fertilizer recommendation system ("RISSAC – RIA") strives for economic yield and medium-good PK-supply (Csathó et al., 2007, Fodor et al., 2008, Fodorné et al., 2008). The aim of this work is to test the "RISSAC-RIA" cost-saving and environmental friendly fertilizer advisory system in ecological condition of the North-Hungarian Region in the winter wheat production.

Materials and methods

Winter wheat (variety Mv Toborzó) was grown under field conditions during the 2007-2008 growing season at Tass-puszta model farm of Károly Róbert College to study the impacts of fertilization on the yield and grain quality. Four fertilization treatments were applied (*Table 1.*) by the fertilizers Genezis NPK 15:15:15, Genezis Ammonium-nitrate (34% N) and Genezis Pétisó (27% N). The "Usual" treatment represents NPK doses that are generally applied by farmers on wheat fields in the region. Nutrient doses of the

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"Balanced" and the "Integrated" treatments were calculated by the "RISSAC-RIA" cost-saving and environmental friendly fertilizer advisory system.

Table 1. Fertilization treatments of the field experiment

Treatment		Fertilizer (trade mark Genezis): * bp = before planting, td = top-dressing	Fertilization kg ha^{-1}		
			N	P_2O_5	K_2O
1	Control	Unfertilized plot			
2	Usual f.	NPK 15:15:15 (200 kg ha^{-1}) bp* Ammonium-nitrate 34% N (200 kg ha^{-1}) td*	30 68	30	30
3	Balanced f.	Pétisó 27% N (168 kg ha^{-1}) bp* Pétisó 27% N (393 kg ha^{-1}) td*	45 106		
4	Integrated f.	Pétisó 27% N (184 kg ha^{-1}) bp* Pétisó 27% N (430 kg ha^{-1}) td*	50 116		

The field trial was conducted by 4x4 randomized block design in four replicates. The basic plot size was 82 m^2. Wheat was sown on the16th of October and harvested on the 10th of July. The experimental field was cultivated with commonly used agrotechnics. The weather condition in the growing season was favourable for winter wheat growing because of adequate precipitation and temperature regimes (*Table 2.*). The soil type of the experiment field is a neutral chernozem brown forest soil of relative favourable agrochemical properties (*Table 3.*).

Table 2. Precipitation and temperature data in the growing season 2007-2008 (Gyöngyös)

Month	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	
Precipitation mm	64	59	44	37	12	59	47	59	62	Σ 443
Number of rainy days	13	18	9	16	11	11	18	14	18	
Mean air-temp. C°	10.2	3.6	-0.9	0.7	3.2	6.2	13.5	16.5	17.7	X 7.8

Table 3. The main soil characteristics of the experimental plots

Characteristics	Measure	Data	Comment
$pH_{(KCl)}$		7.03	Neutral
Plasticity (K_A)		44	Silty-clay soil
Humus	%	2.2	Low
$CaCO_3$ content	%	0.15	Susceptible to acidity
Salinity	%	0.08	
NO_3^-+NO_2^--N	mg kg^{-1}	8.42	Low N-supply
AL-P_2O_5	mg kg^{-1}	361	Very good P-supply
AL-K_2O	mg kg^{-1}	322	Very good K-supply

Grain yield and water use efficiency index were determined and grain samples were taken at harvesting. Methods and tests used to measure wheat quality: Grain moisture, protein content and wet gluten content was determined by NIR analysis (Inframatic 9200 Grain Analyser). Weight per 1000 kernels and test (hectolitre) weight was determined by the Hungarian Standard of MSZ 6367-4:1986. Falling number was determined by the method of MSZ ISO 3093:1995 (V-3A instrument) and Zeleny sedimentation value was measured by the MSZ ISO 5529:1993 (FTL-205 Zeleny tester). Statistical analysis of data was conducted by analysis of variance and $LSD_{5\%}$ was calculated.

Results and discussion

Each fertilizer treatment resulted in significant yield excess compared to the control, but there were no significant differences between fertilized treatments. The yield was determined mostly by nitrogen nutrition. Phosphorous and potassium fertilizers that were applied only in the 2nd treatment ("usual" fertilization) didn't enhance the grain yield of wheat. Better water utilization was also observed in fertilized plots, even in balanced and integrated treatments. The weight per 1000 kernels was not influenced significantly by fertilization. Higher nutrient doses resulted in higher yield, but the weight per 1000 kernels was somewhat less in fertilized treatments. This tendency was also noticeable at the test (hectoliter) weight (*Table 4.*).

Table 4. Effect of fertilization on grain yield, water utilization and quality parameters of winter wheat

Fertilization (Table 1)	Yield ($t\ ha^{-1}$)	Water use efficiency index ($kg\ mm^{-1}$)	Grain moisture content (%)	Weight per 1000 kernels (g)	Test weight ($kg\ hl^{-1}$)
1. Control	4.39	9.91	12.2	48.62	78.06
2. Usual f.	6.58	14.85	12.2	46.44	77.41
3. Balanced f.	6.82	15.40	12.1	45.74	76.96
4. Integrated f.	6.82	15.40	12.2	46.15	76.40
Mean	6.15	13.89	12.2	46.74	77.21
$LSD_{5\%}$	0.83		0.2	4.71	1.30

The main analytical parameters of grains are presented in *Table 5*. The protein content was increased considerably by each fertilization treatment according to the unfertilized control. The positive effect of nitrogen nutrition on the protein content of wheat grain could be verified in this field experiment too. Protein content of wheat yielded on fertilized treatments was higher than the limiting values of EU standard (10.5%) as well as Hungarian standard (12%). Wet gluten content sowed the same tendency to protein content. Each fertilization treatment resulted in 2.7-4.2% rise in water insoluble gluten protein compared to the control and these were statistically significant changes. The best quality wheat was grown in treatment 3 (balanced nutrition level).

Table 5. Effect of fertilization on grain quality parameters of winter wheat

Fertilization (Table 1)		Protein content (%)	Wet gluten content (%)	Falling number (sec)	Sedimentation value (ml)
1.	Control	12.4	26.1	310	45
2.	Usual f.	13.4	28.8	360	58
3.	Balanced f.	14.0	30.5	360	66
4.	Integrated f.	13.9	30.3	367	61
Mean		13.4	28.9	349	57
$LSD_{5\%}$		0.6	1.84	40	7

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Fertilization resulted in considerable improvement of the Hagberg falling number, but there were no significant differences between each fertilized treatments. The sedimentation value (Zeleny value) is a complex parameter of quality and availability of wet gluten. 20-35 ml test value is required for baking quality. The positive effect of fertilization on grain quality was also provable by this parameter.

Conclusions

Quantity and quality of yield were improved mainly by nitrogen, but the higher nitrogen rate that was applied in "integrated" treatment (166 kg ha^{-1}) could not surpass the effect of balanced nitrogen level (151 kg ha^{-1}). Quality characteristics were also better in balanced level treatment, but these were not significant differences. Baking quality wheat ("Malmi I") could be produced by using of recommended fertilizes rates of the RISSAC – RIA HAS fertilization advisory system. This good quality could be achieved by less fertilizer doses, compared to the higher NPK rates that were typically (generally) applied by farmers in the region. Water utilization of wheat was also improved by fertilization.

Acknowledgements

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STUDY OF THE WATER USE OF DIFFERENT GENOTYPES OF CORN HYBRIDS IN DIFFERENT CROP PRODUCTION MODELS

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Abstract: In 2011, in a year with special water supply we tested different corn hybrids (DKC 4795; DKC 4995; KWS Kornelius; NK Cobalt; PR37 N01). Three different sowing dates (v1 - April 5, v2 - April 21, v3 - May 10), three different plant densities (58,500 plants ha^{-1}, 70 200 plants ha^{-1}, 82 300 plants ha^{-1}) and two fertilizers (80 kg ha^{-1} N, 147.5 kg ha^{-1} N) were used.
The water use of the corn hybrids was examined under different agrotechnical factors. Our results showed that different hybrids responded differently to agronomic factors. At different plant density the hybrids' water exploitation was differing. The best water use was reached at 58,500 plants ha^{-1} (38.0 - 40.8 mm kg^{-1}). At the different genotypes also a significant differences was found (DKC4995 58500 plant ha^{-1} 40.8 kg mm^{-1}, NK Cobalt 82300 plant ha^{-1} 34.8 kg mm^{-1}). The increased amount of N fertilizer decreased the water use of the hybrids (80 kg ha^{-1} N – 39.1 kg mm^{-1}; 147.5 kg ha^{-1} N – 37.7 kg mm^{-1} in the average of hybrids). We found hybrid specific differences (DKC4995 80 kg ha^{-1}N 40.8 kg mm^{-1}; NK Cobalt 80 kg ha^{-1}N 36.3 kg mm^{-1}). At the effect of water households of sowing times we found out that the distribution of precipitation in the crop year was more significant than the absolute amount of precipitation during the vegetation period. According to our water use analysis we obtained the best water use at the late sowing time with less than 23 mm of precipitation.

Keywords: corn, water use, yield

Introduction

Corn is one of the most important arable plants of Hungary. The yield is mainly influenced by the weather of the cropyear. The huge influence of the weather on the crop yield has already been declared by various other authors (Blasko and Zsigrai, 2000; Kumar, 2008; Kismányoki and Debreczeni, 2002). We are not able to influence the climatic factors which secure a high yield, however we can lessen the harmful effects of weather by choosing the right hybrid to the given area and by finding the hybrid specific agrotechnical solutions (Pepó, 2006). The yield production in the most important Hungarian crop field areas is mainly influenced by the quantity of precipitation supply (Jolánkai, 2005). The examination of sowing time is needed as the average amount of precipitation decreased by 40 mm per year and the average temperature increased by 1°C. Due to the climate changed now early springs are typical. This has the effect that the sowing times have to be replanned, as there is a close and significant relation between the sowing time and the yield crop (Sárvári and Boros, 2010). According to Rajkainé and Szundy (2004) the different genotypes has significantly diverse water needs. Németh (1996) declared that there are critical phases in the growing time which is generative phase. The precipitation need of the plants, as well as their sensitivity to the lack of water is growing. The drought time is usually in July and August so this is time of the high sensitivity of corn.

Materials and methods

The experiment was carried out 6 km from Debrecen, next to the main road 47. The soil is square and homogeneous. The soil type is brown forest soil with good organic content

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(2.3%), pH measured in KCl was 6.0. Al-soluble P_2O_5 content is good (159.5 mg kg^{-1}), while the Al-soluble K_2O content is quite well (254.8 mg kg^{-1}). The bound value is 36.3, and the NO_2^--NO_3^- content is 13.4 mg kg^{-1} *(Table 1).*

Table 1. Most important physical and chemical properties of the soil in the experimental field

Depth of soil (0-30cm)	pH (KCl)	Bound value	$CaCO_3$ content%	Humus content %	NO_2^- + NO_3^- content	P_2O_5	K_2O
			m/m%	m/m%	mg kg^{-1}	AL-soluble	
						mg kg^{-1}	mg kg^{-1}
Average of samples	6	36.3	<0.1	2.3	13.4	159.5	254.8

The area was previously sowed with autumn wheat. After the harvest and the detrition of straw residues we disking and in the autumn we plowed (32-35 cm depth). During the spring cultivation the plow was closed by a smoother with Cambridge roller. We used two N fertilizer treatments (80 kg N ha^{-1} and 147.5 kg N ha^{-1}). The dosage of fertilizer was accomplished the following way: 80 kg N ha^{-1} of fertilizer was spred on the area. Afterwards toghether with the sowing we spread further 67.5 kg N ha^{-1} fertilizer to one half of the experiment. The seed-bed was made by a combinator. We used three sowing terms for the experiment (5th April, 21st April and 10th May). We uses three different plant densities (58500 ha^{-1}, 70200 ha^{-1} and 82300 plants ha^{-1}), five hybrids (DKC 4995, DKC 4795, PR37 N01, NK Cobalt, KWS Kornelius) were examined. The experimental plots were chosen as per incidental blocks and with two repetitions. The size of the plots was 225 m^2. We sowed by a 6 rowed KUHN type sowing machine. Soil disinfection was not made. We treated the area against weeds, after the second sowing time with Adengo (izoxaflutol, tienkarbason-metil, ciprosulfamid) chemical by 0.4 l ha^{-1} dose. The treatment after the third sowing time was not effective enough, so we repeated the treatment: Laudis (tembotrion, izoxadifen-etil) in a dose of 1.75 l ha^{-1}. Afterwards a cultivator treatment was made in the area. The harvest took place on the 1st October. All sowing times were harvested with a Claas tucano 440 type geringhoff board combine harvester. The harvested crop of each plot was weighed with the help of a mobile scales located next to the field. The grain moisture was measured with a Dickey John multi grain quick measurer.

Results and discussion

In 2011, in a year with special water supply we examined the water use of different corn hybrids in different crop production models. According to the experiments we found out that the higher the plant density the worse the water use of the plants. This tendency was not visible at only one hybrid (KWS Kornelius), where no significant difference was visible at the three plant densities, however we found out that here as well the lowest plant density (58500 plant ha^{-1}) had the highest yield result (39.1 kg mm^{-1}) – *Figure 1*. The experiment showed that the DKC 4995 hybrid had the best water use (40.8 kg crop ha^{-1} mm^{-1}), which was also visible at the yield crop (11794 kg ha^{-1}). After examining the hybrids' average results we found out that the water use and the yield crop of the low plant density (58500 plant ha^{-1}, the related 39.5 kg yield mm^{-1} water use and 11430 kg ha^{-1} yield) and average plant density (70200 plant ha^{-1}, the related 38.6 kg yield mm^{-1}

water use and 11129 kg ha^{-1} yield) was significantly higher than the high plant density (82300 plant ha^{-1}, the related 37.2 kg yield mm^{-1} water use and 10720 kg ha^{-1} yield).

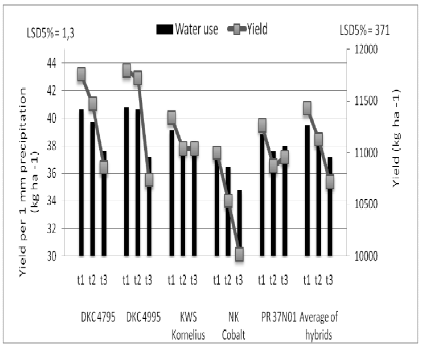

Figure 1. Effect of plant density on the water use and yields of maize hybrids.
(Average of the sowing times and nutrition)
(Debrecen, 2011)

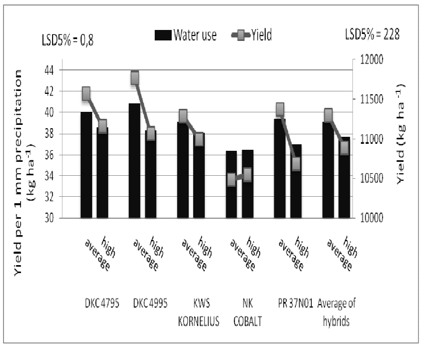

Figure 2. Effect of nutrition on the water use and yields of maize hybrids.
(Average of plant densitys and sowing times)
(Debrecen, 2011)

In the following we examinded how the two fertilizer doses (which we had choosen) influenced the crop yield of the hybrids and their water use *(Figure 2)*. According to the results the increased amount of fertilization (147.5 kg ha^{-1} N) effected a decrease in water use and yield crop compared to the average amount of fertilizer (80 kg ha^{-1} N).

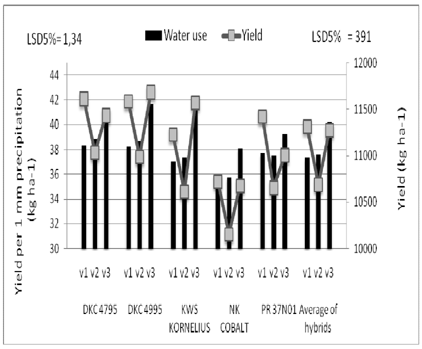

Figure 3. Effect of the sowing dates on the water use and yields of maize hybrids.
(Average of plant densitys and nutrition)
(Debrecen, 2011)

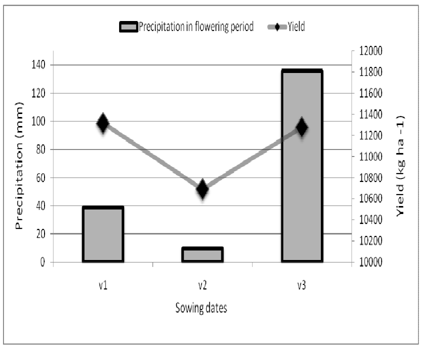

Figure 4. Precipitation in flowering period in different sowing dates.
(Average of hybrids, plant densitys and nutrition)
(Debrecen, 2011)

The decreasment was significant at the DKC 4795, DKC 4995, KWS Kornelius, PR 37N01 hybrids and in their averages, while in the case of NK Cobalt type hybrid we achieved the best crop yield result (10548 kg ha^{-1}) and the best water use (36.5 kg yield mm^{-1}) with the increased fertilization. This however is not a significantly better result than in the case of the average fertilization results (10488 kg ha^{-1} and 36.3 kg yield mm^{-1}). In the experiment we analyzed how the hybrids adapt to the different sowing times *(Figure 3).* According to our water use calculations the best water use was achieved at

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the late sowing time with 23 mm less precipitation (early – 37.3; average – 37.6; late – 40.3 mm^{-1} in hybrid average). In the case of the effect of sowing times to the water use we found out that the distribution of precipitation during the vegetation period (v1 – 303 mm; v2 – 284 mm; v3 – 280 mm) is much more important than the absolute amount of precipitation in the vegetation period. The precipitation in the flowering time is of highest importance at the yield crop developement *(Figure 4).* The figure shows that the significantly bad results of the average sowing time is due to the drought in the blooming time.

Conclusions

In our experiment we analyzed the effects of plant density, nutrients supply and the sowing time on the different corn genotypes. According to the final results we found out that with the increasing of plant density the water use decreased continuously. Only the KWS Cornelius did not show significant difference. In the case of nutrient supply we found out that the water use of hybrids was better (39.1 kg yield mm^{-1} in average hybrid) in case of average fertilization than in increased fertilization (37.7 kg yield mm^{-1} in average of hybrids). During the experiment in the case of sowing time in average of hybrids we can support the results of Németh (1996), according to who the critical time of corn development is the time of generative phase. It affects problems in the plant development when the plant is under abiotic stress in this period. According to our results the late sowing time showed always better results in water use than the early or the average sowing time in 2011 year.

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RELATIONSHIP OF FEED QUALITY AND WATER SUPPLY ON DRY AND MESIC PASTURES

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Abstract: Irrigating pastures is a viable option only in a few selected areas in Hungary, even though pasture is a water demanding culture. Species composition will be impacted by the climate change, reduced winter and spring precipitation and the increasing number of hot days as well as the rise in temperature. Coverage by dicots and C4 grasses will increase, resulting in a change in feed quality. Yield losses and deteriorating quality should be compensated by an adaptive agricultural technology. We examined the impacts of 3 utilisation technologies and seasonal changes on dry and mesic pastures in the years 2006-2010. Results indicated a significant difference in feed quality and factors determining nutrient content caused by water supply. On the mesic pasture, humidity had a significant and substantial negative impact (highest significance, highest r-value) whereas the mesic pasture was essentially affected by precipitation. On the mesic pasture, high temperatures, strong radiation and high amounts of precipitation all had negative impacts on the digestibility and metabolised energy content of feed. Raw protein contents only showed a strong correlation with annual precipitation.

Keywords: dry and fresh grass, nutrient content, water supply, correlation, precipitation

Introduction

The plant material produced by pasture management is used as feed. The quality of feed is of paramount importance. Quality is most often characterized by raw protein and raw fiber content, digestibility of organic matter, metabolized energy (ME) and net energy contents (NE); these being the most important indicators of quality (Szemán et al., 2010). We also used these parameters, except for NE as the Hungarian and Austrian calculation methods for this indicator differ (Tasi et al., 2011).

Our objective was to analyses the effect of frequency of use, various regeneration periods, water supply and season (that is annual weather patterns) on the quality of the pastures of differing species composition at the two sites (Bajnok et al., 2010). As for quality, special attention was paid to the botanical composition of the vegetation and nutrient content, analyzed in the laboratory (Szemán, 2007). In this paper, only results on nutrient contents are discussed.

Materials and methods

Our study included two pasture sites with differing species composition. The experiments were completed in 2006. The effect of 3 pasture utilization systems (*Table 1*), simulated by cutting, on dry matter yield, nutrient and mineral contents of the feed coming from the pastures and the vegetation itself was analyzed. Drought sensitivity and the effect of the season were also considered. Our project was supported by the National Development Agency. (Contract No. Tech 08-A4/2-2008-0140). Our partner, the Hungarian Meteorological Service supplied important data from its measuring stations positioned in the vicinity of the two sites. Daily data of precipitation, mean temperature, global radiation, relative humidity and wind were processed. Dry matter contents were established by cutting plots as a whole, weighing the yield and drying it

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until a stable weight. Plot size was 16 m^2; treatments were repeated 3 times in space. Quality parameters were established by laboratory analyses in Austria (LFZ Raumberg-Gumpenstein), using standardized European methods, in the frame of a research cooperation. The software SPSS was used for statistical analysis. Results are presented in accordance with the methods given by Pajor, 2011.

Table 1. Sampling dates in the 3 pasture utilization systems at the 2 sites from 2006 to 2010

Utilization system	Cut	Dry pasture	Mesic pasture
Utilization in protected areas, delayed first cut (2x/year)	1.	16 June	17 June
	2.	6 October	7 October
Regular meadow utilization (3x/year)	1.	12 May	13 May
	2.	14 July	15 July
	3.	6 October	7 October
Regular strip grazing (4x/year)	1.	5 May	6 May
	2.	9 June	10 June
	3.	28 July	29 July
	4.	6 October	7 October

Note: a long regeneration period was allowed before the last cut, as the vegetation was killed by the heat in August.

Pasture 1 (Bösztör) is a dry goat pasture with a saline undersoil dominated by small Festuca species. It is located in a nature conservation area. Pasture 2 (Mende) is a sown pasture utilized as a meadow. It is located in the region Gödöllői-dombság. It was established at the end of the 1990s and it is dominated by *Festuca arundinacea*. The Mende pasture is located in a valley and characterized by mesic conditions. It is not protected but it is part of an ecologically managed site.

Results and discussion

In ecological pasture management, applicable production methods are limited while in the case of protected pastures even these are forbidden. Thus, the composition of the vegetation and the quality of feed are mainly determined by the weather. In our experiments, only utilization technologies were applied, these together with various regeneration periods were tested. The effect of these factors and the measurable effects of the weather were analyzed by linear regression. Correlation coefficients representing the strength of the relationship are given in *Tables 2 and 3*. Levels of significance are marked by asterisks.

In the case of the dry pasture, raw protein content was mainly impaired by longer regeneration periods, temperature and global radiation. The increasing frequency of utilization had a beneficial effect on protein content. Raw fiber content did not correlate with any of the examined factors. The digestibility of organic matter and ME both had a negative correlation with humidity and precipitation in the vegetative period but a positive correlation with wind. Humidity had the strongest correlation with these indicators of quality, with the highest correlation coefficient. Quality indicators other than protein content were not affected by utilization parameters.

Table 2. Utilization and weather factors having an effect of nutrient contents, together with correlation coefficients, at the dry pasture

n=36	Utilization per year	Regene-ration period	Precipi-tation	With winter precipi-tation	Humidity	Tempera-ture	Global radiation	Wind
Raw proteins	.367 *	-.471 **	-.085	-.210	.057	-.484 **	-.411 *	.068
Raw fiber	.177	-.201	-.194	.224	-.057	-.168	-.097	.236
Digestibility	.128	-.162	-.357 *	.042	-.501 **	-.418 *	-.226	.464 **
ME	.156	-.205	-.378 *	-.036	-.498 **	-.411 *	-.262	.399 *

* Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

When comparing the dry and the mesic pastures, the most important difference is in the parameters having a significant effect on nutrient contents. In the case of the mesic pasture, the effect of utilization frequency is very significant. The higher the utilization frequency and the shorter the regeneration period, the better the quality of feed from the pasture will be, as its raw fiber content will decrease while the values for other indicators increase. In the case of the mesic pasture, precipitation in the vegetative period correlates only with digestibility, affecting it adversely. ME values always run parallel with those for digestibility, both of them being influenced by various factors in the same way. Annual precipitation also including winter precipitation had an interesting effect on protein and fiber contents. More precipitating resulted in significantly higher fiber contents, which was a rather unexpected result.

Table 3. Utilization and weather factors having an effect of nutrient contents, together with correlation coefficients, at the mesic pasture

n=36	Utilization per year	Regene-ration period	Precipi-tation	With winter precipi-tation	Humidity	Tempera-ture	Global radiation	Wind
Raw proteins	.482 **	-.481 **	-.047	-.531 **	.081	-.140	-.329 *	-.258
Raw fiber	-.546 **	.333 *	.130	.494 **	-.233	.119	.364 *	.290
Digestibility	.574 **	-.391 *	-.430 **	-.123	-.291	-.567 **	-.487 **	.324
ME	.564 **	-.461 **	-.441 **	-.149	-.274	-.588 **	-.526 *	.238

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

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It might be explained by the faster and earlier growth of grass before the first cut caused by winter precipitation, resulting in thicker and longer stems, thus more fiber and fewer proteins, due to a poor stem: leaf ratio. Digestibility and ME content were also adversely affected by high temperatures and strong radiation.

Conclusions

Low frequency of utilization had a significant adverse effect on the nutrient content of pastures as a result of aging vegetation. The effect of weather factors depended on the water supply of the site. In the case of the dry pasture, a strong correlation between feed quality indicators and humidity as well as temperature could be established. On the mesic pasture dominated by *Festuca arundinacea* (a tall species), precipitation increased fiber content and reduced quality. Precipitation, temperature and global radiation had a strong negative correlation with the nutrient contents of feed. Changes in species composition potentially responsible for these phenomena should be further investigated.

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SOIL

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ATMOSPHERIC PRECIPITATION AS PLANT NUTRIENT SOURCE

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Abstract: The composition of precipitation and element loads originating from rainwater were examined at an experimental station (Őrbottyán) in Hungary, in order to identify the aerial input of elements and define their effects on agriculture and environment. The observation represents the dry and wet depositions together. Generally, the lower amount of monthly precipitations resulted in higher EC, pH, NH_4-N, Ca, Na, K concentrations. The highest element yields however, were typical for the wet months. Acidic precipitation under pH 5 was rich in nitric acid forming NO_3-N, but poor in NH_4-N at the Experimental Station. Emission of the nearby cement plant in February and March 2006 caused an increase of Ca, Mg, Na, Sr elements with an order of magnitude compared to the other months and the concentrations of NH_4-N, S, Zn, As, Cr, Pb also lifted considerably in the precipitation. The pH reached 7.0 at this site. Aerial input has considerable agronomical and environmental significance. According to this study the aerial deposition could substitute for 10% K, 15% Mg, 20% P, 30% Ca and N, 40% S element demand of an average 5 t ha^{-1} cereal grain yield with its 5 t ha^{-1} straw. The deposition of Zn, Mn, Fe, Cu, B elements in this site were similar to previous Hungarian and Austrian data, however Pb, Ni, Cd, Co depositions were lower with an order of magnitude, which demonstrates the result of the successful heavy metal pollution control in Europe since 1990.

Keywords: aerial deposition, macro- and microelements, agricultural importance, environmental consequences, nutrient balances

Introduction

In Hungary, Kazay (1904) analysed the ammonium and nitrate content of the rainfall at Ó-Gallya Station between 1902 and 1904. Concentration of NH_4-N was 12 kg ha^{-1} and NO_3-N was 5 kg ha^{-1} in 1902, so he found a 17 kg ha^{-1} $year^{-1}$ N deposition.

Based on data from the 1980's, Nrigau and Pacyna (1988) and Nrigau (1989) estimated that from the total aerial amount of elements human activity is responsible for 96% of Pb, 85%, Cd, 75% V, 66% Zn, 65% Ni, 61% As, 59% Hg and Sb, 56% Cu, 52% Mo, 42%, Se, 41% Cr on a global scale. It was also established that toxic elements accumulate fast in air, water, soil, and in the whole food chain, which is an unknown risk for the future generations.

In Austria Sager (2009) calculated the atmospheric deposition in 1999–2000 from own and literature data as follows: Zn 308, Cu 110, Ni 30, Pb 24, Cr 12 and Cd 2 g·ha^{-1} $year^{-1}$. The Cr and V pollution originated mainly from fertilizers, while Pb and Zn pollution came mainly from aerial deposition. In the case of As, Cd and Ni the two mentioned sources had similar effects.

Ammonia emission was reduced by 60% in Hungary between 1980 and 2000. About 94-98% of this emission originates from agriculture. The main sources are manuring, N-fertilization, animal farms, communal sewage and garbage production (CSOH, 2003). In Northwestern Europe efforts were also successful for the reduction of air pollution (SO_2, NOx, NH_3) since 1990 (Boxman et al., 2008).

According to our analytical data, phosphorous fertilizers had the highest content of microelement pollutants in the 1980's in Hungary. Fertilization caused about 30 g As, 8 g Zn and Cu, 4-5 g Pb, 1-2 g Se, 0.8 g Cd and 0.4 g Ni per hectare load yearly due to the practice of large-scale fertilizer application. Fertilization made only 5-10% of the total pollution, but this source was responsible for the 2/3 of the total As load. However,

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greatest pollution of Zn, Pb, Cd and partly Ni came from atmospheric precipitation. The situation has changed by nowadays. After the 1990's Pb load decreased to 1/5 with the introduction of unleaded fuel, and As decrement was similar due to the reduction of superphosphate application. Income of Pb, Cd and Zn from the Silesian "Black triangle" also declined as the former industrial area has been collapsed (Kádár et al., 2009).

Materials and methods

Samplings were conducted at one of the Experimental Sites of the Research Institute for Soil Sciences and Agricultural Chemistry in Őrbottyán city (Danube-Tisza mid region), where amount of monthly precipitations were measured for 50 years. The measuring equipment was installed 1 m high above the ground and emptied every day at 7 a.m. according to the general meteorological practice. The accuracy of the measurement is 0.1 mm. The solid snow, sleet, freezing rain and hail are measured after melting. The dew, frost and hoar are not considered to be precipitation.

The precipitation samples were stored in glass bottles at 7°C and analysed monthly for 26 properties. Measuring of mineral elements was conducted by ICP technique. Electrical conductivity, pH as well as As, Ba, Ca, Cd, Co, Cr, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Se, Sr, Zn, S, B, NH_4-N and NO_3-N contents were determined. Element yield or atmospheric deposition was calculated by multiplying the rainfall amount with element concentrations. The measuring equipments collected not only rain but also aerosol particles of dry fall-out so wet and dry inputs were sampled together. However according literature data the proportion of dry deposition is diverse depending on elements, but makes only 5-10% of the total aerial input.

Results and discussion

The monthly data of amount, conductivity, pH as well as element concentrations and yields of rainfall are shown in *Table 1.* between January and July 2007. The maximal electrical conductivity, pH, NH_4-N, Na and K concentrations, as well as the lack of NO_3-N connected to the lowest 4 mm amount of rainfall in April. The highest element yield resulted however in the rainiest May and June. The precipitation in March was strongly acidic with pH 4.2. Generally, when the nitric acid forming NO_3-N concentration is 3-5-fold more than the pH increasing NH_4-N concentration, the pH value goes under 5. The NO_3-N excess is also related to the high atmospheric N yields.

During the examined half year total aerial deposition was 14 kg N, 10 kg Ca, 2-3 kg Na and K per hectare. S could be detected only in traces. During the second half-year the amount and composition of the rain did not undergo such dramatic changes so it will not be presented in details.

Table 2. gives an overview about the amount and observed characteristics of measured aerial deposition between 2005 and 2008. The Ca, Mg, Na and Sr concentrations in rainwater raised an order of magnitude in February and March 2006. NH_4-N, S and Zn depositions were also high.

Table 1. Characteristics of the monthly precipitation as well as element yield in 2007 (Danube-Tisza mid region, calcareous sandy soil, Őrbottyán)

Months in 2007	Precipitation mm	Conductivity µS cm^{-1}	pH	Ca	NH_4	NO_3	S	Na	K
				Concentration, mg l^{-1}					
I.	31	62	4.5	3.6	0.7	4.0	n.d.	1.1	1.1
II.	46	54	4.8	3.4	1.1	3.6	n.d.	1.1	0.9
III.	39	78	4.2	4.4	0.8	4.0	n.d.	0.7	0.7
IV.	4	140	7.2	4.7	11.6	0.0	n.d.	1.2	3.1
V.	58	71	6.9	1.9	5.5	1.7	n.d.	1.2	1.2
VI.	61	86	4.5	7.7	0.7	5.8	n.d.	0.9	2.0
Months in 2007	Precipitation mm	Conductivity µS cm^{-1}	pH	Ca	NH_4	NO_3	S	Na	K
				Element yield, kg ha^{-1}					
I.	31	62	4.5	1.1	0.2	1.2	n.d.	0.3	0.3
II.	46	54	4.8	1.5	0.5	1.6	n.d.	0.5	0.4
III.	39	78	4.2	1.7	0.3	1.6	n.d.	0.3	0.3
IV.	4	140	7.2	0.2	0.5	0.0	n.d.	0.0	0.1
V.	58	71	6.9	1.1	3.2	1.0	n.d.	0.7	0.7
VI.	61	86	4.5	4.7	0.4	3.6	n.d.	0.5	1.2
Total:	239	-	-	10.3	5.2	9.0	-	2.4	3.1

n.d. – not detectable

Table 2. Atmospheric deposition to soil at the Őrbottyán Experimental Station (Danube-Tisza mid region, 2005-2008)

Soil characteristics	Unit	2005 July-Dec.	2006 Total	2007 Total	2008 Jan.-June
NO_3-N	kg ha^{-1}	10.7	10.0	19.9	4.3
NH_4-N	kg ha^{-1}	5.7	38.0	9.5	9.2
Total N	kg ha^{-1}	16.4	48.0	29.4	13.5
Ca	kg ha^{-1}	8.0	60.1	13.3	8.6
K	kg ha^{-1}	6.0	16.5	6.3	3.1
S	kg ha^{-1}	5.8	21.1	2.2	0.0
Na	kg ha^{-1}	3.0	13.3	4.1	0.8
Mg	kg ha^{-1}	2.8	15.8	2.4	1.3
P	kg ha^{-1}	1.2	5.6	2.5	1.5
Zn	g ha^{-1}	430	1 391	264	67
Precipitation	mm	406	523	466	273
pH minimum		5.2	4.7	4.2	5.0
pH maximum		6.8	7.0	7.2	5.9
EC minimum	µS cm^{-1}	30	47	25	26
EC maximum	µS cm^{-1}	179	1 996	140	149

These emissions originated mainly from the cement works in city Vác, which is about 14 km far away north-westward from where usually the wind blows. The pH reached 7.0 and conductivity was near to 2000 µS cm^{-1}. Yearly element yields were outstanding: 60 kg ha^{-1} Ca; 48 kg ha^{-1} N; 21 kg ha^{-1} S; 16 kg ha^{-1} K and Mg; 13 kg ha^{-1} Na; 5-6 kg ha^{-1} P. The yields of the notable microelements were as follows: Zn 1391 g ha^{-1}; Sr 202 g ha^{-1}; Cu 153 g ha^{-1}; Pb 7 g ha^{-1}; As 4 g ha^{-1}; Cr 3 g ha^{-1}.

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Conclusions

Aerial deposition varied widely. The deposition of Zn, Mn, Fe, Cu, B elements were similar to previous Hungarian and Austrian data. However, Pb, Ni, Cd, Co depositions were lower with an order of magnitude compared to the earlier data from Mészáros et al. (1993), which demonstrates the result of the successful heavy metal pollution control in Europe since 1990.

Aerial depositions have agronomical importance. The yearly 25-50 kg ha^{-1} N, 6-10 kg ha^{-1} K and 2-4 kg ha^{-1} P aerial depositions could cover the requirement of about 1 t grain yield of cereals *(*Kovacevic et al., 2009).

Yields are increasing year by year in PK treatments of a rye monoculture experiment since 1960 at this site, probably due to aerial N input (Kádár et al., 1984). In dry and unfavourable years the cereal yields remain below 2 t ha^{-1}, no N-effects observed. N supply could be covered by atmospheric N deposition because of the low crop yields. The Zn and Cu inputs are important among the microelements (Győri, 2007; Győri and Ungai, 2009; Loncaric et al., 2008; Izsáki, 2010). This site is poor in Zn and Cu so the aerial deposition can totally cover the supply of these elements for the average yields. The adverse effect of the occasional acid rains can be compensated by the aerial deposition of Ca, Mg and Na.

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ESTIMATION OF SOIL SURFACE ROUGHNESS USING PHOTOGRAMMETRY METHOD

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Abstract: Erosion control or flood protection measures are frequently designed according to volume or discharge of overland flow. To estimate these values, it is necessary to know characteristics of overland flow, which are functions of precipitation, slope angle, slope length, soil characteristics and land use as well as soil surface roughness. The roughness value is defined as rate of disturbance or irregularity of the soil surface at such a scale which is generally too small to be captured by conventional topographic maps. It is described predominately with table values as Manning, Bazin or Allmaras´s Random Roughness index, which is calculated as standard deviation from surface irregularities by microrelief meter (pin meter). Recently, this method is replaced by photogrammetric measurement, resulting in point clouds (X, Y, Z), which describe given surface disturbances with very high resolution. Repeated screenings enable to quantify the change of soil surface roughness during the vegetation period, which does not need to have always decreasing tendency. Significant influence of soil surface roughness on characteristics of overland flow grounds in the fact, that roughness elements on the slope frequently exceed the depth of overland flow which is then forced to flow off these elements.

Keywords: random roughness, overland flow, microrelief meter, photogrammetry, standard deviation.

Introduction

Historical maps (military mapping survey) and also aerial survey photos show the rich distribution of ecostabilization elements that in many cases play also a role in the transformation of surface runoff to subsurface runoff. In the second half of the last century, it came not only to land merging but also to the removal of landscape elements that were fulfilling besides the others also ecostabilization functions. This resulted in increase of soil erosion, sedimentation of water basins and streams, but also flood damage in built-up areas. Although the current realization of various projects (land consolidation projects, water management plans, etc.) restores ecostabilization elements in a certain measure, the positive consolidation of arable land does not occur, because land remains in use of agricultural cooperatives. Except this issue, it is necessary to take into account also to the climatic change, predominately occurrence of local storm events and also extremely heavy regional rains that we are witnessing in spring (but also summer) months of year 2010. Solution of this kind of negative phenomenon can be possible by retaining of water in the land, in depression storage and in slowing runoff, respectively. In this way, soil surface roughness plays important role. Hitherto used roughness values according to Manning or Bazin appear to be inadequate especially in the case of arable land. On the contrary, random roughness index can describe surfaces of differently cultivated soils using microrelief meter but measurement, and especially evaluation is time consuming. It has to be taken into account that the roughness changes almost heterogeneously at each rainfall event, but this change does not necessarily always mean only a reduction (particularly at the high rainfall amount).To eliminate this imperfection, modern technology approach - photogrammetry - can be used as a very important and valuable tool.

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Materials and methods

The term soil roughness is used to describe disturbances or regularities in the soil surface at a scale which is generally too small to be captured by a conventional topographic map or survey. Römkens and Wang (1986, cit. Govers et al., 2000) make a distinction between four types of roughness:

a) microrelief variations, which are due to individual grains or micro-aggregates,
b) random roughness, which is related to soil clodiness,
c) oriented roughness, which describes the systematic variations in topography due to farm implements
d) higher order roughness, representing elevation variations at the field, basin or landscape level.

Because **random roughness** (with oriented roughness) affects various hydrologic and erosion processes on arable land, we pay increased attention to him. Random roughness was estimated using **microrelief meter** (Allmaras et al., 1966). It was designed to measure surface elevations on a 2- by 2-inch grid over a 40- by 40-inch area Its improvement is **pin meter** (Garcia Moreno et al., 2008) with the plot size 1 m^2 (*Figure 1.*). Pin meter consisted of a row of 35-cm high pins placed in a frame in which they could slide up or down to conform to surface irregularities. With rows containing 50 pins spaced at 2-cm intervals, each x-axis reading covered one full metre of ground. The y-axis readings were taken by sliding the instrument across the one square metre plots. The cells on the resulting grid measured 2 x 2 cm, and a total of 2500 readings was taken per square metre (in the case of microrelief meter with 20 pins, number of readings is 400).

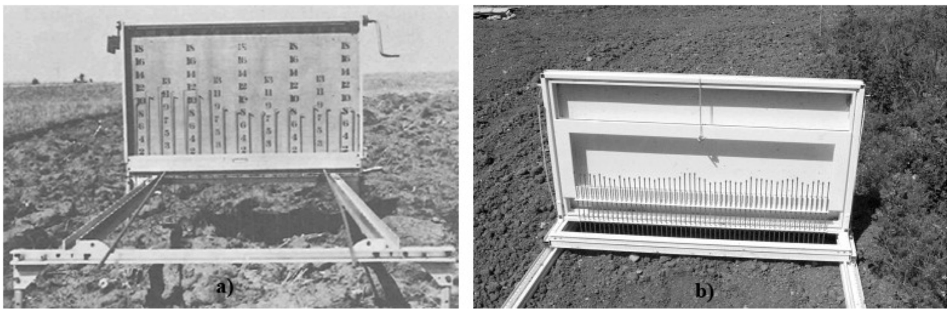

Figure 1. (a) Micorelief meter (Allmaras et al., 1966) and (b) Pin-meter (G. Moreno et al., 2010)

Results and discussion

To gain improvement and refinement, the random roughness determination method (mechanical) described above was replaced by photogrammetry method (Sinka, Antal, Horák, 2011). The research area of 3x3 m (loamy soil) was scanned by camera Canon EOS 5D MARK II in constant height, at a given angle from each side five times with sufficient overlay (total of 20 shots). The obtained images were subsequently processed in Photomodeler Scanner and irregular point field (a cloud of points) was generated to determine surface roughness. Number of measured points far exceeded those of the regular point field of pin meter, and it reached above 100 000 points (after the elimination of almost identical points, i.e. points with spacing up to 0.5 mm). This research was carried out for rugged surface, cultivated by spade *(Figure 2.)*, straightened surface by rake *(Figure 3.)* on June 29, 2010, and for straightened surface modified by 267 mm of rainfall (August 10, 2010, *Figure 4.*).

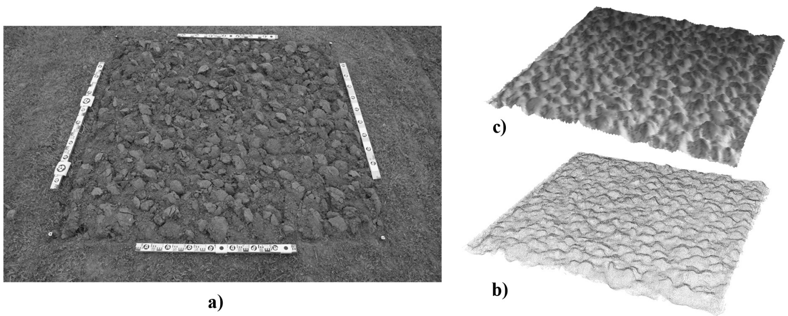

Figure 2. Rugged surface - (a) the plot, (b) a cloud of points, (c) grid (Šinka, 2010)

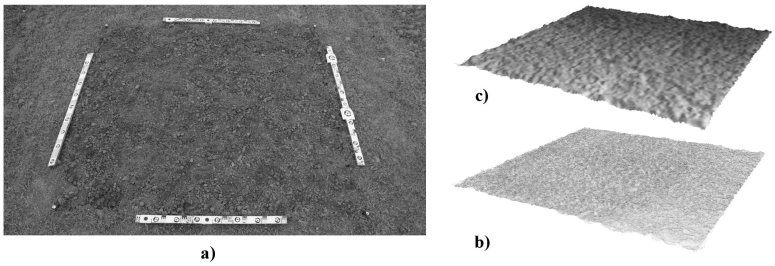

Figure 3. Straightened surface - (a) the plot, (b) a cloud of points, (c) grid (Šinka, 2010)

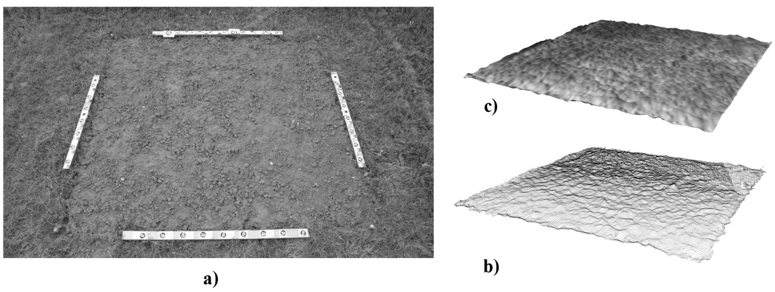

Figure 4. Straightened surface after rain - (a) the plot, (b) a cloud of points, (c) grid (Šinka, 2010)

Digital elevation models (DEM) were interpolated with very high resolution (1 mm) from measured point elevations. To remove any general slope effect, we considered the

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height residuals "z" from the plane (not "z" as absolute altitude). The value of random roughness index was determined through the calculation of the standard deviation from DEM and it reached 31 mm for rugged surface, 19 mm for straightened surface and 17 mm for straightened surface after rain. Rainfall of 267 mm on the site (3x3 m) did not cause overland flow, since its contributing area was densely grassed. This implies that a reduction in roughness value from 19 to 17 mm was solely due to the impact of raindrops. In order to express the impact of overland flow on the soil surface roughness (and vice versa), it will necessary to define more research sites with different land uses of their contributing areas (narrow row and wide row crops, permanent grassland, etc.) and carry out the research for several years.

Conclusions

Value of random roughness obtained by photogrammetric scanning is 31 mm for rugged surface, 19 mm for straightened surface and 17 mm for straightened surface after rain. Recalculating this random roughness values to Manning (Basin) roughness coefficient, it is possible to include them into formulas of surface runoff characteristics determination.

Acknowledgements

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This study was supported by the grant agency KEGA 037SPU-4/2011, KEGA 020/SPU-4/2011 and APVV 0139-10.

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WATER USE EFFICIENCY, THE PHOTOSYNTHETIC PARAMETERS AND THE QUALITY OF WINTER WHEAT

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Abstract: The environmental adaptability of crop production is basically determined by the selection of biological background (plant species and varieties) suitable for the region and the site. The aim of our work is to parametrize the water use efficiency, the plant assimilation, its intensity, dynamics and the most important characteristics and the relationships to the quality in winter wheat trials. The measurements were carried out at the research site of the University of Debrecen in small parcel experiments. We measured the leaf net CO_2 assimilation rate, stomatal conductance, intercellular CO_2 level, the transpiration, the leaf temperature and the air temperature by LICOR LI-6400 portable photosynthesis system in field trials on the nutrient supply. The soil of the experimental area is calcareous pseudomiceliar chernozem with favorable water regime. We have examined the assimilation parameters, the productivity and quality of winter wheat varieties. We have compared the yield results, at similar agrotechnical conditions at different nutrient supply levels in seven years. We have defined the connections between assimilation parameters, water use parameters, the yield and quality parameters of wheat varieties also.

Keywords: wheat, quality, photosynthesis, water use

Introduction

Our research objectives were to determine the relationships between the nutrient supply, the photosynthetic parameters, yield quantity and quality of different winter wheat varieties via small- plots field trial on nutrient supply. From the external elements, the climatic conditions have the largest effect. We examined the photosynthesis of winter wheat at different nutrient supply in seven years. Researchers studied the influencing factors of the photosynthesis system of the crops from different aspects.

Bindraban (1999) found that the photosynthesis of wheat depends mainly on the light intensity and the effect of nitrogen supply is low. Vidal et al. (1996) estimated, that in consequence of the tripling the light intensity, the photosynthesis intensity was doubled. Shangguan et al. (2000), Futó (2003) agreed that the nitrogen and water supply have great effect on the photosynthetic gas exchange. The higher nitrogen supply lowered the water use efficiency of the plants and the net photosynthetic rate decreased. The effect of nitrogen nutrition on photosynthetic characteristics was not identical under different water status.

Fernandez et al. (1996) monitoring physiological parameters (leaf water potential, leaf conductance and net photosynthesis rate) showed that water relationships of maize were not affected by the reduced N fertilization. Plant reproduction is sensitive to water deficits, and in maize the water deficits inhibit photosynthesis (Boyer-Westgate, 2004). Under N stress photosynthesis was reduced by a decreased light absorption and by the decreased utilization of assimilates (de Groot et al., 2003). Schmitt-Edwards (1981) data indicate that C_4 species maize had greater nitrogen use efficiency than either the two C_3 species examined. Csajbók et al. (2007) write that the differences between plant species in photosynthesis were significant but not in every cases. Changing the illumination intensity caused significant differences in the net photosynthesis rate. The CO_2 assimilation of the maize was higher than potato or winter wheat above 500 μmol photon $m^{-2}s^{-1}$ light intensity.

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Materials and methods

The varieties belong to different ripening class under uniformed technology in 7 years between 2001 and 2007. The observation was carried out at the Látókép Plant Cultivation Research Site of the Centre for Agricultural and Applied Economic Sciences, University of Debrecen. The soil of the experimental area is calcareous pseudomiceliar chernozem. The soil specific plasticity index (K_A) was 43, the pH value was nearly neutral (pH_{KCl}=6.46). Examining the water conditions of the soil, it can be stated, that it is typical to the chernozem soils, i.e. has favorable water regime, excellent water holding capacity (808 mm in the 0-200 cm layer), unavailable water content is 295 mm in the 0-200 cm layer, the amount of disponible water in saturated state is 513 mm in the 0-200 cm layer of which 342 is readily available. The watertable is at 8-10 meters depth. The small-plot experiments were set up in split-plot arrangement with four repetitions. In each experimental year we applied the same fertilizer dosage. The forecrop was sweet corn in each year. The gross area of a parcel was 18 m^2 in the split-plot design. In the experiment we have tested the following wheat varieties: GK Öthalom (2001-2007), Lupus (2001-2007), Fatima 2 (2001-2005), Mv Mazurka (2006-2007).

Assimilation parameters were measured in the field with a LICOR 6400 portable photosynthesis system. We measured the leaf net CO_2 assimilation rate, stomatal conductance, intercellular CO_2 level, the transpiration, the leaf temperature and the air temperature, air pressure. We used 2000 μmol photon m^{-2} s^{-1} photosynthetic active radiation (PAR) with 90% red (630 nm) and 10% blue (470 nm) light. We measured six times per leaf, in four repetitions. Water use efficiency % (WUE) and water use coefficient (WUC) was calculated from the net photosynthesis rate and transpiration. WUC means the amount of transpirated water for 1 g CO_2 assimilation. The measurements of quality parameters were performed at the Institute of Food sciences, Quality assurance and Microbiology, Centre for Agricultural and Applied Economic Sciences, University of Debrecen. The values of wet gluten contents, gluten elasticity values, farinograph index and the Hagberg Falling Number were determined according to the Hungarian standards (MSz ISO 5531: 1993, MSz 6369-5: 1987, MSz ISO 5530-3:1994 and the MSz ISO 3093: 1995, respectively).

We analyzed and evaluated the data of experimental results with the SPSS 13.0 statistical software package. The accuracy of the statistical analysis were given at the level of LSD5% according to the method of Sváb (1981).The results were evaluated with analysis of variance, and Pearson's correlation analysis. Weather of the experiment years was very different. There were unfavorable weather conditions i.e. long drought periods in 2003 and 2007, with weaker vegetative developments and low yields, favorable weather conditions with excellent vegetative developments and excellent yields in 2004 and 2005, nearly average weather conditions with fairly good yields in 2001, 2002 and 2006.

Results and discussion

Comparing the data of varieties, we can see that there are significant differences in the net photosynthesis rate between the varieties in all of the seven years with 5% error level. After data processing we found that there were significant differences on P=0.1% level in the net photosynthesis, the stomatal conductance and transpiration between the nutrient levels in every year. The photosynthesis intensity of Mv Mazurka variety was remarkably higher than the others at better nutrient supply levels.

The maximum photosynthetic activity was detected at $N_{60}P_{45}K_{53}$ kg ha^{-1} in case of the four varieties (*Figure 1*). The photosynthetic gas exchange parameters of wheat are remarkably improved by nutrient supply in well watered conditions. The water stress through decreased stomatal conductance has significant negative effect on the assimilation parameters. We measured highest photosynthetic intensity in 2005 and 2004 years. In these years was favorable weather conditions and the yield was the highest. According to the evaluation of the quality parameters it can be stated that the wet gluten content of Mv Mazurka was the highest on every fertilizer level in average, but it was only in 2006, 2007 in the experiment. There are no significant differences between GK Öthalom and Lupus in the Hagberg Falling Number, Mv Mazurka has the highest values (436-475 s) and the Fatima 2 the lowest (278-312 s).

Table 1. Correlations between the fertilization, the yield, the quality, and the assimilation parameters of wheat (2001-2007, Debrecen)

	Yield	Photo	Trans	WGC	GEV	Farin	Fall	WUE %	WUC cm^3 g^{-1}
Fert	0.81*	-0.01	0.28	0.54*	0.47	0.60*	0.21	0.29	-0.002
Yield	1	-0.03	0.66*	0.27	0.24	0.30	-0.10	-0.03	0.29
Photo		1	-0.41	0.69*	0.54*	0.51*	0.78*	0.55	-0.56*
Trans			1	-0.21	-0.24	-0.21	-0.58*	-0.54*	0.66
WGC				1	0.85*	0.93*	0.85*	0.58*	-0.48
GEV					1	0.92*	0.64*	0.47	-0.26
Farin						1	0.76*	0.57*	-0.47
Fall							1	0.68*	-0.84*

Pearson- correlation coefficients, * Correlation is significant at the 0.05 level (2-tailed).

Fert: fertilization doses, Photo: photosynthetic activity, Trans: transpiration, WGC: wet gluten contents, GEV: gluten elasticity values, Farin: farinograph index, Fall: Hagberg Falling Number, WUE:water use efficiency, WUC: water use coefficient

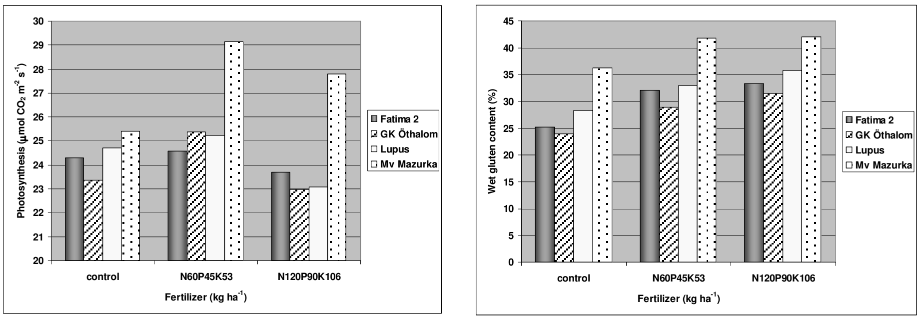

Figure 1. Photosynthetic activity and wet gluten content of winter wheat varieties (2001-2007 Debrecen)

Coming up to our expectations the fertilization has significant effect on the yield (r=0.81) and also the quality parameters (r=0.21-0.60). There was no correlation between the net photosynthesis rate and the fertilization level (r=-0.01) and was weak correlation between the transpiration rate and fertilization (r=0.28). Our measurements

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show strong connections between the measured quality parameters of winter wheat. There is very close, positive, significant correlation between the wet gluten contents and farinograph index (r=0.93), between the gluten elasticity values and farinograph index (r=0.92). There is close, positive, significant correlation between the wet gluten contents and the gluten elasticity values (r=0.85), between the wet gluten contents and the Hagberg Falling Number (r=0.85), between the farinograph index and the Hagberg Falling Number (r=0.76). There is medium positive correlation between the gluten elasticity values and the Hagberg Falling Number (r=0.64).

As we analyzed the correlations between the assimilation parameters and the yield and quality of wheat, we could see that there is no correlation between net photosynthesis rate and yield (r=-0.03), but there is medium, positive, significant correlations between the transpiration level and the yield (r=0.66). There are medium to close correlations between the net photosynthesis rate and the quality parameters. There is close, positive, significant correlation between net photosynthesis rate and the Hagberg Falling Number (r=0.78). There are medium, positive, significant correlations between the net photosynthesis rate and the wet gluten contents (r=0.69) the farinograph index (r=0.51), and the gluten elasticity values (r=0.54).

Between the transpiration values and the Hagberg Falling Number there is negative medium correlation (r=-0.58). That means, that the better water conditions could cause higher enzyme activity and lower falling number in winter wheat- as show the results of our experiments. There is close, negative, significant correlation (r=-0.84) between Hagberg Falling Number and water use coefficient (WUC).

Conclusions

The results show that there are significant differences in the net photosynthesis rate, the stomatal conductance, the transpiration and water use efficiency between the varieties and can be found significant differences also between the nutrient levels in every year.

Our measurements show strong connections between the measured quality parameters of winter wheat varieties. There are medium to close correlations between the net photosynthesis rate, the water use parameters and the quality parameters.

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EXAMINATIONS ON CHINESE SILVER GRASS (*MISCANTHUS SINENSIS*) RHIZOMES WITH DIFFERENT QUALITIES IN SMALL PLOT EXPERIMENTS

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Abstract: Rhizomes with different qualities (length, bud number) were examined in small parcel experiments under watered and non watered conditions then the establishment of the Miscanthus stand was analyzed. It was concluded that under given weather conditions emergence became quicker as a result of watering, in June, however, no statistical difference appeared between watered and non watered parcels. In case of "A" rhizomes the rate of establishment was more than 97%, in case of "B" rhizomes this value was above 86% according to our observations. Hereby it is justified that mechanical slicing of rhizomes and classification after picking them up that significantly enhance the costs of propagation material production do not mean statistically proved benefit in the establishment of a Miscanthus stand under appropriate water supply.

Keywords: Chinese silver grass, rhizome, biomass energy

Introduction

According to our previous researches Miscanthus is not particularly demanding about soil requirements, it can be produced successfully even in areas with not so favourable characteristics and temporary water pressure (Mikó, 2007). Its water demand is similar to that of corn that is approximately 500-600 mm per year (Beale et al., 1997). Seeds of the plant are sterile hence it can only be propagated vegetatively (by its seedlings or rhizomes) (Heaton et al., 2004). The development of a proper Miscanthus stand is supported by good soil preparation, planting in the optimal period (from the end of March until the middle of May) and the acquisition of good propagation material (Jones, 2004). Determining the quality of rhizomes as propagation materials however, is more difficult than in the case of seed grains (Fogarassy, 2001).

According to the relevant literature the most important quality indicator parameters are rhizome length and the number of buds on it (Lewandowski et al., 2003). Production of propagation material can be done by hands, the disadvantages of which are a great demand for manpower and slowness, thus production is strongly limited while the size of reproductive material is more homogenous. On the other hand, through a mechanical removal of rhizomes, heterogeneity of reproductive material can cause problems. Additionally, subsequent classification enhances the costs of production. (Pósa et al., 2011). In the international literature, size of rhizomes suitable for cultivation is indicated as 10-15 cm, however, as was mentioned above, this size can be provided only with a significant extra cost (Lewandowski et al., 2003).

In an experiment set by the Institute of Crop Production, Szent István University (Gödöllő, Hungary) two propagation materials that possessed different parameters, derived from the same habitat and were given the same treatment have been compared under watered and non watered conditions.

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Materials and methods

Small plot experiments were set in Gödöllő, Pest County in 2011, in randomized block arrangement in sandy loamy soil with good water management. KA (Arany-fixity):34, humus content was between 1.9 and 2.3%. Spring in 2011 had an average water supply, hence no significant difference was found in the soil layer laying in 10-20 cm depth while the moisture content of the soil was being measured. Pre-emergence irrigation presumably has greater significance in a dryer year (e.g. in 2009).
3-5 cm long rhizomes with a maximum of 3 buds (B) and 6-10 cm long rhizomes with a maximum of 5 buds (A) have been compared in small plot experiment (3 m^2 per plot) under watered (W) and non watered (NW) conditions in 3 repetitions. The establishment process was conducted on 13 May 2011, when 15 rhizomes were established per plot. The distance between two plants and two rows was uniformly 50 cm. Soil was irrigated on 13 May 2011 and 26 May 2011. Each and every time 10 mm water was spread per plot. Measurement of soil moisture was carried out one day after the irrigation using PT-1 type humidity analyzer based on electrical conductivity. Number of plants and shoots per plant were being monitored in each plot in every week along the entire vegetation season. For data evaluation Microsoft Excel 2010 program and analysis of variance were used.

Results and discussion

Table 1. shows soil moisture values per week during one month following the establishment. For Miscanthus the moisture content of soil in 10-20 cm depth is an essential factor, therefore the rhizomes had been put in that particular depth and the majority of them remained there subsequently. It can be concluded that when the establishment occurred (14 May 2011) the moisture content of soil in the given depth was 26 mass percent (*Table 1.*), that enabled the first shoots to appear only one week after they were planted. The moisture content of subsoil is sufficient (26.6-30.1 mass percent). There was no significant difference in moisture content between the watered and non watered plots (about 1%), yet the average number of plants in watered plots was higher in the case of both rhizome types (A, B).

Table 1. Values of soil moisture measurements (mass percent)
Gödöllő, 2011

	14.05.2011		27.05.2011		04.06.2011		11.06.2011	
	W	NW	W	NW	W	NW	W	NW
2 cm	22.2	20.2	13.3	7.7	6.8	5.6	4.2	4.4
10 cm	**25.9**	**25.7**	**25.6**	**24.2**	**22.8**	**21.6**	**24.1**	**24.6**
20 cm	**26.4**	**25.9**	**26.8**	**24.8**	**28.0**	**24.5**	**25.9**	**26.6**
30 cm	27.3	26.6	28.5	26.7	26.8	27.2	28.7	29.1
40 cm	28.7	28.3	31.3	29.6	29.4	29.0	31.5	31.6
50 cm	30.2	30.1	31.7	31.0	31.6	30.9	32.4	32.0

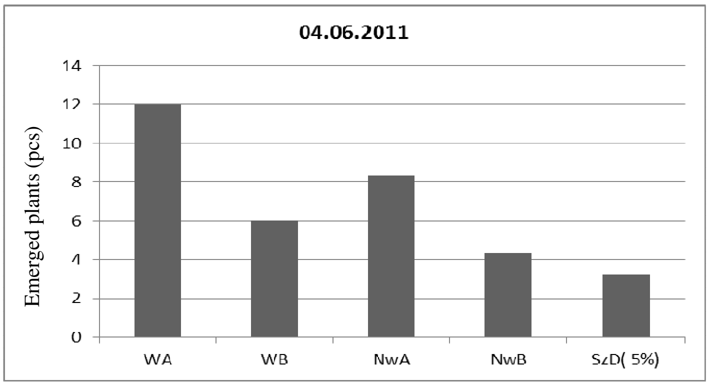

Figure 1. Number of emerged Miscanthus plants, means of plots
Gödöllő

Figure 1. shows the average plant number per plot on the 21st day after the establishment. The highest plant number was counted in WA plots (12 on the average). Significant difference was found between WA and WB plots, since half of Miscanthus plants was counted on the average in WB plots than in WA plots. Comparing WA and NwB plots it can be established that the rate of emergence in the watered area was 30% higher than in the non watered area that can be supported by statistics as well. Between WA and NwB plots no significant difference have appeared, while in watered plots the rate of emergence was 38.46% higher on the average. Under non watered conditions nearly double the number of rhizomes emerged in NwA plots than in NwB plots. Moisture content of soil in the rooting zone was 21.6 - 28 mass percent.

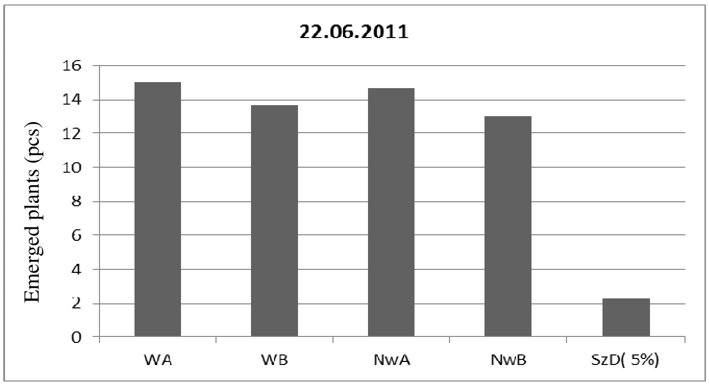

Figure 2. Number of emerged Miscanthus plants, means of plots
Gödöllő

Figure 2. represents the average number of emerged plants on the 39th day after the establishment. In the figure it is seen that no statistical difference can be revealed among the plots. In the case of 10 cm long rhizomes (plots W1 and Nw1) the rate of

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emergence reached 97.77-100%, while in the case of 5 cm long rhizomes (plots W2 and NW2) this rate was 86.66-91.11%.

Conclusions

According to the experimental results we came to the conclusion that spring and early summer months with an average water supply equalize the germination of propagation materials (rhizomes A and B) with different parameters and so the establishment of Miscanthus. Although rhizome with more and longer buds (A) emerged sooner and more dynamically after putting into the soil making the number of emerged plants statistically provably higher in the first month, this benefit disappeared on the occasion of the plant count on 22 June 2011 and no significant difference appeared then in emergence between both rhizomes types.

In case of "A" rhizomes we observed 97% establishment, while in case of "B" rhizomes this rate was above 86%. Pre-emergence irrigation makes emergence safer and provides initial benefit, but this benefit is also moderated and remains under significance threshold at the 25 mass percent soil moisture content measured in this experiment in a 20 cm soil layer. Presumably this benefit will become more definite in a drier year.

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IMPACT OF MINING ACTIVITY ON SURFACE WATER QUALITY AND FLORA DIVERSITY

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Abstract: The quality of water in surface streams is influenced by various anthropogenic and natural factors. Mining activities on the surface and in underground and by-products of these activities significantly affect contamination of soil, water and air and bring about irreversible changes in georelief and country. Accumulation of mining debris and its storing resulted in creation of mullock heaps and sludge beds, wherein the leaching of waste material, seepage and contamination of surface and underground waters („blue water“) caused by heavy metals takes place; with consequent turning in "green water", which is reflected in specific vegetation of the mullock heaps. The study concentrates on evaluation of selected indicators of surface waters quality (presence of heavy metals: Cu, As, Cd, Pb, Ni, Cr, Fe, Co) and diversity of synanthropic vegetation in the Slovinský brook drainage basin in former mining region of Middle Spiš (48°52´961´´N; 20°51´038´´E). Samples of surface water were taken in 2010 and 2011 on five sites and values of heavy metals were determined by atomic absorption spectrometry. Flora diversity was evaluated according to the Braun – Blanquet´s scale. In the samples, excessive values of copper, arsenic, iron and quicksilver were determined. With regard to synanthropic vegetation in the studied area, dominant abundance of *Agrosis tenuis*, *Rumex acetosella*, *Silene inflata*, was recorded. All species have wide ecological valency and heavy metals resistence are important for colonisation of mullock heaps.

Keywords: heavy metals, contamination of water, mining activity, synanthropic vegetation

Introduction

Among human activities, mining is responsible for contamination of water and soils in large areas of the globe (Liu et al., 2005; Abreu et al., 2008). Changes of landscape can be expressed through the information about number, intensity and diversity of relations among system's components (Ivanová et al., 2011). Long-term mining activities and industries focused on the processing of mining products is signed significantly to pollution of surface waters (Torma and Fazekašová, 2007; Samešová and Ladomerský, 2003). Waste material heaps with a high content of heavy metals are often accumulated close to the watercourses. Seepage of contaminants into surface and groundwater reduces water quality and impacts specific vegetation that grows on the toxic substrate. Specific communities of plants are indispensable for rehabilitation of polluted sites. The research area was the Spiš territory, according to archaeological and archival documents known to intensive mining, mineral processing and metallurgy activities (Brehuv et al., 2004), with the aim to assess the state of the Slovinský brook pollution with heavy metals (Cu, As, Cd, Pb, Ni, Cr, Fe, Co) and determining the diversity of flora growing in the area along the stream.

Materials and methods

Slovinský brook flows through the two former mining sites Krompachy and Slovinky, one of the largest deposits of copper ores in Spiš (Čech et al., 2011). According to the hydrological division Slovinský brook belongs to the field of sub-basins 4-32 Hornád and basic basin 4-32-01 Hornád under Hnilec. According to the type of discharge (Šimo

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and Zaťko, 1980) it belongs to the highlands with snow-rain regime type of discharge. Characteristics of the Slovinský brook basin are shown in the *Table 1.* Fieldwork was conducted in 2010 and 2011 and was focused on surface water quality and diversity of flora. Surface water samples were taken at five different sites in Slovinský brook (1. runoff from mine [48°52'961"N; 20°51'038"E], 2. heap [48°51'803"N; 20°49'163"E], 3. above water house [48°51'397"N; 20°48'402"E], 4. populated area [48°54'741"N; 20°52'420"E], 5. confluence of Slovinský brook and Hornad river [48°55'201"N; 20°52'236"E]). All of the five sites are located within the 9 km portion of this brook. Collection and water treatment was performed according to the methodological guidelines of the Ministry of Environment of the Slovak Republic. The heavy metals (Cu, As, Cd, Pb, Ni, Cr, Fe, Co) were determined by AAS method in an accredited laboratory. The results were compared with values of heavy metals in samples that were collected at the same sampling sites in 1985. We recorded the species composition of flora in the proximity of the sampling sites. On the research localities was in 2011 performed a semi-quantitative analysis of present taxa on an area of 16 m^2. Frequency and cover of species population was determined by estimation based on the seven - stage combined scale by Braun - Blanqueta (1964). Nomenclature of plant taxa is listed by Madhold and Hindák (1998).

Table 1. Characteristics of Slovinsky brook basin

Basin area [km^2]	Length of the valley [km]	The highest point of basin [m.a.s.l.]	Riverhead altitude [m.a.s.l.]	The lowest point of basin [m.a.s.l.].	Precipitation [mm]	River runoff [mm]	Average flow [$m^3.s^{-1}$]
78,59	16,1	1127	1050	367	855	197	0,49

Results and discussion

According to the normative values of the Government Regulation in Slovakia about quality of surface water, the water samples from Slovinský brook exceeded the limit values of Cu, As, Pb and Fe. The value of Cu was the highest in the third site in 2011. The limit value for copper was here exceeded more than sevenfold. In comparison with the previous years, this value is extremely high. Excessively high levels of Pb and Fe were recorded in the same site in 2011. The Pb value exceeded the limit value almost fivefold more and Fe was three times higher. In the immediate vicinity of the third site, a heap of waste material is situated. Currently, close to the heap there is an intensive forestry activity that is likely to undermine the stability of the heap, causing excessive release of contaminants into the water stream. High values were measured throughout the period at site 1., it is a place of direct discharge of water from the mine that flows into Slovinský brook in a few meters. The biggest changes were determined on the third site in the long run, with extreme increase of As, Pb and Fe values since 1985. The As value on site 1. consistently remains above the permissible limit value. In comparison with year 1985, the values of As (loc.4.) and Pb (loc.1.) have increased. As well as Bálintová at al. (2010) recorded, our results confirm, the long-term mining activities in Spiš region have negative impact of surface water contamination by heavy metals. The observed values of heavy metals are reported in *Table 2.*

Table 2. The measured values of heavy metals in Slovinský brook [mg.l^{-1}]

Locality	Year	Cu	As	Cd	Pb	Ni	Cr	Fe	Co
1.	1985	14	251	0,3	5	7	2	0,6	7
	2010	0,5	176	0,3	5	2	2	0,189	3
	2011	4	237	0,3	16	2	2	0,634	2
2.	1985	10	12	0,4	5	13	2	0,6	7
	2010	3	3	0,3	5	2	2	0,059	2
	2011	6	3	0,3	5	2	2	0,059	2
3.	1985	2	2	0,3	5	2	2	0	2
	2010	2	1	0,3	5	2	2	0,067	2
	2011	148	2	1,2	95	3	2	6,56	2
4.	1985	2	16	0,3	5	6	2	0,1	3
	2010	3	14	0,3	5	2	2	0,092	3
	2011	7	33	0,3	5	2	2	0,085	2
5.	1985	2	21	0,8	5	3	2	0	11
	2010	4	14	0,4	5	2	2	0,103	2
	2011	5	26	0,3	5	2	2	0,098	2
limit value *		20	20	1,5	20	20	50	2	50

* Source: Government Regulation SR č.269/2010 Z.z. 329

For the survival of plants on toxic substrates, the ability of adaptation is very important. Some plant species produce so-called tolerant ecotypes in which tolerance to one or more heavy metal is genetically fixed. Identified floristic relationships at the individual localities are closely related to the different ecological conditions of habitats. A common feature of all sites was the occurrence of species that are known to be resistant to heavy metals (*Agrostis capillaris, Silene vulgaris, Arabidopsis arenosa, Vulgarities acetosella, Agrostis stolonifera*). According to our findings, we can confirm that the species that we recorded in the Slovinský brook basin coincide with the species, which in the area Banásová (1976) recorded. The greatest species diversity was found at the confluence of the Slovinský brook and Hornád river and there was found and identified the incidence of invasive species (*Helianthus tuberosus* a *Solidago gigantea*). The species composition of plants in the Slovinský brook basin processed upon registration is shown in *Table 3*.

Conclusions

Mining and industrial activities in Slovinský brook basin have a negative effect on the pollution of surface waters and flora composition. In the long term view, the values of heavy metals is stabilized below the limit values, with the exception of sites occurring near the heap, where intensive forestry activity might have probably impaired the stability of the heap. The below-limit values remained unchanged in a long - term in the place of confluence of the Slovinský brook and Hornád river, where there is the place of dilution of contaminated water. There has been a dominant presence of plant species with wide ecological valence and resistance to heavy metals (*Agros tenuis, Rumex acetosella, Silene inflata*), which are important in settlement activities at ore heaps, as well as the presence of invasive species (*Helianthus tuberosus and Solidago gigantea*).

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Table 3. The species composition of flora in the Slovinský brook basin.

Location	Altitude [m.a.s.l.]	Species
1.	459	*Dryopteris filix-mas* +, *Chrysosplenium alternifolium*+, *Silene vulgaris* +, *Agrostis stolonifera* r *Arctium lappa* r
2.	587	*Agrostis capillaris* 1, *Poa pratensis* 1, *Avenella flexuosa* +, *Luzula luzuloides* +, *Arctium lappa* r, *Arctium tomentosum* r,
3.	568	*Anthriscus sylvestris* 1, *Dryopteris filix-mas* 1, *Carex acuta* +, *Geranium palustre* r, *Chrysosplenium alternifolium* r, *Silene vulgaris* r
4.	392	*Bellis perennis* 1, *Poa pratensis* 1, *Potentilla anserina* 1, *Plantago lanceolata* r, *Taraxacum officinale* +, *Trifolium pretense* +,
5.	367	*Avenella flexuosa* +, *Helianthus tuberosus* +, *Chenopodium album* +, *Poa pratensis* +, *Solidago gigantea* +, *Tanacetum vulgare* +, *Taraxakum officinale* +, *Trifolium pretense* +, *Arctium x ambiguum* r, *Juncus effusus* r, *Potentilla anserina* r, *Viola trikolor* r

1 – plant cover under 5%, + plant cover negligible , r - rarely

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ASSESSMENT OF WATER BALANCE IN APPLE AND PEAR TREES BASED ON A LYSIMETER EXPERIMENT

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Abstract: Over the past few decades the variability of climatic factors had direct and indirect effects on agricultural and horticultural production. Due to the amount and the more extreme spatial and temporal distribution of rainfall, the water regime of plants can get unbalanced. Nevertheless the high quality and quantity fruit production could be provided only with optimal water supply. Knowing the transpiration tendency of fruit trees, a water and energy saving irrigation system could be worked out. The lysimeters with compensation system operated in the Karcag Research Institute of the Research Institutes and Study Farm of the CAAES of the University of Debrecen provide the possibility to recognise the transpiration dynamics of different fruit tree varieties in each phenological stage. Among the investigated trees the pear variety William's had the highest transpiration. A part of the absorbed water is transpirated through the leaves therefore the determination of the leaf area could help to understand the transpiration process more accurately. Some parameters of the fruit trees and their canopy were determined by means of a Leica ScanStation C10 3D laser scanner, while the gained data were processed and evaluated with Leica Cyclon 7.1 software. The trunk diameter and the canopy extension of the investigated trees were determined on the base of the laser scanning data.

Keywords: transpiration, lysimeter, laser scanning

Introduction

Presently in Hungary less than 100,000 hectares of orchards can be found, from which apple is cultivated on one of the largest areas. Apple and pear orchards cover about 60% of the total pomiculture in Hungary, although in the last period the production was reduced (Gonda and Apati, 2011). Horticulture is a water demanding sector. The data of the Central Statistics Office show that 28% of the apple and pear orchards can be irrigated, but only 21% is irrigated, though high quality fruit-growing is difficult without proper irrigation. Furthermore in some horticultural farms there is no irrigation, or its techniques are improper. There are several experiments going on around the world to develop the methods of irrigation in order to elaborate different technology combination for water and energy saving micro-irrigation. One of the biggest professional challenges of the following years is to develop the water resource management for apple and pear trees. For this we have to identify the water demand of the trees in the different phenological stages, the irrigation turns, the watering technology and the transpiration surface. Lysimeter systems, developed remote sensing and global information technologies (GIS) - which are less spread in horticulture - could help to solve this problem.

A lysimeter is a soil column covered by green vegetation, which is placed in an appropriate container and in natural environment, and suitable to determine any part of the water balance equation, if the remaining parts are known (McIlroy and Angus, 1963).

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The status and water regime of the soil (Várallyay, 1978) as well as the plant transpiration have a great importance in consideration of yield production (food safety), or irrigation. If the plant transpiration in the different phenological stages is determined, the amount of the required irrigation water can be estimated. Several studies have already shown that lysimeters are effective tools to examine the effect of water and material flow in recent and future land use methods (Meissner et al., 2000; Zsembeli, 2002; Zsembeli et al., 2011).
The plants are transpirating the uptaken water through their leaves. Knowing the leaf area a more accurate picture could be obtained from the relationship of the transpiration surface and the water loss. There are several widely spread methods to measure the leaf area (Ross, 1981; Bognár, 2003), but most of these are slow and invasive techniques. Nowadays, thanks to the increasing technological development, remote sensing tools and methods have spread in the determination of leaf area (Cohen et al., 2003). Laser scanning is an active remote sensing system to collect information from the investigated object in a fast, accurate and non-destructive way (Huang and Pretzsch, 2010).

Materials and methods

On 1st March 2010 2 pear (*Bosc kobak* and *William's*) and 1 apple varieties (*Regal Prince*) were planted in 3 replications into 9 lysimeters with compensation system of the lysimeter station of the Karcag Research Institute of the Research Institutes and Study farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen. Each lysimeter has a surface area of 0.8 m^2 and depth of 2 m. The permanently maintained groundwater level is at the depth of 90 cm serving as the water supply (subsurface irrigation) of the trees in dry periods. The soil surface was covered with plywood that impeded evaporation getting out and natural precipitation getting into the soil. Therefore the amount of water used from the supplying container equals the transpiration of the fruit trees.
Before the fall of them we collected the leaves from the investigated trees (3rd November), then each of them was scanned with an Area Meter 100 (ADC AM 100) developed by the Analytical Development Company. Thus the number and the surface area of the leaves were determined too.
For further investigation of the fruit trees we used an active remote sensing instrument in data acquisition. On 3rd September (fully developed canopy condition) we carried out a terrestrial 3D laser scanning measurement. The ScanStation C10 by Leica Geosystems uses the time-of-flight (TOF) principle for ranging. The light waves travel with a finite and constant velocity in a certain medium. Therefore, on the base of the time delay created by light travelling from a source to a reflective target surface and back to the source (round trip) their distance can be calculated. The scanner sweeps along the examined object with a green laser light. The laser beam deflection is occurred by a Smart X-Mirror™. This is an automatic fast spins polygon mirror system, which provides creating a point cloud composed of millions of points.

Results and discussion

The detecting of the transpiration values was begun at the end of June. The first intensive growing stage of canopy has approximately ended by this time and evolved the 70-80% of the foliage. The transpiration values were detected weekly till mid-October. The cumulative transpiration of the investigated fruit trees was compared (*Figure 1.*) in order to characterize the water use of them. The number (in parentheses) after the name of each fruit tree variety indicates the number of the lysimeter where the variety was planted.

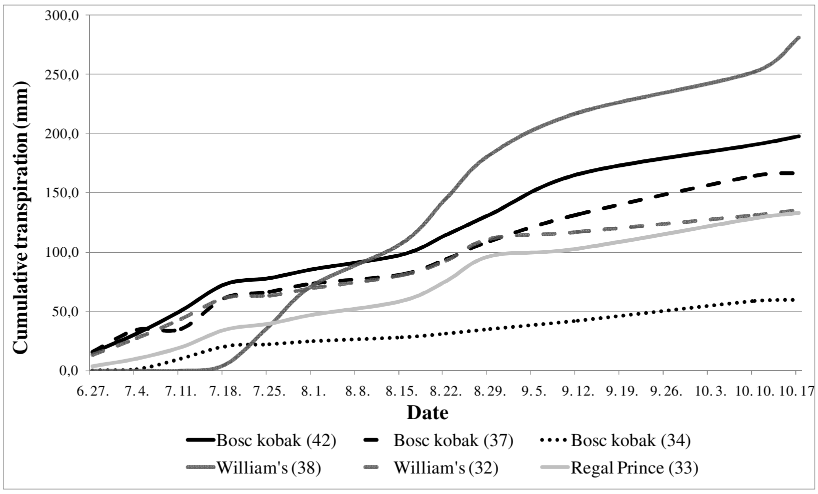

Figure 1. Cumulative transpiration of the investigated fruit trees

Three fruit trees from the nine planted in 2010 died (one *William's* and two *Regal Prince*), therefore these three lysimeters were replanted in 2011. Naturally no transpiration data were gained valid for these trees in 2011.

On the base of the cumulative transpiration values it could be established that the trees had a different transpiration characteristics. It is worth to compare the cumulative transpiration of investigated fruit trees with the leaf area, since the water loss practically happens only through the leaves. On the other hand, the individual development of the trees was different, thus the more developed trees have produced a bigger biomass and therefore their water use and transpiration were also higher. Expressing the transpiration values for 1 cm^2 leaf area, the transpiration values can be compared even better. If we divide the cumulative transpiration values of the fruit trees with the leaf area scanned with the ADC AM 100, their water loss per cm^2 can be got as the result. By calculating the average transpiration per a leaf area unit of the trees with the same variety, it can be established that *William's* had the highest (0.032 mm cm^{-2}) and *Regal Prince* with the largest leaf surface area had the lowest transpiration values (0.018 mm cm^{-2}) regarding the examined tree varieties.

As the detecting frequency of transpiration was weekly, the increase of transpiration on July 18th and on August 29th must be correlated to the weekly heat amounts. Between

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these two dates no significant increase of transpiration could be detected, since a more than 8°C decrease of air temperature was experienced.
The terrestrial laser scanning survey from the lysimeter station provided the opportunity to recognize the 3D structure of the fruit trees. The cleaning of the point cloud was carried out with Leica Cyclone 7.1, which is the own software of Leica ScanStation C10. Then it was very simply and fast to determine the trunk diameter, the tree height, the canopy expansion, etc.

Conclusions

The changing weather conditions and the less and less precipitation make the yield generation uncertain in orchards too. The transpiration dynamic of fruit tree varieties in the different growing stages are increasingly important in horticulture, because the optimal amount and timing of irrigation can provide the harmonic development of trees and proper fruit quality and quantity. By determining the leaf area and the transpiration we have identified the tree variety with the highest transpiration. Further experiments planned in order to determine the leaf area, thus the transpiration area with laser scanning technology.

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EFFECT OF WATER SUPPLY ON THE NO_3-N TURNOVER IN LONG- TERM MINERAL FERTILISATION EXPERIMENT

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Abstract: Water, the base of life on Earth, is an essential element of the plant-soil system. After integrating into the organisms, it can also be referred to as green water. When in the soil, this essential element is known as ground water and its quantity is mainly depends on rainfall. As for plants, nitrate is a highly important form of nitrogen. On the other hand, it carries risk.
A certain amount of nitrate is washed out from the plant-soil system due to top-to-bottom water movement. Since Nitrate diffuses in the soil solution, it can reach the deeper layers of the soil moving together with ground water, thus it is potentially dangerous to drinking water resources. The plant-soil system is to be examined with respect to these two phenomena.
The level of nitrate seepage is determined by the amount of nitrate accumulated in the soil, the dosage of N-fertilization and the amount of rainfall. In our research, we determined the movement of nitrate in the case of different N-dosage (0, 80, 160, 240 kg•ha^{-1}) by drilling down to 3 m, with samples of 20 cm layers. In order to make the N-account of the soil, we measured the yield and N-take of the crop.

Keywords: nitrate washed, mineral fertilization

Introduction

The minimisation of environmental pollution from N fertilisation, the need to adjust N fertilisation top plant requirements and the elaboration of a precision recommendation system for N fertilisation all require the N regime and N-supplying ability of various soil to be estimated as accurately as possible under various ecological and technological conditions (Izsáki and Iványi, 2002).
The soil N regime, the accumulation and leaching of NO_3-N are influenced by numerous factors, such as N fertilisation practice, plant N uptake, the N-supplying ability of the soil, ecological factors, cultivation technology, and farming and soil use methods (Kádár and Németh, 1993; Kramer et al., 2006; Decrem et al., 2007). The results of numerous long-term experiments confirmed that N accumulation and NO_3-N leaching are primarily due to N fertilisation in excess of plant demands (Németh and Kádár, 1999; Izsáki and Iványi, 2005). The N turnover, and N accumulation, and leaching plant environment is affected by the water supply of territory, the distribution of rainfall and periodical movement of the level of groundwater. In those territories where groundwater can only be found in the deep and moisture cannot penetrate the layer between the surface and the groundwater nitrate can accumulate -even in big amount (Németh and Csathó, 2005). While in those territories where extremely moist and dry periods alternate, major leaching of NO_3-N can be observed (Izsáki, 2010.)
The aim of the experiment is to evaluate the effect the water supply and N fertilisation on the N turnover in chernozem meadow soil on the basis of the results of a long-term experiment between 2008-2011.

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Materials and Methods

The long-term mineral fertilisation experiment was set up at the Experimental Station of Szent István University Faculty of Economic, Agricultural and Health Sciences, Tessedik Campus, in 1989. The soil of the experimental area is a chernozem meadow soil, calcareous in the deeper layers, with the following main properties at the beginning of the experiment: depth of the humus layer 85-100 cm, $pH_{(KCl)}$ of the ploughed layer 5.0-5.2, humus content 3.0-3.2%, $CaCO_3$ content 0%, upper limit of plasticity according to Arany (K_A) 50, clay content 32%. The mean groundwater depth was 300-350 cm.
The mineral fertiliser treatments involved all possible combinations of four levels each of N, P and K, giving a total of 64 treatments, laid out in three replications in a split-split-plot design with a sub-sub-plot size of 4x5= 20 m^2. One aim of the experiment was to examine the effect of N fertilisation on plant nutrient uptake and yield, the mineral N content and N-supplying capacity of the soil, and NO_3-N leaching. The N fertilisation rates were N_0=control, N_1 =80; N_2=160; N_3=240 kg·ha·year^{-1}. The effect of N fertilisation was investigated P_1 (100 kg·ha·year^{-1}·P_2O_5) and K_1 (100 kg·ha·year^{-1}·K_2O) levels.
The crop sequence in the various N regime cycles was as follows between 2008 and 2011: maize (*Zea mays* L.), soybean (*Glycine max* L.*)*, canary grass (*Phalaris canariensis* L.) and winter barley (*Hordeum vulgare* L.).
In order to calculate the soil N balance, measurements were made on the yield and N uptake per plot. Samples of whole aboveground plant organs were taken for N analysis immediately before harvesting from 2x1 m per plot. The N content of the plant organs was determined using the macro-Kjeldahl method.
In order to monitor the migration of NO_3-N was carried out by deep-drilling to depths of 300 cm in 2007 and 2011. Soil samples were taken every 20 cm from three drillings per plot, after which the samples for each level were united. The NO_3-N content was then determined with Kjeldahl method.
The rainfall data of the investigated period (2007-20011) can be seen in *Table 1*.

Table 1. Amount and distribution of rainfall during the experimental period, mm (Szarvas, 2007-2011)

Mounth	Year					
	1901-1975	2007	2008	2009	2010	2011
January	30	19	14	11	71	16
February	32	41	3	30	63	18
March	31	37	48	4	30	29
April	44	3	48	1	64	8
May	59	89	37	16	142	72
June	68	68	155	75	39	73
July	51	43	42	43	60	66
August	52	31	56	38	54	30
September	39	82	37	12	146	0
October	43	62	14	68	31	-
November	49	26	6	118	74	-
December	40	47	4	57	114	-
Total	538	548	464	473	888	-

Results and Discussion

When calculating N balances it is assumed that the N uptake of the crop is derived from fertiliser. When no mineral fertiliser is applied or the N fertiliser does not cover the plant uptake the N balance is negative, indicating a decrease in the original N supplies of the soil.

The investigation results from the period between 1990 and 2007 of the long-term mineral fertilisation experiment set up in 1989 were published by Izsáki (2010). In this paper, we analyse the results of the 2008-2011 period.

In our experimental cycle the N take of the plants was 394 kg·N·ha^{-1} in plots without N fertilisation. At N rate of 80 kg·ha^{-1} was negative, even when at the case of 160 kg·ha^{-1} N fertilisation the rate was roughly balanced. The top dose of N fertilisation (240 kg·ha^{-1}) already resulted a 341 kg·ha^{-1} positive N balance in the course 4 years. When the balance of N-fertilised plots is compared with that of the control plots (Soil balance N-Soil balance N_0) the difference provides information on the extent to which the soil was enriched with nitrogen in excess of plant N uptake. In our experiment the N supply of the soil at N rate of 80, 160 and 240 kg·ha^{-1} theoretically increased by 217, 422 and 735 kg·ha^{-1} (*Table 2.*). On the other had, we could only observe only 9, 7 and 7% in NO_3-N form in the 300 cm soil profile. This can be attributed to the fact that the winter season of 2009/2010 and the autumn-winter of 2010 was very moist (*Table 1.*) and the groundwater rose up to the surface for a long stretch of time, and it went down under 300 cm by the end of the cycle. The movement of groundwater due to the excessively moist and dry periods resulted in the leaching of large amount of NO_3-N.

Table 2. Estimated N balance of the experiment, kg·ha^{-1}
(Szarvas, 2008-2011)

Items of the balance	N application rate kg·ha^{-1}·year^{-1}			
	0	80	160	240
a/ N applied	0	320	640	960
b/ N uptake	394	497	612	619
c/ Soil balance (N applied-N uptake)	-394	-177	28	341
d/ Difference compared to the control (Soil balance N-Soil balance N0)	-	217	422	735
e/ NO3-N in the soil, 0-3 m	29	49	59	78
f/ NO3-N difference compared to the control, 0-3 m	-	20	30	49

When we compare the NO_3-N content of the soil of year 18 and 22, we can see that the NO_3-N content in the soil of year 22 decreased drastically (*Table 3*).

Table 3. Effect of N fertilisation on the NO_3-N content in the soil profile, kg·ha^{-1}
(Szarvas, 2007, 2011)

Depth cm	N application rate kg·ha^{-1}·year^{-1}							
	0		80		160		240	
	2007	2011	2007	2011	2007	2011	2007	2011
0-100	42	15	88	13	121	15	148	33
100-200	35	14	39	24	114	13	107	17
200-300	77	0	106	12	144	21	174	28
0-300	154	29	233	49	379	59	429	78

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Year 18 shows the level of N supply clearly. The maximum of NO_3-N accumulation was found in 200-300cm deep irrelevant of N supply The 160 and 240 N supply increased the NO_3-N content of the soil double as opposed to the control, thus increasing the risk of leaching.
In year 22 NO_3-N accumulation tended to characterise the N supply levels, but not the same extent. In this period 80 % of the NO_3-N accumulated earlier in different layers was leached. Thus when the two year investigated the loss of NO_3-N is as follows: N_0=125 kg·ha^{-1}, N_{80}= 184 kg·ha^{-1}, N_{160}= 320 kg·ha^{-1} and N_{240}= 351 kg·ha^{-1}. The greatest NO_3-N loss was observed at N_{160} and N_{240} supply. The rise and fall of groundwater due to the alternation of extremely moist and dry weather caused major NO_3-N leaching.

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WATER SUPPLY AND FERTILIZERS RESPONSES

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Abstract: The paper reports the results achieved in some long-term fertilization experiments on acid and calcareous sandy as well as on calcareous chernozem soils. Fertilizer responses have been analysed and correlations were examined between fertilizer application, rainfall recorded during the vegetation period and yields. There is also a short historical overview given regarding the soil – water – nutrient – crop yield relationships.

Keywords: fertilization, water supply, calcareous soils, crop yield

Introduction

Historical

There was an ancient saying that "corruption is the mother of vegetation". Yet the early investigations consistently ignored this ancient wisdom when they sought for the principle of vegetation. Thus the great Francis Bacon believed that water formed the "principal nourishment" of plants. Van Helmont (1577-1644) regarded water as the sole nutrient for plants and his son thus records his famous Brussels willow experiment: "…After exactly 5 years I dried the soil and got the same 200 pounds that I started with, less about 2 ounces. Therefore the 164 pounds of wood, bark and root arose from the water above." The experiment was simple and convincing, but the conclusion was incorrect. Two factors had escaped Helmont's notice: the role of air and the missing 2 ounces of soil (In: Russel, 1973).

In 1699, John Woodward setting out from the experiments of Van Helmont grew spearmint in water obtained from various sources. The weight of plant however, increased with the impurity of the water as we can see on *Table 1*. "Vegetables are not formed of water, but of a certain peculiar terrestrial matter" – he concluded and discussed the use of manures and the fertility of the soil from this point of view. The best manures, he continues, are parts either of vegetables or of animals, which ultimately are derived from vegetables (Russel, 1973).

Table 1. Effect of impurity of the water on the weight and transpiration of the 77 days old spearmint plant (Woodward 1699, in: Russel 1973)

Source of water or impurity	Weight of plants, g		Gained weight, g	Used* water, g	Gained weight/ used water
	Put in	Taken out			
Rain-water	1.84	2.97	1.14	195	171
River Thames	1.82	3.51	1.69	162	96
Hyde Park conduit	7.15	16.18	9.03	854	95
Hyde Park conduit + garden mould	5.98	24.44	18.46	972	53

* Transpiration

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P and K fertilizer responses in dry and wet years

In dry years there is a grater response to P and K dressing and the critical PK level in the soil must be relatively higher (in % compared to control) under dry conditions. There is a close correlation between soil water content and PK diffusive flux in soil and PK uptake. Drying out of the arable layer reduces PK availability while water supply from the subsoil may still be sufficient to meet plant demand. Leaching is a special case of mass flow in downward direction caused by a downward hydraulic potential. Its magnitude depends on solute concentration and groundwater recharge (Grimme, 1990).

There are observations from field and pot experiments demonstrating and confirming this theoretical argument. During 11 years of field experiment Bruns (1935) found yield differences between control plots and K fertilized plots to be greatest in dry years. Barber (1959) recorded a varying effectiveness of P and K fertilization from year to year, although P and K contents in the soil of the individual treatment did not vary. He found that the reduction of yield, which was obtained in dry years was least on those plots with the highest nutrient contents in the soil.

Van der Paauw (1958) published the results of 12 years of field experimentation, which showed that the yield response of potatoes to 400 kg ha^{-1} K_2O rate increased with the number of rainless days during the growing season. Similar results were obtained with sugar beet. Comparing the K response in wet (1986) and a dry (1989) year, the control treatment yield dropped off by nearly 50% in dry year, while with the highest K dressing the same yield was attained in both years.

In these experiments authors assumed that plants' water requirement was largely met, especially in Nederland, in Van der Paauw's experiment. The reduced soil water content affected in some way the nutrient availability and nutrient got in first minimum. Otherwise yield should have been reduced in dry years in spite of K fertilization. So, K availability is reduced before water availability becomes a limiting factor, this applies to all nutrients the major portion of which travels to the roots by diffusion, e.g. K and P. In dry years only soils with a high P and K status will attain maximum yield.

Effect of fertilization and water supply on yield and water usage were examined also in recent studies (Győri et al., 2005; Huzsvai and Nagy, 2005; Németh and Izsáki, 2007; Nagy, 2009; 2010; Rácz and Nagy, 2011).

Materials and methods

The calcareous loamy chernozem formed on loess contained in its ploughed layer 5% $CaCO_3$, 3% humus and 20-22% clay with a $pH_{(KCl)}$ 7.3. The groundwater depth was about 13-15 m, the site is drought-sensitive. Calcareous sandy soil had 1% humus, 2-4% $CaCO_3$ and 5-10% clay with a $pH_{(KCl)}$ 7.5. The groundwater table was about 3-5 m, the site is drought-sensitive. Acid sandy brown forest soil contained in its ploughed layer 0.5% humus and 5-10% clay with a $pH_{(KCl)}$ 4.5. The groundwater depth was 2-3 m. This sandy soil was poorly supplied originally with elements N, P, K, Ca, Mg.

Results and discussion

According to the data of our long-term fertilization experiments with maize, the water supply plays a fundamental role during the critical period between July 15 and August

15. In the case of water shortage both the processes of flowering and grain development will be hindered, as it can be seen in *Table 2*. On this calcareous chernozem soil with low P-supply, over fertilization with phosphorus leads also to yield losses of maize. The reason is the P-induced Zn-deficiency. In such situations, the P/Zn ratio in the leaves of flowering maize might increase over 200-300 (Kádár, 1992).

The absolute yield surpluses are the highest usually in normal or good years reaching about 3 t ha^{-1} or 133% compared to the control. In dry years, the absolute yield surplus made up 2 t ha^{-1} or 153% to the control. So, the relative P-responses are higher than in a "normal" year. Thus, in moderately dry period P-fertilization can counterbalance up to a certain point the water deficiency, increasing water use efficiency. When the water supply is in the first minimum, cannot meet the plant demand at all, the P-fertilization will not increase the yield but will make even more trouble and cause a direct yield loss, as it can be seen from data presented in *Table 2*. The underlined maximum grain yield was obtained on plots without fertilization for 23 years.

Table 2. NPK fertilizer responses of maize as a function of precipitation during the critical period between 15 July and 15 August (Calcareous chernozem loamy soil, Nagyhörcsök, Mezőföld region)

Treatment	68 mm, 1987		53 mm, 1983		10 mm, 1990	
N P K	t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
Control	8.7	100	3.8	100	2.5	100
NK	10.0	115	4.5	118	2.0	80
NKP_1	11.7	<u>133</u>	4.9	129	1.7	68
NKP_2	11.3	128	5.8	<u>153</u>	1.4	56
NKP_3	10.5	122	5.2	137	1.2	48
NKP_4	9.5	109	5.0	132	1.3	52
$LSD_{5\%}$	0.5	8	0.5	13	0.6	24
Mean	10.2		4.9		1.9	

Treatments: N=100 kg ha^{-1} yr^{-1} N; K=100 kg ha^{-1} yr^{-1} K_2O; P_1=60, P_2=120, P_3=180, P_4=240 kg ha^{-1} yr^{-1} P_2O_5

Bocz (1995) reports about the effect of fertilization and irrigation on maize grain yield in good, dry and very dry years. Author stated that against yield losses in dry periods fertilization was a good tool in 1970's and 1980's in Hungary. In 1990's there were very dry periods in many years when the fertilization was a factor of yield decrease. Often, there were higher green mass on fertilized plots in the first vegetative stages while in generative stage of development hindered the grain building because of running-out water supply in soil.

Analysing relationship between rainfall, nutrient supply and the yield of winter wheat, rye or triticale there is another picture to be realized. No direct correlation was detected in our long-term field experiments between the sum of rainfall recorded during vegetation period, the yields of winter rye and fertilizer responses on calcareous sandy soil. Presumably, favourable distribution of rainfall is more important than its sum on this poor water regime soil. Unbalanced fertilization may contribute to considerable yearly fluctuations of yield, the very high so called "year effect" (Kádár et al., 1984).

In another long-term field trial with winter wheat conducting an acid sandy soil in Nyírlugos Experiment Station there was obtained about the same average grain yield on control plots (1.7 t ha^{-1}) in dry and normal years. Yield losses on NPK fertilized

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treatment made out 10-12% in dry years compared to the normal ones. In the case of drought the control plots yielded approx. 30% less than in the average years. However, yield losses on NPKMg treatment reached 48% (2.1 t ha^{-1}). In wet years the yields declined even more than in very dry years. The unfertilised plots yielded 80% less than in normal years, while fertilized ones about 60% less (Márton, 2002; Kádár et al., 2011).

Conclusions

When plants are not well supplied with nutrients, transpiration coefficient tend to be higher, water is less efficiently utilized for crop. The larger part of the nutrients taken up by the plants has to move to the plant roots. This transport is realized with diffusion or with mass flow in the soil solution. Drying reduces nutrient availability in soil, thus in dry years there is a grater response to PK dressing.

In drought however, the soil reserves may not satisfy any more the plant demand, partly during generative phase, thus fertilization often lead to yield losses in maize.

Concerning cereals (wheat, rye, triticale) both the very dry and wet years are unfavourable. In wet years the fungi disease occurrence is considerable, which may depress the yields. Infestations appear often in "overfed" stands.

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NEW POSSIBILITY IN GREEN AGRICULTURE

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Abstract: Boosting the economy in green way is a goal for many nations, but not all agree with meaning of 'green'. The green growth is: growth achieved by saving and using energy and resource efficiently to reduce climate change and damage to the environment, securing new growth engines through research and development of green technology, creating new job opportunities, and achieving harmony between the economy and environment.
The use of wood residue as a fuel source for pulp and paper industries has led to the production of wood ash as by-product. Land spreading is a potentially sound method for the disposal of wood ash, which is an alternative soil liming agent. The calcium carbonate equivalence of the ashes used ranged from 26 to 59%, indicating that the acid-neutralizing power of wood ash varies from source to source. This study was conducted to determine the effect of wood ash amendment during the early growth of maize (*Zea mays* L. cvs. PR 37N01) in laboratory conditions. The dry matter accumulation, the length of shoots, relative chlorophyll contents and contents of elements were measured. The pH compensation effect was look after during the examination. The content of elements of wood ash was analyzed. The average nutrient release percentages were: phosphorus (P), 13%; potassium (K), 109%; magnesium (Mg), 31%; calcium (Ca), 128%; sodium (Na), 14%. The dry matter of shoots and roots, the relative chlorophyll contents in the second and third leaves of maize increased in the wood ash treatments comparison to the control.

Keywords: biofertilizer, crop nutrition, wood-ash

Introduction

In recent years, the interest in biomass as an energy source has increased. The need to replace fossil fuels with renewable sources in order to tackle the problems associated with global warming is an important reason for promoting the use of biofuels (Senneca, 2006). Wood is a major source of biomass that is especially suited for heat production in large scale installations. It has not only a considerable practical potential, but it is also reasonably cheap compared to other sources of renewable energy (Engfeldt, 2006). Thus, recycling of ashes from biofuels to soil has an important role to play in sustainable harvesting and use of biofuels. There is a tight connection between the water (ground, surface) quality and the chemicals to be used in agriculture. Therefore, to change the chemicals to renewable by-products may have a crucial importance to support the green water philosophy.
The aim of present study was to evaluate the physiological effect of wood-ash on plant growth, shoot/root ratio and relative chlorophyll content. Additional impact of microorganisms containing biofertilizer also was scanned.

Materials and methods

Maize *(Zea mays* L. cvs. PR 37N01*)* seedlings were used in the experiments. After sterilization seeds were then soaked in 10 mM $CaSO_4$ for 4 hours and then germinated

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on moistened filter paper at 25 ^oC. The seedlings were transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1 mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 10 µM $ZnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. Iron was added to the nutrient solution as Fe(III)-EDTA at a concentration of 10 µM.
The filtrate of wood ash was added to the nutrient solution. The filtrates were made from 1 g wood ash and 100 ml distilled water. This was shaken 2 hours, and after that it was vacuum filtrated. 10 ml dm^{-3} wood ash filtrate was applied per pot.
The seedlings, 12 for each basic treatment, were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 ^oC, relative humidity of 65–70% and a photosynthetic photon flux of 300 µmol m^{-2} s^{-1}) in controlled environmental room. The volume of experiment pots were 1.7 L, with one pot containing 4 plants. Two types of treatments were performed and two control: 1. absolute control (distilled water), 2. control (nutrient solution), 3. wood ash, 4. wood ash + bio-fertilizer.
The biofertilizer as an *Azotobacter sp*. and *Bacillus sp*. containing organic fertilizer, was added to the nutrient solution in the quantity of 1 ml dm^{-3}.
The element contents of materials were determined using an OPTIMA 3300DV ICP-OA Spectrophotometer. The relative chlorophyll contents were investigated using a Chlorophyll Meter, SPAD - 502 (Minolta). The relative chlorophyll contents of the 2nd and 3rd leaves of the maize were measured. The number of repetitions was 60. The dry weight of shoots and roots were measured with the use of thermal gravimetric analysis, after drying at 85 C° for 48 h.
The wood ash originated from Törökszentmiklósi Mezőgazdasági Zrt., Hungary.

Results and discussion

The ash has alkaline properties and is therefore frequently used as a liming agent in acid soil (Lerner, 1986). In addition, it contains salts, oxides and hydroxides of Ca, K, Fe, Al, Mn, Na, Mg and various trace elements in lesser amounts (Pepin and Coleman, 1984) and its use in crop production has been shown to increased yield (Meyers and Kopecky, 1998). The elements content of our investigated wood ash are shown in *Table 1.*

Table 1. Contents of examined elements (Al, Cd, Cr, Ni, Sr, Ca, Fe, K, P, Zn) in wood-ash (mg kg^{-1})

Toxic elements					Essential elements				
Al	Cd	Cr	Ni	Sr	Ca	Fe	K	P	Zn
6,423	0.968	9.21	9.29	762	129,424	6,401	109,494	13,157	599

The element composition of ash depends on the combustible material, combustion technology and type of wood (Etiégni and Campbell, 1991). In addition to important fertilizer nutrients, different ashes also contain considerable amounts of heavy metals (e.g. As, Cd, Ci, Pb and V) that are potentially toxic to humans and flora and fauna.
The roots can uptake the examined elements, and since they have significant role in the main physiological processes of plants. Their amounts were measured in the shoots, and in the roots (*Table 2* and *Table 3*).
Larger concentration of Al and Fe were measure in the roots than in the shoots. The concentration of Al was approximately twice higher in roots at the wood ash treatment

than in the control roots. The content of Fe, Mg and P decreased in the wood ash and bio-fertilizer treatments.

Table 2. Concentration of examined elements (Al, Ca, Fe, Mg, P,) in the shoots of maize seedlings (mg kg^{-1}) effecting by wood ash and bio-fertilizer

Elements	Treatments			
	Abs. control	Control	Wood ash	Wood ash+ biofert.
Al	19.6	4.16	6.26	5.13
Ca	4,543	7,266	6,719	6,740
Fe	112	91.4	114	129
Mg	3,207	2,159	1,874	1,748
P	7,962	16,090	15,825	13,507

Table 3. Concentration of examined elements (Al, Ca, Fe, Mg, P,) in the roots of maize seedlings (mg kg^{-1}) effecting by wood ash and bio-fertilizer

Elements	Treatments			
	Abs. control	Control	Wood ash	Wood ash+ biofert.
Al	23	49.4	95.5	60,7
Ca	1,363	4,837	4,078	5,342
Fe	57.6	1,074	649	971
Mg	407	2,128	1,087	1,322
P	2,783	5,563	4,004	5,513

Phosphorus levels in plants were not affected by either wood ash application. However, wood ash is a source of P (Ohno and Erich, 1990) and its application should increase soil values for P (Ohno, 1992). The contents of measured elements were higher when biofertilizer was applied – except the Al.

Differences were observed in the dry matter accumulation during the experiment. The results are shown in *Table 4.*

Table 4. Effects of wood-ash and bio-fertilizer on the shoots/ roots ratio of sunflower seedling (g $plant^{-1}$)

Treatments	Shoot		Root		Shoot/root	
	Mean	S.D	Mean	S.D.	Mean	S.D.
Abs. control	0.047	0.01	0.042	0.02	1.11	0.020
Control	0.125	0.03	0.030	0.01	4.16	0.025
Woods ash	0.198	0.05	0.037	0.00	5.35	0.063
Wood ash +biofert.	0.175	0.01	0.025	0.01	7	0.041

The dry matter accumulation of shoots increased in wood ash and wood ash + bio-fertilizer treatments. The dry matter of shoots increased with 58% in the wood ash and

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40% in the wood ash + bio-fertilizer treatments. The dry matter of roots increased with 23% in the wood ash treatment. This amount decreased with 20% in the wood ash + bio-fertilizer treatment comparison to the control roots. The shoots/root ratio was the highest when wood ash and bio-fertilizer treatment was applied. This value also increased in wood ash treatment comparison to the control.
Low chlorophyll contents affect photosynthetic activities. The decreasing dry matter accumulation can be explained by the lower level of the chlorophyll contents. The relative chlorophyll contents increased with 3 Spad units in the 2^{nd} and with 1 Spad Unit in the 3^{rd} leaves when wood ash was applied. This values increased with approximately 5 Spad Units in the 2^{nd} and 9 Spad Units in the 3^{rd} leaves of maize when wood ash and bio-fertilizer were added to the nutrient solution comparison to the control (results are not shown).
The wood ash has alkalic effect. The pH of wood ash was 12.44. We measured the pH of nutrient solution before and after the nutrient solution chancing. The wood ash has pH increasing effect. The pH of nutrient solution which contains wood ash was higher with 2 pH than the control. The bio-fertilizer had small pH compensation effect (results are not shown).

Conclusions

Application of wood ash would be beneficial in acidic soil. The addition of wood ash into nutrient solution increased the Al uptake of plants. The dry matter accumulation of shoots increased in wood ash and wood ash + bio-fertilizer treatments. The relative chlorophyll content also increased in all treatment comparison to the control.

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THE WATER STORAGE IN SOIL AT ITS DIFFERENT CULTIVATION

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Abstract: The aim of this contribution is to compare water storage in soil profile of heavy soil. Soil treatments were carried out between 2007 and 2011 years. Two tillage variants were examined - conventional tillage and no-tillage variant with direct sowing. Volume soil moisture, respectively water storage in soil profile was determined from disturbed soil samples taken during vegetation season in 2-weeks intervals in depth 0.0 - 0.8 m from each 0.1 m with three replications. Gravimetric method was used at it. Obtained water content values were recounted at maximum water content on percentage of moisture of field water capacity (W_{FWC}), at average water content on percentage of moisture of threshold point (W_{TP}), at minimum water content on percentage of moisture of wilting point (W_{WP}). Maximum values of soil water storage decreased under value of field water capacity. Higher average water storage was measured for no-tillage technology in comparison with conventional tillage variant. Effect of tillage technology was statistically significant only for minimum water storage in depth 0.0 - 0.8 m.

Keywords: water storage, heavy soils, soil cultivation

Introduction

Water storage in the aeration zone of soil (no-saturated area of soil) is the amount of water in soil between soil surface and level of groundwater. Water flow between these two boundaries is dependent upon addition meteorological conditions as well as from the physical properties of soil. Amount of soil water, which on concrete stand in definite part of vegetation is available for agricultural plants, is possible to number for example by empirical equations, which deliver to relation between rainfall and potential evapotranspiration (Demo et al., 2000). Tillage of soil is basic element of the technological systems of agricultural plant cultivation on arable land (Fazekašová et al., 2011). Water sources are delimited, and as published Várallyay (2011) control of the hydrological cycle and soil moisture regime has priority significance both in economical production and environment production.
The aim of this work was to compare water storage in profile of clay-loamy soil at different tillage.

Materials and methods

Between 2007 and 2011 at the experimental place of Plant Production Research Centre - Agroecology Research Institute Michalovce a field experiment took place on heavy Gleyic Fluvisol. The effect of various tillage of soil on water storage and soil properties was researched. The experimental site is located at Milhostov, on the East Slovak Lowland nearly of the city Trebišov with latitude 48° 40' N, longitude 21° 44' E, altitude 101 m. The long-term mean yearly precipitation shows 559 mm, during vegetation season 348 mm, the mean annual temperature is 8.9 °C, during vegetation season 16.0 °C.

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Field stationary treatment consisted from ten plots. Crop rotation for the 1st experimental plot, where research of soil water storage was realized, was as follows: soya bean - winter wheat - grain maize - spring barley - soya bean.
In field experiment two tillage technologies - conventional tillage (CT) with ploughing and direct sowing without ploughing (NT) - were examined.
Volume soil moisture, respectively water storage in soil profile was determined from disturbed soil samples taken during vegetation season in 2-weeks intervals in depth 0.0 - 0.8 m from each 0.1 m with three replications. Gravimetric method was used at it.
Obtained water content values were recounted at maximum water content on percentage of moisture of field water capacity (W_{FWC}), at average water content on percentage of moisture of threshold point (W_{TP}), at minimum water content on percentage of moisture of wilting point (W_{WP}).
Obtained data was tested by statistical methods, from which variance and regression analysis methods were used.

Results and discussion

Effect of various tillage systems on soil water storage was valued from point of view of its maximum (W_{max}), average ($W_{Ø}$) and minimum (W_{min}) values in vegetation season. From *Table 1.* influenced equalisation of average values for individual years and in valued soil profile 0.0 - 0.3 m.

Table 1. Maximum, average and minimum water storage [mm] in soil profile 0.0 - 0.3 m

parameter	tillage	2007	2008	2009	2011	xY
W_{max}	CT	108.73	117.11	109.30	111.42	111.64
	NT	106.15	112.87	108.43	121.90	112.34
	Δ CT-NT	2.58	4.24	0.87	-10.48	-0.70
$W_{Ø}$	CT	78.55	104.65	86.12	94.73	91.01
	NT	77.11	98.21	96.14	100.90	93.09
	Δ CT-NT	1.44	6.44	-10.02	-6.17	-2.08
W_{min}	CT	40.90	86.48	67.21	63.66	64.56
	NT	36.79	84.71	74.32	68.38	66.05
	Δ CT-NT	4.11	1.77	-7.11	-4.72	-1.49

Maximum water storage (*Table 1.*) in observed period was determined range 106.15 till 121.90 mm for profile 0.0 - 0.3 m. Maximum differences between tillage variants of soil were 10.48 mm, ascertained in year 2011. Tillage systems had not statistically significant effect on maximum water storage. Maximum water storage in this soil profile was recounted to moisture of field water capacity. In observed period, maximum values reached 87.78 till 100.80% of moisture of field water capacity.
Differences of average water storage in profile 0.0 - 0.3 m between tillage systems weren't statistically significant. Experimental year statistically significant effected values of this parameter. Average water storage reached 76.25 till 103.48% of moisture of threshold point. This facts correlate to results published Mati et al. (2007), Kotorová and Mati (2008a, b) and Gomboš and Pavelková (2011).

Minimum water storage during vegetation period refers to the wilting point. In depth 0.0 - 0.3 m minimum water storage reached 36.79 till 86.48% of wilting point moisture. In average higher minimum water storage was determined for no-tillage variant. Our results confirmed positive effect of soil protective technologies at soil moisture saving.
Water storage was valued also in profile 0.0 - 0.8 m. Results from these observations are shown in *Table 2*.

Table 2. Maximum, average and minimum water storage [mm] in soil profile 0.0 - 0.8 m

parameter	tillage	2007	2008	2009	2011	xY
W_{max}	CT	284.57	309.79	287.97	302.83	296.29
	NT	265.86	283.52	290.08	341.02	295.12
	Δ CT-NT	18.71	26.27	-2.11	-38.19	1.17
$W_{Ø}$	CT	205.92	279.21	222.07	255.79	240.75
	NT	206.41	253.59	250.97	276.18	246.79
	Δ CT-NT	-0.49	25.62	-28.90	-20.39	-6.04
W_{min}	CT	103.55	235.41	182.65	189.25	177.72
	NT	92.70	216.63	193.91	196.55	174.95
	Δ CT-NT	10.85	18.78	-11.26	-7.30	2.77

Maximum water storage (*Table 2.*) in profile 0.0 - 0.8 m was determined range 265.86 till 341.02 mm. Maximum differences between tillage variants of soil were 38.19 mm, ascertained in year 2011. Tillage systems had not statistically significant effect on maximum water storage. Better water storage was determined at no-tillage variant. In observed years between 2007 and 2011, maximum values reached 87.63 till 112.41% of moisture of field water capacity. Differences between soil tillage technologies weren't significant.
Average values of water storage in profile 0.0 - 0.8 m were equal and range 205.92 till 279.21 mm. In average higher water storage was determined for no-tillage variant (Δ = 6.04 mm). The maximum difference was ascertained for year 2009 and higher average water storage had no-tillage variant (*Table 2.*). Average water storage in rated soil profile reached 81.37 till 110.33% of moisture of threshold point. For heavy soils of the East Slovak Lowland Pavelková and Mati (2008) found out average soil water storage lower than level of threshold point, and so the values of the easily accessible of the soil water were negative.
Another situation was found out for minimum water storage in profile 0.0 - 0.8 m. Values of this parameter range 92.70 till 235.41 mm, what is the 52.64 till 133.67% from moisture of wilting point. The highest difference between tillage variants (18.78 mm) was determined in year 2008. Statistically significant effect of different soil tillage technology was determined only for minimum water storage in depth 0.0 - 0.8 m.

Conclusions

Maximum, average and minimum water storage in soil profile 0.0 - 0.3 m and 0.0 - 0.8 m were observed during vegetation season on the East Slovak Lowland.
In depth 0.0 - 0.3 m higher maximum, average and minimum were higher on no-tillage variants in comparison with conventional tillage variants.

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In dept 0.0 - 0.8 m higher water storage for no-tillage variant was observed only for average water storage (6.04 mm).

Effect of different tillage of heavy soils on the East Slovak Lowland effected soil water storage in soil profile 0.0 - 0.8 m.

From time course of soil water storage at different soil tillage result its variability affected by depth of soil profile and soil tillage technology.

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POLLUTION STUDIES ON THE UGLJESNICA RIVER: THE HEAVY METAL STATUS OF SURFACE WATERS IN THE CITY OF KRAGUJEVAC

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Abstract: Surface water samples from the Ugljesnica in the City of Kragujevac, Serbia were analyzed quantitatively for the concentration of eight heavy metals, namely: Lead, Cadmium, Iron, Zinc, Manganese, Copper, Arsenic and Mercury, using Atomic Absorption Spectrophotometer. Lead (Pb) recorded the highest mean value of $0.582 mgL^{-1}$ while Mercury had the least mean concentration of $0.000824 mgL^{-1}$. The Ugljesnica River receives effluents from industrial, agricultural and domestic sources. Average concentrations of Lead, Cadmium and Manganese had higher concentrations than the MPC values set as standard guidelines for drinking water, indicating to the existence of public health risks. There is a need, therefore, for continuous monitoring of the concentrations of heavy metals in the surface water as well as for comprehensive conservation efforts by relevant organizations.

Key words: Pollution, heavy metals, River Ugljesnica, seasonal variation

Introduction

Heavy metals are inorganic elements essential for plant growth in traces or very minute quantities. They are toxic and poisonous in relatively higher concentrations. Two factors contribute to the deleterious effects of heavy metals as environmental pollutants. Firstly, they metals are non-biodegradable nature biological half-lives. Secondly they are easily assimilated and can be bio-accumulated the protoplasm of aquatic organisms and the human body system, causing damage to nervous system and internal organs (Lee et al., 2007; Lohani et al., 2008). Some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for the life processes in animals and plants while many other metals such as Cd, Cr, Pb and Co have no known physiological activities (Suthar and Singh, 2008; Aktar et al., 2010).

The aquatic system receives a large amount of heavy metals from variety of sources; it be can be either natural or anthropogenic. Heavy metals are transported as dissolved species in water or as an integral part of suspended sediments. These potentially toxic pollutants can endanger public health by being incorporated in the food chain, or being released into overlying waters which serve as drinking water supplies. River Ugljesnica is one of the tributary Lepenica that is significantly influenced by anthropogenic activities, resulting in pollution and deterioration of the surface water.

However, regardless highlz hazardous natures of heavy metals in aquatic environment, research on these metals in the Ugljesnica are scanty (The Study, ″Environmental protection and development of ecological system in Kragujevac by 2010″ Science, 1993).

This study aims at investigating the current status of heavy metals concentrations in the surface water of Ugljesnica River during various seasons. It attempts to provide a baseline data upon which future computations of the water quality as a result of increased urbanization and industrialization would be based.

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Materials and methods

The source of the Ugljesnica River is in Ramaca at the foot of Mt. Bozurova Glava at 690 m a.s.l. The River is 31 km long and its catchment area is 150 m^2. It flows through the Kragujevac Valley from Grbice until its confluence with the Lepenica. The Lepenica, the largest tributary of the Velika Morava, is used for both water supply and irrigation of agricultural crops. The research area has a temperate continental climate characterized by extremely dry periods during summer and autumn, and rainy periods during spring and winter.

In order to achieve the research objective and evaluate the heavy metals and As contamination during various seasons (spring and autumn), samples were collected from four various locations: course of the river (1), middle of the river (2), above the collector – lower course of the river (3) and below the collector – river mouth (4).

Samples were collected from in May 2009 for the spring season, and in October for the autumn season. Criteria for the selection of sampling station were based on locations having largest potential pollutants of the Ugljesnica (general waste landfills and sewer wastewater collection). Source of the river is taken as the location for which it was expected that the least polluted. The landfill is located in the middle of the river, and the collector in the lower reaches. Sampling was performed below and above the collector.

The collected samples were filtered (Whatman no. 42) and fixed with concentrated nitric acid (to ph not exceeding 2.0) for further analysis (APHA, 1998). Concentrations of heavy metals in water samples were determined using an Atomic Absorption Spectrophotometer (Perkin-Elmer, 3300/96, MHS-10) equipped with a specific lamp for particular metal. Average values of three replicates were taken for each determination. Appropriate drift blank was taken before the analysis of samples.

Results and discussion

Heavy metals have been used as indices of pollution because of their high toxicity to human and aquatic life (Omoigberale and Ogbeibu, 2005). Amman et al., (2002); Nouri et al., (2006) have linked the high concentrations of heavy metals in aquatic ecosystems with effluents from different industries and agricultural fields due to the indiscriminate use of heavy metal – containing fertilizers and pesticides.

In this study, the concentrations of eight heavy metals in the Ugljesnica surface water were decreased in the order: Pb>Zn>Mn>>Fe>Cd>Cu>As>Hg (*Table 1*). Lead (Pb) had values that ranged between 0.002mgL^{-1} and 4.510mgL^{-1}; Zinc (Zn) recorded values of between 0.021mgL^{-1} and 2.573mgL^{-1}; Manganese (Mn) had values that ranged between 0.016 mgL^{-1} and 1.779mgL^{-1}. The range values of other metals were: Iron (Fe): 0.133mgL^{-1} 0.656mgL^{-1}; Cadmium (Cd): 0.002$mgL^{-1}$to 1.098$mgL^{-1;}$ Cooper (Cu): 0.004mgL^{-1} to 0.862mgL^{-1}; Arsenic (As): 0.0011mgL^{-1} to 0.0015mgL^{-1}; Mercury (Hg): 0.0005mgL^{-1} to 0.0011mgL^{-1} The maximum and minimum value, mean and standard deviation of individual metals are illustrated shown in *Table 1*.

Statistical tests showed that the metal concentrations were significantly different between sampling stations. Maximum concentrations of heavy metals were detected in sample No. 4 during the autumn season. The levels of Lead and Cadmium were about one thousand times the MPC value, whereas those of the other metals increased several dozen times. With the sampling site (point 4) below the waste water collector, this pollution was understandably induced by waste water discharge into rivers. The content of heavy metals and as for the other test samples was below MPC values set for drinking water.

Table 1. Statistical analysis of the heavy metals concentrations in surface water of River Ugljesnica, City of Kragujevac (mg L^{-1})

Heavy metals (mg/l)	Seasons	N	Mean	SD.	SDErr	Min.	Max.
Lead (Pb)	Spring	4	0.029	0.049	0.024	0.002	0.102
	Autumn	4	1.135	2.250	1.125	0.007	4.510
	Total	8	0.582	1.588	0.561	0.002	4.510
Cadmium (Cd)	Spring	4	0.016	0.015	0.007	0.003	0.029
	Autumn	4	0.277	0.548	0.274	0.002	1.098
	Total	8	0.146	0.385	0.136	0.002	1.098
Iron (Fe)	Spring	4	0.205	0.051	0.025	0.134	0.250
	Autumn	4	0.277	0.254	0.127	0.133	0.656
	Total	8	0.241	0.174	0.061	0.133	0.656
Zinc (Zn)	Spring	4	0.028	0.010	0.005	0.021	0.043
	Autumn	4	0.664	1.273	0.636	0.021	2.573
	Total	8	0.346	0.900	0.318	0.021	2.573
Manganese (Mn)	Spring	4	0.062	0.032	0.016	0.016	0.091
	Autumn	4	0.522	0.841	0.420	0.021	1.779
	Total	8	0.292	0.603	0.213	0.016	1.779
Cooper (Cu)	Spring	4	0.009	0.004	0.002	0.004	0.014
	Autumn	4	0.225	0.425	0.213	0.005	0.862
	Total	8	0.117	0.301	0.106	0.004	0.862
Arsenic (As)	Spring	4	0.001	0.184	0.092	0.0011	0.0015
	Autumn	4	0.001	0.214	0.107	0.0011	0.0015
	Total	8	0.001	0.186	0.066	0.0011	0.0015
Mercury (Hg)	Spring	4	0.0008	0.212	0.106	0.0006	0.0011
	Autumn	4	0.0008	0.201	0.101	0.0005	0.0011
	Total	8	0.0008	0.199	0.070	0.0005	0.0011

Table 2. Some heavy metals cocentration (mgL^{-1}) mean values, compared with some standard guidelines values of drinking water quality

Guidelines	Pb	Cd	Fe	Zn	Mn	Cu	As	Hg	References
SOS	0.01	0.003	*	3.0	0.05	2.0	0.01	0.001	SOS, 1999
WHO	0.01	0.003	*	*	0.40	2.0	*	*	WHO, 2003
EPA	0.05	0.003	*	*	*	1.30	*	*	EPA, 2002
Study of the Ugljesnica River	0.020	0.000	0.137	0.026	0.058	0.114	*	*	Study of the Ugljesnica River, 1993

SOS: Standard organization of Serbia; WHO: World Health Organization: EPA: Environmental Protection Agency

It was also observed that the measured concentrations of all (eight) heavy metals and As were found to be higher during the autumn period than during the spring season - understandably so due to the decreasing water level in October, resulting in increased mineralization of the water and, hence, elevated levels of heavy metals and As.

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A comparison of the concentration of some of the heavy metals with standard guideline values for drinking water and those of earlier studies on the Ugljesnica River is shown in *Table 2*.

The result obtained in this study showed that Pb, Cd and Mn had values that were higher than those recommended by the Environmental Protection Agency (EPA) (2002), World Health Organization (WHO) (2003) and Standard Organization of Serbia (1999). The mean concentration of Pb, Cd and Mn rose above the values recorded in 1993. The concentration levels of these metals would markedly impair the portability of the water.

Conclusions

Average concentrations of Lead, Cadmium and Manganese had higher concentrations than the MPC values set as standard guidelines for drinking water, indicating to the existence of risks to public health. The Ugljesnica river receives high amounts of wastes from industrial, agricultural and domestic sources. With more industries discharging their effluents into the river, the prospects of a greater pollution is high, so also is an increased risk to public health. There is need, therefore, to constantly monitor the concentration levels of heavy metals in the river as well as mounting comprehensive conservation efforts by relevant organizations.

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DEVELOPMENT OF THE SOIL WATER REGIME AS A CONSEQUENCE OF CLIMATE CHANGE

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Abstract: Climate change is felt by humans mostly in relation with the change of air temperature and precipitation. But for the country presents climate change a greater threat, which changes its whole character, especially through the changes in soil water regime. Changes in soil water regime may significantly influence hydro-ecological conditions of area, the position of groundwater level and the soil water storage too. The soil water storage is for us one of the reliable indicators of water sufficient in the country. Therefore, in this paper, we are dealing with consequences of climate change on soil water storage. The impact of climate change was solved by meteorological characteristics modified by climate scenario CGCM 3.1. Soil water storage was determined by mathematical model GLOBAL for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 a 2081-2100 and was compared with the reference period 1981-2000.

Keywords: climate change, soil water storage, mathematical modeling

Introduction

Ongoing climate changes are appearing as a consequence of inherent variability of climate system, but also by the influence of external factors - natural factors, but also factors caused by human activity. Increase of concentration of greenhouse gases is causing an increase in average global temperature, changes in precipitation regime, sea level rise and others. Some effects of global warming are already evident today, for example extreme weather phenomena in the form of droughts, heavy precipitation, heat waves and increase of the intensity of tropical cyclones and storms (IPCC, 1998, 2001).
Therefore are experts trying to create prognosis for development of the meteorological elements in order to adapt to incoming changes. At present many workplaces in the world are working on the Global Circulation Models (GCMs), which provide climatic scenarios of various climatic parameters (Lapin and Melo, 2004; Stehlová and Štekauerová, 2008).

Materials and methods

The impact of climate change was in these case solved by meteorological characteristics modified by climate scenario CGCM 3.1., which is the latest version of the Canadian related model of the atmosphere and ocean circulation. By the regional modifications we used emission scenario A2, which is a pessimistic scenario. It corresponds to the idea of a very heterogeneous world, where the basic idea is to rely on them and to preserve local identity, respect local traditions. Population in the 21st century continuously growing, economic development is strongly regional oriented and growth in gross domestic product is considerably slower than other group of scenarios (Melo, 2004).
Scenario of climate change were developed for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100. The simulation of the soil water storage with

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these modified values for each time horizons as well as for reference period 1981-2000 was made by model GLOBAL (Majerčák and Novák, 1994).
Model GLOBAL is one-dimensional model allowing a calculation of moisture distribution, respectively the moisture potential in real time. The base of the model is a numerical solution of Richards's equation using method of finite elements.
Input data into the model include soil hydrophysical characteristics, initial condition, which may be soil moisture or water potential and boundary conditions.
The meteorological characteristics of the area, represented by daily precipitation, average daily air temperature, daily sunshine duration, average daily water vapour pressure and average daily wind velocity for each day of the modeled period were as the upper boundary conditions. The groundwater level was as lower boundary condition.
Into the model also enter characteristics of vegetation growing on the soil surface of area (leaf area index, evaporating surface roughness, evaporating surface albedo, root zone depth and the critical relative humidity) and we used characteristics of grass. This model includes an algorithm for abstraction of water by root of plants, which significantly increases the accuracy of modeling of soil moisture, especially in the upper soil layer (Novák, 1989).
The impact of climate change on soil water storage was applied for the area of Záhorská lowland in the cadastre of Malé Leváre village. As we can see on *Figure 1.*, Malé Leváre lies in western part of Slovakia. So all input data are taken from Malé Leváre area, only the upper boundary conditions, represented by meteorological characteristics are taken from the nearest meteorological station of Slovak Hydrometeorolocical Institute (SHI) Malacky.

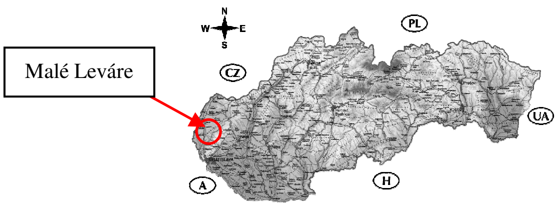

Figure 1. Location of Malé Leváre village in Slovakia

Results and discussion

Analysis of the impact of climate change on course of soil water storage in Malé Leváre area was made on the basis of outputs from the model GLOBAL. Output was consisted of many characteristics, from which we have focused on the daily water storage in selected soil layer of 0-15 cm below the soil surface. For better expression of results we calculated the average daily data for climate scenario CGCM 3.1., emission scenario A2 for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 and then we described them in graph form and afterwards we compared them with a reference period 1981-2000.
For better overview of course of soil water storage for each time horizons we decided to plot in graph only the vegetation period (IV.-IX.), where are more visible differences. So, the following *Figure 2.* shows the course of the average daily water storage in soil

layer 0-15 cm during the vegetation period in time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 as well as for the reference period 1981-2000.

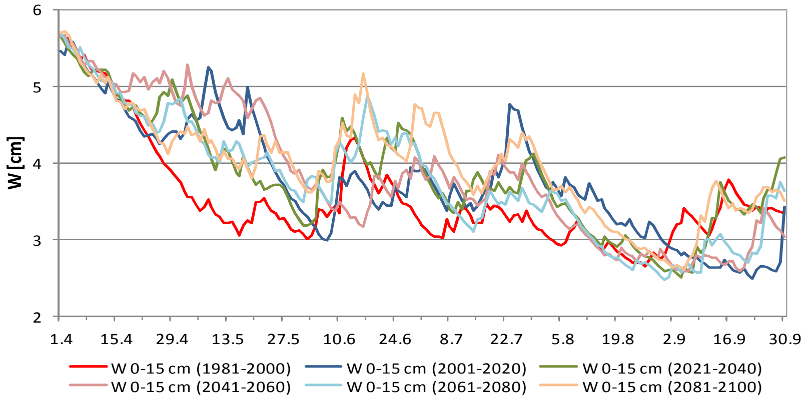

Figure 2. Courses of average daily water storage for reference period 1981-2000 and for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080, 2081-2100 in soil layer 0 - 15 cm

On *Figure 2* we can see that courses of soil water storage for each time horizons are during the vegetation period decreasing. In comparison with the reference period 1981-2000, differences with time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 are various and cannot be made some statement.
Therefore, we decided to calculate from these daily data monthly and annual average values for each time horizons as well as for reference period 1981-2000. So, the following *Figure 3* shows the course of the average monthly and annual water storage in soil layer 0-15 cm in time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 as well as for reference period 1981-2000.

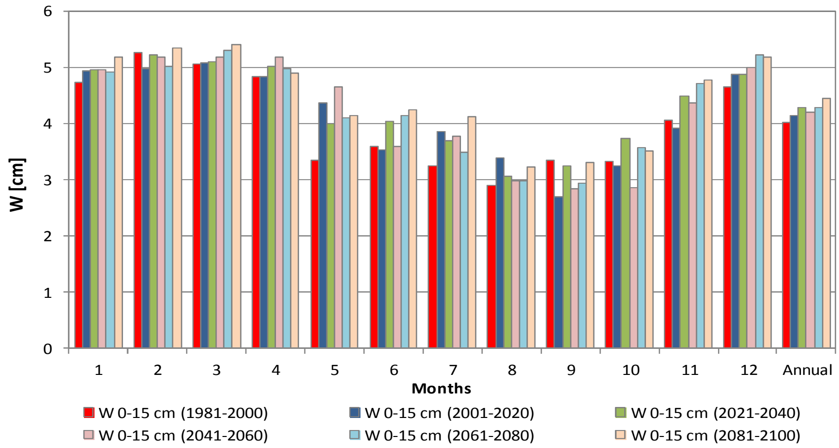

Figure 3. Course of average monthly and annual water storage for reference period 1981-2000 and for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080, 2081-2100 in soil layer 0 - 15 cm

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On *Figure 3* we can see that course of average monthly soil water storage, especially during the vegetation period, is various and there is no continuity in the increase of soil water storage values over time horizons. But if we see on the course of average annual soil water storage, it has continuous increase trend, what is also shown in *Table 1*. *Table 1* also documents the level of percentage increase of average annual soil water storage in each time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080 and 2081-2100 compared to reference period 1981-2000.

Table 1. Comparison of average annual water storage in soil layer 0 - 15 cm for the reference period 1981-2000 and for time horizons 2001-2020, 2021-2040, 2041-2060, 2061-2080, 2081-2100

	1981-2000	2001-2020	2021-2040	2041-2060	2061-2080	2081-2100
W (0-15 cm)	4.02	4.14	4.28	4.21	4.28	4.44
% increase	100%	+ 3%	+ 6.50%	+ 4.70%	+ 6.50%	+ 10.50%

Conclusions

Based on the observed results we can concluded that climate change, manifested mainly by temperature and precipitation changes, according to the assessed emission scenarios A2, which is a pessimistic scenario, did not cause dramatic changes in the hydrological regime of Malé Leváre area in compare with reference period 1981 - 2000. According to the simulated outputs can occur slightly increase of the water storage in the simulated soil layer 0 - 15 cm. Using percentages occur until 2100 to the increase of soil water storage up to 10.5%.

Acknowledgements

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EFFECT OF SOIL TILLAGE ON SOIL WATER CONTENT

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Abstract: The effect of three different tillage methods on soil water content were studied in a long-time field experiment on eutric cambisol type of soil at the University of Pannonia, Keszthely, Hungary. The design of the experiment is split-plot. The gravimetric soil moisture and soil porosity was measured in 0-20 and 20-40 cm soil layers in a maize culture. The results were evaluated with statistical methods.
Differences were found in soil moisture content between the ploughing, discing and no-tillage methods, and also between the examined layers. This paper summarizes plant and soil interrelations regarding soil cultivation and soil water content on maize production.

Keywords: soil moisture, porosity, tillage, maize yield

Introduction

Soil moisture is one of the most important ecological factors for plants and soil life. Cultivation changes the original porosity, while soil moisture and air content can vary in certain soil levels depending on soil properties, cultivation type and timing (Riar et al., 2010; Kovac et al., 2005; Husnjak et al., 2002). Also, higher levels of organic matter has a positive effect for soil structure (Tate, 1987). The most important factors of soil organic matter management are cropping structure, rotation, plant residue incorporation, farmyard- and organic manure usage. Cultivation may also change the physical properties of the soil, together with biotic (roots, fauna) and abiotic factors (climate) causing a good or bad soil state, for different time period (Gyuricza et al., 1998; Birkás, 2008). The effect of inefficient tillage can ruin the soil structure, porosity, air and water management, and soil fertility can also decline (Birkás et al., 2009; Spoljar et al., 2011).

Materials and methods

The maize section of a 21 year old maize-winter wheat bicultural tillage experiment was studied in 2011. The soil was a Ramann-type brown forest soil (Eutric Cambisol) containing 41% sand, 32% silt, and 27% clay. The available phosphorus content of this sandy loam soil was low (AL- P_2O_5: 60-80 mg kg^{-1}), the potassium content was medium (AL-K_2O: 140-160 $mgkg^{-1}$) and the humus content was fairly low (1.6-1.7%), with a pH_{KCl} value of 7,3. The 100 year average annual precipitation was 683 mm, but the distribution was often uneven. The long-term annual mean temperature was 10.8 °C. The precipitation of the year 2011 was unusually low, just 342,8 mm.
The experiment has two factors; the main factor is tillage, with three different cultivations: ploughing (a1), no tillage drilling (a2) and shallow discing (a3). The second factor is fertilizing, there are five levels of N fertilizer, N0 (N:0, P_2O_5:100, K_20:100), N1 (N:120, P_2O_5:100, K_20:100), N2 (N:180, P_2O_5:100, K_20:100), N3 (N:240, P_2O_5:100, K_20:100) N4 (N:300, P_2O_5:100, K_20:100). The trial was arranged in a split-plot design with four replications. Undisturbed soil samples were taken from a 0-20 and a 20-40 layers respectively in a maize culture on 8-10 August 2011. The soil moisture content was measured with gravimetric method. Maize yields were converted to 86% dry matter content. Analyses were done using SPSS ANOVA.

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Results and discussion

The maize yield was fairy low because of the rain shortage. From the experimental treatments only the cultivation had a significant effect on the maize yield. Nutrition had no strong impact (*Figure 1*).

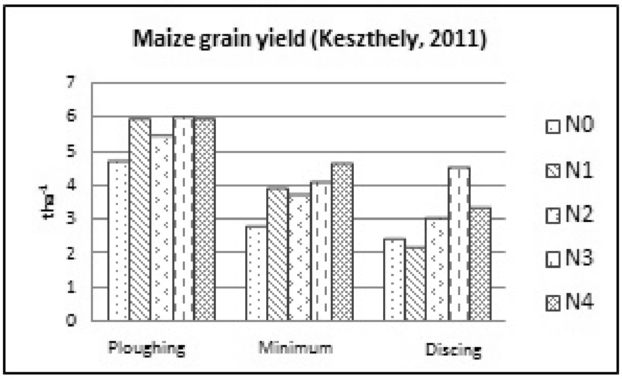

Figure 1. Maize yield in all nutrition and cultivation variant. Keszthely

Effect of fertilization had a positive, but not significant effect on the maize yield. In case of discing, variant nutrients have shown the biggest yield increasing effect. In every case, there was a significant difference between the cultivating variants in the average of nutrient treatments. The highest and lowest yields were found at the ploughing and discing variants, respectively (*Figure 2*).

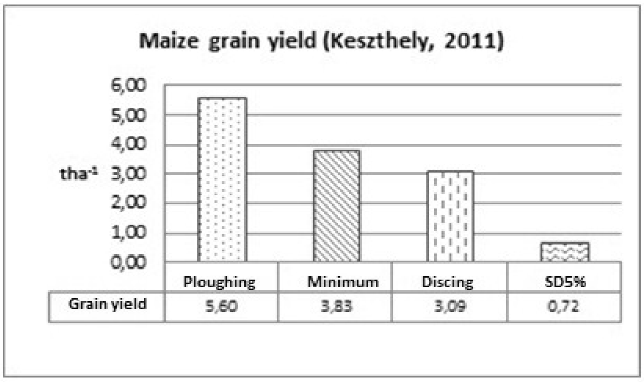

Figure 2. Maize yield at different cultivation variants. Keszthely

Gravimetric soil moisture content was higher on the upper layer, and lower at the profound layer, but there was no significant difference in the ploughing variant. Minimal and discing treatments caused significantly higher moisture in the 0-20 soil layer. Ploughing resulted in a significantly less moisture content in the 0-20 cm soil layer than discing and minimum tillage. Minimum tillage caused the highest moisture content, higher than discing and ploughing. In the 20-40 cm layer there was no significant difference between the tillage treatments (*Figure 3*). Neither was there was significant difference between the nutrient treatments. These results show that in this dry year, ploughing has caused lower water storing ability and lower soil moisture.

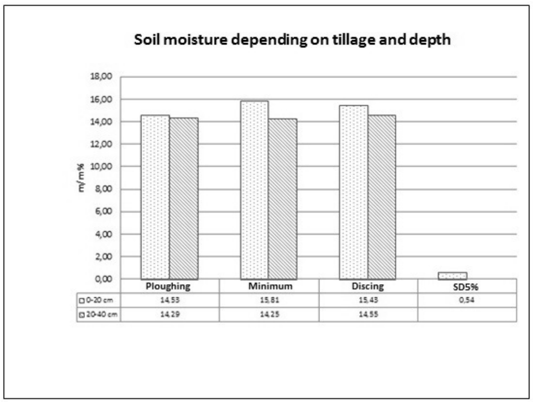

Figure 3. Soil moisture content in different soil layers and cultivation. Keszthely

The measured bulk density values are shown on *Figure 4*. From the analysis of the values it is determinable that there was significant difference only between the different soil layers. Neither the tillage nor the N-supply were significant.

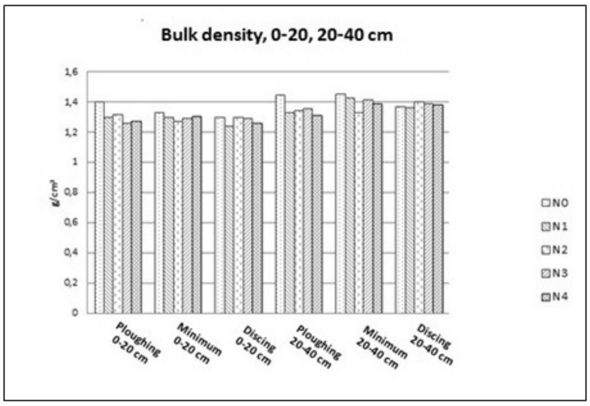

Figure 4. Soil bulk density in different soil layers and cultivation. Keszthely

In the 20-40 cm layer the soil was slightly more compact - especially in the minimum and discing tillage variants – than in the regularly cultivated 0-20 cm layer above that (bulk density: 0-20 cm 1,297 g/m^3; 20-40 cm g/m^3 1,382; $LSD_{5\%}$: 0,031 g/m^3). In the majority of cases it can be observed that the highest bulk density values were measured at the N0 control plots, probably because of the lower organic matter content and aggregation, but this cannot be proved statistically.

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Conclusions

Based on the results it is determinable that under extremely dry weather conditions of the year 2011, tillage had a significant effect to the grain yield of maize. The effect of N-supply was not significant in this year. The highest yield was obtained by ploughing, which has significantly outyielded the other two tillage variants.

The tillage affected the soil moisture especially in the upper cultivated soil layer. Ploughing has resulted in the lowest, and minimum tillage the highest soil moisture content. In case of discing and minimum tillage the soil moisture content of the upper layer was significantly higher than that of the lower layer. In the 20-40 cm layer there was no significant difference between the effects of different tillages.

From the analysis of the results of bulk density measurements it was determinable that there was significant difference only between the different soil layers. Neither the tillage nor the N-supply was significant.

Acknowledgements

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IS SURFACE RUNOFF AN IMPORTANT COMPONENT OF WATER BALANCE ON AGRICULTURAL LAND IN GROWING SEASON?

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Abstract: Surface runoff is considered as an undesirable phenomenon in landscape. It depletes plants with water, decrease dotation of underground water and causes water soil erosion and local floods. The primary reason for surface runoff from agricultural land is the effect of energy of raindrops on the soil surface and subsequent formation of crusts which causes a dramatically lower infiltration rate. Effects of agricultural soils management on surface runoffs were studied at the Forage research station in Vatín, Czech Republic, from 2007 to 2011. To assess the size of the surface runoff, system of runoff plots was established (6 pairs, area 10 m^2, slope 5°). The plots represented bare soil, maize, winter wheat, potatoes and grasslands. Proportion of surface runoffs from individual rainfall events during the growing season was assessed. Stand of maize, potatoes and bare soil during this period showed significantly higher surface runoffs (444, 421 and 597 m^3 ha^{-1} resp.), than stands of extensively and intensively managed grassland and winter wheat (42, 43 and 90 m^3 ha^{-1} resp.). Row crops are known to accelerate soil erosion but they are also considerable source of water losses. In some years surface runoff formed up to 15% of the volume of precipitations during the growing period (V-IX); with the heaviest rainfalls surface runoff accounted for more than 50% of the precipitation.

Keywords: surface runoff, heavy rains, soil crust

Introduction

The Czech Republic is located on the watershed of three seas, and virtually all major streams, which spring in our territory, divert water to neighbouring states. The consequence of this fact is the total dependence of our water resources on atmospheric precipitation. However, runoff from landscape is accelerated by improper management of agricultural land. The large-scale farming prevails, which is associated with the use of large land units and heavy farm machinery. These factors create conditions for the formation of surface runoff with all its negative consequences. Given that agricultural land covers 53.7% of the Czech Republic, significantly influences the water balance of our country.

Janeček (2002) states that in our country occurs on average at each point 5 to 6 short torrential rains with precipitation sums above 10 mm. Surface runoff occurs mostly as a result of these rains on sloping land. In connection with the climate change a higher probability of precipitation events with extremely high erosion potential and high frequency of drought episodes can be expected (Dubrovský et al., 2005). Water management in the landscape is likely to become a limiting factor for sustainable development.

Surface runoff is the cause of lower groundwater recharge from rainfall, increasing soil erosion damage, resulting in loss of nutrients, surface water quality degradation and eutrophication (Hejduk and Kasprzak, 2005).

Materials and methods

Effects of intensive rains on water regime of agricultural soils were studied on a Forage research station in Vatín, Czech Republic (49°15´5″N, 15°58´15″E) since 2007 to 2011.

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The system consisted of twelve rectangular plots (2.5 x 4 m) characterised by a slope 5^o arranged into six pairs, of which half exposed southwards and other half northwards. In the lower part each plot, a gutter was connected to a reservoir enabling collection and measuring of surface runoff. The soil in these model catchment areas was classified as a sandy clay loam cambisol. The site is situated at an altitude of 540 m a.s.l., mean annual precipitation and mean annual temperature are 617.5 mm and 6.9 ^{o}C, respectively. Runoff phenomena were studied with regard to the crop and tilling operations. This paper analyses summer periods when silage maize was present on the plots (May to September). Surface runoffs were measured after each rainfall. The main evaluated parameter was surface runoff coefficient φ_o defined as the ratio of surface runoff (H_o) to the given precipitation (H_s) expressed in millimetres.

A pair of plots (northern, southern slope orientation) were sown or planted with crops typical for the region. During the growing period, each pair of plots cultivated as follows:

1.Permanent grassland managed in a standard way (3 cuts, 100 kg N + PK ha^{-1}).
2.Permanent grassland managed extensively (2 cuts, no fertilizing). Both permanent grasslands were established in 2001.
3.Bare soil (control variant) - land has been maintained without weeds using herbicides. 4. Winter wheat (sowing without tillage after harvest potatoes in late September).
4.Silage maize (sown in rows spaced 75 cm in early May in ploughed soil, the soil surface was treated with pre-emergent herbicide)
5.Potatoes (row spacing 70 cm).

Variants 3-6 were alternated in the crop rotation within individual years. Fertilization was applied to individual crops according to methodical procedures and before the potato planting farmyard manure was ploughed down in the rate of 40 t ha^{-1}.
Individual measurements were taken as the average volume of surface runoff from both the slope orientation. For statistical analysis one-way ANOVA was used (Statistica 7.1, StatSoft) with subsequent testing of differences between means according to Tukey (p=0.05).

Results and discussion

The results listed in *Table 1.* show that during the period under research the highest outflows was noticed from bare soil, silage maize and from potatoes. Differences between these three variants were not significant. Small differences between the runoffs from these stands can be explained by the fact that the soil surface was not protected from raindrops impacts during May and June on stands of maize and potatoes. As a result, a crust was formed on the soil surface. Its presence significantly increased surface runoff coefficient. The maize and potatoes stands caused annually an average runoff of 11.9% and 11.2% of water from precipitation fallen during the growing season (V-IX). The crust originates on exposed soil surface during torrential rains. Kinetic energy of raindrops leads to the destruction of soil aggregates and subsequent clogging of soil pores (Fohrer et al., 1999). The presence of crust radically reduces the infiltration rate into the soil and causes the formation of surface runoff. Torrential rainfall can cause from 200 to 500-fold reduction in infiltration capacity of freshly prepared soil for sowing (Kasprzak, 1987). Significantly lower runoffs were found on plots with winter wheat and on both types of permanent grassland (*Table 2*.). Similar results described Hejduk and Kasprzak (2004) from analysis of data measured in Brno-Kníničky, which confirmed high protective function of grasslands against surface runoff formation during a growing season.

Table 1. Comparison of surface runoffs in the growing season (V.-IX.) from individual soil covers in the period of 2007 – 2010 ($m^3\ ha^{-1}$).

Growing season (V-IX)	Soil cover					
	Intensively managed grassland	Extensively managed grassland	Winter wheat	Bare soil	Silage maize	Potatoes
2007	37.8	30.6	32.5	424.4	383.8	376.4
2008	56.8	44.8	99.9	808.3	483.6	728.8
2009	54.8	44.4	73.9	436.5	384.5	278.6
2010	39.2	70.6	62.5	596.1	594.4	223.1
2011	22.8	24.8	170.6	718.5	374.5	498.8
Average 2007 – 2011*	42.3 [a]	43.0 [a]	89.9[a]	596.8 [b]	444.2[b]	421.1 [b]
Comparison to bare soil (%)	7.1	7.2	15.1	100	74.4	70.6
Proportion of precipitations (%)	1.1	1.2	2.3	15.8	11.9	11.2

* Values characterised by the same letter are not significantly different ($p < 0.05$)

One reason for the lower runoff from grasslands is the fact that unlike annual crops, the former creates a permanent vegetative soil cover. Grassing of arable land also leads to an increase in content of soil organic matter, which is associated with more stable aggregates and infiltration rate. Accumulation of organic matter is due to both lack of cultivation (limited mineralisation) and high production of underground biomass (Nösberger et al., 2000). Grasslands represent also an ideal environment for the development of earthworms. They accelerate the decomposition of litter on the soil surface and significantly increase the infiltration rate, especially in soils with a higher proportion of clay particles (Binns et al., 1999). Given that the soil at the experimental plots was not compacted by heavy farm machinery, it is likely that in practice the coefficients of surface runoff were greater. Reliability and credibility of measured data were confirmed by the fact that surface runoff appeared to elementary runoff plots always in the same time period and its duration was the same as in adjacent conventionally managed agricultural land.

Table 2. Comparison of surface runoffs ($m^3\ ha^{-1}$) and surface runoff coefficients from the experimental plots after heavy rain at May 26th 2007. The sum of the rain was 17.5 mm.

Parameter	Soil cover					
	Intensively managed grassland	Extensively managed grassland	Winter wheat	Bare soil	Silage maize	Potatoes
Surface runoff	2.5	1.5	3.5	93.5	82.5	82.5
Surface runoff coefficient (%)	1.4	0.9	2.0	53.4	47.1	47.1

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Conclusions

Stands of silage maize and potatoes form significantly higher surface runoff (an order of magnitude) than the grasslands and winter wheat during the growing season. These differences are increasing especially in the case of recurrence of torrential rains. Surface runoff causes soil erosion, local flooding, degrades the quality of surface water sources (fertilizers and pesticides applied), and deprives plant of soil moisture. Increasing trend in the occurrence of torrential rainfall can be expected due to the ongoing climate change and, consequently, the higher surface runoffs will lead to a greater soil moisture deficit and to a limitation of row crops production.

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CHANGES IN WEED INFESTATION DUE TO DIFFERENT SOIL TILLAGE IN CONDITIONS OF THE CZECH REPUBLIC AND HUNGARY

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Abstract: Weed infestation in cereals (spring barley and winter wheat) was evaluated in two locations in the Czech Republic (CZ) and Hungary (HU). The aim of the work was to compare the effect of different soil tillage systems on weed spectrum. In Zabcice (CZ, South Moravia region) conventional and minimum tillage was compared in spring barley in 2005 - 2009. Different technologies of soil tillage significantly influenced weed spectrum and intensity. More frequent occurrence of *Consolida orientalis*, *Fallopia convolvulus* and *Silene noctiflora* were observed in variants with conventional soil tillage. The weed species *Cirsium arvense* and *Veronica polita* were abundant in a minimum tillage variant. In HU, in location Hatvan, main attention was paid to *Bromus tectorum*, important grass weed in winter wheat, when six different tillage treatments were evaluated. The results showed that the highest occurrence of this weed was in variant with shallow tillage (direct drilling or different ways of loosening).

Keywords: weeds, *Bromus tectorum*, spring barley, winter wheat, soil tillage

Introduction

After "Velvet Revolution" in 1989, in the Czech Republic there was a period of agriculture transformation, when state farms and cooperatives were privatised. Consequently, this process had a significant impact on agronomic standards, and a lack of financial resources also negatively affected the level of plant protection. Faults in usage of herbicides together with the adoption of reduced soil tillage resulted in higher weed infestation on arable land, especially increase of the weeds *Cirsium arvense*, *Elytrigia repens* and *Artemisia vulgaris* occurrence from 1989 to 1993 was very high (Mikulka et al., 2009). The production potential of agricultural system which is connected with higher weed infestation can be limited due to a source of vegetation factors (water, nutrients, light), what is a result of crop-weed competitiveness. Almost, depending on the effect of efficient weed management, the crop yield and quality of harvest is decreased and there is a risk of negative effect on environment, as well.

Materials and methods

The impact of different soil tillage variants on weed infestation was studied in field trials in the Czech Republic and Hungary. Weed spectrum in spring barley was evaluated in locality Zabcice (South Moravia region) in the Czech Republic in 2005 - 2009. Crop sequence was as following: grain maize, spring barley, safflower, winter wheat and winter wheat. Two variants of soil tillage were used - conventional tillage (CT, ploughing to the depth of 0.24 m) and minimum tillage (MT, loosening to depth of 0.1 m). Weed infestation was estimated in spring, before application of herbicides**,** on

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area of 1 m^2, in 16 replications. Results of weed infestation from the field experiment were evaluated by multi-dimensional analysis of ecological data.

Similarly in long-term tillage experiment in Hatvan (Hungary) the effect of different tillage treatments on *Bromus tectorum* was evaluated in winter wheat, in year 2005. Six variants of soil tillage were used: ploughing-a1 (0.26-0.30 m), direct drilling-a2, loosening-a3 and a4 (depth 0.12-0.16 m; 0.16-0.20 m), disking-a5 (depth 0.16-0.20 m) and combination of loosening (depth 0.40 m) with disking (depth 0.16-0.20 m)-a6. Weed cover was assessed using method of modified Újvárosi on area of 1 m^2 (Németh, 1994) in four replications in each variant.

Results and discussion

In spring barley crop stand in Zabcice 32 weed species occurred. The results of weed infestation as average in years 2005 - 2009 are given in *Table 1*.

Table 1. Number of weed species on soil tillage variants

Weed species	soil tillage		Weed species	soil tillage	
	CT	MT		CT	MT
Amaranthus sp.	0.68	0.79	*Laminum amplexicaule*	0.05	0.06
Anagallis arvensis	0.01	0.00	*Lamium purpureum*	0.00	0.02
Artemisia vulgaris	0.01	0.00	*Microrrhinum minus*	0.03	0.00
Carthamus tinctorius	0.05	0.01	*Persicaria lapathifolia*	0.06	0.03
Cirsium arvense	0.18	0.82	*Plantago major*	0.01	0.01
Consolida orientalis	0.11	0.03	*Silene noctiflora*	1.00	0.15
Convolvulus arvensis	0.00	0.17	*Sinapis arvensis*	0.03	0.02
Euphorbia helioscopia	0.02	0.00	*Sonchus oleraceus*	0.01	0.01
Fallopia convolvulus	1.30	0.58	*Stellaria media*	0.00	0.01
Fumaria officinalis	0.16	0.01	*Thlaspi arvense*	0.07	0.20
Galinsoga parviflora	0.07	0.03	*Tripleurospermum inodorum*	0.00	0.01
Galium aparine	0.68	1.30	*Veronica persica*	0.00	0.02
Helianthus annuus	0.00	0.05	*Veronica polita*	0.42	0.66
Hyoscyomus niger	0.00	0.01	*Viola arvensis*	0.01	0.02
Chenopodium album	1.81	1.19	*Zea mays*	0.00	0.02
Chenopodium hybridum	0.09	0.14	Number of species	2.99	2.54
Lactuca serriola	0.02	0.00	Number of individuals	6.87	6.38

According to frequency of weed species occurrence, CCA analyses determine spatial arrangement of weed species and influencing factors (*Figure 1.*). Weed species and the effect of soil tillage as factors are represented by points of different shape and color. The closer is the position of a point of the particular species to a point of the particular variant factor, the closer and stronger is usually their mutual relationship.

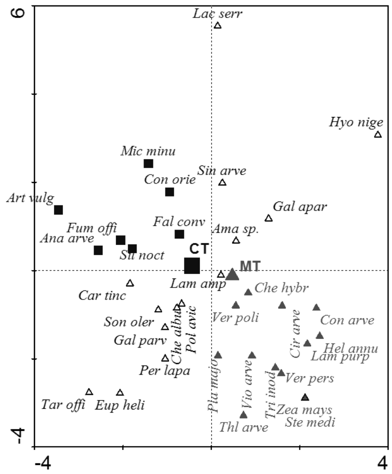

Figure 1. Ordinary diagram recording impacts of different soil tillage on weed species in spring barley crop stand

Legend to ordinary diagram: Variants of soil tillage, ■CT - conventional tillage, ▲MT - minimum tillage;

Abbreviations of weed species: *Ama sp.* - *Amaranthus sp., Ana arve* - *Anagallis arvensis, Art vulg* - *Artemisia vulgaris, Car tinc* - *Carthamus tinctorius, Cir arve* - *Cirsium arvense, Con orie* - *Consolida orientalis, Con arve* - *Convolvulus arvensis, Eup heli* - *Euphorbia helioscopia, Fal conv* - *Fallopia convolvulus, Fum offi* - *Fumaria officinalis, Gal parv* - *Galinsoga parviflora, Gal apar* - *Galium aparine, Hel annu* - *Helianthus annuus, Hyo nige* - *Hyoscyomus niger, Che albu* - *Chenopodium album, Che hybr* - *Chenopodium hybridum, Lac serr* - *Lactuca serriola, Lam amp* - *Laminum amplexicaule, Lam purp* - *Lamium purpureum, Mic minu* - *Microrrhinum minus, Per lapa* - *Persicaria lapathifolia, Pla majo* - *Plantago major, Pol avic* - *Polygonum aviculare, Sil noct* - *Silene noctiflora, Sin arve* - *Sinapis arvensis, Son oler* - *Sonchus oleraceus, Ste medi* - *Stellaria media, Tar offi* - *Taraxacum officinale, Thl arve* - *Thlaspi arvense, Tri inod* - *Tripleurospermum inodorum, Ver pers* - *Veronica persica, Ver poli* - *Veronica polita, Vio arve* - *Viola arvensis, Zea mays* - *Zea mays.*

The most frequent weed species on variant with conventional tillage (VT) were: *Anagallis arvensis, Artemisia vulgaris, Consolida orientalis, Fallopia convolvulus, Fumaria officinalis, Microrrhinum minus, Silene noctiflora*. These weed species probably germinate from "old" weed seed bank, when the deeper soil layers are turned regularly. Weed species as *Cirsium arvense, Convolvulus arvensis, Galium aparine, Chenopodium hybridum, Lamium purpureum, Stellaria media, Thlaspi arvense, Tripleurospermum inodorum, Veronica persica, Veronica polita, Viola arvensis* had higher occurrence in variant with minimum tillage (MT). Soil tillage has a significant influence on weed occurrence in spring barley stand, similarly as results of Bauman et al. (2002). A reduction in tillage intensity can lead to shifts in weed species and densities with increased prevalence of perennial weeds and some annual grasses (Buhler 1992; Derksen et al., 1993).

The effect of different soil tillage method is visible in *Table 2*. The lowest coverage of *Bromus tectorum* was in variant with ploughing (a1) and the highest in variant with

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direct drilling (a2). Especially on loosened variants, where shallow tillage or direct drilling was applied, weed coverage rapidly increased during vegetation period. Results of this experiment confirmed the international publications, according to the *Bromus tectorum* spreading mostly in the shallow tillage treatments. Camara et al. (2003) found that conservation tillage was less productive than mouldboard ploughing probably because of lack of downy brome (*Bromus tectorum* L.) control in the conservation tillage systems.

Table 2. Frequency of *Bromus tectorum* occurrence, Hatvan, 2005

Date of survey	Average weed cover % in tillage treatments					
	a1	a2	a3	a4	a5	a6
12.4.2005	0.03	31.25	41.75	15.00	16.75	10.00
4.7.2005	0.88	78.15	42.50	39.25	35.75	30.75

Conclusions

The results shown, that soil tillage is an important agronomic measure, which can influence the structure and intensity of weed infestation. Reduction intensity of soil tillage creates better conditions for germination of annual weed species which favour covering of seeds with shallow soil layer. This theory was confirmed within results from long-term trials by weed species *Galium aparine, Chenopodium hybridum, Lamium purpureum, Stellaria media, Thlaspi arvense, Tripleurospermum inodorum, Veronica persica, Veronica polita* and *Viola arvensis* in the Czech Republic and by *Bromus tectorum* in Hungary. On the other hand, minimum tillage system is also connected with higher occurrence of some perennial weeds as *Cirsium arvense* or *Convolvulus arvensis.* Reduced soil tillage must be compensated by efficient chemical control.

Acknowledgements

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EFFECT OF MANURING WITH COMPOST EXAMINED ON THE ORGANIC MATTER AND WATER MANAGEMENT OF THE SOIL AS WELL AS ON THE VEGETATIVE DEVELOPMENT AND YIELD OF MAIZE

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Abstract: Agricultural utilisation of biologically decomposable organic waste materials after the procedure of composting is beneficial for the land in many ways. Compost can be rich in nutrient therefore it is useful for boost the level of organic matter of the soil, improve soil structure, and indirectly for climate protection due to reducing carbon loss. Effect of two different types of compost was examined on the circulation of organic matter and water in the soil as well as on the vegetative develpoment and yield of maize. Doses of compost used in randomised complete block experiment with four replicates were as follows: 8 t ha^{-1}, 15 t ha^{-1}, 24 t ha^{-1} Growth of maize was investigated to monitor its development, therefore height of the plant, width and lenght of leaves were measured, and LA, LAI were calculated five times during the vegetation period.
Concerning the examined parameters (plant height, width and lenght of leaves, LA, LAI, maize yield) slightly depressive effects were found for the tested composts and dosages.

Keywords: compost, soil, maize

Introduction

Sustainable waste management strategies are becoming increasingly important due to the need to conserve and recycle soil organic matter. Application of compost to soil replacing inorganic fertilisers in conventional farming practice has potential benefits in reducing the substantial carbon emissions associated with mineral fertiliser manufacture and transportation (Pelletier et al., 2008; Cherif et al., 2009). This practice would also contribute to reducing the volume of domestic and commercial organic waste deposited in landfill sites, which is desirable in an environmental context that might finally contribute to climate protection (Hackl and Mauschitz, 2008; Erhart et al., 2005, 2008). Inputs of complex organic materials to soils have been found to increase soil organic matter (SOM) contents (Benedek et al., 2009) and to have beneficial effects on soil structural stability and water-holding capacity (Lakhdar et al., 2009; Ramos and Martinez-Casasnovas, 2006; Weber et al., 2007; Nagy et al., 2011). For crop production, the biological breakdown (decomposition, utilisation and turnover) of organic wastes applied to soils is essential as it releases nutrients from complex organic forms to mineral, plant-available forms to support growth. Therefore compost utilization may promote nutrient availability, plant growth, stimulate respiration and photosynthesis (Paterson et al., 2011), which finally could lead to the improvement of plant yield (Erhart et al., 2005; 2008). According to Singh and Jagadeesh (2009), the response of crops to the compost supply depends on several factors such as C/N ratio,

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its degree of humification and nutrients content. Erhart et al. (2008) confirmed this as they found that on the fertile experimental site, the yield response to the compost applications was low in the beginning, but increased with the duration of the experiment.
In the present paper, the results of the first year of a three-year-long experiment is discussed focusing on the effects of fertilization with two kinds of composts in different dosages on plant growth and yield of maize in field conditions.

Materials and methods

Field trial was conducted on the experimental area of the Institute of Plant Production (University of West-Hungary, Faculty of Agricultural and Food Sciences, Mosonmagyaróvár, Hungary) in 2011. Two different kinds of composts (from the composting plant of the City of Vienna [B] and Győr [G]) were compared in the trial. The soil was calcerous alluvial meadow soil with moderate supply of nitrogen and potassium and with good supply of phosphorus. Experiment was carried out in randomized complete block design in four replications. Doses of the tested composts were as follows: [1] 8 t ha^{-1}, [2] 15 t ha^{-1}, [3] 24 t ha^{-1}. Area of each experimental plot was 225 m^2. Maize (DKC 3511) was used as test plant in the trial. Date of sowing was 26. 04. 2011. Plant density was 70.000 plants ha^{-1}. No mineral fertilization was applied. Growth of maize was investigated to monitor its development, therefore plant height, leaf width and lenght were measured five occasions during the vegetation period. Leaf Area (LA) and Leaf Area Index (LAI) was determined with Montgomery's formula. Maize yield was measured after harvesting (18. 10. 2011.) each plot with a plot combine.

Results and discussion

In 2011, neither plant height nor the values of LAI showed any significant differences due to compost treatments (*Figure 1* and *Figure 2*). However, slightly depressive effect was found for the measured vegetative objects which might be explained by the results of the ongoing soil analyses. Compared to the control the highest differences for plant growth and LAI were observed in the case of G3 (24 t ha^{-1}) treatment, but these results were not statistically proved. The lack of treatment differences indicates that expected preferable effects of compost application was not manifested in plant growth.
Maize yields of the treatments were measured to determine the effect of the types and doses of applied composts. The yields measured in the trial ranged between 7.76 and 11.14 t ha^{-1}. Yields were decreased in all cases of compost applications by 0.37-3.04 t ha^{-1} except for B1 (8 t ha^{-1}) treatment compared to the control plot results (*Figure 3*). Considerable depressive effect (-3.04 t ha^{-1}) was observed for G1 treatment (8 t ha^{-1}) compared to the unfertilized control. This is line with literature (Erhart et al., 2008).

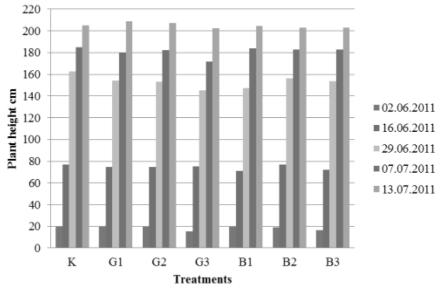

Figure 1. Plant height

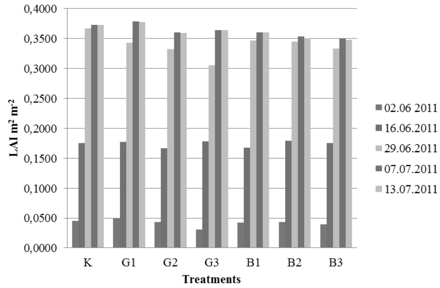

Figure 2. LAI

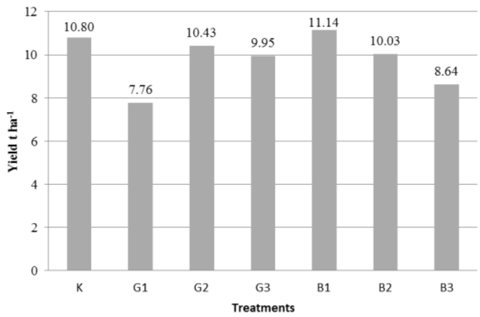

Figure 3. Yield

Conclusions

Based on the results obtained so far, it can be stated that further researches are needed to assess the long-term effect of repeated compost application to soil and the potential cumulative effects on soil structure and water cycle. According to the first year's experiences, it can be stated that compost application had moderate effect on the growth of the vegetative parts of maize. This behaviour might be attributed to the slow-release fertilizer effect of compost.

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AN ANALYSIS OF THE WATER RETENTION CAPACITY FUNCTION OF A SOIL OF A HETEROGENEOUS PORE STRUCTURE IN SOIL CONSERVING TILLAGE SYSTEMS

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Abstract: In our field experiments we examined the ways the different soil conserving tillage systems affect the soil's physical properties and their moisture retention, in view of the expected impacts of the projected climate change. The soil of a heterogeneous porous structure was characterised on the basis of the distribution of the pore sizes in the different soil tillage systems, with the aid of a complex water retention curve. The function fitted to the measured values of the pF curve showed a clear distinction between the macroporous and the microporous domains dominating the soil's water dynamics. The Durner model used in this study enables a distinction between the soil's heterogeneous pore systems which we used for indicating the effects of tillage. We studied the differences appearing in the soil physical and soil hydrological attributes resulting from direct seeding (zero soil disturbance), ploughing, disking and other agrotechnological operations. The zero-tillage technology showed a macropore domain that hardly changes with the depth being studied while in the case of ploughing the changes in the pore domains clearly indicated the tillage depth. Differences were found between the agrotechnological operations in terms of both the distribution of the pore sizes and the moisture forms found in the soil. The specific effects of the different treatments were most accurately reflected in the applied complex function by the changes in the *w* factor reflecting the ratios of the pore domains in the different treatments.

Keywords: macropore domain, dual porosity, complex pF curve, w-value

Introduction

As is well known, the soil's pore size distribution is altered by the various means of soil disturbance (Dexter et al., 2004; Várallyay, 2004). The ratio of macropores is a quantifiable and relatively easy to establish structural factor equally affecting root growth, soil moisture dynamics and the aeration conditions (Farkas, 2001).
The unimodal models are not suitable for adequately expressing the structure of soils of heterogeneous pore distribution. Therefore Durner (1994) suggested linear superposition of the 'sub-curves' for the examination of soils of heterogeneous pore structures. Durner's method was based on the idea that the water retention curve of a dual porosity soil can be expressed by superimposing one unimodal pF curve on another (linear superposition).
Our experience shows that mathematical models based on unimodal curves are of limited use for estimating the moisture dynamics of tilled soils. For this reason the need emerged earlier on for the use of a function that is suitable for the description of the hydrology functions of soils of complex porous systems in these models.

Materials and methods

Our studies were carried out in the long term soil tillage experiments set up at Szent István University in 2002 (Birkás and Gyuricza, 2004a). The area is covered by Calcic

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Cernic Chernozem, (WRB) developed on a loess basis. Ours was a single-factor experiment in a stripe arrangement set up in 13 m x 150 m experimental plots in 3 iterations. The examined soil tillage systems and tillage depths are as follows: ploughing (SZ, 26-30 cm); disking (TÁ, 16-20 cm); disking combined with deep loosening (LT, L: 40-45 cm, T: 16-20 cm), two tine tillage treatments (with cultivators) (SK, 12-16 cm and K, 16-20 cm), and direct seeding (DV) (Birkás and Gyuricza, 2004). The samples were taken from the 5-10 cm, the 15-20 cm, the 30-35 cm and the 40-45 cm deep layers thereby characterising the surface layer, the tilled layer, the tillage pan and the undisturbed layer. The typical values of the water retention curve (the amounts of water retained in the soil against a suction force corresponding to the pressure of 0.01 m, 0.025 m, 0.1 m, 0.3 m, 1 m, 2 m, 5 m, 25 m and 150 m high water columns) were established with the aid of the Várallyay method (Várallyay, 1973).
The parameters of the Durner curve were established with the aid of the *SWRC fit* on-line programme developed by Seki (2007).

Results and discussion

We described the effects on the soil's pore volume of the different tillage systems studied in our experiment on the basis of the differences found in the range of soil moisture content that is available for plants, using the water retention curves based on complex fitting.

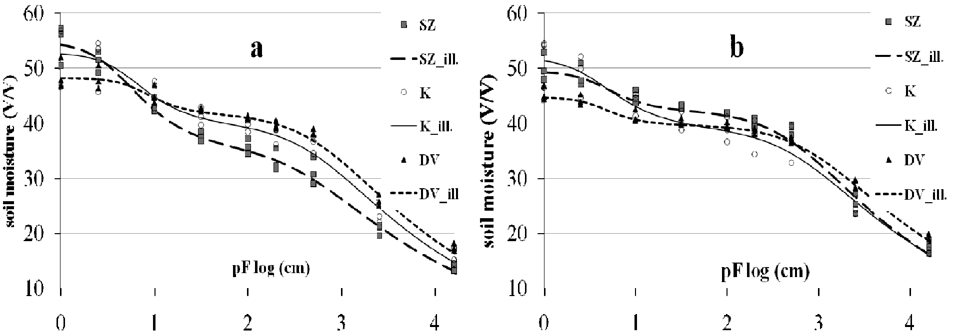

Figure 1. Dual porosity curves of different tillage treatments in the examined soil layers

Remark: (SZ) Plowing (measured), (SZ_ill) Plowing (fitted function), (K) Cultivation (measured) (K_ill) Cultivation (fitted function). (DV) No tillage (measured), (DV_ill) No tillage (fitted function). Depth: a) 5-10 cm, b) 20-25 cm

As has already been mentioned, in the low suction force range (pF<2) the shapes of the functions are determined in the top soil layer (*Figure 1.a*) by a variety of natural and anthropogenic impacts besides the various agrotechnical procedures. In the 5-10 cm layer the saturation water content was higher after ploughing and shallow tine tillage (54.63-53.2 m^3/m^3) than after the other treatments. A large amount of water may be removed from the soil after ploughing even *by a low suction force* which is indicative of the high water conductivity and quick depletion of the large spaces of the macropores resulting from the loosening effect of tillage.

Significant differences are also observed in the deeper layers as well - 15-20 cm (*Figure 1.b*) - the saturation water content ratios being typically higher (49.4 - 51.8-m^3/m^3) after tine tillage (16-20 cm) and ploughing.
Since the disk pan tends to be found in this range of depth (disking does not go deeper than 16-20 cm) along with the maximum depth of tine tillage treatments, the saturation water content ratios measured in this layer provide valuable information on tillage pan development.

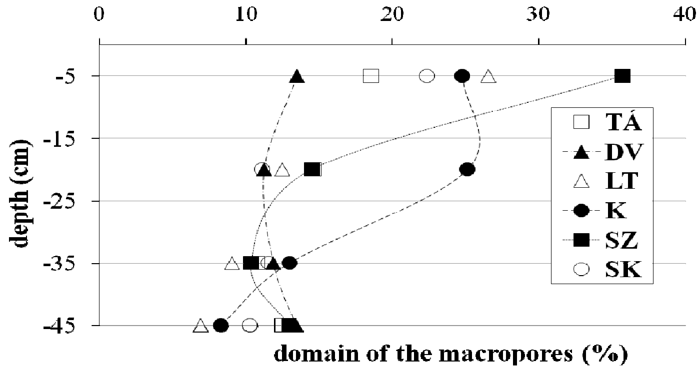

Figure 2. Changes in the macropore ratios in the different layers of the different treatments

Remark: SK- shallow cultivator, SZ- ploughing, K- cultivator, LT- loosening + disking, DV- direct seeding, TÁ- disking.

The effects of the different tillage techniques were found to be possible to detect primarily in the macropore domain. *Figure 2* shows the changes in the macropore domains, fracture ratios, inter-aggregate space sizes of the dual porosity pF-curves, in the examined layers of the soils after different tillage treatments.
The ratio of the macropore domain was found to be particularly high (35%) after ploughing, showing a likelihood of a more cloddy structure and the presence of larger aggregates in the top soil as is confirmed by practical experience. The smallest pore volume was found after direct seeding, as a consequence of the minimum soil disturbance and the more compact soil condition in the first place. The macropore ratios found after disking, disking combined with deep loosening and after tine tillage and shallow tine tillage show a favourable soil condition on the basis of the w values (18-27%) of the DM model in the top 5-10 cm layer.
Our results showed that the most favourable soil structure resulted in the tilled layer (15-20 cm) from tine tillage (K, 16-20 cm). Tine tillage - with cultivators - was found to result in the best loosening effects to a depth of 20-25 cm.
Among the technologies inevitably resulting in pan forming the reduction of the pore volumes in the soil after ploughing, disking and after disking combined with deep loosening could already be detected at a depth of 20 cm. The loosening effect penetrating to a depth of 45 cm could not be detected in the case of disking combined with deep loosening. In this treatment disk pan forming was a more dominant process than loosening and the 10% macropore ratio at the depth of the tillage pan reflected the compacting effects of the disks. The effects of disking and ploughing are indicated in

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the decreased macropore ratios in the layers underneath the tillage depth, showing the presence of a compacted layer. Direct seeding represented the treatment with the least soil disturbance as was well-reflected by the modest change in the macro-space in the depth studied in the experiment.

Conclusions

This paper presents an examination of the effects of conventional and up-to-date soil conserving tillage systems on the soil's water retention curves and porosity conditions with the aid of the 'dual-modal' model. The multimodal type analytical curves were closely fit the measured pF data than did the unimodal models. The multimodal curves were found to be more useful in characterising the heterogeneous porous system. Another benefit offered by multimodal curves was that they can be divided into several homogeneous subsystems. The shape of the curve can offer important additional information on the effects of the different soil tillage systems on the soil therefore the multimodal pF curves can be better and more highly integrated indicators for analysing the agrotechnological effects on the soil. Our results lead to the conclusion that under the site conditions studied in the experiment the deep tine tillage system - with cultivators - created the soil condition with the most stable structure, the one that is the most favourable from the aspect of air and water transport.

Acknowledgements

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EFFECT OF HEAVY METAL POLLUTANTS ON THE HUMIFICATION PROCESSES IN THE SOIL

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Abstract: The ratio of soluble and insoluble humus compounds affects the fate of heavy metal pollutants in the soil. Huminic acids can decrease, while fulvic acids can increase the solubility of heavy metals. It also seems likely that metal pollutants affect the ratio of huminic and fulvic acids. The aim of this study is to clear up the effect of heavy metals (Hg, Cd, Cu, As, Pb, Zn and Cr) added in high concentration to the soil on the ratio of humus compounds. NaF and NaOH extractants were applied to isolate humus compounds. The quotient of the NaF extractable and NaOH extractable fractions gives the humus stability number (Q). The higher stability number means the higher ratio of insoluble (stable) humus fraction. It can be found that heavy metal pollutants affect the humification processes in the soil. The ratio of less stable humus fraction was increased by metal pollution compared to the stable one. The question is, if the less stability number was caused by increase of NaOH extractable fraction or decrease of NaF extractable one. It was establish that the amount of the NaF extractable fraction did not change compared to the control, while the amount of NaOH extractable fraction increased significantly.

Keywords: heavy metals, humification processes, humus compounds, humus stability number

Introduction

Humus gives the soil a special ability to store water and make it available to plants. Because of more efficient water utilization, losses from leaching and evaporation are reduced, and irrigation intervals can be extended. Studies on metal-polluted soils showed that the decomposition of organic matter was affected by high rates of trace element contaminants, so that plant debris accumulate over the mineral soil, without greater destruction and forming Mor (Bajabane et al., 1999; Benedetti et al., 1996) It was caused by the changes in humus organisms, in particular earthworms (Nahmani and Lavelle, 2002). Similar phenomenon occurs when a site is polluted by hydrocarbons (Gillet and Ponge, 2006). We also expect similar changes in humus forms, as a result of decreased humus forming ability in cultivated soils in case of detrimental effects of heavy metals on soil decomposition processes. We also propose that these effects can increase the soil humus content a few years after the pollution, by the temporary increasing of organic matter input to the soil system, due to of killing of decompositors. These humus forms will be probably not stable (not condensed) compounds. Increasing respiration was observed on some heavy metal polluted plots seven years after pollution. It can be resulted by increasing amount of organic matter (Máthé et al., 2007). There are also evidences about interrelations between humus compounds and heavy metals by complex forming. It has a contradiction in effect of mobilisation of these metals. A part of humus compounds (fulvic acids) increases, but another part (more condensed forms) decreases solubility of some heavy metals (Bajabane et al., 1999, Benedetti et al., 1996; Gillet and Ponge, 2002). The aim of this work is to study the correlations between concentrations of the NH_4-acetate + EDTA soluble heavy metals and the amount of different humus forms in dry soil condition. The method was based on the different solubility in NaOH and NaF of humus fractions with different ages and stabilities. The determination of humus concentrations was based on the measurement of light absorbances of humus.

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Materials and methods

The field experiment

The long term field experiment on heavy metal loading was initiated in Tass-puszta Model Farm of Károly Róbert College. The soil at the experimental site is a mildly acidic chernozem brown- forest soil (vertic cambisol). Selective physical and chemical properties are the following: $pH_{(H2O)}$ 6.4; $pH_{(KCl)}$ 5.4; hydrolytic acidity ($y_{1)}$ 9.5; no $CaCO_3$ in the cultivated layer, humus content 3%, upper limit of plasticity (K_A) 45 and 30-35% clay content. The dominant mineral particles are clay and silt. The soil is well drained, with good hydraulic conductivity and adequate pore sizes for water retention. The yearly precipitation is 550-600 mm, but its distribution is uneven during the growing period. The weather condition was very dry in the sampling season (*Table 1*).

Table 1. Precipitation and temperature data in the sampling season 2005

Month	Precipitation mm	Number of rainy days	Mean air-temperature C°
March	15	3	3.6
April	102	8	11.4
May	64	5	16.6
June	37	4	18.9

Sampling, chemical analysis of the soil

The field trial was set up with 8 elements (Al, As, Cd, Cr, Cu, Hg, Pb, Zn) on three application rates (30, 90 and 270 kg element ha^{-1}) each and all in triplicate. Only the effects of As, Cd, Cr, Cu, Hg, Pb and Zn elements applied at the highest dose (270 kg element ha^{-1}) on humus solubility was studied in this work. Two soil samples were collected from each replication and these samples were studied separately. The samples were taken from the upper horizon of the soil (0-30 cm). The easily soluble, exchangeable amounts of applied heavy metals were determined from NH_4-acetate + EDTA extraction used ICP-AES plasma emission spectrophotometer.

Analysis of humus compounds

The method that was used for analysis of the humus forms required low mass of soil samples. Humus compounds were isolated using two different extractants, NaF and NaOH (Hargitai, 1968). The NaOH soluble humus fraction represents the less stable (usually younger) humus, without Ca^{++} ion saturation. The NaF dissolves the stable and Ca ion saturated, or condensed humus. The optical absorbance of the humus solutions was used to characterise the humus concentrations in the soil. The quotient of the optical densities of the NaF extractable and NaOH extractable fractions gives the humus stability number (Q). The higher stability number means the higher ratio of insoluble (stable) humus fraction. Statistical analysis of data and relationships was conducted by an analysis of variance (ANOVA) and quadratic regression analysis.

Results and discussion

In the field experiment the stability number of the humus was decreased by each studied heavy metal pollutants. This effect was significant at each treatment on p = 0.05 level (*Table 2*).

Table 2. Effect of heavy metal pollutants on the stability index of humus

Treatments (270 kg element ha^{-1})	Stability index	Differences between treated samples and control
Untreated control	4.930328	0.000
Chromium (Cr)	2.757952	-2.17238
Cadmium (Cd)	2.306683	-2.62365
Zink (Zn)	3.00081	-1.92952
Mercury (Hg)	2.630766	-2.29956
Cupper (Cu)	1.783055	-3.14727
Lead (Pb)	1.83357	-3.09676
Arsenic (As)	2.512343	-2.41799
$SD_{5\%}$	0.4072	

This means that the character of the humus was changed by heavy metal pollutants. The decrease of stability index can resulted by the high increasing of less stable humus fraction or decreasing of more stable humus fraction or by combination of both effects. For this reason relation of contaminant metal content and humus solutes of both solvents (NaF, NaOH) were studied by regression analysis. Our aim was to determine the effect of the easily soluble heavy metal concentrations on the quantity of stable and less stable humus fractions independently of chemical characters of heavy metal salts. A strong quadratic regression was obtained between metal ion concentrations and the amounts (measured by optical densities) of the of NaOH soluble, unstable young humus fraction (*Figure 1*).

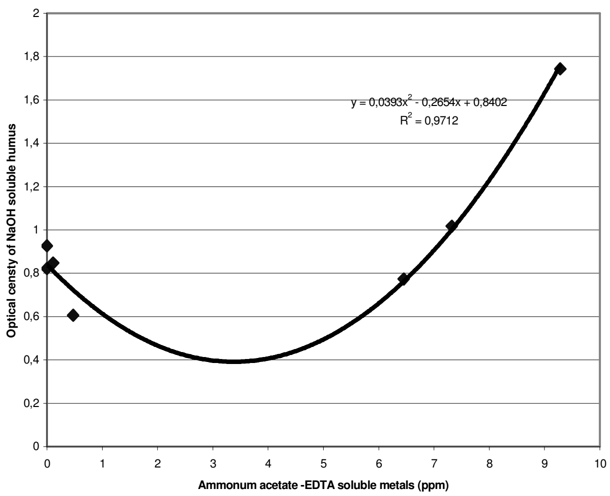

Figure 1. Correlation between soluble metal pollutants and the amount of the instable huminic substances

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The quadratic equation of regression between metal concentration and unstable (young) humus content in the soil is:

$$y = 0,0393x^2 - 0,2654x + 0,840$$

y = amount of the NaOH soluble humus (characterized by its optical absorbance).
x = NH_4-acetate+EDTA soluble concentration of different metallic pollutants in the soil (mg kg^{-1}).

In contradiction to this result, there was not any correlation between the metal concentrations of the soil and the more stable (NaF soluble) humus contents.

Conclusions

We studied the effect of concentrations of different NH_4-acetate+EDTA soluble heavy metals on the humus stability number in a brown forest soil. The stability number is an index, which shows the ratio of the more and less soluble humus compounds. The decreasing of this index was resulted from the effect of different metal pollutants compared to the untreated plots. A strong regression was proved between concentrations of pollutants and the content of instable humus fraction of the heavy metal amended soil. The regression can be characterized by a quadratic equation that consists of a quadratic and a linear part. Both of two parts has a significant but adverse effect on the soluble humus. The linear member of the multiple regressions shows a negative trend, while the quadratic one has a positive trend. Probably the positive quadratic part represents the effect of the organic matter enrichment caused by killing effect of pollutants on soil living organisms, while the negative action of the linear component was resulted by organic matter consumption of soil microbes.

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GREEN WATER - *AMBROSIA ARTEMISIIFOLIA* L. ON WINTER WHEAT STUBBLE

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Abstract: One of the important issues in agro-environmental protection is the pollen emission of common ragweed (*Ambrosia artemisiifolia* L.). A decrease in pollen emission can only be achieved if we have adequate knowledge of common ragweed's biology, its spread and the dynamic processes of the population. Its damage is not only important from a human health point of view, but also from that of plant production and plant protection. Winter wheat is an important crop in Hungary, being seeded on approximately 1.2-1.3 million hectares annually. The present research investigates the spread of common ragweed in cereal stubble fields, and its water content.
The research was carried out near the town of Keszthely on a 4 hectare sample area of 20 hectare field, on a brown forest soil (Eutric cambisol). For the planning of terrain measurements, one of the most modern GPS basic software was used, provided by the Georgikon Faculty of the University of Pannonia, Hungary. Desktop application, a connecting GPS database and map server services have made it possible to use several formats of online, offline or analog source data throughout the planning phase. Geodesic accuracy terrain measurements were carried out using the data of the Georgikon GNSS Base Station. The obtained data were also used to build a 3D terrain model. A field level terrain model was not only used for measurement planning, but also for GPS analysis. The GPS data obtained throughout the measurements and analysis were organized in an up to date database structure, which was of great help while processing the data, and made it possible for other projects to access the data in an effective and simple way.

Keywords: common ragweed, *Ambrosia artemisiifolia*, biomass production, water content, GIS and GNSS technology

Introduction

Common ragweed is abundant in cereal and cultivated row crops, in disturbed fields, waste places and occasionally along the edges of roadsides (Bassett and Crompton, 1975). In Hungary, *A. artemisiifolia* was first reported in the first half of the 1920's as an arable weed (Priszter, 1957). On the summarized list of weed flora of winter wheat and maize - at the time of the First National Weed Survey in 1950 - *A. artemisiifolia* was the 21st most important weed in Hungary (Tóth et al., 2001; Lehoczky et al., 2010; 2011). It has increased in distribution and based on the summarized results of weed survey on wheat and maize fields in late summer of 2008 and 2009. *A. artemisiifolia* became the most important weed of arable lands in Hungary, with the highest mean cover of 5.33% (Lehoczky et al., 2009; Béres and Novák, 2011). By the time of harvest, common ragweed can create a dense stand in cereals and continuous ground cover in wheat stubbles (Ujvárosi, 1973).
On cereal stubble fields, *A. artemisiifolia* occurred in the density of 54 plants$\cdot m^{-2}$, and almost no other weeds were present (Lehoczky et al., 2011). So much density could mean significant amount of biomass and green water (as water content of weeds) in fields. Moreover, Lehoczky et al (2006) established tight correlation between the weediness and the water content of soil.

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The aim of our research was to analyze the significance of weediness and biomass production of *A. artemisiifolia* with special regard to the water content of the plants using modern GNSS-GIS techniques.

Materials and methods

The study was conducted in Keszthely, Hungary on a brown forest soil (Eutric cambisol). The 4-acre area was chosen from a 20 acre field.
The survey was carried out on 29 July 2009, 22 days after harvest. Thirty measurement points were identified with the help of DGPS and the GNSS system guaranteed a precision of minimum 5 cm.
All aboveground parts of every ragweed plant were collected from a 1 m^2 area in each sampling point, and the fresh and dry-matter weights of plants were measured.
The ArcCatalog and ArcMap modules of ArcGIS 9.3.1 software were used for creating new layers and point highlighting editing in the previous measurements as well. For data collection, the Trimble 5800 GPS rover device was used, which is capable of dual phase real time kinematic measurement, with a TSC2 12.22 version software survey controller. The GIS procession was carried out using the ESRI ArcGIS 9.3.1 system. Geo-databases and shape files were used as well.

Results and discussion

In the present experiment, we found a correlation between the density of *A. artemisiifolia* and the biomass production on the given areas that can be described with the help of a function as follows: y=-0.0551x2+2.6403x-5.0876; r=0.7426; n=28; P<0.01.
Based on this correlation it can be stated that the biomass production was growing in parallel with the plant number of young ragweed, reaching a maximum at 24 plants. Following that point, biomass production did not grow any further, but started to fall.
This phenomenon showed that, within the ragweed population under the conditions of our experiment (sources: nutrients and water), strong interspecific competition appeared.
Considering the distribution of *A. artemisiifolia* within the field it can be stated that 3 weeks after the harvest of winter wheat the cover of the area by ragweed was highly concentrated and carpet-like.
The density of *A. artemisiifolia* varied within the field, ranging between 4 and 44 plants per square meter (*Table 1*).
The fresh biomass of *A. artemisiifolia* within the area varied between 30.0-271.2 $g \cdot m^{-2}$ (*Table 1*).
The dry biomass of common ragweed ranged from 5.6 to 56.9 $g \cdot m^{-2}$ in the experimental area, and the total dry weight of its biomass was 203.3 $kg \cdot ha^{-1}$. The average water content of plants was 81 %.

Table 1. Density, fresh and dry biomass production of common ragweed

	Density (plants·m^{-2})	Fresh weight (g·m^{-2})	Dry weight (g·m^{-2})
interval	4-44	30.0-271.2	5.6-56.9
mean	20.9	115.6	22.2
deviation	10.0	10.8	50.9

Later examinations on the sample area (29/09/2009) showed that dry biomass production of *A. artemisiifolia* increased tenfold between the initial and second sampling, to 516.3 g·m^{-2} in two months, with 11% of the dry matter being seed (Lehoczky et al., 2011).
The water content of *A. artemisiifolia* at the time of the examination is shown in *Figure 1*.

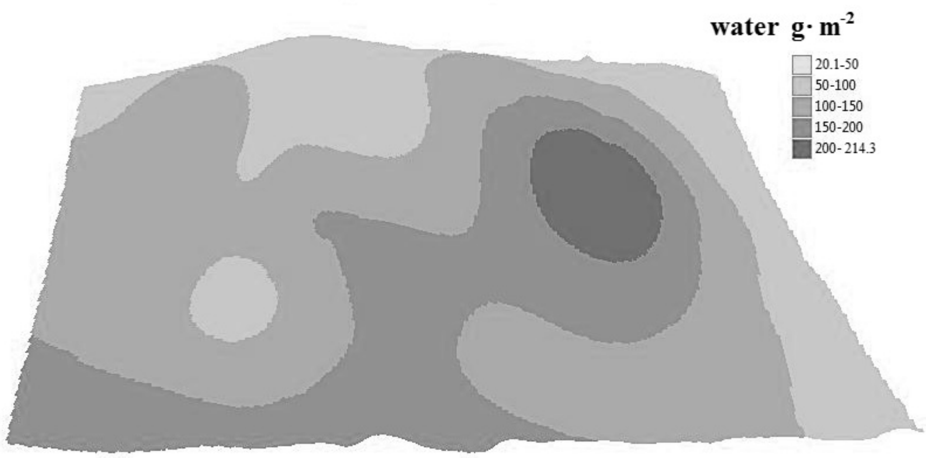

Figure 1. The distribution of water content of common ragweed on the experimental field.

Water content of common ragweed ranged from 24.2 to 214.3 g·m^{-2} on the stubble. Based on the pattern of distribution, green water volume was 824.1 kg·ha^{-1}.
Covering stubbles by ragweed, water content of plants can represent significant amount, especially if the evaporated water in the course of transpiration and growing is also taken into consideration.

Conclusions

Study was conducted on density, biomass production and green water content of common ragweed on winter wheat stubble. As the results of the measurements, specific data were collected on the above mentioned parameters. The GIS-GNSS system was highly applicable to evaluate the biomass and water quantity of common ragweed in the field.

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Three weeks after the harvest of winter wheat, *A. artemisiifolia* was present on the area in high density. Its dry biomass production was on average 203.3 kg·ha^{-1}.
Based on the result of correlation analysis it can be stated that the biomass production is growing in parallel with number of young ragweed plants, reaching a maximum which was at a plant density of 24 plants·m^{-2}. After that point, biomass production started to fall.
According to the results, common ragweed is able to produce biomass in significant amount on winter wheat stubbles.
Three weeks after the harvest, 1027.3 kg·ha^{-1} fresh biomass was produced, which contained 203.3 kg·ha^{-1} dry matter. The fresh biomass contained 81% water in average. The water content of common ragweed was 824.1 kg·ha^{-1}.
On the basis of the evaporated water amount in the course of transpiration and growing, *A. artemissifolia* can significantly reduce the available water content of soils.
Based on the results, it was concluded that the weed control of stubbles performed in time had a great importance not only for the effective plant protection, but also in terms of the water cycle of soil-plant system.

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WATER AND IRRIGATION MANAGEMENT BASED ON THERMOGRAPHIC SURVEY

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Abstract: Apple orchard is relatively not highly water consumer comparison with cereal species. However, to ensure optimal water capacity values calculating breeding season it is the most important risk factor. Nowadays, in Hungary there isn't any intensive apple and pear orchard, where they would question the importance of the irrigation. Modern irrigation system strongly requires proper irrigation scheduling and control. Out of several technologies infrared thermography can be a good solution for both irrigation scheduling and water stress monitoring. The research fields were apple, orchard at Pallag in Hungary, which is situated in Nyírség meso-region. In our study airborne thermographic survey were applied to achieve more precise and effective water tsress detection and irrigation management. Based on the results, the airborne thermographic survey and CWSI is an effective method for surveying the waterstress of the plantation.

Keywords: canopy temperature; crop water stress index; evaportranspiration; irrigation scheduling

Introduction

Hungary has favuorable agro ecological potential for apple fruit production (Soltész and Szabó, 1998; Hrotkó, 1999), although intensive apple orchards need irrigation to avoid plants from water stress and increase the apple yield security and quality. Modern irrigation system strongly requires proper irrigation scheduling and control. Since canopy temperature acts as a good indicator of plant water status, infrared thermography is considered for the identification of plant water stress and is also used as a tool for irrigation scheduling method (Wang and Gartung, 2010). If plant water stress increases, transpiration decreases and plant temperature may exceed air temperature. On the other hand, non-stressed plants will have canopy temperatures less than air temperature, particularly when vapour pressure deficit (VPD) is not greater than 4 kPa (Olivo et al., 2009). The crop water stress index (CWSI) relates canopy–air temperature difference to net radiation, wind speed and vapour pressure deficit (Jackson et al., 1981). However, a surrogate measure is calculable from the temperatures of the canopy and reference leaf surfaces corresponding to fully transpiring and non-transpiring canopies (Jones, 1999a; Jones et al., 2002; Moller et al., 2007). Thus, by monitoring plant canopy temperature and the temperatures of wet and dry leaves, it is possible to estimate the underlying plant water stress status and therefore, intelligently control the related irrigation process.

Materials and methods

The examinations were carried out at a micro-irrigated intensive apple orchard in Debrecen-Pallag in 2011. The examination site is the part of the Experimental Pomology Site and Study-Farm of the University of Debrecen, Centre for Agricultural and Applied Economic Sciences.

The HEXIUM mobile infra red camera with microblometer sensor and 384x288 pixel resolution was used for the water status detection of the apple trees. has. There is an IR camera included. With 50 frames/sec a real-time imaging is possible. The images can be

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seen on the colour LCD. With the 16 bits/pixel image you get an image that can be coloured later as you like with a post-processing algorithm. The camera sensitivity is 0,05 °C, and its measurement interval is between. -20 and 120 °C, but the optimal temperature is between -25 and 60 °C for proper working.

A key procedure for the evaluation of crop water stress from plant canopy temperature was to calculate CWSI based on the data collected from IR thermography systems. The CWSI described by (Jones et al., 2002) is of the following generic form:

$$CWSI = \frac{T_c - T_w}{T_d - T_w}$$

where T_d and T_w represent the reference temperatures for dry (nontranspiring) and wet (fully transpiring) leaf surfaces respectively. T_c is the temperature of the transpiring surface, i.e., the actual measured temperature of all sunlit leaves to represent the sunlit portion of the canopy. Although alternative methods for estimating reference temperatures may be found (Guilioni et al., 2008), reference leaves, which are artificially treated real leaves with known conductance to water vapour, can be physically embedded in the scene (Jones, 1999b) and so the reference temperatures T_d and T_w can be estimated from the leaf temperature distribution. In this study the reference temperatures T_d and T_w can be estimated from the leaf temperature and air distribution. Before the CWSI calculation masking was made in order to eliminate the background ad keep only the apple trees on the infra red image. The image processing was made based on Hunyadi et al (2010), in IR Player, Surfer9 and the CWSI analysis were carried out in Idrisi Tajga software environment.

Results and discussion

Thermographic survey was made on 25th of August, 2011. Since heat warming was announced at that day by the Hungarian Meteorological Services it was an appropriate opportunity for surveying the effect of extreme high temperature on the apple tree canopy. The survey was made between 04:30 and 16:00, thermographic images were taken in every 30th minutes.

Once the temperatures Td, Tw and Tc are identified using the pixel-by-pixel temperature data associated with the IR image. (*Figure 1.*).

Figure 1. Thermographic image on apple trees (°C), 5 AM

Parallel to the thermographic investigation, the air temperature was also measured by analogous thermometers in shade. The air temperature reached its minimum at dawn. Based on thermographic image, the temperature parameters of apple yield, leaf, trunks were investigated. (*Figure 2.*).

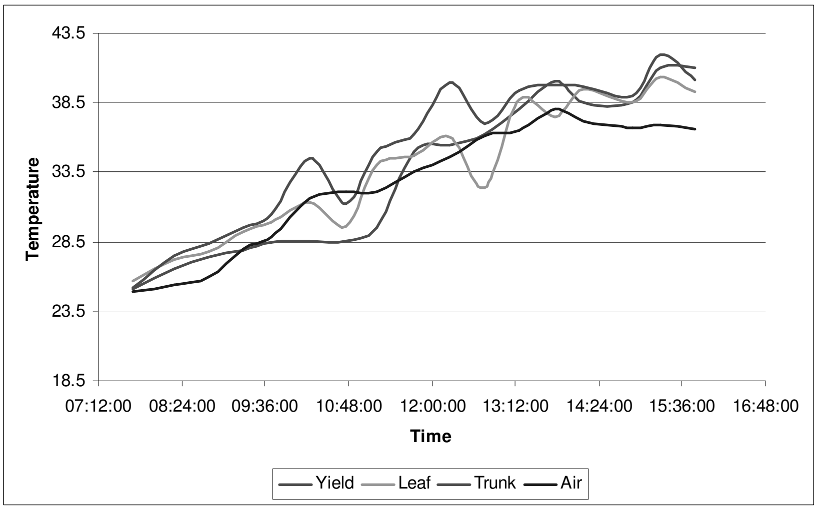

Figure 2. Temperature changes (ºC) in apple orchard

The result suggests that parallel to the air temperature, the temperature of the examined apple tree parameters also increased. Furthermore, the leaf temperature exceeded the air temperature, which shows water deficiency and the inadequate transpiration. Based on CWSI image, those parts of the canopy were easily eliminated, where the increased water stress occurred. This due to water deficiency, caused by the lack of precipitation and irrigation, stomatal closure can occur thus, according to several studies (Pethő, 1996) the photosynthesis is blocked and reach its minimum. Not only the transpiration is blocked but also the CO_2 uptake, therefore reactive hidroxil radicals are produced which are harmful for the chloroplasts and cell membranes, which eventually causes the water stress symptoms in plants.

Based on CWSI image, it can be stated, that irrigation was urgently needed for the orchard. This result is also confirmed by soil water monitoring survey, which was carried out by tensiometers. According these results, irrigation should have been started on 10th of August. Therefore, based on the CWSI the irrigation was started the following day.

Conclusions

The leaf temperature exceeded the air temperature, which shows water deficiency and the inadequate transpiration. Based on CWSI image, those parts of the canopy were easily eliminated, where the increased water stress occurred. It can be stated, that

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irrigation was urgently needed for the orchard. This result is also confirmed by soil water monitoring survey, which was carried out by tensiometers.

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EXAMINATION OF AN ALTERNATIVE WAY TO PREVENT NITRATE LEACHING IN SOIL BY USING GLYCEROL AS A BIODIESEL BY-PRODUCT

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Abstract: Using nitrogen fertilizer can be a potential contamination to underground water. In general, disposal of an industrial by-product is a potential pollution. There are such cases, when two potential pollutants can extinguish each other harmful effect. Contaminated glycerol as a by-product from biodiesel production is available in increasing amounts. The conventional utilization of glycerol can not be substantially increased, therefore investigation of alternative ways of usage should be searched for. The contamination content of the glycerol by-product mainly consist of useful materials from plant seeds and potassium hydroxide catalyst. Glycerol such as sugars represents an easily accessible source of energy for microorganisms in soil. It is well known that if nitrogen poor organic matter (e.g. straw) added into the soil, it can cause, through assistance of microbes, temporary reduction of the nitrogen supply. Our experiment was performed in small scaled soil columns. Different treatments were applied on a sandy soil. Nitrate leaching can be significantly decreased by using glycerol treatment.

Keywords: Nitrate leaching, C/N ratio, glycerol, nitrogen immobilization, by-product

Introduction

Nitrate is very mobile in soil (Tisdale and Nelson, 1966). The other nitrogen forms (ammonium-N, organic-N) are quickly converted into nitrate in well-ventilated soils. Nitrate can accumulate in the deeper soil zones (Kádár and Németh, 1993), and moving down it can contaminate the groundwater (Németh, 1995). Nitrate leaching was particularly fast in small soil columns under laboratory condition (Lasztity et al., 1994; Lasztity et al., 2010). The added organic materials control the nitrate leaching (Grüner et al., 2007).
In European Union biodiesel is rapeseed-oil methyl ester (Kovács, 2000). Approximately from 100 litres of vegetable oil are produced 75 litres of biodiesel and 25 litres of crude glycerol (Wilkie, 2008). In generally the glycerol used by cosmetic and chemical industry but biodiesel by-product is contaminated by vegetal parts. But this „vegetal contamination" makes it perfect for use by-product like fertilizer on fields. Glycerol of biodiesel production is well utilized by micro-organisms (Papanikolaou et al., 2008; Temudo et al., 2008). A couple of studies have investigated that utilization of glycerol by micro-organisms is a great possibility to convert that into value-added products (Barbirato et al., 1998; Johnson and Taconi, 2007; Yazdani and Gonzalez, 2007).
The carbohydrates and similar organic materials directed in the soil have a strong effect on the nutrition providing abilities of the soil (Gulyás and Füleky, 1994; Kovács et al., 2011). In particular this effect shows through the change of the amount of nitrogen that can be taken from the soil by changing the C/N rate (Tisdale and Nelson, 1966). The glycerol is an easily available and adequate carbon source for micro-organisms (Lee et al., 2001; Tickell, 2003). It can intensify microbial activity which can help to increase availability of vegetal nutrient. Provisionally, microbes immobilize nitrogen of chemical fertilizer and mineral nitrogen part of soil, but later mobilize those (Tolner et al., 2010). The glycerol increase storage capacity of soil and help adsorption of nutrients. There is a correlation between organic carbon and mineral nitrogen content of the soils based on

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the results of long term experiments (Vágó et al., 2005). There are differences in the microbial activities of these soils (Kátai et al., 2005). Szegi et al. (1988) examined the interaction of cellulose and nitrogen according to the kinetics of soil microbial respiration.

Materials and methods

The experiments were carried out using two types of soil columns. The first type of columns (diameter: 6 cm, length: 10 cm) contained 400 g soil (C1), the second type of the columns (diameter: 4 cm, length: 3 cm) contained 80 g soil (C 2).
A sandy soil from Fót was applied for treatments. The main properties of this soil: saturation percentage, K_A=28.33, lime content, $CaCO_3$ %=8%, pH_{H2O}=8.2, humus content, H %=1.4%., AL-P_2O_5=95 ppm, AL-K_2O=120 ppm.
The solution were: 1000 mg N dm^{-1} KNO_3 (7.221 g of KNO_3 were dissolved in 1000 cm^3 solution) and glicerol 5% C content (128.55 g 95% glycerol in 1000 cm^3 solution). Four types of treatment were used. (*Table 1*).

Table 1. The treatments of the first type of soil columns (C1)

Treatment	N ppm	N-sol. cm^3	C %	G-sol. cm^3	DV cm^3
1. Control	0	0	0	0	100
2. N	100	40	0	0	60
3. Glycerol	0	0	0,5	40	60
4. N+glycerol	100	40	0,5	40	20

The treatments of the second type soil columns (C2) were similar to first type soil columns (C2) (*Table 2*).

Table 2. The treatments of the second type soil column (C2)

Treatment	N ppm	N-sol. cm^3	C %	G-sol. cm^3	DV cm^3
1. Control	0	0	0	0	20
2. N	100	8	0	0	12
3. Glycerol	0	0	0,5	8	12
4. N+glycerol	100	8	0,5	8	4

The columns were leached with 100-100 cm^3 distilled water (C1) and 40-40 cm^3 distilled water (C2) for 3 days. The nitrate and glycerol contents were measured in the effluent solutions. After 3 days this method was repeated using half dose of distilled water.
The nitrate content was determined by diphenylamine test. The glycerol content was determinate with refractometer (CARL ZEISS F1). We used a program for ANOVA which made by Tolner in Microsoft Office Excel (Aydinalp et al., 2010; Sipos et al., 2009; Vágó et al., 2008). This program was created by an algorithm of Sváb (1981).

Results and discussion

The experimental dates of two types of soil columns (C1 and C2) were evaluated using two ways ANOVA. The nitrate-N concentrations are in ppm (mg dm^{-3}) unit (*Table 3*).

Table 3. The means of nitrate concentrations (ppm, mg dm^{-3})

	Control	N	Glycerol	Glyc.+ N	Time mean
3.day	338	2375	0	128	710
4.day	275	1625	0	0	475
5.day	225	1063	0	0	322
6.day	125	838	0	0	241
7.day	30	353	0	0	96
Treat. mean	199	1251	0	26	369

Investigate of treat means it can be seen that the nitrate content in the effluent solutions decreased using glycerol treatment. The effect of the N treatment was reduced by glycerine (Glyc.+N) significantly ($LSD_{5\%}$=231). The glycerol treatment reduced the effect of the control treatment significantly (10% probability) ($LSD_{10\%}$=191). The time means show decreased tendency ($LSD_{5\%}$=213).
The glycerol was not measured in effluent dilution of soil columns which did not get glycerol treatment. The glycerol-C contents in effluent solutions are in *Table 4*.

Table 4. The means of glycerol-C concentrations (%)

	Glycerol	Glyc.+ N	Time mean
3.day	0.50	0.05	0.28
4.day	0.50	0.40	0.45
5.day	0.20	0.35	0.28
6.day	0.30	0.10	0.20
7.day	0.28	0.25	0.26
Treat. mean	0.36	0.23	0.29

The soil in columns blocks the leaching of glycerol. The slow effect significantly forced by the effect of nitrogen treatment. Because of nitrogen treatment the mean concentration of leached glycerol were reduced from 0.36% to 0.23% ($LSD_{5\%}$=0.06%) and the glycerol content appeared in the effluent solution one day later ($LSD_{5\%}$=0.13%).

Conclusions

In summary, the glycerol treatment significantly reduced the flow of nitrate through the soil column. Nitrate treatment reduced the effluent glycerol content. Both effects suggest that the treatments provided favourable conditions for microbial activity, so the nitrogen immobilized totally and the glycerol immobilized partially.

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THE CHANGE OF WET GRASSLANDS IN EXTREME CLIMATE-RAINFALL ALONG THE RIVER IPOLY (HUNGARY)

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Abstract: The study represents prepared habitat maps from two different years in which precipitation was extreme – the year 2000 was one of the driest while the year 2010 was one of the wettest year in Carpathian Basin. The studied area is situated in northern Hungary, beside Ipoly River, in municipality area of Drégelypalánk – a smaller proportion in Hont and Ipolyvece. Its extent is 621,5 hectares. During the field survey habitat plots were recorded using a hand-held GPS device; aerial photograph helped the exact determination. Processing of the data, establishment of database of mapped area and editing of maps were performed by ESRI ArcView GIS 3.2 and ESRI ArcGIS 10.0 software. The maps (with a scale of 1:15 000) represent vegetation and habitats of the examined area. They display changes occurred within habitats, in habitat types determined by their nature, consistence and habitat changes which occurred in their frontiers. Vegetation change caused by the changes in precipitation can be tracked with the maps which display habitat changes. To explore vegetation - precipitation relationships it is extremely important for researches to determine the local appearance of global impacts. In addition, habitat maps can be useful in utilization, management, conservation planning, as well as long-term monitoring.

Keywords: precipitation, habitat map, vegetation, climate extreme

Introduction

As a result of global climate change, intensification of climate extremes can be observed in recent decades in Europe with the result of more frequent periods of drought and flood release in the Carpathian Basin (Bartholy and Pongrácz, 2007). The changes in meteorological parameters suggest that if the observed trends persist then extreme hydrological conditions (e.g. low water) will continue to grow - especially in sensitive areas (Nováky, 1991; Koncsos and Szabó, 2003). The effect of climate change is a key issue concerned the water management of the areas. Significant change of water balance of an area affects water supply of the area (Nováky, 1991; Nováky et al., 1985), it has its impact on flora and fauna of wetlands, on composition of the ecosystem and in generating significant economic and social changes (Nováky, 1991; Láng et al., 2007).
Measurements show that from the beginning of 20th century the national average annual rainfall decreased (Bartholy and Pongrácz, 2005; 2006).
Habitat maps presented in this study display the effect of climate and rainfall alterations in terms of vegetation. Mapping conducted in the two most extreme years: the year 2000 was the driest in the measured period while the year 2010 was the wettest year in the past 110 years. The investigated vegetation and habitat types were flood-basin areas along the river which are known to react the most sensitively to environmental changes (Simon, 2000; Borhidi, 2003). Based on habitat maps from 2000 and 2010 we can see whether extreme precipitation effects on vegetation and habitat transformation can be determined and if a change is detected, then what kind of vegetation and habitat types are affected and in what way.

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Materials and methods

The studied area is situated in northern Hungary, along the River Ipoly, in municipality area of Drégelypalánk – a smaller proportion in Hont and Ipolyvece. Its extent is 621,5 hectares. Water, marsh and meadow vegetation representatives of Ipoly are the most precious flora while original forests are presented only in fragments. During intensification of agriculture the majority of meadows were drained and ploughed. The remaining parts are very valuable, most of them are protected or proposed for protection (Maglocký and Feráková, 1993; Füri, 1996; Hrivnák et al., 1997; Kovács and Máthé, 1967). Regular flooding, mowing and protection against eutrophication are important for their existence. The examined meadows in Drégelypalánk were extremely rich in number of species and in rare plant communities. Primarily marsh and high sedge meadows are to be found here, however sedgy reeds and stocks can be found as well as floating euhydrophyte communities.

The mapping in 2000 was coordinated by Danube-Ipoly National Park and Ipoly Union, within the habitat recording framework of nature conservation perspective. The habitat map of the year 2010 connected to the project titled; "Standardized GIS-based environmental monitoring development of the catchment area of River Ipoly" with the aim of that the processes, environmental influences and impact endurers in the catchment area could be tested jointly. This all is in favour of establishing those knowledge that are essential for protection-centered decisions of authorities (Verrasztó, 2010).

Field recording was performed in 2000 and 2010. Aerial photographs were taken in order to differentiate preliminary vegetation units in the field. For exact field determination of habitat plots hand-held GPS device was used. General National Habitat Classification System (Fekete et al., 1997) was applied to determination of habitats. Data processing, database creation and preparation of maps were made by ESRI ArcView GIS 3.2 and ESRI ArcGIS 10.0 software.

During editing habitat maps it was important to clearly trace and evaluate changes of habitat types. The two maps were coloured according to the same key in order to notice the changes at first sight and be construed which habitat plot transformed. The scale of maps served good separability criterion since small-sized habitat plots were also represented, which could not be properly displayed in smaller scale.

Results and discussion

In the studied area, 140 habitat plots from 31 habitat types (in 2000) and 152 habitat plots from 32 habitat types (in 2010) were recorded. The found habitats are presented in *Figure 1*.

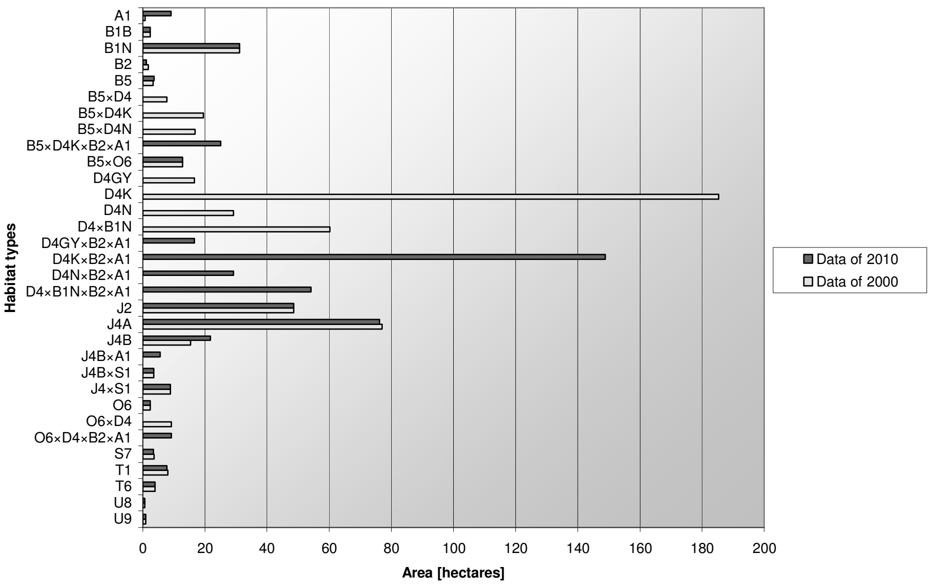

Figure 1. Territorial distribution of habitat types according habitat maps both in 2000 and 2010.

The results show clearly there is a significant difference in the aspect of habitats between the two examined periods. Changes were found in the coverage of habitats and in characteristic habitat types of certain habitat plots. The number and extent of wetlands has increased significantly to 2010. The number of habitat plots in euhydrophyte (A1) habitat category increased from 1 to 7, while their surface area from 0,09 hectare to 9,16 hectares. If the wetlands (A and B habitats and their complexes) are considered as a whole, the results show they were present in the dry period in case of 31 plots (154,88 hectares), while 60 plots (366,71 hectares) in the rainy period, i.e. they dominated 59% of the examined area in 2010. There was a significant change in the area and composition of habitat complexes as well. On the map from the year 2000, 8 different, two-habitat-types-formed complexes were represented, while on the map from the year 2010 there were 12 different – in several cases three- or four-habitat-formed – complexes shown. In total only 3 categories (J4B×S1, J4×S1, B5×O6) were presented in both years, so the majority of complexes transformed while the area increased from 137,09 hectares to 356,49. The map prepared in the wetter year (2010), clearly shows that the aquatic vegetation in the low-lying treeless habitats appeared almost everywhere. A significant change occurred in the low-lying meadows (D4) and the aspects of their subtypes too. These habitats also appeared alone in 2000, their territory was 231,14 hectares. They went through a total transformation and their presence can be just observed in complexes in 2010. The area of J4B habitat and habitat plots also increased. Among the O habitat categories, O2×O3×O4 complex appearance in 2010 is also due to water effects.

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Conclusions

According to the maps, vegetation had changed significantly between the compared years, in the extremely dry conditions (2000) and the extremely wet year (2010). In the two examined years vegetation showed a very large difference and well-indicated the environmental changes. Extension of wetlands significantly increased. Areas of meadows and marsh decreased and on their place forming habitat complex new aquatic habitat forms appeared. Number of habitat complexes also increased because of the presence of steady-linked water and joint habitat types and fragments. Extent of forest plots had not changed substantially but there was growth in the proportion of bushy areas, which may be the result of natural succession. Aftermath of permanent water coverage new habitat types appeared on the surface of river drift. These habitat types abound in ruderal, pioneer weed species.

Acknowledgements

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DETERMINATION OF SAMPLE PREPARATION METHOD FOR LASER DIFFRACTION: FROM SUSPENSION TOWARDS SOIL PASTE

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Abstract: Soil texture is one of the key variables in the system water – soil – plant. It influences all basic soil characteristics, e.g. water content, saturated hydraulic conductivity, available water capacity, porosity, soil temperature. Two samples of coarse soil and medium fine soil collected in the Nitra River catchment, West Slovakia were used for analysis to investigate different methods of sample preparation to find the uniform method with the best correlation between laser diffraction and pipette method. Regarding the obtained results, it can be concluded that samples prepared in soil paste form were the most suitable for laser diffraction analysis.

Keywords: soil texture**,** laser diffraction, soil sample preparation, soil suspension, soil paste

Introduction

Representation of different particle size fractions in soil is one of the basic soil properties. It determines soil texture that is one of the key variables in the system water – soil – plant. Soil texture influences all basic soil characteristics, e.g. water content, saturated hydraulic conductivity, available water capacity, porosity, soil temperature (Fazekašová, Bobuľská and Macková, 2011; Fazekašová et al., 2011; Stekauerova and Surda, 2011). Knowledge on the size distribution of soil particles is used for land use proposals, in the crop cultivation as well as for determining soil tillage and fertilization. Classification of soils according to particle size is one of the oldest systems of soil classification. Nowadays, there are various techniques used to determine the particle size distribution. The most common are sieve method and sedimentation methods. Significant progress in computer technology led to the progressive development of the laser diffractometry. This optical method uses scattering of electromagnetic waves on the particles to determine the particle size distribution. Angle of the scattered light beam is inversely proportional to particle size. According Eshel et al. (2004), one of the biggest advantages of laser diffraction is a short analysis time, high reproducibility, need a smaller amount of sample, extensive range of size measurement and fraction classes. On the other hand, because sedimentation methods and laser diffraction are based on different principles, the distribution of grain size fractions determined by the laser diffraction is not comparable with the sedimentation methods in the ratio 1:1 (Vandecasteele and De Vos, 2001). This often discourages professionals to accept the laser diffraction as a method of determining soil texture, despite its many benefits. Several authors dealt with comparison of laser diffraction and pipette method (e.g. Vandecasteele and De Vos, 2001; Eshel et al., 2004; Jakab et al., 2010). Obtained results were influenced by method of sample preparation prior to analysis, method of determining the particle distribution, as well as by the settings of measuring device during the analysis. All this variables make the comparison of obtained results difficult.
This paper investigates different methods of sample preparation to find the uniform method with the best correlation between laser diffraction and pipette method.

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Materials and methods

Two collected samples of coarse soils and two of medium fine soils were taken in the Nitra River catchment, West Slovakia and used for analysis. All samples were weighted, pretreated by 0.05 M sodium polyphosphate solution (Graham's salt, $(NaPO_3)_n$) and covered 24 hours prior to analysis. Organic matter and carbonates were not removed due to their low content. Soil paste (method 4 and 5) was prepared at such a consistency that the soil was consolidating easily, but did not flow when the container was tipped.

1. ***method – susp_24U10***: 5 g of fine soil was mixed in 100 ml beaker with 45 ml of tap water and 5 ml of Graham's salt, ultrasound – energy level No. 10.
2. ***method – r_3g_24U5***: 3 g of fine soil was mixed with 3 ml of Graham's salt, ultrasound – energy level No. 5.
3. ***method – r_3g_24U1***: 3 g of fine soil was mixed with 3 ml of Graham's salt, ultrasound – energy level No. 1.
4. ***method – sp_5g_24U5***: 5 g of fine soil was mixed with required volume of Graham's salt solution to obtain soil paste, ultrasound – energy level No. 5.
5. ***method – sp_5g_24U1***: 5 g of fine soil was mixed with required volume of Graham's salt solution to obtain soil paste, ultrasound – energy level No. 1.

Samples were analyzed by laser particle analyzer Analysette 22 Microtec Plus (Fritsch GmbH, Idar-Oberstein) using wet dispersion. Applying the concept of convergent beam, the device allowed to measure particle size over a very wide range - from 0.08 up to 2000 mm. Analyses were done at the full measurement range using Fraunhofer theory and automatic calculation model in 3 measurements per sample with 3 repetitions. Measured results were averaged and compared with fraction size distribution determined by pipette method.

Results and discussion

The *Figure 1* shows linear regression relationships between the particle fractions distribution determined by pipette method (PM) and laser diffraction (LD). Left column shows results of both soil texture classes together (coarse and medium fine), right column separately. At the first sight, the correlation between PM and LD is not very significant, but after further analyses, it can be concluded that all the applied preparation methods showed satisfactory results for medium fine soils (the best method 5 where R^2 =0.8499). In the contrary, none of the correlation coefficients was satisfactory for coarse soils. Using the method 1, soil suspension was obtained. Due to problem of sedimentation that was observed predominately at sandy samples, the results were very variable. Although, the method showed relatively high correlation for medium fine samples, the reproducibility of the repeated measurements was the lowest, and few results had to be excluded from the further analyses. Methods 2 and 3 resulted in watery soil paste, which gave more repeatable results, but still there occurred sedimentation of sandy samples and the results still may be burdened with measurement errors.

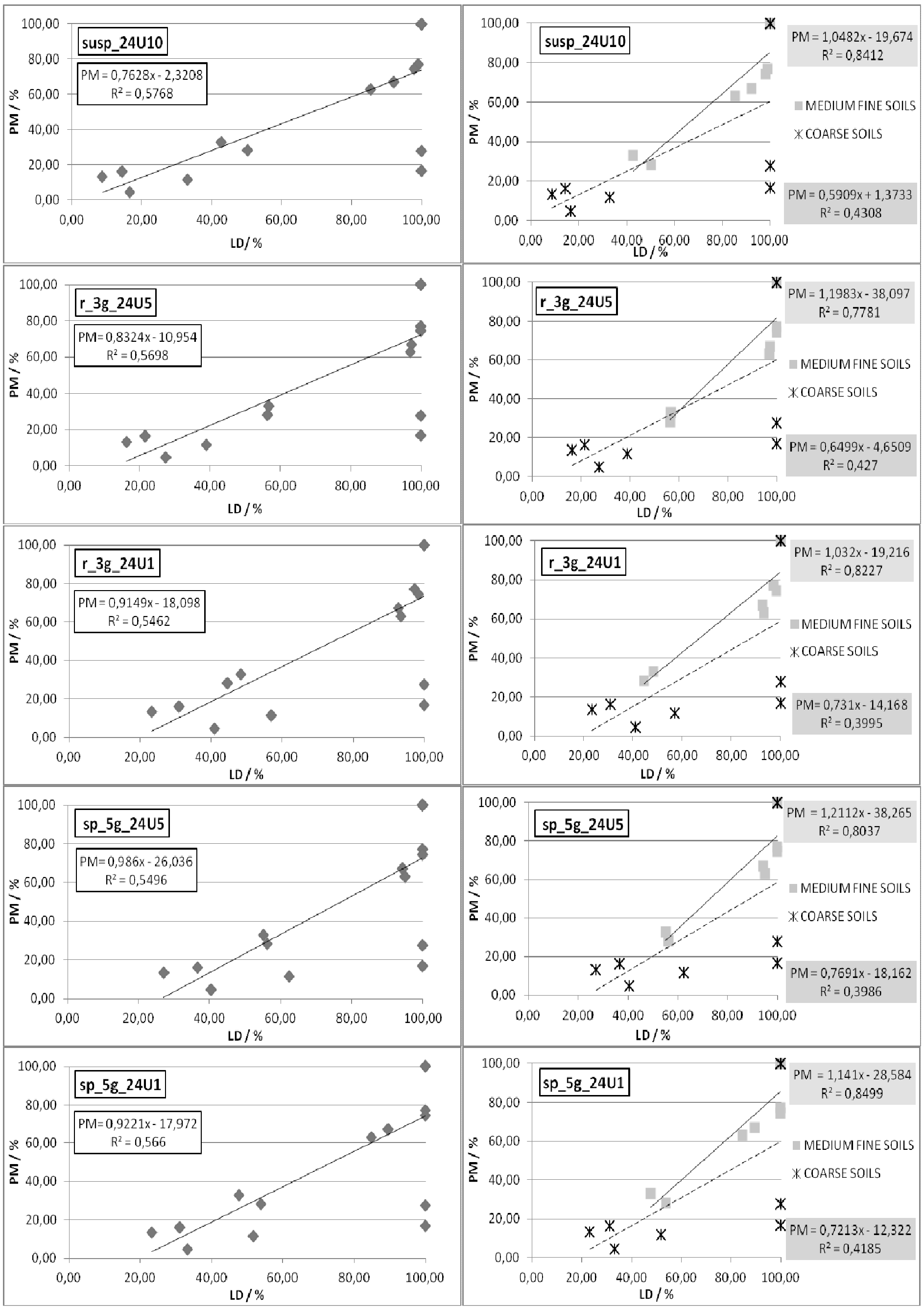

Figure 1. Comparison of calculated particle size distibution using different methods of soil sample preparation

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The highest reproducibility of repeated measurements was gained when the soil samples were prepared in the form of thicker soil paste (method 4 and 5) that prevented settlement of the fine particles on the bottom. Although these methods had high reproducibility also for coarse samples, the low correlation indicates that further research should be done with bigger set of samples. Regarding the obtained results, it can be concluded that samples prepared in soil paste form were the most suitable for laser diffraction analysis.

Conclusions

Because of its advantages, laser diffraction is recommended method of soil texture determination. Comparison of the results confirms the importance of sample preparation method and its effect on particle size analysis. It is recommended to test the accuracy of the suggested methods on a larger set of samples.

Acknowledgements

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MODELLING THE SOIL-PLANT WATER CYCLE IN MAIZE PRODUCTION

A case study for simulation of different sowing dates on chernozem soil

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Abstract: The more and more extreme distribution of rainfall enforces the development of the most accurate water management and soil moisture detecting possible. Monitoring and modelling are two possible solutions. The aim of our examinations was to simulate the effect of different sowing dates of maize on the soil-plant water cycle on chernozem soil in the 2009 growing season. The modelling was performed by the AGROAQUA irrigation decision support system. This study was conducted at the Látókép Experimental Station of the Centre for Agricultural and Applied Economic Sciences, Debrecen University (47°30' N, 21°36' E, 111 m asl). The investigated sowing date treatments were early sowing (ES) at 5th April, optimum sowing (OS) at 20th April and late sowing (LS) at 14th May. In the OS treatment, the soil was dried out to the wilting point at the sowing depth; water deficit was 13 mm from emergence to the end of May. From the intensive grain filling period (18th July) severe water deficiency (60–75 mm) was observed. In ES, compared to the OS treatment, water deficit was eliminated at emergence. Significant water deficit (75–90 mm) was developed after 15th July, during the grain filling phase only. At delayed sowing the water shortage of the sowing depth was significantly higher at emergence than in the ES and OS treatments. A more moderate water deficiency was simulated at silking and in the grain filling period, since the potential evapotranspiration (PET) decreased at this time.

Keywords: AgroAqua, irrigation decision support systems, crop simulation modelling, sowing dates

Introduction

The modelling of maize and the water cycle of soil is done by using the general modelling principles. In these days, several models are used both in scientific and practical fields (Kiniry et al., 1997; Stockle et al., 1997). This modelling technique makes it possible what is otherwise impossible to examine in practice or it can only be analysed at huge costs and by spending enormous amounts of time. It can be studied what would have happened if maize had been sown earlier or later than at the time interval conventionally used for many years for a specific growing area. Would the situation have been more or less favourable? Is the water supply of plants really the most beneficial in the case of the classic sowing date? To what extent does sowing date affect the water cycle of plants and the soil? Questions arisen above can be answered using our recently developed irrigation decision support system.

The aim of our examinations was to simulate the effect of different sowing dates of maize on the soil-plant water cycle on chernozem soil in the 2009 growing season.

Materials and methods

This study was conducted at the Látókép Experimental Station of the Centre for Agricultural and Applied Economic Sciences, Debrecen University (47°30' N, 21°36' E, 111 m asl). The experimental station is located in a moderately warm and dry

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production area at the north-eastern part of the Great Hungarian Plain. The soil of the experimental site was a lowland pseudomyceliar chernozem (Mollisol-Calciustoll or Vermustoll/Pachic or Typic, silt loam, USDA '90 taxonomy). Field capacity of the examined soil layers can be characterised by 0.27–0.34 cm^3 cm^{-3} moisture content, and by 0.10–0.12 cm^3 cm^{-3} for the wilting point.

The climate of the experimental site is continental, with a mean annual precipitation of 566 mm of which 345 mm occurs during the growing season. The weather in 2009 was characterised by remarkable drought periods. The amount of rainfall from April to September was 187 mm, which was 153 mm lower than the 50 year average. The permanent lack of precipitation was observed both after sowing in May and at silking and during the grain filling phase in July and August. The lack of precipitation was accompanied by heat periods in July and August. The mean temperature of both months was 0,8 and 1,5 °C higher than the many years' average, respectively (*Figure 1*).

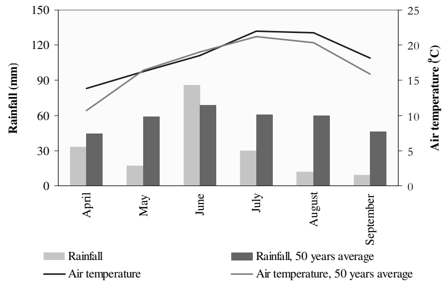

Figure 1. Monthly average of air temperature and rainfall over the 2009 crop season (Látókép, 2009)

The modelling was performed by the AGROAQUA irrigation decision support system. For simulation purposes a simple capacitive model was used, in which the simulation of atmospheric drought was also incorporated (Huzsvai and Rajkai, 2009). Simulation runs were started at 1 January with an initial soil water content of 85 % field capacity in all cases.

The investigated sowing date treatments were early sowing (ES) at 5th April, optimum sowing (OS) at 20th April and late sowing (LS) at 14th May. Emergence occurred at 15th April (ES), at 2nd May (OS) and at 21th May (LS), respectively.

Results and discussion

In the first step, the effects of OS treatment conventionally used for many years in the north-eastern growing area of the Great Hungarian Plain were examined. *Figure 2* shows the critical and actual soil water content and the water deficit at the active rooting depth. Interpretation of the figure: if the hell gray area does not covers the dark grey one, maize will suffer from water deficiency.

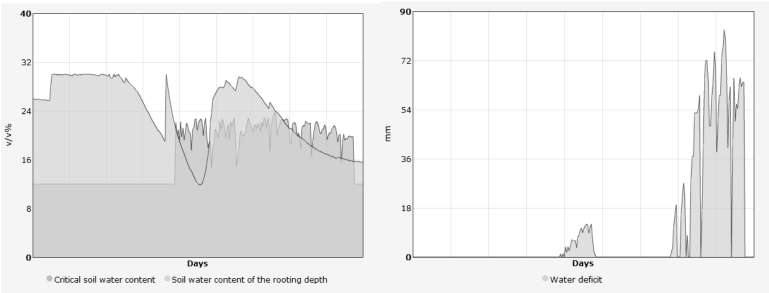

Figure 2. Effect of optimum sowing date on the critical and actual soil water content and the water deficit of the active rooting depth (Látókép, 2009)

In the OS treatment, the soil was dried out to the wilting point at the sowing depth. Water deficit was 12−13 mm from emergence to the 9/10 leaf stage of maize (last decade of May). From the intensive grain filling period (18th July) remarkable water deficiency (60−80 mm) was observed.
In comparison with *Figure 2*, the water deficit at the time of emergence and during May practically disappeared in the ES treatment. The "real" water shortage came after 15th July, long after the flowering of maize. The extent of water deficiency was between 75−90 mm in the active root zone (*Figure 3*).

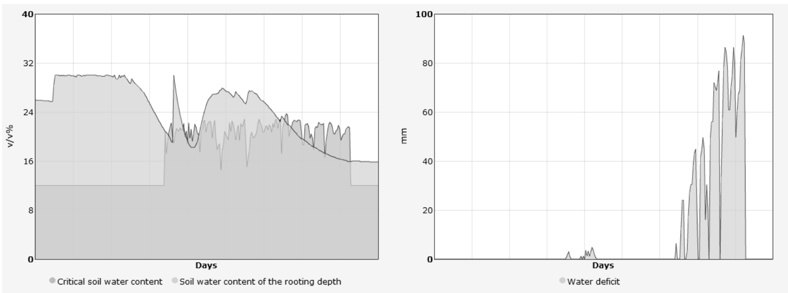

Figure 3. Effect of early sowing date on the critical and actual soil water content and the water deficit of the active rooting depth (Látókép, 2009)

At delayed sowing the soil was significantly drier at the time of sowing than in the ES and CS treatments, the water deficit of the soil reached 18 mm. The reason for this phenomenon is that there was hardly any rain in May, but the extent of PET was high. The upper 10 cm layer of the soil dried below the wilting point. In LS, compared to the OS and ES treatments, a more moderate water deficiency was simulated at silking and in the grain filling period (50−75 mm), since the maximum rooting depth was reached by maize and the PET decreased at the late period. (*Figure 4*).

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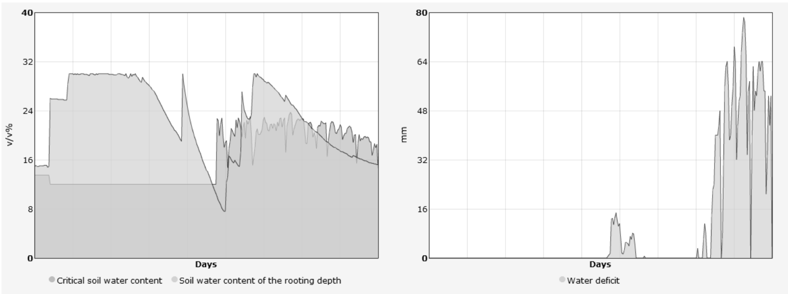

Figure 4. Effect of late sowing date on the critical and actual soil water content and the water deficit of the active rooting depth (Látókép, 2009)

Conclusions

Based on the results of this study, the water shortage around emergence can be avoided by earlier sowing, but the water deficit at silking and grain filling stage of maize will be developed sooner and it will have a larger magnitude than in the case of conventionally used ("optimum") planting date. The model predictions indicate that under delayed planting conditions the water shortage at planting and emergence is more significant than in the case of the early and the optimum sowing dates, although the water deficit around grain filling period is more moderate.

When rainfall significantly delays field and planting operations, decisions like delayed sowing in late May and switching to early maturity hybrids are completely reasoned from professional point of view. However, under unfavourable weather conditions physiological maturity and harvest so much could be delayed as well as moisture content of maize will be so high that drying costs could significantly increase.

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QUANTIFICATION OF CAPILLARY WATER INFLOW FROM GROUNDWATER TABLE INTO THE AERATION ZONE OF THE SOIL

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Abstract: During the time periods without precipitation the soil water content dynamics in lowland territories is affected only by actual evapotranspiration (Et_a) and by capillary water inflow (I_k) from groundwater table (GWT). The existence of hydraulic contact between aeration zone of the soil and GWT is an essential condition for water inflow from GWT. Real values of soil water content (W_p) can be obtained by direct monitoring. Actual decline of soil water content W_p during time period without precipitation, i.e. between two rainfall events, can be then compared with the volume of water, expended on Et_a. If Et_a=W_p, consumption of water by the evapotranspiration process is not compensated by capillary water inflow from GWT. When Et_a>W_p, then distinction Et_a–W_p represents I_k, i.e. value of water inflow from GWT.

In this study is presented the estimation method of capillary water inflow (I_k) from GWT into the aeration zone of the soil during the time periods without precipitation. Data from soil moisture monitoring on selected locality of Zitny Ostrov area were used. Selected locality Kalinkovska horaren represents agricultural ecosystem. This data was completed by set of values of actual evapotranspiration Et_a, obtained by numerical simulation on hydrological model HYDRUS-ET.

Keywords: capillary water inflow, soil water storage, soil moisture monitoring

Introduction

Assessment of the water volume balance (Štekauerová et al., 2001a,b; Kutílek-Nielsen, 1994) in the soil aeration zone (estimation of the soil moisture conditions) in lowland areas in certain time period is based on a simple balance equation (1). Let us suppose that in time $\mathbf{t_0}$ the water storage in soil aeration zone corresponds to value $\mathbf{W_0}$ and in the time **t** to value $\mathbf{W_t}$ (in both cases expressed in mm of the water column). Taking into account that flows of water over the borders of the soil aeration zone participate on formation or on change of water storage (it means that the position of groundwater table and vegetation cover of soil directly influence the water regime of soil), the change of water volume $\mathbf{\Delta W = (W_t - W_o)}$ in time interval $\mathbf{\Delta t = (t - t_o)}$ can be expressed as:

$$\mathbf{(W_t - W_o) = I_k + P - E - T - I_p,} \qquad (1)$$

where:

$\mathbf{W_0}$ – the initial water storage in soil aeration zone, $\mathbf{W_t}$ – water storage in the reviewed time interval in hydrological year, $\mathbf{I_k}$ – capillary water inflow, **P**- precipitation, $\mathbf{E_p}$- evaporation of water from soil surface, **T** – transpiration of vegetation cover, $\mathbf{E_p + T = E}$ (also $\mathbf{E_o}$ or $\mathbf{E_a}$, $\mathbf{E_r}$), $\mathbf{I_p}$ – water outflow from soil aeration zone by seeping into lower horizons or to the groundwater table.

Components of water balance equation quoted on the right side directly affect the change of water storage in the soil aeration zone $\mathbf{\Delta W = (W_t - W_o)}$ by their course in the quoted time interval $\mathbf{\Delta t = (t - t_o)}$. The change of water storage $\mathbf{\Delta W}$ can be quantified in the area of interest by direct monitoring in the vertical of the soil aeration zone (for instance by the neutron probe measurement) i.e. in their temporal and spatial manifestation – of course, depending on measurement frequency and spacing of the measurement points on the surface selected locality. $\mathbf{\Delta W}$ can be also determined by

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assessment of individual balance equation elements quoted on the right side (1). Two methodological procedures are applied in order to determine values of these components of water balance. The first of them (Nagy and Igaz, 2009) is founded upon direct (in situ) methods of their determination in selected locality (Štekauerová et al., 2001; Šútor, 2000). The second method is based on numerical simulation of water regime (Stehlová and Štekauerová, 2008) through the use of the mathematical model (Šimunek et al., 1997).

Materials and methods

Quantification of the water inflow from the groundwater table into the aeration zone of the soil during the extreme meteorological events, such as a long lasting time periods without precipitation (PWP) can be done in the conditions of different ecosystems and soil types. In this article the locality Kalinkovska horaren from territory of Zitny ostrov has been chosen. This locality, which represents agricultural ecosystem was selected for a several reasons. The direct monitoring of soil moisture was conducted on this locality from 1989 to 1996 (Šútor, 1998). In these years the monitoring was organized on 17 localities. On the selected locality during the monitored time period the course of soil water content decreased to the value of wilting point several times. It means that long lasting time periods without precipitation appeared so it is possible to study their effect on soil water content dynamics.

Soil on the locality Kalinkovska horaren belongs to type of clay loam. In the year 1994 the maize (*Zea mays*) was grown on this locality.

Beside the soil moisture monitoring was on the selected locality measured also the depth of ground water table level beneath the soil surface. For the locality Kalinkovska horaren maximal measured value was 310.5cm, minimal value was 198cm and average value for the measurement period was 248.3cm.

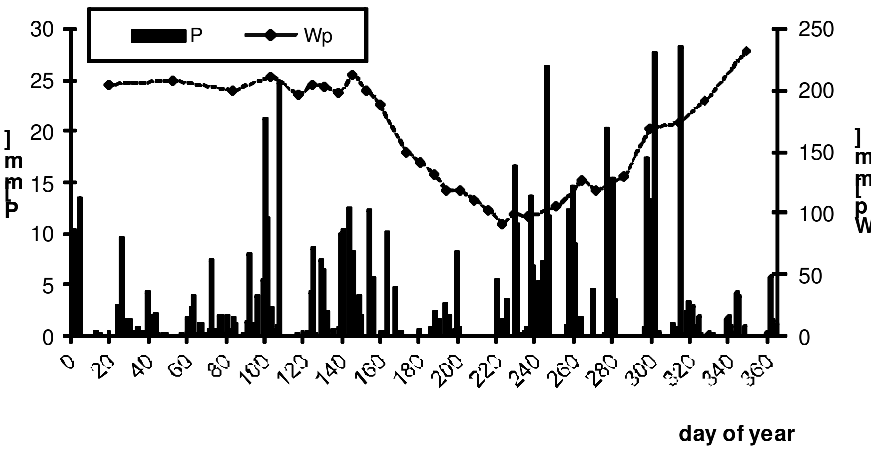

Figure 1. Soil water content dynamics (W_p) in aeration zone from locality Kalinkovska horaren and daily precipitation totals (P) from year 1994

At the same time the hydrophysical, vegetative, meteorological and hydrological characteristics for the conditions of selected locality were processed in the form suitable as an input to the mathematical model of soil water regime Hydrus-ET (Šimúnek et al., 1997; Šútor and Štekauerová, 2000; Štekauerová et al., 2001).

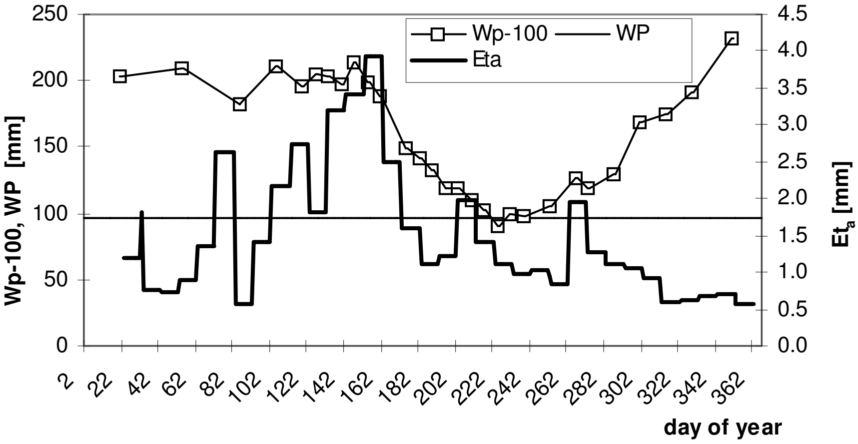

Figure 2. Monitored values of soil water content dynamics for the 100cm soil profile (W_p-100), values of water content representing wilting point (WP) and values of actual evapotranspiration (10-day moving average) (Et_a) in year 1994 for locality Kalinkovská horáreň

Response of the soil water content dynamics on the maximal and minimal daily precipitation totals for site Kalinkovska horaren can be seen on *Figure 1*. Time axe on *Figure 1* and *2* is described not with a calendar date, but with a term day of year. Day of year ranges from 1 to 365 (366 for leap years).

Results and discussion

On *Figure 2* is presented, that course of Et_a and W_p during time periods without precipitation have a close relation between each other. The consumption of water from the aeration zone of the soil by the process of evapotranspiration in chosen time intervals is higher than decline of measured values of soil water content W_p. Hence during 40 days without precipitation (155th - 195th day of year) is valid that $Et_a > W_p$. Distinction $Et_a – W_p$, according to previously mentioned analysis, represents I_k, i.e. value of water inflow from GWT. Components of the process for the estimation of the capillary water inflow (I_k) from groundwater table (GWT) into the aeration zone of the soil and its contribution to the soil water content dynamics are stated in *Table 1.*

Table 1. Components of the quantification process of capillary water inflow from groundwater table into the aeration zone of the soil

Locality	Date	Sum of days	ΔEt_a [mm]	ΔW_p [mm]	I_k [mm]	I_k [mm/day]
Kráľovská lúka	14.7.-11.8.1994	40	81,68	67,7	13,98	0,35
Kalinkovská horáreň	14.7.-11.8.1994	40	84,29	65,9	18,40	0,46

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Conclusions

According to water balance equation, representing creation and dynamics of soil water content in the aeration zone of the soil, we can state, that during the time periods without precipitation soil water content can be affected only by actual evapotranspiration (Et_a) and capillary water inflow (I_k) from GWT. For these simplified conditions of water balance was elaborated the methodology for the quantification of the equation element - I_k. Through the use of direct monitoring of selected locality we obtained the data files, containing the values of soil water content dynamics. Consequently, these values were graphically compared with the values of daily precipitation totals (*Figure 1*) and with values of actual evapotranspiration (*Figure 2*). On *Figure 3* is presented, that course of Et_a and W_p during time periods without precipitation have a close relation between each other. The consumption of water from the aeration zone of the soil by the process of evapotranspiration in chosen time intervals is higher than decline of measured values of soil water content W_p. Hence during 40 days without precipitation (155th - 195th day of year) is valid that $Et_a > W_p$. Distinction $Et_a – W_p$, according to previously mentioned analysis, represents I_k, i.e. value of water inflow from GWT. Components of the process for the estimation of the capillary water inflow from GWT into the aeration zone of the soil and its contribution to the soil water content dynamics for both monitored localities are stated in results.

Acknowledgements

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EVALUATING THE EFFECT OF ACIDITY AND HUMIDITY ON THE OPTICAL CHARACTERISTIC OF A SOIL SAMPLE

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Abstract: The potash fertilizing can result in arise of hydrochloric acid in the soils. Trough chemical reaction with the calcium carbonate content of calcareous soils it generates strongly hygroscopic calcium chloride. The stronger hygroscopic feature of the soil surface can be detected in the infra red region. Hyperspectral remote sensing makes possible to evaluate the topsoil of large areas in fast and economic way. The spectroradiometer of the Hungarian Institute of Agricultural Engineering is capable of gathering spectral information in the wavelength range of 350 to 2500 nm. The spectral information referring to soils are usually studied in the upper range of this interval. Reflectance spectra of soil samples treated with hydrochloric acid were evaluated under laboratory conditions. Measurements were carried out on absolute desiccated and air-humid soil samples. The spectral characteristics of two salts found in highest concentration in the soil samples were studied. There are the calcium carbonate (in untreated) and calcium chloride (in hydrochloric acid treated samples).

Keywords: hyperspectral technology, soil acidity, humidity

Introduction

The soil's basic functions may suffer a loss by natural or anthropogenic acidification. This problem is very important in Hungary because the half of the country area is susceptible for acidification (Várallyay et al., 1980). The exact value of soil acidity is necessary for estimating the lime requirement for amelioration and protection of soils (Várallyay, 2006; Husti, 2006) and for applying the appropriate liming technology (Vágó et al., 2008; Tolner et al., 2008). The new method the soil acidity can be determined by the pH-stat titration of the soil suspension (Czinkota et al., 2002; Simon et al., 2006; Vágó et al., 2010).
Finding diagnostic soil parameters is equally important in geology, agricultural and environmental sciences. The hyperspectral remote sensing technology makes possible to evaluate the topsoil of large areas in a fast and economic way as compared to the conventional methods. The airborne hyperspectral imaging sensor AISA DUAL and the ASD FieldSpec®3 Max portable field spectroradiometer operated in the Institute of Agricultural Engineering are capable of gathering spectral information in the wavelength range of 350nm to 2500 nm. The spectral information referring to soils specific to the mineral compositions are to be found usually in the upper range of this interval (Kardeván et al., 2000; Kardeván, 2007). Detection of soil acidity with spectral remote sensing is not easy, because indirect effects of the pH changes can only be analysed by measuring the reflectance spectra from the surface of the soil. The experiments of Seilera et al. (2007) proved that the quantitative changes of OH group concentration cause changes in reflectance spectra, which can be measured. The quantity of the OH group is correlating with the amount of the acid groups of the soil, as well. The samples with different pH value were produced with varying hydrochloric

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acid treatment of the soil samples. In the course of the experiment, a change in the water absorbing ability of the soil was observed. The water content of the samples strongly influenced the reflection (Neményi et al., 2008; Milics et al., 2004). Therefore, we especially paid attention to the desiccation of the examined samples. In the experiment described below, we have analysed in laboratory the reflectance spectra of different pH values of the same soil sample.

Materials and methods

Sandy soil samples from Fót were applied for the treatments. The main properties of the soil are the following: saturation percentage, K_A=28.33, lime content, $CaCO_3$ % = 8%, pH_{H2O} = 8.2, humus content, H % = 1.4%, AL-P_2O_5 = 95 ppm, AL-K_2O = 120 ppm.
Treatments:

1. Control: without any treatment
2. S+$CaCO_3$: Soil + added $CaCO_3$ 0,375% (Ca content is 0,15%)
3. S+$CaCl_2$: Soil + added $CaCl_2$ 0,415% (Ca content is 0,15%)
4. S+$CaCl_2$+$CaCO_3$: Soil + added $CaCl_2$ 0,415% (Ca content is 0,15%) + added $CaCO_3$ 0,375% (Ca content is 0,15%)

The relfectance spectra of all four treated samples were examined in absolute dry and air humidity equivalent state. The absolute dry samples were made through a drying process on 105 °C. The air humidity equivalent samples were in balance with the laboratory's air humidity. The dried samples reached this state in 24 hours. The spectra were collected with ASD Fieldspec 3 MAX spectroradiometer by using ContactProbe sensor-head in three positions. Each position was measured ten times with twenty scans providing with avarage spectra composed from ten times twenty measurements.

Results and discussion

One of the two material used for the treatments was $CaCO_3$. This is typical component of the neutral and weakly alkaline soils. The other material was $CaCl_2$ which formed from $CaCO_3$ as a result of adding potash.
The average reflectance spectrums of each treatment were composed on which continuum removal was performed. The continuum removed average spectra are presented in *Figure 1*.

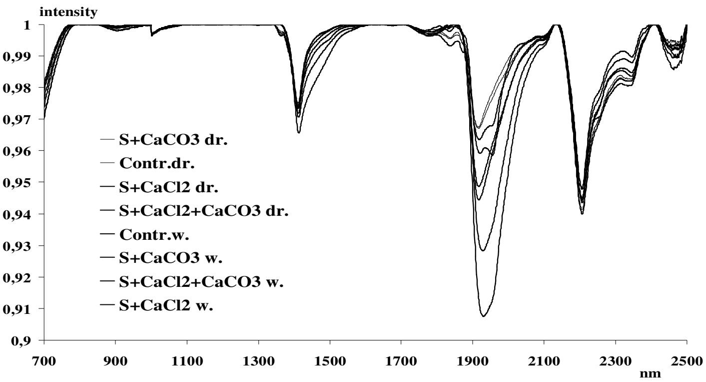

Figure 1. The continuum removed average spectra

The average reflectance spectrums of each treatment were composed on which continuum removal was performed. The continuum removed average spectra are presented in Figure 1.

Largest differences were found in the wavelength range between 1900 nm to 2100 nm. The order of curves differentiating in curve minima in the region are the same as the order of treatment description highlighted on *Figure 1*.

The smallest deviation from the maximal reflection was found at the absolute dry samples signed with "dr". The highest reflection among them was found at soil sample S+$CaCO_3$ dr. The lowest reflection was found at the combined soil sample treated with both $CaCO_3$ and $CaCl_2$. Among samples with air humidity equivalent moisture content (signed with "w") the untreated control showed the highest reflection, while samples treated with $CaCl_2$ showed the lowest reflection. The $CaCl_2$ is strongly hygroscopic, thus the change in intensity is probably caused by the different moisture content.

This effect is more conspicuous if the difference spectra of absolute dry and air humid equivalent samples are examined. The difference spectra in the wavelength range of 1200 nm to 2200 nm are presented in *Figure 2*.

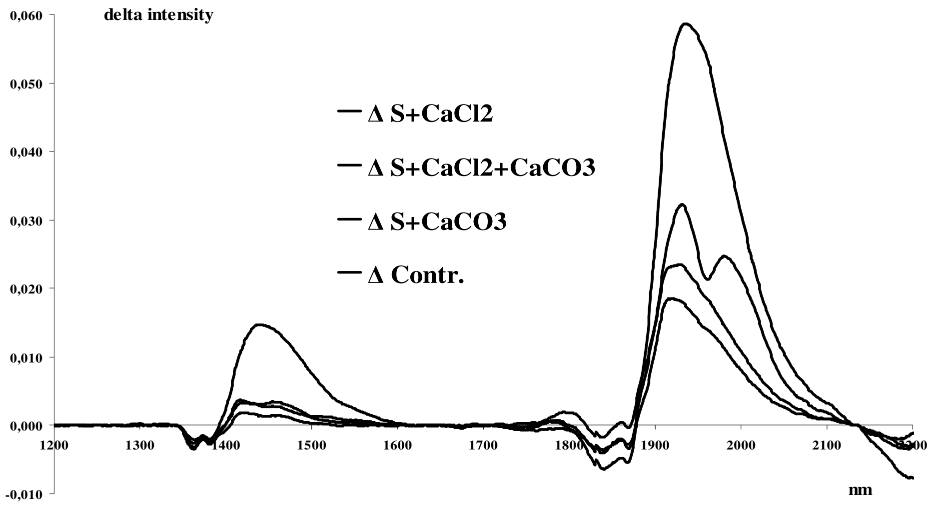

Figure 2. The difference spectra in the wavelength range of 1200 nm to 2200 nm

On *Figure 2* the order of curves differentiating in curve maxima in the region of 1200 nm to 2200 nm are the same as the order of treatment description highlighted on *Figure 1*.

The largest difference was generated by the most hygroscopic $CaCl_2$ treatment. Having combined the $CaCl_2$ and $CaCO_3$ treatments a smaller, two-peaked curve was received. We cannot state for sure that the peak has divided. To examine the phenomenon further experiments are needed. The smaller peak, however, indicates that probably the $CaCO_3$ treatment reduces significantly the effect of $CaCl_2$ treatment. The smallest difference and probably the smallest effect of moisture were generated by the control soil sample of $CaCO_3$ treatment.

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Conclusions

As a consequence it can be stated that as a result of the $CaCl_2$ treatment the difference between absolute dry and air humid equivalent state of acid soil samples can be defined with optical examination. This way it can be distinguished from the effect of the $CaCO_3$ content soils. After further experiments with the help of the described correlations based on spectral data gathered in dry or wet condition with remote sensing method one can gain information on the soil acidity.

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PENETRATION RESISTANCE MEASUREMENTS IN A SHORT ROTATION WILLOW EXPERIMENT

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Abstract: Growing woody plants for energy production may offer a real alternative in the coming years for reasonable utilization of sites of unfavourable conditions for cropping. An experiment was set up in 2007 at Szent István University, Crop Production and Biomass Utilisation Demonstration Centre under unfavourable site conditions on rust-brown forest soil in Gödöllő with woody energy plants. Five different willow species (*Salix sp.*) and three different levels of nutrient supply (control, fertiliser, compost) were studied in the experiment. This paper describes the changes in soil condition during a four-year period following the establishment of the short rotation coppice (SRC) plantation on brown forest soil at Gödöllő in an experiment with different willow species. The description of the soil condition was based on results of soil resistance measurements. The soil resistance measurements taken at depths down to 50 cm it was found that the different levels of nutrient supply had no direct impact on penetration resistance. Soil resistance was found to have increased in comparison to the levels measured in other land use systems (growing of sunflower based on tillage involving ploughing, winter wheat without ploughing) by a statistically confirmed degree (under the SRC plantation in the 0-20 cm layer: 2.1-2.8 MPa, 20-50 cm: 3.4-3.6 MPa) but no detrimental level of compaction was found.

Keywords: short rotation willow, soil condition, penetration resistance, moisture content

Introduction

Research on short rotation coppice (SRC) plantations has been pursued from a great variety of aspects during the past decades. Methods and various technologies that can be most reliably applied in sites of different ecological conditions have been developed (Bai et al., 2008). The aspects and subjects of research have included the choice of species and varieties, the establishment of the optimum number of trees per unit of area, improvement of various vegetative propagation methods and planting technologies, studies of tree care and protection techniques and their impacts as well as the development of harvesting technologies (Barkóczy et al., 2007). An abundance of domestic and international research results have been produced on the favourable impacts of woody energy plants on the process of climate change and on the possibilities of utilisation for phytoremediation and landscape rehabilitation (Laureysens et al., 2004; Mola-Yudego and Aronsson, 2008). Much less research has been aimed at studying the impacts of energy wood plantations on the soils' physical, biological and chemical condition (Liebhard, 2009). The impacts of conventional field crop production on soil condition have been studied in detail (Józefaciuk et al., 2001; Birkás et al., 2009) and many of the research findings can be applied to energy wood plantations as well but owing to the specifics of the technologies applied there is a need for concrete specific research as well. The aim of this study is to describe the changes in the condition of the soil during the first four years following the establishment of an energy wood – willow - plantation on the brown forest soil of the Gödöllő region.

Materials and methods

Our research was set up at the Crop Production and Biomass Utilisation Demonstration Centre of Szent István University in 2007. The soil of the research plot was, for the

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most part, rust-brown forest soil based on sand (*Chromic Luvisol*). The experiment was carried out in a two-factor random block arrangement in three replications. Five different willow varieties and clones (*Sven, Inger, Tordis, Tora, Csala*) were used in the experiment. Three different nutrient supply levels were set up for each variety: 1; surface compost cover (50 t/ha), 2; nitrogen fertiliser applied in the spring (50 kg/ha), 3; control without added nutrient. The compost and the fertiliser were delivered in rows, in early May. The applied technology: twin-row arrangement, with 70 cm distance between rows and 2.5 metres between the twin rows which makes it easier to carry out mechanised treatments. The cuttings were planted at 40 cm spaces. Chemical weed control was applied during the growing season in the rows, along with mechanical weed controlling carried out with rotary cultivator on two occasions. Soil resistance was measured with penetrometer at 10 cm intervals to a depth of 50 cm (Daróczi, 2005). Biometric evaluation was carried out applying the technique described by Baráthné et al. (1996).

Results and discussion

Soil resistance is an indicator expressing soil compaction, a parameter providing a general description of the site's physical state at the same time. The soil resistance values measured in the 0-50 cm soil layer in the case of the different treatments applied in the experiment are presented in *Table 1*.

Table 1. Soil penetration resistance (MPa) in different plant nutrition treatments of the short rotation coppice experiment (2007-2010)

Depth (cm)(1)	Treatment			
	Control	Fertilizer	Compost	$LSD_{5\%}$
2007				
0-10	0.5±0.1	0.6±0.1	0.6±0.2	ns
10-20	0.4±0.1	0.6±0.3	0.8±0.3	ns
20-30	1.2±0.2	1.6±0.1	1.6±0.3	ns
30-40	1.2±0.1	1.7±0.1	1.7±0.4	ns
40-50	1.0±0.1	1.2±0.1	1.2±0.2	ns
2008				
0-10	1.3±0.1	1.3±0.1	1.2±0.1	ns
10-20	1.7±0.1a	1.6±0.1b	1.6±0.1b	0.1
20-30	2.6±0.4	2.2±0.1	2.2±0.1	ns
30-40	3.0±0.3a	2.6±0.1b	2.8±0.1ab	0.3
40-50	3.3±0.3a	2.8±0.2b	3.1±0.1ab	0.4
2009				
0-10	2.8±0.2	2.7±0.3	2.9±0.3	ns
10-20	3.5±0.2	3.5±0.5	3.6±0.3	ns
20-30	4.6±0.1	4.5±0.6	4.4±0.5	ns
30-40	5.1±0.4	4.7±0.7	4.7±0.5	ns
40-50	4.9±0.4	4.6±0.8	4.6±0.4	ns
2010				
0-10	3.1±0.1	3.1±0.2	2.8±0.2	ns
10-20	2.8±0.3	2.6±0.1	2.6±0.2	ns
20-30	3.1±0.5	2.8±0.3	2.8±0.2	ns
30-40	3.4±0.6	2.8±0.3	3.1±0.3	ns
40-50	3.4±0.6	2.9±0.2	3.0±0.3	ns

The measurements were taken twice every year: once at the beginning of the growing season (in April) and once at its end (in September). The values presented in the table

are the averages calculated from the two measurements. Measurements were taken separately in the various nutrient treatments within the scope of the experiment.
The low soil resistance values measured in the year in which the experiment was set up reflected a favourable soil looseness that is characteristic of tilled soils. Tillage carried out in preparation of the plantation of woody energy plants is designed for a minimum of a 15-year plantation lifetime (Mola-Yudego and Aronsson, 2008), therefore it is particularly important to make sure that primary tillage results in a favourable soil condition for the cuttings. The top soil layer must not contain an impenetrable compact layer because that may undermine the quality of the plantation, the cuttings may end up at different depths in the soil, and severe damage in the way of broken cuttings may be caused at spots of heavier soil compaction.
The measurements taken in 2008 showed a significant increase in the soil penetration resistance in comparison to the initial values, which had been caused by the lack of tillage. The mechanical treatment between the rows loosens the top soil layer to a depth of a few centimetres but the soil's penetration resistance did not reach critical levels of compaction that would have been characteristically harmful in the given site circumstances even in deeper layers. The measurements showed no statistically significant differences in terms of the soil penetration levels between the different nutrient treatments, but differences between the treatments were found. Since as an average of several years we found that the different modes of plant nutrient supply had no direct impact on soil penetration resistance. The evaluation of the long term effects, that is how the soil's physical and biological state changes without tillage over a longer period of time, is a much more important aspect in the assessment of the soils under energy plantations (Laureysens et al., 2004). In the course of the measurements taken in the third year of the experiment we found 80-120 % higher soil penetration resistance levels than in the preceding year. What needs to be taken into account in evaluating these findings is that the year concerned was an extremely dry one, which had a profound impact on the soil resistance values. Research conducted by Birkás et al. (2004) confirmed that high soil penetration resistance measured in a period of drought cannot be regarded as a clear sign of recompacting. The measurements taken in the fourth year of the experiment showed no significant differences between soil penetration resistance values in any soil layer and at the same time a process of evening out across the different soil layers could be observed: the same penetration resistance levels were measured in the top and in the deeper soil layers.
The production of woody energy plants qualifies as field crop production in terms of land use, therefore we are regularly taking measurements with the aim of evaluating the soils under different forms of land use. Soil condition assessment was carried out in the course of 2010 in the field where the SRC experiment had taken place, under the same site conditions. Primary tillage in the form of ploughing had been carried out before the sowing of sunflower and ploughless tillage had been applied before winter wheat during the preceding year. *Table 2* shows the average values of the measurements taken on five occasions during the growing season. Statistically lower soil resistance levels were measured in the top soil layer under winter wheat and sunflower than in the energy plantations. In the 10-20 cm layer however, no statistically confirmed difference could be identified. The resistance of the deeper layers differed between the various treatments but no critical level of compaction could be found in any of the sites.

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Table 2. Soil penetration resistance (MPa) in different land use systems (Gödöllő, 2010, averages of 5 measurements)

Depth (cm)	Treatment		
	Energy crop	Sunflower	Winter-Wheat
0-10	2.1±0.2a	1.7±0.1b	1.7±0.1b
10-20*	2.8±0.7	2.1±0.4	2.1±0.3
20-30	3.6±0.1a	2.2±0.2b	2.2±0.1b
30-40	3.4±0.3a	3.1±0.6a	1.9±0.1b
40-50	3.4±0.1a	3.3±0.1b	1.7±0.1c

*non significant

Conclusions

Few reliable research results have been produced in recent years under domestic condition by ecological evaluation of woody energy plants. The assessment of the long term impacts of the plantations is impeded by the small number of more than 5-6 years old SRC plantations are to be found in Hungary. Based on the measurements taken in the first four years of an SRC experiment on rust-brown forest soil it is concluded in this paper that an increase in the soil penetration resistance could be found over the medium term in a site where the soil was prone to settling but the degree of compaction did not reach a critical harmful level. In the SRC experiment the level of soil penetration resistance exceeded the levels measured in the case of conventional tillage with or without ploughing, but these values confirm earlier results described in a number of international reports, according to which the soil's physical and biological state can improve under woody energy plantations over the medium term.

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NITROGEN BALANCE AS AN INDICATOR OF THE NITRATE LEACHING RISK

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Abstract: Nitrogen balance on soil surface was calculated for 5 farms in the period of 3 years. Though there was no whole farm N balance exceeding the limit set to 50 kg ha^{-1} in whole 3 year period and only few of them in single year results, single field balance exceeded the limit quite often. In case of high surplus the particular field can be the point where the loss occurs. On the two of farms were no fields with N balance higher than 50 kg ha^{-1} in several years in row. On the three examined farms was the limit exceeded on 32%, 12% and 41% of acreage in two years in row and on 1%, 0,5% and 10% in three years in row. On these fields is risk of leaching even higher. This kind of results is lost when only whole farm balance is taken into account. Nitrogen surplus does not have to mean loss of given amount of the nutrient because other important influences, like soil conditions, weather course and management practices, play their role. However such results indicate increased risk of leaching. Further analysis found, that mostly cereals (winter wheat), oilseed rape, silage maize and special crops but also grain legumes and fodder mixtures are grown on fields with N surplus. Therefore complex farm assessment should include not only whole farm balances but also more detailed analysis.

Keywords: surface balance, farm level balance, field level balance, leaching

Introduction

When results of soil sampling or percolation water analysis are not available, nitrogen balance is often used to identify nitrates leaching risk from arable land. Farm level nitrogen balance is also one of commonly used indicators for complex farm assessment. Thou farm level indicator value is usually taken into consideration, input data collection and firs step of calculation occur on field level. Field level results are than aggregated to the single value of farm level balance using weighted arithmetic average and loosing information on variability of results. Even if whole farm balance is within optimal limit, there may exist fields with nitrogen surplus (higher leaching potential) or deficit several years in row.

Materials and methods

Nitrogen balance was calculated on 5 farms in 3 years period using nitrogen balance tool in German model REPRO (Hülsbergen, 2003). Further analysis was carried out using basic statistical methods.
Farm level nitrogen balance (usually used in field production assessment) was calculated based on single field information and single field balance. Dada from farms in different site conditions and with various production structure were used. Three of farms were organic (OF) and two of farms were conventional (CF). In table 1 are given the basic characteristics of the farms.
As a tolerable upper limit of nitrogen balance indicating the loss potential, was according to referenced method and also other sources (Hlušek, 2007; Klír et al., 2007) set to 50 kg N ha^{-1}.

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Table 1. Basic characteristics of examined farms

	OF1	OF2	OF3	CF1	CF2
Production area	Beet area	Hills area	Potatoes area	Beet area	Potatoes area
Soil texture	loamy	loamy to clayey	loamy to sandy	loamy	sandy, loamy
precipitation	530 mm	760 mm	750 mm	520 mm	750 mm
Acreage	195 ha 156 ha AL 34 ha GL	1817 ha 432 ha AL 1385 ha GL	540 ha 293 ha AL 190 ha GL 0,3 ha PC	492 ha AL	2200 ha 600 ha AL 1600 ha GL
Livestock	–	0,34 LU ha^{-1} (618 LU)	0,39 LU ha^{-1} (215 LU)	–	0,35 LU ha^{-1} (770 LU)
Market crops	rye, spelt, buckwheat	rye, spelt	buckwheat, spelt, potatoes, onion	sugar beet, barley, poppy	wheat, rape seed
Fodder crops	rye, legumes mixtures	wheat, rye, triticale, cereal mixtures, horse bean	legume-cereal mixtures, legumes	–	clovergrass, silage maize
Intercrops	(phacelia)	mustard, lolium	phacelia, mustard	–	(mustard, phacelia)

AL – arable land; GL – grassland; PC – permanent cultures; LU – livestock unit

Results and discussion

There was nitrogen balance of different level found on examined farms. Whole farm N balance values exceeded 50 kg N ha^{-1} in few cases for single year, in one year on farms OF2 and CF1 and in two years on farm CF2. When taking whole 3-year period into account, set limit was not exceeded at any farm. However, more detailed examination identified number of single fields with nitrogen surplus. *Figure 1* shows number of such fields and *Table 2* contains information of acreage affected.

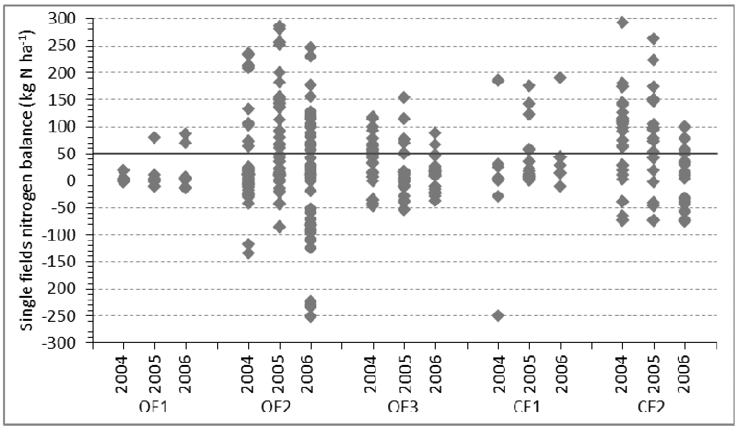

Figure 1. Values of single field N balance on 5 farms in 3 years of consideration (kg N ha^{-1})

Nitrogen surplus (especially in single year balance) does not have to mean loss of given amount of the nutrient because other important influences, like soil conditions, weather course and management practices, play their role (Sieling and Kage, 2006; Constantin et al., 2010) and part of loss may occur in gaseous form (Bechmann et al., 1998). Salo and Turtola (2006) document good correlation between surface N balance and amount of leached N only in conditions with risky management.

Table 2. Farm level and single field N balance (kg ha^{-1}) and area with N surplus in 2 or 3 years in row (%)

		2004	2005	2006	2004–06	2 years in row	3 years in row
OF1	farm level balance	2,73	6,57	8,43	5,91		
	min single field value	-2,32	-11,55	-14,48	-3,67		
	max single field value	19,01	79,28	86,21	30,23		
	% area with balance > 50 kg N ha^{-1}	0,00	10,55	12,64	0,00	0,00	0,00
OF2	farm level balance	30,33	85,33	1,86	39,17		
	min single field value	-135,33	-87,57	-251,02	-107,04		
	max single field value	234,00	285,80	245,83	216,02		
	% area with balance > 50 kg N ha^{-1}	19,16	55,37	38,15	38,21	33,39	1,15
OF3	farm level balance	18,56	21,23	5,58	14,79		
	min single field value	-47,24	-53,18	-37,11	-23,31		
	max single field value	118,17	153,78	87,18	70,87		
	% area with balance > 50 kg N ha^{-1}	32,35	17,71	2,32	10,07	18,73	0,50
CF1	farm level balance	43,01	40,1	56,5	46,54		
	min single field value	-250,26	1,36	-11,36	-64,66		
	max single field value	185,18	174,73	189,38	77,79		
	% area with balance > 50 kg N ha^{-1}	27,07	31,09	14,33	54,57	0,00	0,00
CF2	farm level balance	67,9	59,92	–5,07	43,42		
	min single field value	-74,18	-74,39	-74,65	-48,63		
	max single field value	292,02	263,08	99,08	110,60		
	% area with balance > 50 kg N ha^{-1}	62,75	57,17	16,67	42,88	41,20	10,86

Sieling and Kage (2006) concluded that surface balance may be good indicator of the leaching potential if set up over a longer period. On examined farms were identified fields with N surplus higher than set limit in 3-year period balance and also in single year balance but 2 or even 3 years in row. *Table 2* shows the portion of affected acreage of each farm. On the two of farms were no fields with N balance higher than 50 kg ha-1 in several years in row. One of the farms is organic farm without any fertilizing using mineral or farmyard fertilizers, the second one is conventional farm with intensive narrow specialized production using only mineral fertilizers with some features of precision farming. On the other three examined farms was the limit exceeded on 33%,

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19% and 41% of acreage in two years in row and on 1%, 0,5% and 11% in three years in row. On these fields is risk of leaching even higher. The largest areas with N surplus were found on conventional farm with high portion of fodder crops and combined mineral and organic fertilization. The next farm belongs to organic system and uses very intensive farmyard manure to fertilize the fields. The third farm has very diverse crop structure and medium intensity of organic fertilization.
Further analysis found, that mostly cereals (winter wheat), oilseed rape, silage maize and special crops but also grain legumes and fodder mixtures are grown on fields with N surplus. Therefore complex farm assessment should include not only whole farm balances but also more detailed analysis focused on single fields or crop management.

Conclusions

Longer term results of nitrogen balance may be used as indicator of nitrate leaching risk. When using farm level balance, information about system heterogeneity and about single fields is lost. Even if whole farm balance is within optimum limit, several fields with nitrogen surplus in 2 or 3 years in row were identified.

Acknowledgements

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EFFECT OF DIFFERENT SOIL TILLAGE ON INFILTRABILITY AND PHYSICAL SOIL PROPERTIES IN MAIZE MONOCULTURE

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Abstract: Reduced soil tillage technologies are widely used in Czech Republic due decreasing of cost and reduction of the negative effects of water erosion. The influence of conventional and conservation tillage on water infiltration into soil and soil physical properties were observed at field trial with loamy haplic Luvisol in South Moravia region of Czech Republic. Measurements were done in grain maize at three variants of soil tillage – conventional (PL - ploughing), reduced (ST - shallow tillage) and direct sowing (NT - no tillage) - in years 2008 – 2011 with two terms of observation - during vegetation (June) and after harvest (November). A double ring infiltrometers were used for soil infiltrability measurement with three replications at each variant of soil tillage. Soil physical properties (bulk density and soil moisture) were determined from three depths of soil (0 – 0.1 m, 0.1 – 0.2 m, 0.2 – 0.3 m). The values of infiltration rate, bulk density and soil moisture were statistically evaluated using analysis of variance (ANOVA). Although the results of infiltration rate were different among the tillage variants in individual terms of measurement, statistical evaluation did not prove significant differences among tillage variants. Contrary to the infiltration rate, the results of soil physical parameters were significantly different among all variants. The highest values of bulk density and soil moisture were found out for no-tillage variant whiles the lowest for conventional.

Keywords: conventional and reduced soil tillage, water infiltration, bulk density

Introduction

Reduced soil tillage technologies are widely used in Czech Republic due decreasing of cost and reduction of the negative effects of water erosion. More than half of agricultural land in the Czech Republic is endangered by water erosion (Janeček, 2007). Soil tillage technology influences the physical and hydraulic properties of soil and crop residues on the surface, both play an important role at formation of water runoff. The effect of soil tillage on soil hydraulic properties is not uniform as illustrates the review of Strudley et al. (2008). To confirm the impact of tillage on soil infiltration and soil physical properties, an experiment with three tillage technologies – conventional, reduced and no-tillage (direct seeding) was conducted and four years results evaluated.

Materials and methods

The observation was made in stationary field experiment at locality Visnove (48°58'N, 16°10'E) in South Moravia region (Czech Republic) with loamy haplic Luvisol. The experimental field was cropped with maize monoculture since 2001 (except year 2009 with spring barley) and treated with following variants of soil tillage:

- ploughing (PL) as traditional tillage system – to the depth of 0.22 m, spring harrowing, cultivation by tiller Horsch Phantom before seeding, seeding with precise drilling machine Kinze 3600, rolling

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- shallow tillage (ST) to the depth of 0.10 – 0.12 m with disc tiller Horsch Phantom, seeding (Kinze 3600), rolling
- no-tillage (NT) – direct seeding with Kinze 3600

Water infiltration into soil was measured from 2008 to 2011 in two terms – during vegetation (June) and after harvest (November). Three sets of double ring infiltrometers (diameter of 0.28 m and 0.54 m) were used at each variant to monitor the decrease of water volume in time (for two hours). Simultaneous soil samples were taken from depth of 0 – 0.30 m for labour analysis of soil physical properties.

Results and discussion

The infiltration rate was calculated from cumulative infiltration for each replication, then fitted by exponential trend and averaged in defined time intervals.

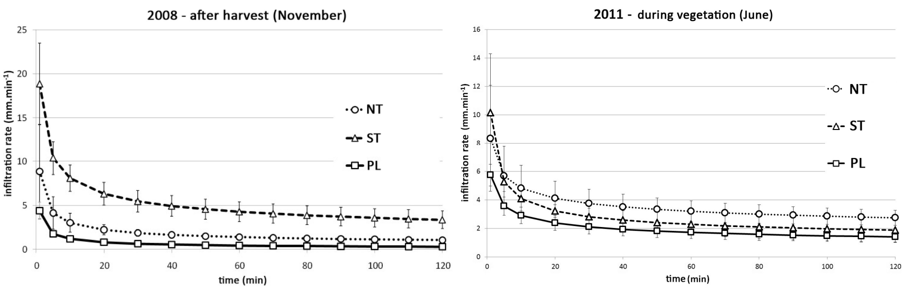

Figure 1. Examples of infiltration rate curve – 2008 (after harvest) and 2011 (during vegetation)

The analysis of variance of infiltration rate results proved insignificant differences among the soil tillage treatments or year and term of observation (*Figure 2*).

Table 1. Averaged infiltration rate ($mm.min^{-1}$) of soil tillage variants (PL- ploughing, ST - shallow tillage, NT - no tillage) in defined time intervals (1, 5, 10, 30, 60 and 120 min)

	2008						2009					
	vegetation			after harvest			vegetation			after harvest		
var	PL	ST	NT	PL	ST	NT	PL	ST	NT	PL	ST	NT
1	13.48	4.8	7.41	4.39	18.88	8.86	8.9	23.44	16.31	23.37	20.89	15.33
5	3.16	2.55	4.9	1.76	10.4	4.14	5.52	6.86	6.69	11.32	9.08	10.14
10	1.71	1.94	4.11	1.19	8.09	3.02	4.52	4.11	4.56	8.31	6.41	8.5
30	0.65	1.27	3.13	0.65	5.46	1.87	3.31	1.86	2.48	5.1	3.76	6.44
60	0.35	0.97	2.64	0.44	4.28	1.4	2.73	1.14	1.69	3.75	2.73	5.41
120	0.19	0.74	2.23	0.3	3.37	1.06	2.26	0.7	1.15	2.77	2	4.56

	2010						2011					
	vegetation			after harvest			vegetation			after harvest		
var	PL	ST	NT	PL	ST	NT	PL	ST	NT	PL	ST	NT
1	15	2.52	7.98	31.98	2.09	5.91	5.74	11.51	8.35	4.98	6.32	5.92
5	9.16	1.78	4.19	12.03	1.15	2.84	3.57	4.84	5.68	3.21	4.18	3.74
10	7.47	1.53	3.22	7.9	0.89	2.09	2.91	3.48	4.83	2.65	3.51	3.07
30	5.47	1.22	2.18	4.05	0.59	1.3	2.11	2.2	3.75	1.97	2.66	2.25
60	4.53	1.05	1.73	2.66	0.46	0.97	1.72	1.71	3.2	1.63	2.25	1.85
120	3.77	0.91	1.39	1.75	0.35	0.73	1.41	1.36	2.74	1.35	1.90	1.52

The results of infiltration rate (*Table 1*) and ANOVA graphs (*Figure 2*) show the differences between the tillage variants changing in 5-minutes and 60-minutes interval of measurement. In 5th minutes was the highest infiltration rate for PL variant and the lowest for NT variant. But this order was changing through time intervals and in 60-minutes the infiltration rate of NT was increasing to the level of PL variant. This corresponds to the review of Strudley et al. (2008), which describes the tendency of NT to increase macro-pore connectivity and deeper movement of water. Lipiec et al. (2006) noted that the differences in initial infiltration and reduction of infiltration rate with time among tillage treatments imply higher capability of conventional tillage pore system to increase amount of water infiltrating before filling macro-pores and reaching steady state.

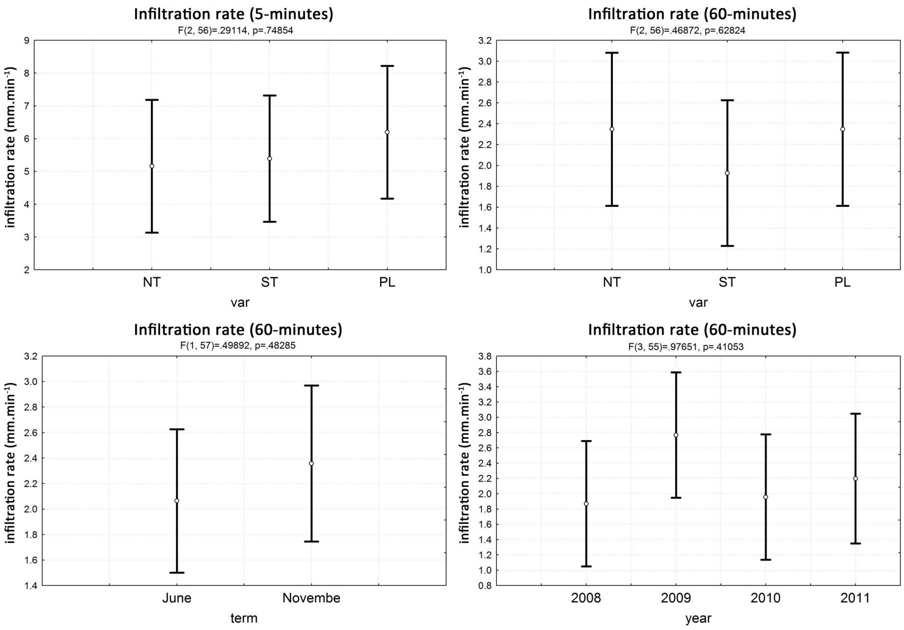

Figure 2. ANOVA graphs of the infiltration rate (5-minutes and 60-minutes intervals) for the soil tillage variants, term and year.

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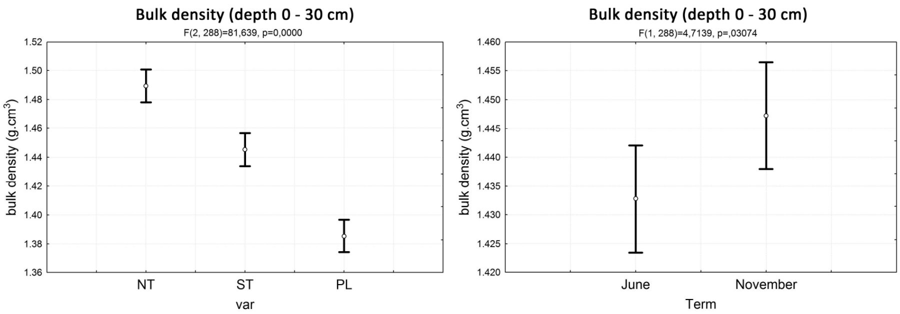

Figure 3. ANOVA graphs of the bulk density for the soil tillage variants and term of observation.

The rate of infiltration is controlled by the pore size distribution and the continuity of pores or pathways (Kutílek, 2004). The macro-pore connectivity and crack effects in soil profile are probably reason of the higher infiltration in autumn terms of measurement. The soil is compacted after maize harvest and the NT variants have more vertical pathways to drain water deeper. But similar to the comparison of tillage variants, differences between terms were not significant as well. Contrary to the infiltration rate, the results of bulk density (*Figure 3*) and soil moisture (not presented in this paper) proved significant differences between the conventional and reduced tillage variants.

Conclusions

Although the results of water infiltration rate were different among the tillage variants in individual terms of measurement, statistical evaluation of four year experiment did not prove significant differences of infiltration rate among conventional (PL), reduced (ST) and direct sowing (NT) tillage variants at the observed locality. Instability of the variants order during the observation involves further research.

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WATER

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THERMAL REGIME CHANGES OF SPECIAL CROPS BY SPRINKLE COOLING IRRIGATION

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Abstract: Uniqueness of special crops lies in their lifespan that exceeds 20 years. Water potential is different in particular parts of the crown with respect to aspect, distance from the edge of the crown and age of tissues. The water demand varies with an age, shape and fruitage and irrigation of these crops (orchards, hop gardens and vineyards) evidently increases and stabilizes yields. The correct application of irrigation water depends on plant phenophases and temperature. Increased vegetation temperature is evidential in the last decade. The plant responds to this change by increased evapotranspiration. Plants cannot prevent overheating of the leaf surface by increased transpiration, stomata are closing, transpiration is interrupted, plants lose turgor – photosynthesis does not take place, even at available water sufficiency in the soil, often even for several hours. Using correctly aimed cooling irrigation it is possible to reverse this unfavorable state. Vegetation temperature reduces, relative humidity increases and microclimate of the plant habitat is so adjusted that there is no restriction of photosynthesis. Another benefit of cooling irrigation, besides increasing the yield, is improving of juiciness, fruit coloring and sugar content. This paper introduces the impact of conditioning irrigation on temperature regime changes of apple trees in the conditions of Slovakia.

Keywords: cooling irrigation, special crops irrigation, climate change.

Introduction

The conventional cooling, where the irrigation water withdraws temperature, which is needed for changes of the state from the air, from the plant environment and cooling air surrounds plant. By this is decreasing the vegetation temperature. This irrigation has to be performed continually, while cooling is not a very effective.

Water cooling is performed with irrigation application by sprinklers on plants, while relatively cold water directly cools the leaves surfaces; there through the vegetation temperature is decreased. A disadvantage is a permanent irrigation, during the critical temperatures, what can cause water and soil´s nutrients losses during soil profile washing.

Third possibility is to use micro-sprinklers for cooling through the vapor; where the minimal water amount on the leaves surfaces, but mainly the fine drops in the surroundings of the aerosol change form state. This cools tightly around vegetation environment and leaves surface, while the result is synergic. This irrigation method is the most effective from the view of the plants protection, but also from the view of low water consumption.

Water, which is applied on plants, uses one or more above mentioned mechanisms. The climatic conditions, application method, duration and amount, under which is water applied is applied, determine the relative contribution during each method. An effective irrigation system will seek the most effective evaporation cooling (Van der Gulik, 1995; Snyder et al., 2005).

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Materials and methods

From the available literature is not obvious, how exactly air-conditioning effect of the cooling irrigation, will become evident on temperature of the vegetation, how the cooling effect is, how long it lasts, and what has the direct connection with the using of the management of the air-conditioning irrigation regime. The literature sources indicate only examination of the quality change and fruits colouring during the air-conditioning irrigation and that only during last 3 weeks before harvest. Another well-known research was oriented on the content changes of the acids, colorants, enzymes and further matters in fruits by using air-conditioning irrigation. A research, which is oriented on the direct management of the irrigation regime and their effect during using air-conditioning irrigation, is not know from the available literature. Our measurements have been performed in the fruit-garden area of the Slovak Agricultural University in Nitra during the month August 2011. Apples variety was Idared, lines widths were 4,5 meters; plants spacing 2 meters; silvicultural shape – vertical pelmet; and age of the vegetation: about 20 years.

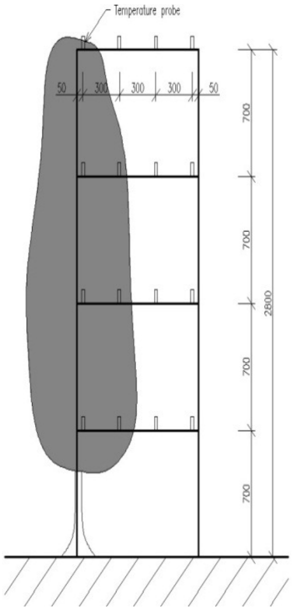

Figure 1. Scheme of probes

For observation of the temperature changes has been used digital temperature sensors Dallas DS 1820, with accuracy 0,1 °C. They were connected in groups and then coupled into sensor Hygrosens USB 128. Irrigation water temperature 12 °C. It were used about 30 temperature sensors for the irrigation variant in one measure profile, which was right on the lines direction and a similar configuration was used for non-irrigated variant. The sensors configuration is shown in the enclosed chart on the *Figure 1*.

The micro-sprinkler irrigation was applied by Flippers` micro-sprinklers, *Figure 2*, from the Israelite firm Naan Dan. The water consumption was 25 litres per hour for one micro-sprinkler, working pressure 2,5 bar; sprinklers distance were 4 meters. The micro-sprinklers were placed on the wooden construction, under the trees in the high of 3 metres so; that the upper trees branches did not restrain full sprinklers functionality. The micro-sprinkler is constructed by that way, that the spurt beam has fan shape, which is overset in the direction of the lines. The sprinkler dribbling is 6 metres; the width of the irrigation strap was 2 meters. Therefore there were irrigated only plants; the inter-straps were not irrigated. The lines orientation was north-south and as a result whole plants were gradually enlightened by sun. During the morning sun lighted eastern part and after-noon western part; while any part of the plant was shadowed permanently


Figure 2. Sprinkler - Flipper

Results and discussion

Measurements had been performed in the range of the schema, shown on the *Figure 1*, while displayed graphs represent only examples of the characteristics` results. From the outcomes analyse results that applied irrigation, by the microsprinkler irrigation, influences on the vegetation temperature with an important measure. The biggest exposal was measured on the top surface of treetop; which is threatened by the scorching of the leaves and fruits the most, with the present physiological evolution restrictions during the growth and progress. The results are obvious from *Figure 3* and *4*. For the objective research of the cooling process during the irrigation followed by the temperature increasing after the irrigation shut-down, it was changing the intervals with and without irrigation. The irrigation interval, as well as interval without irrigation, lasted 1 hour. The reference measurements of the air temperature had been performed by the standard meteo-station, which was placed about 100 m from the experimental base. From the results it is clear, that the irrigation reliably decrease temperature of the vegetation in the most threaten parts about 8 °C.

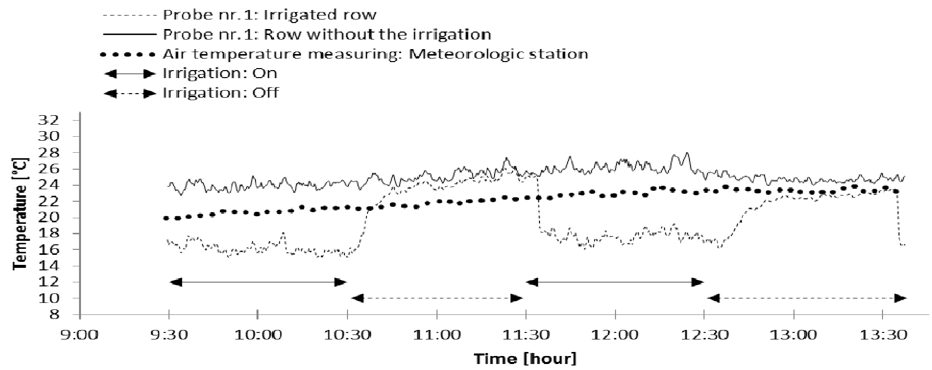

Figure 3. The progression of the temperature change on the thermometer No.1

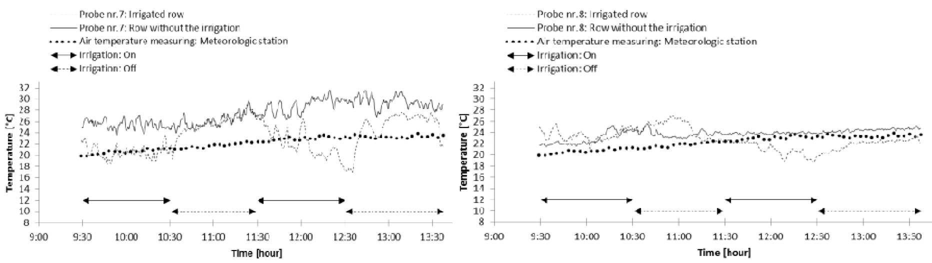

Figure 4. The progression of the temperature change on the thermometer No.7 and 8

The cooling was displayed practically right after the beginning of the irrigation by the advancement and after the irrigation cut-off the temperature was increasing 20 minutes until the state, which was in the control – no irrigated line. From the reason of the irrigation water saving, it was important to assess the irrigation regime by this way, that the period with irrigation and without irrigation were 10 minutes, what stabilized temperature of the vegetation until 24 °C. This assured also the physiological

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development without the water stress as well as plants and fruits protection against scorching.

Conclusions

From the presented work it arises that the correctly projected and running cooling irrigation in the orchard, by an important measure decreases the vegetation cover mainly in the treetops parts; those are exposed to the direct sunshine. The temperature decreases of the exposed surfaces can reach about 8 °C. This temperature decrease represent an important plants and fruits protection against scorching and at the same time it avoids to start the water stress what has a key importance for the physiological evolution in all phenophases.

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PRECIPITATION PATTERNS ON WOODLAND DISTRIBUTION
Blue and green water relations at regional scale

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Abstract: Long term variables of precipitation as the functions of blue water and climate envelopes as the ones of green water were analysed at regional scale in South-Transdanubia, Hungary. Gaussian probability distributions were constructed to define precipitation availability within and between selected BIOCLIM variables and MÉTA habitats. Blue water utilization of riverine and swamp woodlands, mesic deciduous woodlands, closed dry deciduous woodlands and other tree dominated habitats are presented in this study.

Keywords: habitat distribution model (HDM), climate envelope, MÉTA woodlands, landscape ecology

Introduction

Climate effect to biodiversity is a hot topic of ecological research, using distribution, niche theory and bioclimatic envelope models for predicting occurrences of species or habitats. Climate is known to be an essential environmental source in determining vegetation distribution and classification for European scale, especially in woody habitat types. It is important that we are able to describe current habitat distribution in a reliable way according to climate surface and quantify their climate envelope by a climatic niche concept. It will be reassuming used for analysing and detecting functional landscape diversity and climatic sensitivity of woodlands, to be able to understand the impacts of precipitation at different scales. Habitat distribution models (HDMs) often built up on bioclimatic variables as abiotic predictors according to niche stability. They can evaluate range of occurrence from environmental point of view, and can provide novel capacities for understanding general and specific drivers of occurrence.

According to large scale geobotanical division of Europe, region is suited into the belt of submontaneous oak-hornbeam woodlands mixed with thermophilous oak woodlands with steppe oak woodlands or riparian vegetation and Transsylvanian thermophilous oak woodlands with tree steppes (Ozenda and Borel, 2000). Several types of semi-natural woodlands as MÉTA habitats are the most representative vegetation forms in South-Transdanubia as well as in Hungary (Bölöni et al., 2008; Salamon-Albert and Horváth, 2008). Their existence is significantly influenced by the climatic precipitation through the two-way soil moisture control (Várallyay, 2010). They include temperature and precipitation data that are ecologically defined by the BIOCLIM variables (Hijmans et al., 2005). They are widely used for interpretation of habitat distribution or suitability in vegetation science as well as in productivity estimation (Attorre et al., 2007; Zimmermann et al., 2010). They are derived from measured precipitation data in order to generate more biologically meaningful variables, forming some blue water function in the ecosystems. They represents annual trend (e.g. annual sum), seasonality (e.g. annual range), extreme or limiting environmental factors on short or medium time scale, (e.g. driest month), and combined with some temperature variable (e.g. coldest quarter).

In this study climate characteristics of semi-natural woodlands by precipitation variables were revealed. Analyses will be carried out in order to define availability of BIOCLIMs

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on habitat distribution, exploring statistically described specifics of climate surfaces and envelopes.

Materials and methods

30-year averages (1961-1990) of precipitation data were measured and interpolated at regional weather stations by the Hungarian Meteorological Service (Mersich et al., 2001). BIOCLIM calculation and re-interpolation for the units were carried out by the Hungarian Academy of Sciences (Czúcz et al., 2009). Selected precipitation variables for the analyses are BIOCLIM-12 as annual sum, BIOCLIM-13 as one of wettest (June) and BIOCLIM-14 as one of driest month (February), BIOCLIM-16 as one of wettest or warmest (June to August), BIOCLIM-17 as one of driest (January to March) and BIOCLIM-19 as one of coldest quarter (December to February). In first step, scatterplots were constructed on BIOCLIM ranges of total area as climate surfaces (S, n=39450) and of habitats as climate envelopes: riverine and swamp woodlands (J, n=3842), mesic deciduous woodlands (K, n=7177), closed dry deciduous woodlands (L, n=1980) and other tree dominated habitats (R, n=9129) queried from MÉTA database. In second, area version of Gaussian curves as a nonlinear multipeak model was calculated. Fitting results were verified by chi-square value and coefficient of determination (R^2). Blue and green water relations are interpreted as the representatives of peak number and proportion in climate envelopes to regional climate surfaces as blue water utilization.

Results and discussion

Three groups of precipitation variables were analysed referred to long period as a year (BIOCLIM-12), short periods as the months (BIOCLIM-13, -14) and medium periods as the quarters (BIOCLIM-16, -17, -19). Coefficient of determination (R^2) as the measure of model prediction ranged between 0.63 to 0.99 according to blue water variables and habitats. All the Gaussian curves of the surfaces and the habitats were statistically significant at $p<0.05$ level. Coefficient of determination values are suitable to estimate relative effectivity of precipitation variables in habitat occurrence. Lowest R^2 values were detected by BIOCLIM-12 in case of all the habitats, especially in closed dry deciduous woodlands (0.63). Highest values were discovered by BIOCLIM-13 and -14 (0.92 to 0.99), especially the precipitation of driest month in all the habitats (0.99). Coefficient of determination on BIOCLIM-16, -17, -19 variables varied in a wide range. Highest value of mesic deciduous woodlands by the coldest quarter (0.98), riverine and swamp woodlands by the wettest one (0.96), closed dry deciduous woodlands (0.93) and other tree dominated habitats (0.94) by the driest one was resulted.

Climate surface on annual precipitation (BIOCLIM-12) and driest quarter (BIOLIM-17) emerge with the highest number of peaks besides worst habitat utilization (<64.3%). Ones of medium periods (BIOCLIM-16, -19) display moderate number of peaks and properly high habitat utilization (cc. 80%). Ones of short periods (BIOCLIM-13, -14) have resulted least peaks with significant habitat utilization (>91.7%) as the equivalent in peak numbers of surfaces and envelopes. Mesic deciduous woodlands are the exception both by small value of mean and each proportion of climate utilization.

Table 1. Peak number of climate surface (S) and peak proportion of climate envelopes originated from the Gaussian multipeaks. Habitats and variables see in Materials and Methods.

	S	**J (%)**	**K (%)**	**L (%)**	**R (%)**	MEAN ± SD
BIOCLIM-12	7	71.4	28.6	71.4	85.7	64.3 ± 24.7
BIOCLIM-13	3	100.0	100.0	100.0	100.0	100.0 ± 0.0
BIOCLIM-14	3	100.0	66.7	100.0	100.0	91.7 ± 16.7
BIOCLIM-16	4	75.0	75.0	100.0	75.0	81.3 ± 12.5
BIOCLIM-17	7	57.1	28.6	57.1	57.1	50.0 ± 14.3
BIOCLIM-19	4	100.0	50.0	100.0	100.0	87.5 ± 25.0
MEAN ± SD	4.7 ± 1.9	83.9 ± 18.6	58.1 ± 28.0	88.1 ± 19.0	86.3 ± 17.6	

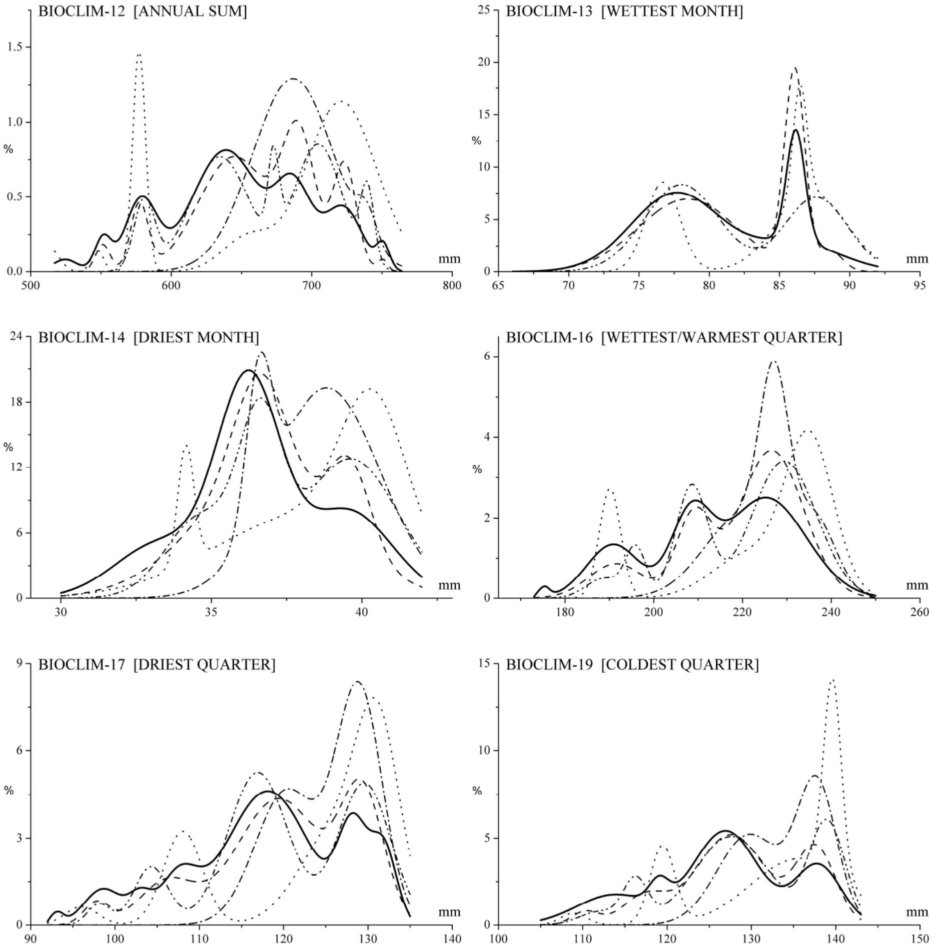

Figure 1. Climate function of woodland habitats by precipitation variables. Symbols: ― climate surface, climate envelope of ··· = J habitats, –·– = K habitats, –··– = L habitats, – – = R habitats. Meaning of habitats and variables see in Materials and Methods.

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Riverine and swamp woodlands (J), closed dry deciduous woodlands (L) and other tree dominated habitats (R) have resulted the highest similarity in peak differentiation by BIOCLIM-13, -14 and -19 (*Table 1.*).

Conclusions

Green water function of semi-natural woodlands are most significantly determined by the short period variables, especially the precipitation of driest month (BIOCLIM-14). These habitats are least determined by the long period climate variable (BIOCLIM-12). Among woody habitats mesic deciduous woodlands (K) display the worst position on climate utilization by their small envelope number proportion to climate surface. Other tree dominated habitats (R) as a mixed group of woody habitats have a tight correlation to all of precipitation variable, potentially including the stands of several types of woody habitats, especially mesic and closed dry deciduous woodlands. Peak patterns of riverine and swamp woodlands (J) are similar to closed dry deciduous woodlands (L) by their climate utilization. Both of them are hardly determined by the local (e.g. soil) water regime, amount of climate precipitation causing a mediate and delayed effect for the occurrence and spatial pattern. In summary it is concluded, that mesic deciduous woodlands potentially could be the most and other tree dominated habitats could be the less sensitive to blue water relations according to their climate envelope characteristics.

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AGROAQUA: DEVELOPMENT OF AN IRRIGATION DECISION SUPPORT SYSTEM IN HUNGARY

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Abstract: Based on the most recent climate change predictions referring to the Carpathian basin, the probability of the occurrence of drought periods will increase in the future. Therefore, the examination of irrigation strategies adjusted to local environmental conditions is especially important today. The aim of our examinations was to develop an irrigation decision support system (IDSS) capable of modelling the water cycle of maize and soil and climatic drought simulation which is frequent in Hungary. The results of the IDSS can be accessed online. The most important information for users are provided by the daily values (water cycle, PET, actual evaporation, transpiration of the soil and vegetation, LAI, critical water content, water deficit, etc.) calculated and modelled by the irrigation recommendation. Knowing these, one can decide about the necessity of irrigation, its starting date and the extent of irrigation. One has the opportunity to try out irrigation methods that have never been established in practice. By altering the applied technological elements, one can utilise alternative opportunities and one can make tactical and strategic decisions. Even questions starting like "What would have happened if…" can be answered with this system. One can carry out analyses that are interesting from the aspect of crop growers, whereas scientific propositions (e.g. sowing date, effect of edaphic factors on the water cycle of the given crop, etc.) can also be examined.

Keywords: irrigation decision support systems, crop simulation modelling, critical soil water content

Introduction

Our natural resources, including the water available for irrigation, are restricted; therefore the examination of irrigation strategies adjusted to local environmental conditions is especially important today. Simulation system models are developed to help decision makers and crop growers in order to increase the effectiveness of management (Cabelguenne et al., 1997; Farré et al., 2000).

In Hungary, actual crop yield is mainly determined by precipitation supply and the water supply ability of the soil. Therefore, during the simulation process, one has to accurately simulate the water of the soil and the actual transpiration of the crop. The simple capacitive model fits this purpose, but the simulation of climatic drought also has to be incorporated (Huzsvai and Rajkai, 2009). Climatic drought means that the water uptake of crops cannot keep up with evaporation. Stomata close and despite the fact that there is enough available water in the soil, plants suffer from temporary water deficit and the incorporation of dry matter becomes slower.

The aim of our examinations was to develop an irrigation decision support system capable of modelling the water cycle of maize and soil and climatic drought simulation.

Materials and methods

The modelling the soil-plant water cycle and climatic drought was performed by the AGROAQUA computerised irrigation decision support system, which was developed at the Institute of Land Utilization, Engineering and Regional Development of the Centre for Agricultural and Applied Economic Sciences, University of Debrecen. For simulation purposes a simple capacitive model was used, in which the simulation of atmospheric drought was also incorporated (Huzsvai and Rajkai, 2009).

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The modelling of temporary water deficit was performed by further developing the idea and work of Doorenbos and Kassam, 1979 who classified field crops into five groups based on drought sensitivity, where 1 means drought sensitive plants and 5 means drought tolerant plants. The principle of this method is that it takes as a basis the critical soil moisture level at which plants start to close their stomata, while considering the soil management characteristics of the soil. Critical soil moisture was estimated by using the following equation:

$$\Theta_{ws} = (1-p)(\Theta_{fc} - \Theta_{wp}) + \Theta_{wp}$$

where:

Θ_{ws}: Critical soil moisture content (m^3 m^{-3})
p: Soil water depletion as a function of the PET
Θ_{fc}: Field capacity (m^3 m^{-3})
Θ_{wp}: Wilting point (m^3 m^{-3})

In the above equation, the parameter "p" was determined in an experimental way, as shown by *Table 1*.

Table 1. Determination of parameter "p"

		PET (mm day^{-1})						
		2	3	4	5	6	7	8
Drought tolerance of field crops	1	0.45	0.38	0.30	0.25	0.23	0.20	0.18
	2	0.60	0.50	0.43	0.35	0.30	0.28	0.25
	3[1]	*0.75*	*0.65*	*0.55*	*0.45*	*0.40*	*0.38*	*0.33*
	4	0.85	0.75	0.65	0.55	0.50	0.48	0.43
	5	0.92	0.85	0.75	0.65	0.60	0.55	0.50

[1]maize belongs to the 3rd drought tolerance category

Potential evaporation was estimated by using the following correlation:

$$PE_s = PET\ e^{-kLAI}$$

where:

PE_s: Potential evaporation (mm day^{-1})
PET: Potential evapotranspiration (mm day^{-1})
k: Extinction coefficient of global radiation (dimensionless)
LAI: Active leaf area index (m^2 m^{-2})

The actual evaporation of the shaded soil surface depends on potential evaporation and the current soil moisture content (*Figure 1a.*). Evaporation can take place from the maximum water capacity to the level of hygroscopic moisture. In order to reduce the number of parameters, we only use three water management characteristics in our model: saturated soil water content (SWC), field capacity (FC) and soil moisture content at wilting point (WP). As for hygroscopic moisture content (hy), we took one quarter of the soil moisture content at wilting point as a basis (Kreybig's method).

The actual evaporation of plants depends on the potential transpiration and the actual moisture content of the soil, also considering the phenomenon of temporary water shortage (*Figure 1b.*). In theory, the range of water uptake by plants is between field capacity to the soil moisture content at wilting point. The water uptake above FC decreases due to the lack of oxygen, whereas the water uptake under WP decreases owing to water deficiency. Between the FC and critical water content, plants evaporate at the level of their potential transpiration.

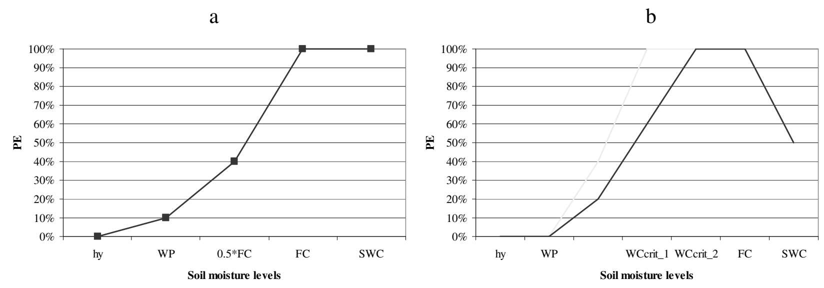

Figure 1a-b. Actual evaporation of the shaded soil surface (a) and the actual transpiration of plants (b)

Results and discussion

The results of the irrigation decision support system can be accessed via a web interface. This way, properly authorised users can access data referring to their own production sites which cover the validated and aggregated daily weather data, the input data of modelling and the results of modelling (*Figure 2.*).

The input data necessary for modelling can be specified via four dialog panels, located at the left side of the AGROAQUA website. In the first "soil" panel, the water management characteristics of the soil, the FC, the WP, the initial moisture content can be edited. In the second "crop" dialog panel the selected crop and the emergence date can be set. In the third "weather" panel weather data series can be selected by users from the database. In the fourth panel the dates of irrigation and the quantity of irrigation water can be adjusted, whereas the previous data can be edited. With **+** button new irrigation events can be added to the database, whereas the **del** button removes all data from the irrigation database (*Figure 2.*).

After setting the input data, the simulation launches automatically and the results are displayed in the charts. After observing the results of simulation, the user can return to the dialog panels. This way, the initial conditions can be changed again, and the simulation can also be launched, this time even considering the applied irrigation water quantities. With this technique, one can estimate the effect of "what would have happened if I had had applied this amount of irrigation water..." on the water cycle of crops.

The most important information for users are provided by the daily scale values calculated and modelled in the irrigation recommendation (water balance, PET, actual evaporation and transpiration of the soil and plants, LAI, critical water content, water deficit, etc.). In the possession of this information, one can decide about the necessity of irrigation, its launching date and the quantity of irrigation water (*Figure 2.*).

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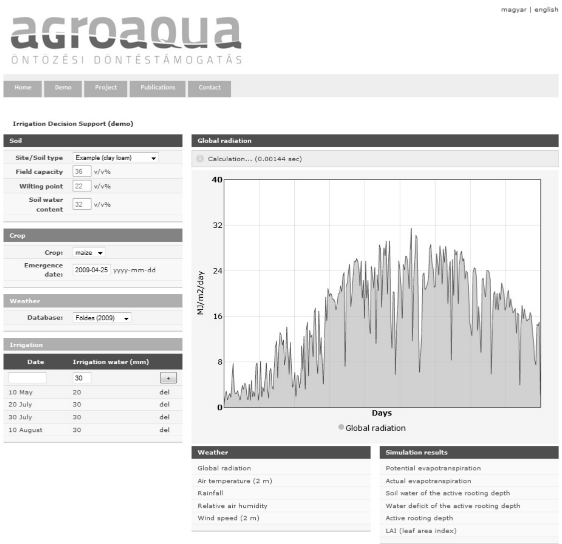

Figure 2. Screen capture of the homepage of AGROAQUA Irrigation Decision Support System

Conclusions

We did not build any recommended water dose or irrigation date into our irrigation decision support system; no irrigation expert advices are given. The developed system focuses on decision support. We provide users with information and decision support and they have to decide about when to start irrigation and what water dose to use based on the technical parameters of their irrigation equipment.

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IMPACT OF HUMAN ACTIVITIES ON THE RIVER WATER MANAGEMENT

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Abstract: Water has some special site-specificities, which means that it has bulkiness, mobility and transience, accompanied with its special management requirements. Still, information on the different various kinds of water resources could be harnessed in a land oriented GIS system (GIS = Geographic Information Systems). *This case study focuses on*
.- concepts, frameworks and strategies, distinction should be made between different geographic entities and scales, also
.- on river basin catchment areas and international river basins traversing distinct climatic zones in dry tropical regions.
In these kinds of tropical regions agricultural sector consumes a large proportion of the available water resources - at very low efficiencies - mainly to satisfy the high crop water requirements, in the order of 1000 to 4000 m^3 t^{-1} of grain produced, but it is really only 100 to 400 mm t ha^{-2}.
There is a dangerous tendency of decreasing crop yields in the semi-arid tropics, while demand of population for food is sharply increasing. This degradation is accelerated by recurrent and continuous droughts and may finally lead to higher order effects, including also migration.
Evaporation is very highly in Nile river basin, as the international one, where after implemented construction of High Asswan Dam in 1964, the Lake Nasser has a total surface area became 6000 km^3, and annual average water loss is 9 km^3 resulted by evaporation. All Egypt Nile water surface is about 55,5 km^3, of which 16% corresponds to the Lake Nasser surface evaporation. In spite of the disadvantages for surface water, it can be advantage, because large and concentrated water demands such as that from large irrigation scheme is usually supplied from surface water storages.

Keywords: River basins, water management, GIS, surface water storage, evaporation

Introduction

This case study focuses on the fields, which are as follows: 1.- Concepts, frameworks and strategies, distinction should be made between different geographic entities and scales; and also 2.- On river basin catchment areas and international river basins traversing distinct climatic zones in dry tropical regions.
Also in field of water management the study emphasize some difficulties, which concern evaporation and sedimentation, which show the importance of the increasing water productivity for agriculture in dry areas.
The global warming process could be resulted in considerable evaporation of partly surface water and soil water closed to face for drying soil, which make the soil be unfavourable for agricultural production (see detailed in Ligetvári et al., 2006).

Materials and methods

The case study aims at *analysing and comparing* the allocation of different water resources in MENA (Middle East and North Africa) region, namely *surface water store* and *groundwater* in field of river basin and catchment areas. There are some compares, which emphasize the advantages of surface water development compared to groundwater.

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Water has some special site-specificities, which means that it has bulkiness, mobility and transience, accompanied with its special management requirements. Still information on the different various kinds of water resources could be harnessed in a land oriented GIS system (GIS = Geographic Information Systems). This system provides data about the influences of warming in dry areas on evaporation of surface water resources.

Results and discussion

The distinction should be made between different geographic entities and scales; and also on river basin catchment areas and international river basins traversing distinct climatic zones are in dry tropical regions.

According to geographic entities and scales in different kinds of tropical regions the agricultural sector consumes a large proportion of the *available water resources* - at very low efficiencies - mainly to satisfy the high crop water requirements, in the order of 1000 to 4000 m^3 t^{-1} of grain produced, but it is really only 100 to 400 mm t ha^{-2}.

There is a dangerous tendency of decreasing crop yields in the semi-arid tropics, while demand of population for food is sharply increasing. This degradation is accelerated by recurrent and continuous droughts and may finally lead to higher order effects, including also migration.

On river basin catchment areas and international river basin evaporation is very highly in Nile river basin, as the international one, where after implemented construction of High Asswan Dam in 1964, the Lake Nasser has a total surface area became 6000 km^3, and annual average water loss is 9 km^3 resulted by evaporation. All Egypt Nile water surface is about 55,5 km^3, of which 16% corresponds to the Lake Nasser surface evaporation (Appelgren, 1994).

In this case countries of the MENA region can also use some important *advantages of groundwater* for their interests. MENA region can improve the irrigation capacity in order to create the wholly unified irrigation system to supply water.

The annual potential evapo-transpiration rates, which are the loss of water to the atmosphere, are greater by between two and 20 times the annual rainfall across the region. of Palestine and Jordan (Al-Boainin et al., 2010.).

For the last decade the surface water of MENA region has sharply decreased because of the global warming, when the level of Death-sea decreases averagely by one meter yearly, and the Jordan –river has not arrive to the Death - sea for a short period of the year (Mughram et al., 2011.).

In spite of the disadvantages for surface water, it can be advantage, because large and concentrated water demands such as that from large irrigation scheme is usually supplied from surface water storage. Also in the same time the groundwater aquifers can provide large storage capacity, which can be able to adapt large volume of flood for a short period of time, and unable to return as significant charge per unit production system of well.

According to the described situation the surface and groundwater using should be harmonizes. On the river basin catchment areas the water management should follow the moderate satisfactory surface and groundwater use based on the optimal water demand and supply balance.

Naturally this water management needs to discover the underground storage capability of water, and also the water demands of the agriculture and other kinds of human uses for water and their economic and environmental possibilities, even cost - benefit ratio in field of economic investments or projects. Within the water management experts should also determine the general capacity of the different aquifers. Also it is required that depth of water level should not be less than 5 to 10 m.

In general river basin catchment areas and international river basins are specific companies of lowland rivers, which were formed as second products of river controls in the last century. Some catchment waters, got into the saved part of flood fillings as water surfaces and ecological surfaces, were immediately radically transformed and started to work as isolated systems. They are unique on the basis of either European or Middle Eastern conditions. Mainly those catchments were kept up, which had water management function and their drainage and water supply was solved based on the water supply-demand balance.

Also it can agreeded on negative influences of the temperate climate conditions in semi-arid areas, where rivers flow all year long, but some times it can occur, namely the depression of the piezometric level of an aquifer underlying a temporary river creates the empty space in aquifer, which facilities its recharge during floods (Appelgren, 1994). But sometimes this flood can be late with less amount of water.

In catchments - similarly to lakes, as surface water resource - specifically developed process is filling-up and decanting-up. Sludge, formed on the bottom, is made of feed-water; flying materials, carried, in the air along the banks, to the backwaters by rainwater; washed away soil particles and of the result of biological processes, then settling material of dead biomass in the water.

Sludge has got great amount of organic matters that is why anaerobic decomposition processes usually come into action, which result the mineralization of organic matters. Specific metabolic emerges between sludge and the water surface above it, in which water vegetation enrichment, specifically, algae proliferation, is helped by minerals, mainly plant nutrients, freed up from sludge. These result the strengthening of eutrophication processes, and finally the acceleration of the destruction of *water quality*.

Sludge, emerged and clogged together in backwaters is - on the one hand objectionable in the point of view of water quality of backwaters; on the other hand, it consists of precious, useful and usable components.

The other authors emphasized the negativ influences of pollution comming from animal husbandry and using fertilizers in detailed based on some examples in EU (Khalif et al., 2010.). It can be declared that pollution can also make demages in the natural environment including water resources in soil water or face water in MENA (Middle East and North Africa) regions. So the wastewater treatment should be developed in this region in order to remain the *water quality* for population and agricultural production.

Conclusions

Mainly the *solutions* are for this water management analysed, which are as follows: decrease the soil erosion, groundwater depletion, increasing water quality in river basin

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and catchment areas. Naturally the *other difficulties* are namely inadequate drainage and consequent waterlogging result in falling agricultural and food production below the potential level. These need better and more successful management and planning.

The water scarcity and human activities with increasing population lead to increasing lack of food based on non effective production system. In order to decrease the inflences of the water scarcity in dry areas, the *water productivity should increase* by different ways, for example to maximize infiltration and water retention in the soil, which means the unproductive water flows to productive transpiration; also to supply water during periods of crop-water deficit by through of protective irrigation system based on the integrated soil and water management. It is important to improve the soil fertility and crop water aviability during the every stage of the growth, which also result in increasing water productivity. By the other words it means that we should follow the best use possibility of limited water resources and garantee the productivity of the soil for long time.

Also some experts decided that "Keeping partly the function of food production, agriculture may play a significant role in energy production or industrial raw material production. For this, a good example can be the utilization of biological materials (biomass) for heating. They can also be used for making fuels, as well as vegetable oils can be used in plastic industry, or medicine and different chemicals may also be made from them." (Fogarassy et al., 2007).

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QUALITY OF WATER IN ZEMPLÍNSKA ŠÍRAVA WATER DAM ON THE VÝCHODOSLOVENSKÁ LOWLAND IN THE SLOVAK REPUBLIC

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Abstract: The water dam Zemplínska šírava is specific anthropogenic hydrogeosystem. It is situated in the Zalužická uplands of East Slovakian lowland of the foothill of Vihorlat hills. It was built (1961-1965) as a retentive dam in the Bodrog river basin (side dam of the Laborec) in the place of the biggest tecnonic subsidence of East Slovakian lowland in Podvihorlat quarternary tectonic depression in its Šírava part. It is the frame of the comprehensive regulation of water schedule on the East Slovakian lowland (1956- 1966). Since the first half of 19th century there was a special hydrogeosystem „ Podvihorlat muds" in the area of present water dam, which was overgrown by the low laying forests and corresponding swamp vegetation (9 – 10 000 years ago, Alleröd). Zemplínska šírava is the twelfth biggest artificial water surface in Europe (length 11.5 km, average width 3.0 km, the biggest width 4.1 km, average depth 9.5 m, maximum 14.7, length 6 to 12 m high dam wall is 7 346 m, dam area depends on the water condition and it varies from 22 to 33.5 km^2, maximum content 334 mil. m^3). The lowest working level of the dam is 107.7 m, the highest 116.6 m. At present time it fullfils the retention function (moderate flood waves) and recreational, which is decreasing with the bad water quality in the dam.

Keywords: Zemplínska šírava, water dam, quality of the water

Introduction

The water dam Zemplínska šírava was built in 1961 – 1965 in the Východoslovenská Lowland on the river Čierna voda (side basin of the Laborec river) to protect agricultural soils in the lowland from floods. The next function of the dam was to increase the water flow of the Laborec in Vojany because of cooling down the blocks of electric power plant, to provide water for irrigation and to prepare conditions for the development of summer tourist trade and recreation. The eastern part of the dam was proclaimed conservation bird territory. In 80ties and 90ties of the 20th century the dam Zemplínska šírava became one of the most popular centre of summer tourism and recreation in Slovakia. As a result of the chemical industry development in Strážske, the water quality in the dam was devaluated and this fact influenced reduction of the recreational function significantly. Question of water quality evaluation, or evaluation of more components of environment was elaborated in many ecological and geographical studies (Hecl and Kotorová, 1996; Torma and Fazekašová, 2007; Krokusová and Čech, 2010; Michaeli and Boltižiar, 2010, 2011; Vilček, 2011).

Materials and methods

The results of monitoring, received by Research Hydrologic Base of the Institute of Hydrology of the Slovak Academy of Sciences in Michalovce, Regional Department of Public Health Service (RÚVZ) in Michalovce and Slovak Water Managing Enterprise Košice, became the background details for the evaluation of the water quality in the water dam Zemplínska šírava. Information on amount of polychlorinated biphenyls

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(PCB) in Zemplínskej šírave and its close vicinity were processed according to the final projects reports of Institute of Preventive and Clinical Medicine in Bratislava (Kočan et al., 1995a,b).

Results and discussion

Water quality in Zemplínska šírava directly depends on the water quality in the upper and in the middle part of the river Laborec. The most important sources of pollution are Chemko Strážske and public sewerage in the towns Humenné and Strážske, there is also surface water and other waste waters, which get into the dam from the tributaries coming from the villages situated in the northern and southern parts of the dam (Búgel, 1999). Streams of the south foothill of Vihorlatské hills (Trnavský, Kamenný, Viniansky, Hrabový, Tomášovský, Jovsiansky potok a Kusín) rise from 600 to 1 000 m altitude. The results of sample analysis, provided by Research Hydrologic Base of the Institute of Hydrology of the Slovak Academy of Science in Michalovce in period of 1993 - 1996, drew attention to the significant changes in their chemism. Their analysis showed increased values of nitrates in the water flow. Slovak Water Managing Enterprise Košice noticed deteriorative water quality in the dam. During 2000-2004 the values of microbiological indicators, which are together with biological indicators the most important, regarding the protection of bathing people, got to the level IV. – V. class of cleanness, which responds to strongly and very strongly polluted water (*Table 1.*). As Slovak Water Managing Enterprise has not included the water quality into the individual classes of cleanness since 2006, this study was restricted by present results of RÚVZ in Michalovce, which checked the values of microbiological, biological and physical-chemical indicators. Sampling was being done in seven terms from 7th June to 30th August 2011. Except the last term, all observed indicators in recreational centres were in limit. Samples from 30th August showed increased occurence of algae in recreational centres Hôrka, Medvedia hora and Biela hora. Limit values of the water transparency were exceeded in the recreational centre Biela hora.

Table 1. Water quality in Zemplínska šírava water dam

Monitored place	Monitored period	Quality class in the group of indicators according to STN 75 7221			
		A	B	C	D
Šírava chanal	2000-01	III.	III.	IV.	V.
Medvedia hora		III.	IV.	V.	V.
Šírava chanal	2001-02	III.	II.	IV.	IV.
Medvedia hora		III.	III.	V.	IV.
Šírava chanal	2002-03	III.	II.	III.	IV.
Medvedia hora		III.	IV.	IV.	IV.
Šírava chanal	2003-04	III.	III.	III.	IV.
Medvedia hora		III.	III.	V.	IV.

Explanation: A – indicators of oxygen schedule, B – basic chemical and physical indicators, C – complementary chemical indicators, D – biological and microbiological indicators
Processed according to Slovak Water Managing Enterprise Košice

The water transparency and eutrophysation are not far the most important problem of the water quality in the dam Zemplínska šírava. In spite of finishing of PCB substances production in Chemko Strážske more than 15 years ago, its content in the Laborec and Zemplínska šírava is still high. The most significant polution by PCB substances were recorded in the waste chanel emerging from Chemko Strážske which joins Laborec River at the village of Voľa. At the turn of years 1987/88 the value of PCB substances ranged from 3 900 to 4 500 ng/l. There was measured a concentration of PCB substances 8 - 250 ng/l in the water of Zemplínska šírava. Regarding sediments on the bottom of the dam, the values ranged from 98 to 3 480 ng/g (Kočan et al., 1995a, b), however according to the instruction of the Department of Environment SR no. 549/1998-2 maximum acceptable concentration of individual congener of PCB substances for evaluation of pollution risks from rivers and dams was specified as 4 μg/kg. In comparison with the sediment samples from the water dam Domaša and the river Ondava, the concentrations in sediments of Zemplínska šírava and Laborec were 100 and 2 000 times higher (Kočan et al., 1995 a, b). Commenting on, we would like to mention that the 80's of the 20th century the norm for the presence of PCB substances in the surface waters was 990 ng/l, while nowadays it is 10 ng/l (Pilváňová, 2007). According to the viewpoint of RÚVZ Michalovce presented on the website www.ruvzmi.sk to 20th October 2011, PCB substances are a little soluble in water and thus there is not any threat of the risk for bathing in Zemplínska šírava. Surface water from Zemplínska šírava was investigated in the laboratory for PCB substances in six congeners, where the limit values were not exceeded. The question is, if it is possible to claim only on the basis of the results of six congeners that bathing in the dam is ragarding the content of PCB substances safe. The next problem is, that although PCB substances are not soluble in water, they are soluble in fats, which are one of the basic building components of a human body. Even though the amount of waste water emitted from Chemko Strážske into the Laborec was decreased from 11 187 300 m^3/per year to 2 830 205 m^3/per year (Oravcová, 2001), sediments with PCB substances remain still there. This factor has an unfavourable influence on the ichtyofauna. The results of blood plasma analysis of people consuming fish from the dam Zemplínska šírava point to the increased content of PCB sustances in their bodies.

Conclusions

Inappropriate water quality in the water dam Zemplínska šírava is the consequence of more factors influence. The first of them is the terrain configuration of the original bottom of the dam. The next is inflow and outflow in the western part of the dam and the chemical industry (production of PCB till 1984). Noticeable area of the dam, shallowness, weak outflow cause the insufficient mixing up of the water in the dam and over-warming of the water area surface, which is followed by eutrophysation. PCB content in the sediments of the water dam on its bottom presents a serious problem. The term of PCB disposal given by Stockholm Agreement dated till 2010, the Slovak Republic did not keep (GEF 10 mil. USD in 2003 for PCB degrading equipment, there is a question how was this money used). Chemko a.s. Strážske is winding up, but environmental load remains and its impact on environment persists.

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RIVER WATER TEMPERATURE - CLASSIFICATION SCHEMES IN SLOVAKIA

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Abstract: Water temperature significantly influences the chemical and biochemical processes reactivity taking place in the stream water environment. Boundary values of the surface water temperature acceptable for life and reproduction are: 21.5 °C for salmonoid fish, and 28 °C for wild carp, according to Slovak Government Regulations. In consequence of water temperature increase, the status of water (in terms of quality) might be even substantially worse. Process of eutrophication comes up in the stagnant water. Presented contribution has two principal aims: 1. Description of water temperature measurement methodology, and methodology of the surface water temperature boundary values determination for ecological status evaluation according to WFD (Water Framework Directive) 2000/60/EC in Slovakia; 2. Statistical analysis of the daily water temperature values measured at 7:00 A.M. in river profiles of the quantitative surface water database. The analyses are based on the water temperature time series from two groups of data: one resulting from the regular daily observations at 7:00 A.M., the second from the irregular monthly observations (app. once a month). Results are presented on the lowland Morava River example.

Keywords: Water temperature, WFD 2000/60/EC, Morava River, legislation

Introduction

Water temperature is one of the twelve physico - chemical elements of water quality, used for the assessment of ecological status of surface waters according to the Water Framework Directive (WFD) 2000/60/EC. Presented article describes development of the methodology for classification scheme determination of water temperature, in order to evaluate status of the surface water bodies in selected Slovakian rivers.

For water state evaluation in WFD sense, such evaluation schemes are used, starting from the reference conditions not disturbed by anthropogenic activities. Particular quality elements characteristic values, within qualification schemes, should characterize individual surface flow body (river) types. For Slovakia, 22 surface water types were defined (Dobiasova et al., 2006). The creation of classification schemes was based on statistical processing of the observed surface water quality data. The statistical examination was focused on the water quality records from the period 1990-2005 covering all types of surface running watercourses in Slovakia (Pekarova et al., 2007). Classification schemes (limiting values) for physico-chemical quality elements were determined from the „very good“ to the „moderate“ ecological status. So within the Classification scheme, two limits were determined, between the: 1. very good and good state (I. and II. quality class); 2. good and moderate state (II. and III. quality class).

Water temperature data archiving in Slovakia

Measurement of water temperature had a long history in the former Czechoslovakia (Novicky et al., 2009). Slovak Hydrometeorological Institute (SHMI) has been

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entrusted by water temperature archiving according to the 412/2010 l.r. (Legal regulation).

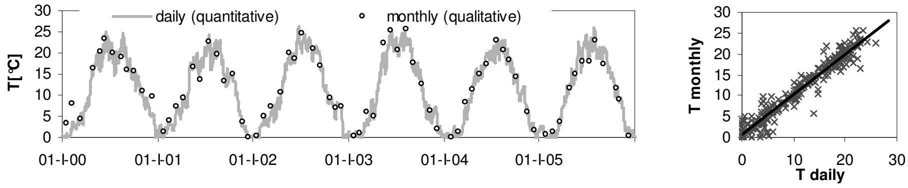

Figure 1. Comparison of the quantitative and qualitative water temperature database, period 2000-2005

The water temperature daily observations are being stored in two databases:
1. The **quantitative** surface water database - daily water temperature observations from the SMHI water gauge stations at 7.00 A.M.
2. The surface waters **quality** monitoring database in Slovakia - water temperature observations (at least once in month) at the water quality sampling sites.

In 2008, the surface water measurement in Slovakia was implemented in 394 stations. In *Figure 1*, an example of the water temperature time course in daily step is presented, as stored in the SHMI quantitative database, together with the monthly measurements from the qualitative database (the Morava river at Zahorska Bystrica - Western Slovakia, period 2000-2005). On right side in this figure, regression is shown of these measurements for 1981-2005 period.

Temperature classification schemes

For water temperature classification scheme determination, we used the long-term historical data stored in the national surface water quality database. Surface water bodies in SR were divided into 10 categories (*Table 1.*). The national quantitative water temperature measurements database has not been used.

Table 1. New classification schemes for the water temperature in SR, surface water

		Water Temeperature[°C]		
Category	Types of surface water body	Class of water quality		
		Government regulation No. 296/2010		
		I.	II.	III.
1	P1M, B1(P1V)	< 25	< 27	≥ 27
2	P1S, P2M, K2M, M1(P1V), I1(P1V), R2(P1V)	< 24	< 26	≥ 26
3	D2(P1V), V3(P1V)	< 23	< 25	≥ 25
4	K2S, V2(K2V)	< 22	< 24	≥ 24
5	D1(P1V), R1(K2V), H2(K2V), P2(K3V)	< 21	< 23	≥ 23
6	H1(K2V)	< 20	< 22	≥ 22
7	P1(K3V)	< 20	< 21.5	≥ 21.5
8	K3S	< 19	< 21.5	≥ 21.5
9	K3M, V1(K3V)	< 18	< 21.5	≥ 21.5
10	K4M	< 16	< 18	≥ 18

(P-Pannonian Basin, K-Carpathians, 1-altitude < 200 m a.s.l., 2-altitude 200-500 m a.s.l., 3-altitude 500-800 m a.s.l., 4-altitude <800 m a.s.l., V-large river-area >1000 km^2, S-medium river-area 100-1000 km^2, M-small river-area 10-100 km^2).

Table 2. Basic daily water temperature characteristics of the Morava river

water temperature	mean value	min	max	*330*-day	*30*-day	cs	cv
[°C]	10.98	0.00	**28.70**	0.90	21.45	0.08	0.68

Therefore, we have concentrated upon a detailed statistical evaluation of daily water temperature measurements on a lowland type river Morava, as an example. For that purpose we used the Morava daily water temperature measurements (at 7.00 A.M.) in gauging station Zahorska Ves, from October 1947 to September 2009. Daily water temperature basic characteristics in Morava river at Zahorska Ves station, are presented in *Table 2*. Water temperature courses of the upper centiles (P99), mean values (P50) and the lower deciles (P10) within individual days of the 1956-2008 period, are shown in *Figure 2*, left side. *M*-daily water temperatures are drawn there on the right side.

T-years water temperature values

In the next, we compared the Morava *T*-years water temperature maxima determined from two series: 1. from the 53-years maximum water temperature series, determined from the daily values, and 2. from the 25-years time series, determined from the monthly observations. Water temperature exceeded in the average once in 100 years, was estimated in the first case to 28.9°C, in the second case to 26.35°C (*Figure 3.*). Morava river at ZahorskaVes belongs to *P1V* type of surface water body. According to *Table 1.*, for the Morava river the I. class limit is 25°C, for the II. class it is 27°C. Water temperature observed at 7.00 A.M., exceeds the 25°C limit with probability once in two to three years. Water temperature observed once in a month, exceeds the 25°C limit once in ten years. Situation is worse with exceedance of the II. class limit. At daily observations, this limit will be exceeded once in 9 to 10 years. These results indicate, that the water temperature limits in the case of the Morava river at Zahorska Ves gauge are underestimated.

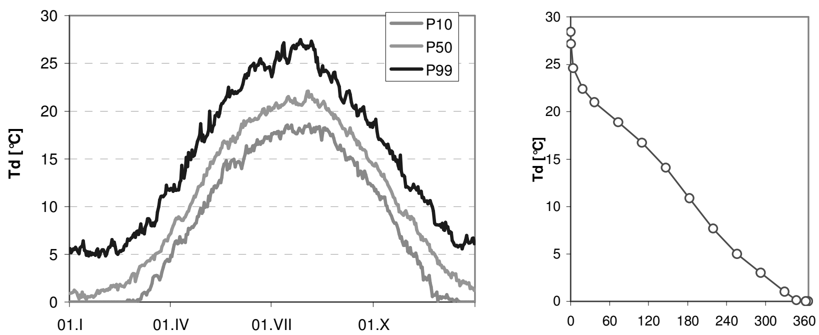

Figure 2. Daily (*Td*) water temperature percentiles (left), *M*-daily water temperatures (right). Morava river, Zahorska Ves sampling site, 1956-2008 period, 7.00 A.M. observed),

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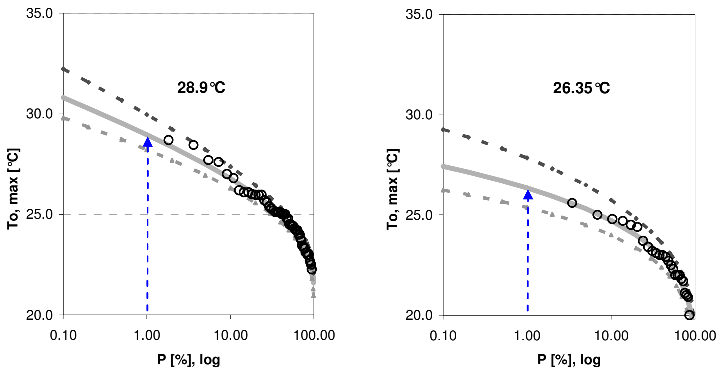

a) b)

Figure 3. Theoretical log-Pearson III. type probability exceedance curve of the maximum annual water temperature (bolt line); upper and lower 90% limits; Measured values *To,max* (black circles).
Left: Morava river, daily observations at 7.00 A.M., hydrological database;
Right: Morava river, monthly observations, water quality database

Conclusions

Water temperature is influenced by various factors. It changes accordingly to the time of the day and within the year. The air temperature, site elevation, and the respective river hydrological situation influence it also. It is therefore necessary to define such classification of surface waters into the quality classes with more precision. It is our next research object to elaborate and propose a more exact classification methodology and schemes for the water quality classes within the SR.

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WEATHER IMPACTS ON MAIZE PRODUCTIVITY IN CROATIA WITH EMPHASIS ON 2011 GROWING SEASON

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Abstract: Maize is the main field crop in Croatia and it is grown on about 35% of arable land of the country. Maize production in Croatia is characterized by very high variations of annual yields, mainly as a result of less or more favourable weather conditions or water availability. In the last 25-year period (1985-2009) yield variation among years were in range from 3.9 to 8.0 t ha^{-1}. Aim of this study was the evaluation of precipitation and mean air temperatures regimes in the east, central and north parts of Croatia in the 2011 with aspect of degree their suitability for maize growing. Precipitation quantities in the April-September period in the studied area in 2011 were only 276 mm or 41% lower and air temperatures 18.7 °C or by 1.7 °C higher in comparison with the long-term mean. Maize crops in the East Croatia were especially exposed to drought stress during August and September, when 21 mm precipitation was recorded or only 20% of long term mean accompanying by 3.3 °C higher air temperature. Based on precipitation and air temperature regimes, the 2011 growing season was unfavourable concerning maize requirements and yield reduction was expected.

Keywords: maize, precipitation, air temperature, growing season 2011, Croatia

Introduction

Maize is the most widespread crop in Croatia and it occupies about 35% of arable land areas of the country. Its production is characterized by great yield fluctuation per year. In the last 25-year period (1985-2009) average maize yield in Croatia varied from 3.9 to 8.0 t ha^{-1}. Weather conditions, especially precipitation amounts and distribution through growing season, along with air temperatures are among most important environmental factors affecting the maize development and yield. As a rule, large quantities of well-distributed rainfall and lower air temperatures during three summer months benefits maize growing (Kovacevic et al., 2010). Many previous studies elaborated the impact of precipitation and air temperatures regime on maize yield variations in the Croatia (Kovacevic, 2004; Josipovic et al., 2010; Kovačević and Josipović, 2005) and it was confirmed that low yield are associated with water shortage and higher air temperatures during July/August. Aim of this study was evaluation the precipitation amounts and mean air temperatures in the east, central and north part of Croatia in the 2011 in relation to theirs suitability for maize growing.

Materials and methods

In this study, the weather data (precipitation and air temperature) are provided by the State Meteorological and Hydrological Service from three weather bureaus: Osijek (OS), Daruvar (DA) and Varazdin (VZ), and they are representing east, central and north parts of Croatia, which occupies close to 60% of the state territory. Data of the State Bureau for Statistics were used as the source for grain yield.

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Results and discussion

In the lowlands (Pannonian) part of Croatia climate is moderate continental characterizing low horizontal changes of temperature and specific distribution of precipitation as more rainfall is in the warmer part of year, from April to September. However, in mid-summer a shorter or longer dry period occurs. As a rule, from the west to the east part of the country, amount of precipitation decreases, while air temperatures increase. Annual precipitation amounts in continental part ranged from 1000 mm in the west to about 600 mm in the east.

Table 1. Monthly values of precipitation and mean air temperatures during maize growing season in different parts of Croatia in 2011 in comparison with favourable 2005 and unfavourable 2007 growing season

Year	Precipitation (mm)							Mean air temperatures						
	Apr	May	June	July	Aug	Sept	Total	Apr	May	June	July	Aug	Sept	Mean
	East part of Croatia (Osijek Weather Bureau)													
2011	20	81	50	74	5	16	246	13.2	16.7	20.8	22.2	23.1	20.3	19.4
2007	3	56	33	27	45	65	229	13.3	18.2	22.3	23.8	22.2	14.5	19.1
2005	55	46	112	171	238	75	697	11.5	17.0	19.5	21.5	19.3	17.1	17.7
LTM	54	59	88	65	59	45	370	11.3	16.5	19.5	21.1	20.3	16.6	17.6
	Central part of Croatia (Daruvar Weather Bureau)													
2011	19	55	44	121	40	27	306	12.6	15.6	20.3	21.7	21.6	18.7	18.4
2007	7	95	62	29	100	146	439	12.4	17.5	21.5	22.5	21.1	13.7	18.1
2005	74	69	45	106	166	110	570	10.7	15.9	18.9	20.8	18.5	16.1	16.8
LTM	77	86	99	86	91	65	504	11.0	15.7	18.9	20.6	19.7	16.1	17.0
	North part of Croatia (Varazdin Weather Bureau)													
2011	25	41	49	102	25	36	278	12.7	16.2	20.5	21.0	21.5	18.4	18.4
2007	5	75	51	106	98	181	516	13.1	17.5	21.6	22.4	20.5	13.8	18.2
2005	98	60	47	184	140	92	621	11.2	16.3	19.2	20.7	18.6	16.2	17.0
LTM	70	84	98	92	98	81	523	10.3	15.1	18.3	19.8	18.9	15.4	16.3

LTM – long term mean 1961-1990

The long term mean of precipitation in maze growing season (April -September) in the East Croatia is 370 mm, what is much lower than in the rest of the continental area (*Table 1.*). In the 2011 growing season all three maize growing areas received for about 40 to 50% less precipitation compared to LTM. According to this, 2011 can be characterized as a dry and unsuitable for good maize yield achieving and it could be compared with also very dry season of 2007. However, rainfall distribution per months was different. Spring was quite dry, but normal or even higher amounts in central and north part fell in the July. On the contrary, maize crops were especially exposed to drought stress during August and September, as in average for all three areas, 49 mm precipitation was recorded or only 31% of LTM, whilst mean air temperature was 3.1 C higher. This was especially noticeable in the east area where during August and September fell only 21 mm precipitation accompanying by 3.3 ºC higher air temperature. Kovačević and Josipović (2005) observed that lack of precipitation and higher air temperatures in summer is the cause of lower maize yields in the East Croatia. It is very well known that the greatest maize need for water is during tasseling, silking, pollination and early grain development (Shaw, 1988), what occurs in most cases from the July through the August, depending on the hybrid maturity group. From that point of view, it is very important precipitation distribution in 10-days intervals, which are very variable depending on the site (*Figure 1.*), but can provide more precise explanation of weather impact on maize yields (Kovacevic et al., 2005). Although the official statistical data about the average maize yield for the 2011 was not available, results from our stationary field experiments in the central part of Croatia shows about 30% lower yield comparing with average Croatian maize yield.

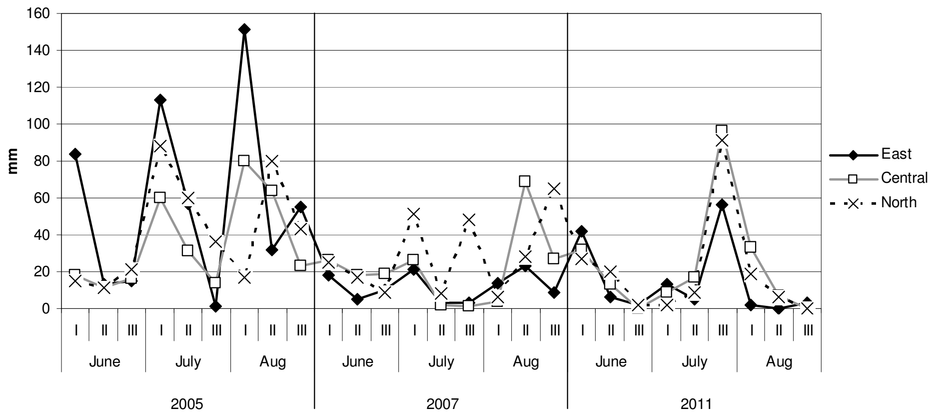

Figure 1. Precipitation in 10-day intervals during summer (June-August) in different parts of Croatia in 2005, 2007 and 2011

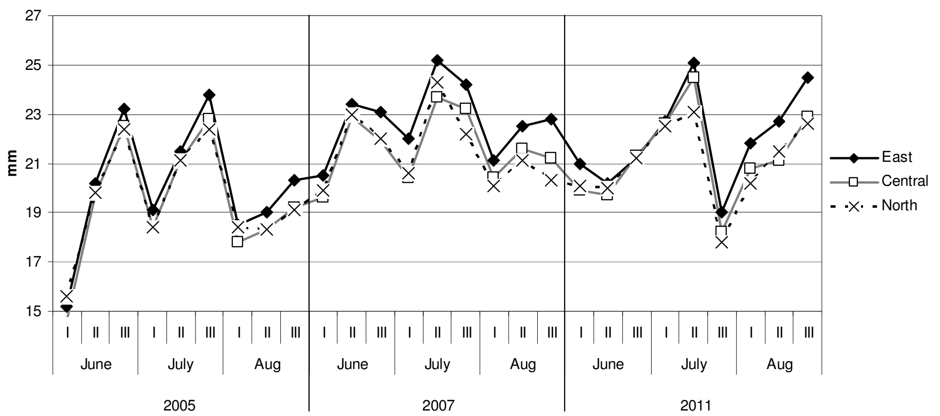

Figure 2. Air temperatures in 10-day intervals during summer (June-August) in different parts of Croatia in 2005, 2007 and 2011

In the last 10 years period (2001-2010) maize grain yield in Croatia varied from 4.2 to 8.0 t ha^{-1} (Croatian Bureau of Statistics, 2011). The growing season of 2007 was very dry and warm and therefore unsuitable for maize growing. The average yield was 4.85

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t ha^{-1}, 4.86 t ha^{-1} and 4.24 t ha^{-1} for Osijek, Daruvar and Varazdin area, respectively, while in Croatia was 4.94 t ha^{-1}. The main feature of this season is extremely dry spring what affected the early maize development and crop establishment. Again, the drought was most expressed in the east and from June to August only 106 mm was recorded (*Table 1.*). On the other hand, season of 2005 was more favourable concerning weather conditions and higher maize grain yield was achieved (6.92 t ha^{-1} for the whole country, and 6.98 t ha^{-1}, 7.44 t ha^{-1} and 6.64 t ha^{-1} for Osijek, Daruvar and Varazdin, respectively). The main characteristic of 2005 is unusually rainy summer and somewhat lower air temperatures. Nagy (2006) reported similar maize yield variability accordingly to water supply, while results of Žemberly et al. (2011) confirmed a significant influence of weather conditions on some maize yield components.

Conclusions

Maize grain yield fluctuation among years could be attributed to adverse weather conditions, especially to drought stress during summer. In years with adequate water supply high maize yield can be expected, but in dry seasons without irrigation, considerable yield reduction is common. The analysis of weather conditions showed differences in precipitations amounts depending on the area studied. The east part of Croatia is particularly susceptible to water deficit during July and August when maize has the greatest water demand. Based on precipitation and air temperature regimes, the 2011 growing season was unfavourable concerning maize requirements and yield reduction is assumed. During summer (June-August) in the East Croatia only 129 mm of rainfall was recorded, which could not cover the needs of maize for water. Although precipitation amounts are very important factor determining maize yield, numerous factors affect plant growth and development. Among others, soil type and real water availability in soil should be taken into consideration.

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EFFECT OF WATER REGIME ON NUTRITION IN THE PLANT-SOIL SYSTEM OF AN PEACH PLANTATION

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Abstract: The water is a key factor in crop growing. Beside the adequate water supply, the water saving will be determine the future agriculture, especially the future fruit growing. Therefore the importance of groundcover technique in fruit nutrition has increased in the last few decades owing to their application in organic farming and it is regarded as excellent water saving and nutrient supply method simultaneously. Despite of this fact the influences of cover materials in the row area of peach trees on soil temperature, fertility and plant nutrition are largely unknown.
A field trial has been conducted on five years old 'Sweet Lady' peach cultivar on a sandy loam soil at Siófok, West Hungary, since 2009. Four in-row ground management systems (pine bark mulch, cow manure, black fabric cover, and no cover with herbicide applications) were evaluated in a plot design with three replicates to study their effects on the soil temperature and nutrient contents of leaves.
It was found that the soil temperature and macro and micro nutrient contents of leaves were significantly affected by the treatments. The fluctuation of soil temperature was more moderate at the usage of mulch and manure. Overall, our results suggest that leaf nutrient concentrations respond differentially to different mulches, and the responses vary with growing season. Our results suggest that the cover management offers possibility to correct and improve the nutrient uptake, productivity and growth.

Keywords: groundcover, fruit nutrition, soil and leaf analysis

Introduction

The importance of ground management has increased in fruit production systems in the last few decades owing to its application in organic farming (Skroch and Shribbs, 1986) and as it is regarded as excellent water saving method (Merwin et al., 1994), and for profitable and sustainable tree fruit production (Geldart, 1994; Derr, 2001). Mulching has several benefits which were summarized by Merwin et al., (1994).
The benefits are variously attributed to the suppression of weed growth, to the conservation of moisture by reducing evaporation and run off, to protection from erosion, to increased infiltration of water, to the increase or decrease of soil-temperature fluctuations, to the enhancement of mineral nutrient availability, to the enhancement of nitrification, to additional nutrients and organic matter derived from a decomposing mulch, or to the preservation or improvement of soil structure (Johnson and Samuelson, 1990; Stevenson and Neilsen, 1990).
Several publications pointed out that mulching has a positive effect on the water and temperature regimes of soil and it involves nutritional and biological factors as well (Skroch and Shribbs, 1986; Faust, 1989; Merwin and Stiles, 1994; Nielsen et al., 2003; Nielsen et al., 2004; Mäge, 1982; Parker and Hull, 1993; Yin et al., 2007).
The importance of groundcover management is intensified by the decrease of available soil moisture and frequent drought events.
Although, the practice of mulching is well known to horticulture, there is a little information about its application and its effects on orchard nutritional management, especially in Central Europe and Hungary. Therefore, the aim of the present paper is to study the effects of different groundcover methods on soil temperature and nutrient availability of peach orchard.

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Materials and methods

The study was conducted at the orchard of Gyümölcsért Ltd. (Fruit Research Experimental Site - University of Debrecen), at Siófok. The 10 ha orchard was planted in 2004, grafted on GF 677 rootstock, at a spacing of 5x3 m.
A randomized block design was used. All treatments consisted of three replicates, and control was used as check. Groundcover matters used were shown in *Table 1*.

Table 1. Applied treatments and doses

Treatments	Applied dose (m^3/plot)
Control	-
Pine bark mulch	3.0
Cow manure	3.0
Black foil	0.5 mm (thickness)

The mulches were applied to the ground without incorporation in April 2009 with 0.75 m wide edges buried in the soil on both sides of a tree row. Each plot consisted of 20 trees. So the total covered area was 90 m^2. For investigation (soil and leaf analysis) cv. 'Sweet Lady'cultivar was selected.
Soil samples were collected from 0-30 cm and 30-60 cm layers by using manual soil sampling equipment (auger) (MSZ-08 0202-77). Soil samples were collected before the treatments were applied, to determine some physical and chemical soil properties. Collected soil samples were dried outdoors, grinded, sieved, homogenized and stored in plastic boxes in dry place until the examination.
Leaf samples were collected at the end of July (100 days after full blooming) in 2009 and in 2010. Healthy, fully-developed leaves were collected from the mid-third portion of extension shoots current year were collected. Collected leaf samples dried, grounded, homogenized and stored until analysed.
Leaf N was determined by dry combustion method according to Nagy (2000). Leaf P was quantified colorimetrically with phospomolybdovanadate method. For determining leaf K flame atomic emission spectrophotometry was used. Leaf Mg and Ca were determined via atomic absorption spectrophotometry.

Results and discussion

Soil properties

Orchard soil type was chernozem soil with medium carbonate content (*Table 2*). The soil pH was near neutral and the humus content was low. The water capacity of the soil was sufficient for fruit growing. Nitrate content of soil was low and decreased by the depth. It showed that the nitrogen supply of the soil was limited mostly in deeper layer. Readily soluble P of soil was medium and steeply decreased by the depth. Soil K was a moderately. AL soluble soil K amount was decreased by depth (*Table 2*).

Table 2. Results of soil analysis (2009)

	Depth [cm]	
Parameters	0-20	20-40
pH [KCl]	7.43	7.52
K_A*	32	31
$CaCO_3$ [m/m%]	4.1	7.7
Humus [m/m%]	1.87	1.02
NO_3^--N [mg/kg]	8.2	3.0
P_2O_5 [mg/kg]	207	92
K_2O [mg/kg]	200	140

Leaf Mineral Composition

The results of leaf analysis are included in *Table 3*. All applied treatments increased N content of leaves. The highest increment was achieved through manuring.

Table 3. Results of leaf analysis (averages, 2009-2010)

	N (%)	P %	K %	Mg (%)	Ca (%)
Control	2.12a	0.19a	1.92a	0.74c	4.33a
Mulch	2.29b	0.20b	2.45c	0.67b	4.85d
Foil	2.17a	0.18a	2.27b	0.65a	4.46b
Cow manure	2.42c	0.17a	2.80d	0.62a	4.15a
Mean	2.25	0.19	2.36	0.67	4.45

In each column, means followed by the same letter are not significantly different ($P<0.05$)

Our results pointed out that leaf P was not affected by treatments significantly. Significant effect was observed at mulching only. The foil treatment decreased leaf P which correlation to those, published by Yin et al. (2007) who used polypropylene foil for covering. The decreasing effect of manuring was unclear for us; supposedly it follows from the low mobilization rate of P from manure. Applied treatments had stronger, significant effect on leaf K. Similarly, leaf Ca is also significantly increased by treatments, except in manuring. However, the treatments decreased leaf Mg consequently (*Table 3*) as Yin et al. (2007) and Neilsen et al. (2003) have reported.

Beside the absolute values of nutrients the binary ratios of them were calculated (*Table 4*).

Table 4. Calculated binary ratios of peach leaves (averages, 2009-2010)

Sweet Lady	N/P	N/K	K/Mg	K/Ca
Control	11.16	1.10	2.59	0.44
Mulch	11.45	0.93	3.66	0.51
Foil	12.06	0.96	3.49	0.51
Cow manure	14.24	0.86	4.52	0.67
Optimal	*14.09*	*1.24*	*5.00*	*1.22*

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Calculated ratios in leaves showed that the applied treatments had a favourable effect on the conditions of nutrient uptake in this orchard (except N/K ratio). Manure containing treatments resulted in the best binary ratios (except N/K) (*Table 4*).

Conclusions

Results of leaf analysis showed that the leaf N, K and Ca concentrations increased but leaf Mg decreased by the treatments. Leaf P was not affected significantly by the treatments. Overall, our results suggest that leaf nutrient concentrations respond differentially to different mulches. Our results suggest that the cover management offers possibility to improve the nutrition of trees and modifies nutrient ratios. Moreover it was found that, groundcover management is a useful tool for satisfying the demand of trees because it improves the availability of nutrients, reduces weed competition, results moderate fluctuation of soil temperature and causes balanced nutrient ratios in leaves. After preliminary results we needed further investigation to determine the optimal rate and form of mulch needed in order to produce a more sustainable peach production system.

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THE EFFECTS OF FISHPOND'S HUSBANDRY ON THE GROUNDWATER IN THE SAND RIDGE BETWEEN THE DANUBE AND TISZA RIVERS

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Abstract: Between the Danube and Tisza rivers there are many fishponds where extensive fish breeding is performed. The total area of the fishponds is over 3350 ha. There can be found both natural and artificial lakes among them. The water drainage towards the Danube and Tisza rivers, their groundwater reduction effect and the evaporation deficit all contribute to the water shortage of the Sand Ridge. Beside the fishponds, gravel mine lakes also have an effect on the water regime of the area.
Many reasons of the quantitative and qualitative problems regarding the groundwater level decrease are known. Out of these reasons, this paper focuses on the effects the fishponds and gravel mine lakes have on the groundwater level. The annual water demand of fishponds between the Danube and Tisza rivers is about 15-20 million m^3. Due to the nature of the fishpond husbandry that amount of water is lost for the Sand Ridge These problems reveal the close connection between the surface and subsurface water, primarily the groundwater. Above the problems of water management, the decrease of the groundwater level near the lakes also raises questions regarding the landscape transformation and the future of the Sand Ridge.

Keywords: fishpond's husbandry, groundwater level, water management

Introduction

One of the most important environmental questions nowadays in Hungary is the aridification, especially in the Sand Ridge between the Danube and Tisza rivers. The problem appeared in neighbouring countries (e.g. Slovakia) as well (Pásztorová et al., 2011). According to the calculation of the Hungarian Meteorological Institute, between 1901 and 2004, a 0.76 °C rise in temperature can be detected in the average temperature of Hungary. At the same time, in contrast with the temperature, a decreasing tendency can be observed regarding the precipitation. The loss of precipitation level reached 11% during the period between 1901 and 2004 (OMSZ, 2005). As a significant sign of aridification the groundwater level decreased 1,5-2 m in average on the observed area during the past 25-30 years. Several reasons of this decrease are known, out of which this paper presents the effects of the fishponds and gravel mine lakes.
In our essay we focus on the water management of fishponds. We show the volume of water that due to the draining leaves the area. Due to the more frequently appearing droughty periods which tend to lengthen, the aridification is the most threatening environment hazard at the area. However the decreasing groundwater level is not only a water management problem, but it also raises the question of landscape transformation of the Sand Ridge.
The complexity of this issue can be perceived by the problem tree we made. This problem tree summarizes the causes, problematic status and their consequences on the water body (*Table 1.*).

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Table 1. Problem tree of the Fishponds and Gravel Mine Lakes

Problem Tree		
Causes	**Problematic Status**	**Consequences on the water body**
groundwater replenishments of fishponds	decreasing groundwater level	decrease in the volume of groundwater
surface water withdrawal	organic matter pollution	degradation of water quality
periodically recurring draining	aridification	mining lakes without water changes
organic matter load	uniformity of vegetation	excessive water withdrawal without official permission
decreasing annual rainfall, infiltration reduction	landscape changes	deterioration of conditions in agriculture

Materials and methods

The source of the fishpond husbandry related data is the closing essay of the consortium led by the ÖKO Plc. This paper includes the estimation of the settlement serial water demands and estimation of the nationwide water demands regarding the partial drainage-basins (ÖKO Zrt.-Vízpart Kft., 2009, 2010).
The area of the Sand Ridge belongs to the region of the Danube-valley Main Canal, the Lower Tisza-valley, and the Nagykőrösi-Sand Ridge from the aspect of water management. The water management plans of the above listed areas contain the data of the natural and artificial lakes that serve for fishing and angling. By processing these data we had an opportunity to survey the water management purpose water supply on the studied area.
The source of the groundwater level data was the „Hydrographic Databank" operated by the Environmental and Water Management Research Institute. Based on the measurement results of the groundwater wells we drew a map that illustrates the fall of the groundwater level. The map was constructed with the ArcGIS 3D software.

Results and discussion

On the surveyed drainage-basins of the right riverbank of the Lower Tisza and surveyed drainage-basin of the Danube-valley Main Canal almost 30 natural and artificial lakes can be found, which are used for fishing and angling. 1/3 of these lakes are definitely utilized for fishing activities. Most of them are deep lakes with large open water surface that serve as a home for various fish communities (Tölg-Tasnády, 1996). In all the cases the management is based on extensive husbandry methods, which has a large area and water demand. Another disadvantage is that overall fishing can be executed only by draining the water of the lake (Tahy-Szalay, 1997).
The water withdrawal on the Sand Ridge between the Danube and Tisza rivers mainly serves agricultural purposes including watering and fishing. In the basin of the Lower-Tisza valley the water withdrawal rate became appr. 4,5 times higher between 2005 and 2008. Due to fishpond's husbandry the water withdrawal in the basin nearly reached a significant 7 times higher rate.
Beside the above mentioned purposes, the subsurface water withdrawal is also important for these fishpond's husbandries, because it is a common practice that wells

are sunk in the bottom of the lake-basins in order to support the water supply this way. These wells mainly bring groundwater onto the surface, therefore the conservation of the lakes also contributes directly to the decrease of the groundwater.

It is the characteristic of the territory that the surface water supply of the sand ridge is not able to meet the water demand of the region. The gravel mine lakes also contribute to this matter, since the evaporation of groundwater that came to the surface is larger, than the evaporation of the natural flora. In the northern part of the Sand Ridge between the Danube and Tisza rivers more than 50 gravel mine lakes are operating with the total surface of more than 1000 ha (VKKI-ATIKÖVIZIG, 2010). Most of them are used as angling lakes, but only the upper 1-2 m layer of their water supply can be taken into account as a natural living-space. It implies that the bred fish stock and the living communities of hydrophytes do not extend to the entire water body. Therefore their presence in the landscape cannot be evaluated positively either from environmental aspect.

Analysing the data we estimate the approximate annual volume of replenishment of fishponds on the area between the Danube and Tisza rivers from surface waters is 15-20 million m^3. This volume is about the 6-8% of the national water consumption of the fishponds.

According to the closing essay on the estimation of the settlement serial water demands and the estimation of the nationwide water demands regarding the partial drainage-basins, the water withdrawal will increase in the future. At national level there can be a 20-25% increase in the fishpond's husbandry until 2015. It implies an appr. 15-18% growth in the total area of fishponds. Taking into account the further reserves of recycling, practically we can calculate an appr. 12-15% increase regarding the fishing purpose water supply in the same period. Considering the above mentioned facts, we can assume a 13,5% growth in water demand and water withdrawal until 2015.

Since, due to the characteristics of the fishpond's husbandry, the water volume of the fishponds is entirely drained into the large water recipients (the Danube and the Tisza rivers) from time to time, this several million m^3 water volume becomes lost for the Sand Ridge in long term and contributes to the aridification.

Not only the fishponds and gravel mine lakes but also the common effect of several other factors resulted in the decreasing tendency of the groundwater level of the past decades.

The withdrawal of surface water and the groundwater level decreasing effect of the water volume of fishponds and gravel mine lakes strengthen the tendency of the groundwater loss. Not even the greater water quantity of the years with large amount of precipitation (such as year 2010) modifies it considerably.

Beside the quantity problems, quality problems also appear. The water drained from the fishponds into the natural waters and canals of the area has a higher organic matter content, is different in their pH and lime content thus it modifies the living conditions in the natural waters, which implies that the hydrological biotopes change.

Conclusions

The fishpond's husbandry related water withdrawal and the water drainage from the area of the Sand Ridge strengthen the problems that can be summarised as aridification. It is a relevant question to ask, which human activities can contribute to the solving or

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reducing the harmful effects. Regarding this matter two basic action courses have been formulated. One of them is the water retaining in the area (even in cases of communal sewages) and spreading of water-saving husbandry forms. The other course is water supplement from the Danube or from the northern parts of the country.
From the aspect of our researched issue, the fishponds both of the action courses are important, since on one hand it is feasible to use technologies with lower water input, and on the other hand the planned Danube-Tisza Canal can also contribute to the water supply of the fishponds decreasing the water withdrawal from the Sand Ridge.
In general, it can be stated, that similarly to other agricultural sectors, in case of the fishpond's husbandry also those solutions must be preferred, which consider the scarcity of surface and subsurface water stocks, and are water-saving at maximum level. This may mean – besides maintaining the extensive husbandry – the forming of fishponds with larger surface and greater depth, which due to their larger volume of water mass decrease the evaporation loss. At the same time these solutions imply a decrease in the number of fishponds, which results in less water volume usage.
In addition, in order to retain water, it is worth to consider introducing new methods within the framework of extensive husbandry, such as draining the water of the fishponds into reservoirs instead of rivers. It creates the right conditions for the multistage water usage including the watering purpose use. Above this, it is necessary to settle the water supply fees and to introduce the right practice for fishpond's husbandry that focuses on the ecological considerations instead of the strictly financial considerations.

Acknowledgements

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USING ISOECOLOGICAL CURVES FOR INDICATION OF THE GREEN WATER DISTRIBUTION

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Abstract: The amount of green water is in close correlation with the biomass. The vegetation-free surfaces in the natural vegetation -generated by anthropogenic effect- influences the quantitative distribution of the green water significantly. The status of the soil moisture, so the anorganic green water source indication can be followed up with the soil moisture index assigned to the plant taxon's ecological indicators. In our research we were examining the water indication of a 41.5 ha uranium mine and its surroundings near Pécs, Hungary. The two mounted mine surrounded with a forested buffer zone is recultivated mainly by grasses. Soil moisture gradient showed significant differences in the investigated area. Based on the vegetation sample's soil moisture index isoline maps were created in order to visualize the appearing differences.

Keywords: Ellenberg indicator values, isoecological map, tailing, recultivated mine

Introduction

The consequence of mining – in order to have raw materials – is often a large vegetation-free area formed of mining tailing materials. Tailings are areas most of the time without cover of soils or vegetation, only rocks, therefore green water free areas. It is an important task of the rehabilitation of the tailings to redevelop the green water regime. Vegetation for the success of this work can be used as an indicator. Soil moisture can be very variable in spatial and time scale therefore its monitoring requests many instruments and long-term measurements. Vegetation – not like the instruments – measures integrated environmental variables. For instance soil moisture data can be estimated based on vegetation status, moreover in case of missing measurement data it can be a reference about the past, therefore this method is cost effective (Zonneveld, 1983). Phytoindication – including moisture content – provides more reliable results in case of evaluation of appearance of many species, as ecological tolerance range is narrower than in case of one species only (Diekman, 2003). One possible methodology for evaluation of phytoindication is application of ecological indices (in agriculture agroecological indices are used). Values of ecological indices are based on the assumption of steady-state competition relations which are in balance with the environmental factors (Bartha, 2002). For this reason they can shift along geographical gradients (Diekmann and Lawesson, 1999). This fact justifies the revision of the Ellenberg (ecological) index (Ellenberg, 1974) - created for the flora of Central Europe – concerning Hungarian circumstances (Borhidi, 1993). Although (agro)ecological indicator values are in the ordinal scale, average based on plant sample's flora and weighted average concerning mass is also often used (Diekman, 2003).
For calibration of soil moisture index by instruments, various experiments were carried out (Ellenberg et al., 1992). Positive correlation has been found between weighted

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average of soil moisture index and average annual moisture content as well as average lowest soil moisture content data (Schaffer and Sykora, 2000).
Ecological indices are used for the spatial-temporal interpretation of environmental parameters (Diekmann, 2003; Morschhauser, 1995; Morschhauser and Salamon-Albert, 2001). In this article authors were investigating the usability of moisture index in connection with green water management for the investigation of the vegetation and buffer zone of a uranium mine tailing located in a forest environment.

Materials and methods

The investigated area is situated in the South-Western slope of the Mecsek Mountains (south of Hungary GPS: 46°05′N, 18°05′E). Total investigated area is 41.5 ha which consist of three parts: a large and a small uranium tailing tips and the buffer zone. The tailing tips are of Permian sandstone; its uranium content is rather low. Topsoling of tailing tips was carried out in a depth of 20 cm and the surface was grass-covered (Morschhauser and Pál, 2010).
Coenological relevés were made using quadrat method. Size of quadrats: generally 400 m^2, in shrubforests 50 m^2, in weed vegetation 16 m^2. In relevés cover of plant species were estimated two times yearly in 2009 – 2010. Site of relevés were chosen so that they should represent the variety of vegetational units. Site of relevés are the same than which were made in 2002 – 2003 (Morschhauser and Milics, 2009). Summarized data (spring and summer examination) of 38 sample plots from the herb layer of the investigated area were analyzed.
The data of relevés were analyzed on the basis of soil moisture index (Borhidi, 1993). Calculations were done by frequency and cover data as well. Herb layer data of the coenological samples were studied based on the soil moisture index, concerning simple average and weighted average of coverage values. Averages of coenological samples of the three different areas (buffer zone, large tailing, and small tailing) were compared in a way that the average of the averages as well as deviation was calculated.
Calculating the share of the categories in % separately, percentage of the drought-tolerant species (W 2, 3, 4) was also calculated for the three areas (concerning flora as well as mass unit). Spatial appearance of the moisture indices were analysed by creating isoecological curves (kriging method) using SURFER 8 software (Morschhauser and Salamon Albert, 2001). Data in the sampling points were: average of moisture index, weighted average, total percentage of the drought-tolerant categories, and their weighted percentage by mass unit.

Results and discussion

There is no significant difference between the three areas based on the weighted W indices or the calculated values for the flora (*Table 1.*). The result is the same in case of spatial evaluation. The unexpected results are caused by the wrong classification of the indifferent species; therefore they are classified as W 5 group in the Hungarian classifications (Borhidi, 1993). Among the indifferent species there are plenty disturbant tolerant and weed species. Their appearance are concentrated to the tailing

(Morschhauser and Milics, 2009). Due to the classification of the indifferent species concentrating into the anthropogenic areas, the averages can not be used.

Table 1. Mean moisture indexes

W flora		W weighed		W(234)		weighed W(234)		
Mean	SD.	Mean	SD.	Mean	SD.	Mean	SD.	
5.86	0.1696	4.74	0.3508	37.30	14.8232	30.66	27.3641	**Total**
5.90	0.1346	4.80	0.3567	26.19	9.2861	26.24	23.2705	Buffer
5.91	0.2074	4.85	0.1465	52.50	9.0498	16.23	16.0245	Small
5.73	0.1782	4.53	0.3705	49.36	7.7402	51.58	33.2990	Large

According to the data the forests of the buffer zones are separating from the tailings in case the W5 category is left out. Xerotolerant (W2,3,4) species appear in both tailings in similar percentage, however rarely become multitudinous, which shows better water management, and similarity to the buffer zone. It can be expected that the whole tailing will separate on the isoecological curve of the xerotolerant species from the buffer zone (*Figure 1.*).

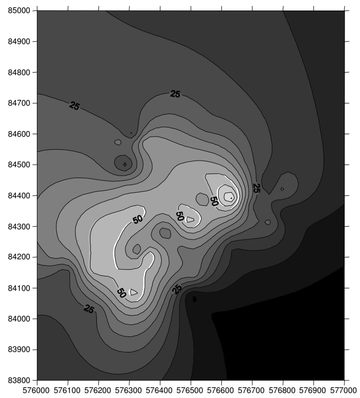

*Figure 1.*Izoecological curve of xerotolerant (W 2,3,4) species

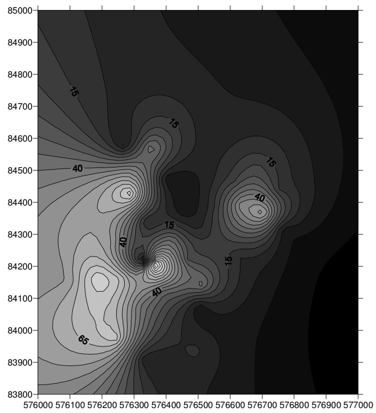

Figure 2. Izoecological curve of weighted xerotolerant (W 2,3,4) species

According to the figure share of xerotolerant species in several samples in buffer zone close to the tailings is higher, however this depends on the forest association as well. Due to two reasons the deviation is higher in the buffer zone. By analysing the vegetation map (Morschhauser and Milics, 2009), it can be concluded that in the buffer zone the share of xerotolerant species are the highest in the acidophilous shrub forest (45,3%), at the same time the lowest in hornbeam – oak forests (below 20%). The proportion of the xerotolerant species are high in the large tailing hill (51.6%) and in the *Robinietum pseudo-acacia cultum* (61,4%). The small tailing differs from the large one, as xerotolerant species coverage is 16%, therefore its vegetation is similar to the buffer zone vegetation (18,8% without *Robinia pseudo-acacia*).

The share of the weighted averaged xerotolerant species shows large deviation in all categories (total, buffer zone, small and large tailing tips) which is understandable based on appearance of isoecological curves on *Figure 3*. South-western part of the

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investigated area including the large tailing and the *Robinietum pseudo-acacia* cultum covered area carries the largest amount of xerotolerant species, while the small tailing fades into the buffer zone. This trend is broken by two samples: in one sample from the tailing *Ambrosia elatior,* in the buffer zone (in a hornbeam – oak forest) *Fraxinus ornus* seedlings appeared in large quantity during spring. During the life-cycle the indices can shift significantly (Parrish and Bazaz, 1985), therefore xerotolerant seedlings of *Fraxinus ornus* can have different values. In the investigated area – excluding these samples – based on the moisture index calculations a (S)W-(N)E direction moisture gradient appears.

Conclusions

Vegetation of the grass recultivated tailing in spite of spontaneous succession significantly differs from the vegetation of buffer zone. Averaging of the vegetation samples based on moisture index can not be used for green water indication, because differences are blurred due to large share of indifferent W 5 category species. In Anthropogenic areas indicator values can differ due to the change of competition between species (Kowarik and Seidling, 1989; Bartha, 2002; Deikmann 2003). Statistical reliability is lower in case of samples coming from low number of species, especially in case of concerning mass (Deikmann, 2003). Indicator values therefore are providing better results in buffer zones, than in anthropogenic mining tailings, in case of monitoring differences. Based on the isoecological curves created for the xerotolerant (W 2, 3, 4) species, it can be stated that the tailing appeared as a dryer isle, as well as caused drought in the surrounding area.

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STUDY OF HYDRAULIC ASPECTS OF POINT SOURCE POLLUTION PROPAGATION IN STRAIGHT REACH OF SMALL MODIFIED STREAM

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Abstract: The article is focused on analysis of physical - hydraulic and geomorphological aspects of the point source pollution propagation in small modified streams. The dispersion transport characteristics of pollution propagation were determined by computational fluid dynamics tools and classical analytical tools of hydromechanics. To calibrate and verify models and calculated characteristics the time-of-travel experiments and discharge measurements were conducted for different boundary conditions. Comparative study of calculation approaches of hydraulic input data for dispersion coefficient calculation for small modified stream based on different level of schematization (1D and 2D hydrodynamic models and analytical method -Manning equation) showed minimal differences in results. Dispersion coefficients for different boundary conditions reached values from 0.21 to 1.49 $m^2.s^{-1}$. On base of results analysis, work expenditure and precision point of view for we prefer 1D hydrodynamic models for short straight reaches of small modified stream.

Keywords: small stream, point source pollution, dispersion coefficient, computational methods of pollution propagation

Introduction

Changes in physical conditions in streams effect, inter alia, transport phenomena including pollution propagation in stream channel. The water quality predictions effects uncertainty in inputs related to the analyzed transport process (Konrdlová et al., 2011; Supuka, 2001). Computational fluid mechanics advances of the past few decades enable new approaches in water quality modelling and intensive development of environmental fluid mechanics. A major connection between this latter field and pure fluid mechanics lies in the determination of terms needed to specify the transport and mixing rates for a given parameter of interest (Rubin and Atkinson, 2001).

Dispersion of pollution in waterways

Water flow in waterway is affected by boundaries. These cause the flow field and its turbulence characteristics to be different in all three co-ordinate directions. The main characteristic of dispersion is dispersion coefficients in relevant directions. Determination of these dispersion characteristics is the key task for solving problem of pollutant transport in streams and for modelling of water quality (Velísková and Sokáč, 2011).

Materials and methods

Researched 200 m long reach of the stream - Mala Nitra River is situated at the southwest part of Slovakia. Mala Nitra is small modified stream with basin area A=76.6 km². Discharge regime is affected by flow regulation of weir located 15 km upstream in bifurcation point with Nitra River. Cross sections changed by natural morphological processes had originally trapezoidal shape with bed width b=4 m, height h=2.5 m and

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slope 1:2. Longitudinal bed slope is S_o=0.0015. Measured discharge values during field experiments were within the interval 0.138 $m^3.s^{-1}$ and 0.553 $m^3.s^{-1}$. Roughness coefficient determined on base of field measurements was n=0.035.

Field Measurements

To improve the estimates of travel times and dispersion rates for given flow conditions time-of-travel experiments were conducted. For determination of discharge, geometry, hydraulic characteristics and discharge measurements were made at characteristic cross sections. *Figure 1*. show field of point velocities with relatively homogenous distribution along the cross section.

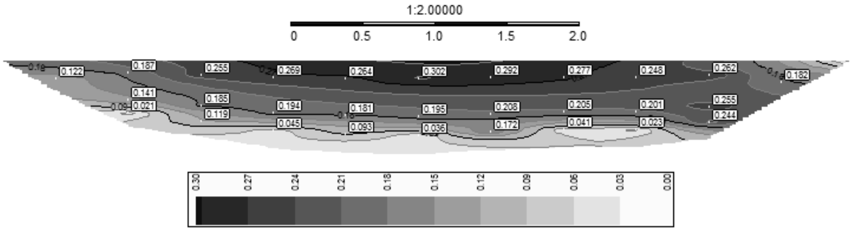

Figure 1. Schematic view on measured velocity field of cross section in RS 15.460 km, 65 m downstream from tracer injection, discharge Q = 0,525 $m^3.s^{-1}$

Hydraulic and flow characteristics calculation

The CCHE2D (Zhang, 2005) and HEC-RAS (USACE) models were applied for flow characteristics calculation in researched reach of the river. The CCHED 2D model calculations have ran in computational mesh of 20 *x* 4000 *cells* with the cell size 0,5m x 0,5 m. From the results in tabular form were abstracted data for 40 cross sections with distance of 5 m. CCHE2D model´s governing equations are the depth integrated two-dimensional equations. HEC- RAS model calculation ran for 9 cross sections obtained by field measurements. To the sections with rapidly changed condition were generated new ones by interpolation. Governing equations of HEC-RAS model are the continuity equation, energy equation and flow resistance equation. The third, analytical solution was based on Manning equation (Macura, 2002). *Figure 2*. represents the graphical output of CCHE2D model – vector velocity field in plan view of the river reach that documents relatively uniform distribution of this characteristics along the river.

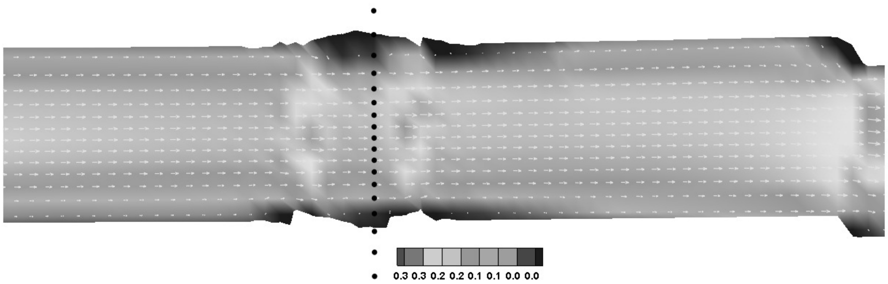

Figure 2. Plan view on velocity field (scale in $m.s^{-1}$) of 30 m long reach (dot line indicates RS 15.460 km), discharge Q = 0,525 $m^3.s^{-1}$

Dispersion coefficient calculation

Dispersion coefficient was calculated by Fischer equation (Velískova and Sokáč, 2011). In equation *D* is coefficient of longitudinal dispersion ($m^2.s^{-1}$), *u* mean velocity ($m.s^{-1}$), W channel width (m), *h* water depth (m) and *u** shear velocity ($m.s^{-1}$).

$$D_x = \frac{0.011 \cdot u^2 \cdot W^2}{h \cdot u*} \quad [1]$$

Results and discussion

Figure 3. represents results obtained on base of CCHE2D model calculation for Q=0,525 $m^3.s^{-1}$. Mean value of *D*=1.48 $m^2.s^{-1}$ with standard deviation 1.12 (*Figure 3*.). *D* calculated on base of HEC-RAS model results reaches value *D*=1.01 $m^2.s^{-1}$.

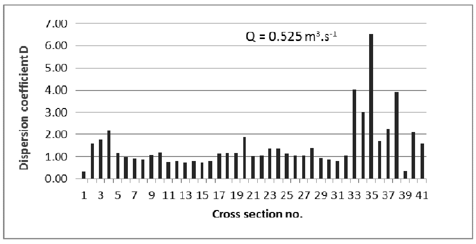

Figure 3. Dispersion coefficient distribution along reach 2D model

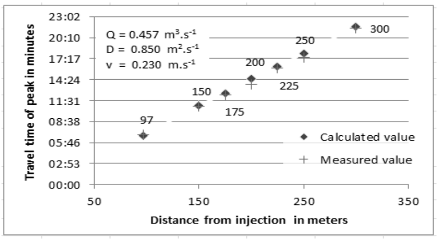

Figure 4. Relation between distance of injection and travel time of pollution peak

With analytical solution we got *D*=1.2 $m^2.s^{-1}$. In further steps we use HEC-RAS model for preparation of hydraulic characteristics needed for *D* calculation. *Table 1.* shows results for different discharges measured during field experiments.

Table 1. Dispersion coefficients D for different discharges Q and water depth h in experimental reach

Q [$m^3.s^{-1}$]	0.553	0.525	0.492	0.457	0.182	0.138
D [$m^2.s^{-1}$]	1.10	1.01	0.96	0.85	0.28	0.21
h [m]	0.50	0.50	0.48	0.47	0.36	0.34

To verify accuracy of analysis the comparison of measured and computed D values was made. For calculation of travel time of peak we used equation [2]. The results presented in *Figure 4.* shows good match.

$$c(t) = \frac{c_o}{2\sqrt{\pi \cdot D \cdot t}} \cdot e^{-\frac{(s-vt)^2}{4D \cdot t}} \quad [2]$$

From hydraulic aspects point of view we have to emphasize an importance of correct assessment of roughness coefficient of river channel that is the most sensitive parameter for hydraulic calculations. In case of geomorphological heterogeneity of channel we recommend to take into account the variation in spatial distribution of roughness coefficient. Also accurate measurements of geometric parameters of the channel, discharge and water surface profile determination are important factors for calibration and verification model in process of the model setup (Halaj et al., 2010).

Conclusions

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Comparative study of calculation methods of hydraulic and geometric inputs needed for dispersion coefficient assessment in small modified stream based on different level of schematization (1D and 2D hydrodynamic models, analytical method based on Manning´s equation) was made. All three methods may be used for determination of dispersion coefficients in short straight reaches of small modified stream. Take into account the precision, level of schematization and work expenditure we prefer 1D hydrodynamic models. Dispersion coefficients for different boundary conditions reached values from 0.21 to 1.10 $m^2.s^{-1}$. These values correspond with findings of Pekárová and Velísková (1998) for Ondava river (D=0,84-1,36) with similar hydraulic and geometric properties of the channel.

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ENVIRONMENTAL CONSERVATION IN FIELD OF LAND AND WATER BETTER INTEGRATION

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Abstract: The study concerns *vertcal and horizontal integration* of land and water emphasing the water qualified *in rainfed dryland*. The vertically means: from groundwater related qualities, through qualities of soil profil, soil surface, slope position and vegetative cover, to overhead climatic qualities. Aslo integration of all aspect horizontally at the landscape level.

UNCED Agenda 21, (United Nations Conference on Environment and Development) determines the integral concept of the land as a system traversed by water, with land use depending on access to water, among other factors, and at the same time, affecting the *passing water* in its pathways, seasonality, yield and *quality* in rainfed dryland.

Also the human activities have impacts on land-water linkages, an integrated approach has to be taken to land and water and their uses. The integrity of the water cycle makes the watershed the desirable spatial unit for conceptual integration.

The land and water integration can be analysed in the Nile, from point of view of Micro-basin:

.- adjustment for sustainable cropping-patterns, and stable farming-system and practices; and enhanced rainfed agricultural production;

.- re-establishment of water harvesting and water management practices and infrastructure founded on community based management and adequate agricultural pricing policy;

.- establishment and enforcement of water protection and recharge areas;

.- community involvement in planning and data collection adapted to actual capability and capacity constraints;

.- community participation in conservation of biodiversity and fisheries resources.

Keywords: environmental conservation, land and water irrigation, UNCED Agenda 21, water cycle

Introduction

The study concerns *vertcal and horizontal integration* of land and water emphasing the water qualified *in rainfed dryland*. The vertically means: from groundwater related qualities, through qualities of soil profil, soil surface, slope position and vegetative cover, to overhead climatic qualities. Aslo integration of all aspect horizontally at the landscape level.

The water use became more difficult because the scarcity of water needs considerable investments to store water to be available from its different resources, which sometimes are very fare from the place of water consumption, for example where the density of population is high and the agricultural areas are cultivated.

In general the annual evapo-transpiration rates became considerable in regions. of Palestine and Jordan, approximtelly this is greater by between two and 20 times the annual rainfall (Al-Boainin et al., 2010.).

Based on the climatic change the growth of population needs more food production resulting in sharply increasing water use on dry areas with unfavourable weather conditions based on the global warming process (Ligetvári et al., 2006).

The water use problem should be solved, because the scarcity of water can stimulate the migration of original local population first from North African regions to other rest of the world, mainly to Europe. Additionally to scarcity of the water international

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organization like UNCED would like to remain the qualified level of water for human consumption in MENA region.

Materials and methods

The land and water mutual connections concern the *blue water* and *green water* definication, also the water charachteristics, its accessible for the plant. There are *interdependences* in point of view of downstream upstream one for water resources. The *land and water management* consists of different approaches for sustainable farming system in rainfed agricultural production, water harvesting, water protection, describe water capacity and also conservation of biodiversity.
In general the *sedimentation accumulation* in surface reservirs is measured in million m^3/year, which show the loss of surface storage capacity.
Somborek, W. G emphasizes importance of the *water quaility*, which concerns the groundwater level and quality in relation to irrigated land use; substratum potential for water storage within local use and conductance dowstream use; presence of unconfined freshwater aquifers; substratum and soil profile as source of construction materials.

Results and discussion

UNCED Agenda 21, (United Nations Conference on Environment and Development) determines the integral concept of the land as a system traversed by water, with land use depending on access to water, among other factors, and at the same time, affecting the *passing water* in its pathways, seasonality, yield and *quality* in rainfed dryland.
The land use has considerable impacts on determining qualified and kinds of water by through of incoming rainfall either on the *vertical return flow* to the air by the way of evaporation or evapotranspiration provided by plants, or on the *horizontal flow* to aquifers and rivers titled as *blue water*.
At the level of *soil surface s*erves can devide to flood flows and infiltration, which last one means *green water* accessble in the zone of the root belonging plants. Naturally the land has surface hydrology, which can content shallow lakes, rivers, marshes and swamps. Also the near surface sedimentary layers and associated groundwater and geohydrological reserve, which were changed by the influences of human activities. Human activities have created the terracing, water storage or drinage system for long period of time, as centuries.
The vertical integration extents from groundwater realted qualities through qualities of soil characteristics, soil surface, slope conditions, and natural or human planted plant cover, even to climatic qualities.
From horizontal approach it means inegration at surface or landscape level. Horizontal approach of integration includes elements of terrain, top of plateau, scarp or upper slope, main slope, lower slope or springle, bottomland or flood plain with mutual influences between each other accompaning with human activites' impacts. These kinds of different influences change the *internal hydrology* and chemical substances in the soil. The land and water linkages stimulate the integrity of the water cycle to create the river basin concerning the upstream – donwstream interdependencies of water resources.

Finally it not be declarated that the water scarcity in dryland agriculture can not be resulted by only hydroclimatic fluctuations but this comes from soil and water management failures and difficulties. They have to strengthen the fertility reproduction of soil within the long period of fallows.
According to green water characteristics, percipitation and water on and in the soil, directly satisfactory to local vegetation and crops, some parts of this is returned to the air – atmosphere through transpiration accompaning with production of biomass, and the other part of this through non –beneficial evaporation. There is a very considerable difficulty, which appeared in North Africa, at first in Sahel, namely as *biomass scarcity* in tropical drylands, which was resulted by the considerable moisture and nutrient deficit, which last one means reducing organic and mineral recycling accompaning with dramatically decreasing the yields, frequently by 50% during the last 15 years according to international compares.
According to different FAO Production Yearbooks (during 1990s and 2000s) for humid natural ecosystems, the return flow water to the air- atmosphere is in the order of two hundreds, 200 m^3/ton biomass dry matter (DM), and in the same time around 1000 m3/ton is required in dry tropical ecosystems of Middle East and North Africa (MENA) Region. While the pearl millet in its different period of production needs from about 1500 m^3/ton grain produced as dry matter to 3000 – 4000 m^3/ton DM. Also for example sorghum has water requirement from 1000 – 1700 m^3/ton grain, as DM, the maize needs between 530- 1250 m^3/ton grain as DM. The natural background of MENA Region is unfavourable for plant production.
In Morocco there is a problem connecting with loss of water storage capacity of surface reservoirs according to the sedimentation. The sediment accumulation in surface reservois was 50 million m^3/year and this was expected to increase to 100 million m^3/year until the end of completing dams construction investments. Now the average annual losses of storage capacity in Morocco became as same as annual volume nedded for irrigating 6000 ha lands.

The other example for water management in North Africa is land and water integration of Nile. *The land and water integration can be analysed in the Nile, from point of view of* Micro-basin:
-adjustment for sustainable cropping-patterns, and stable farming-system and practices; and enhanced rainfed agricultural production;
-re-establishment of water harvesting and water management practices and infrastructure founded on community based management and adequate agricultural pricing policy;
-establishment and enforcement of water protection and recharge areas;
-community involvement in planning and data collection adapted to actual capability and capacity constraints;
-community participation in conservation of biodiversity and fisheries resources decreasing water pollution (as basic principles see in detailed Széles et al., 2008).

The authors analyse how irrigated and highland mixed farming systems can ensure more successful water-use in order to ensure efficient agricultural production.They analyse and compare influences of irrigated and highland mixed on the agricultural production

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and food supply. The technological methods, governmental support for farmers, import of machines, and non over irrigation system can solve soil degradation (Szabó et al., 2010).

Some experts emphasized the *influences of human activities on the gas emission*, which resulted in increasing the global warming stimulating to create the dry areas or exending dessert in more regions on the Earth. The mankind would like to decrease the green house effects coming from more intensive gass emission. At the international level there have been further developments in relation to controlling greenhouse and acidifying gas emission and to protect of air and water quality (Khalif et al., 2010).

Conclusions

Human activities have impacts on land-water linkages, an integrated approach has to be taken to land and water and their uses. The integrity of the *water cycle* makes the watershed the desirable spatial unit for conceptual integration.

Watershed management concerns upstream and downstream which also include the water re-use, drinage and irrigations within conceptional framework for land and water integration. The water re-use is the measure for the *efficiency of water use* and water management, which has importance even *in rainfed dryland* areas.

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ANALYSIS OF THE LONG-TERM DEVELOPMENT OF HEAVY SOILS WATER REGIME

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Abstract: This contribution presents the cumulative values of the selected water regime components obtained during the vegetaion periods from 1970 to 2011. The evaluated values concerned precipitation, potential and actual evapotranspiration and average soil water storage in the root zone to the depth of 1 m under the surface. Soil water storage are evaluated with regard to its availability to plant cover. The analysis was carried out in clay-loam soil profile. The soil profile is situated in the central part of the East-Slovakian Lowland, where this soil type is typical. The backround data used for the analysis were daily values of the analysed water regime components. The values concerning evaporation and soil water storage was measured by numerical simulation on the mathematical model GLOBAL. Calculation rate was one day, i.e. the input and output data were entered and generated daily.

Keywords: precipitation, evapotranspiration, evapotranspiration deficit, root zone, water storage

Introduction

Rainfall and evapotranspiration are the most important elements of water balance in soil. They are decisive elements in the process of biomass creation and the biggest elements of the water balance in the soil. Rainfall are spatially and temporally the most variable meteorological elements. Rainfall distribution is important throughout the year during vegetal period (April to September) and during non-vegetal period (October to March). Vegetal period rainfall is a source of water for biosphere by transformation through unsaturated zone (Kandra and Tall, 2011).

Non-vegetal rainfall are important for the groundwater replenishing and soil water deficiency (that was created in the end of vegetal period) compensation. Water evaporation is a process of water transformation into vapour. It is a regulator of energy fluxes in natural environment. Evaporation from the soil surface, water and plants is called evapotranspiration. Maximum possible evapotranspiration for the particular meteorological conditions is called potential evapotranspiration (ET_0).

Actual evaporated water from soil and plants is called actual evapotranspiration (ETa). Ongoing climate changes are reflected in rainfall redistribution during the year and in air temperature increase (Hlavatá and Čepčeková, 2011, 2007; Čepčeková and Hlavatá, 2011). These changes are manifested in evaporation changes and consequently in the changes of water balance. Changes of water balance in soil result in changes of water storage in the root zone of a soil profile. Water storage in the root zone is the result of interaction processes of the root zone with the surrounding environment within the time interval (Novák, 1995; Fazekašová et al., 2011).

The aim of the inscribed paper is to quantify and analyze average water storage in the field plants root zone of the soil profile. Research works were realized on East-Slovakian Lowland (VSN) in vegetal periods during 38 years. Water storages are analyzed considering water availability for the plant cover. Results of analysis and quantification of ET_0, ET_a and evapotranspiration deficiency ET_d form part of the inscribed paper.

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Materials and methods

The process of evaporation was examined in the central part of Eastern-Slovakian Lowland in the area of Milhostov (48°40'11,08"; 21°44'18,02"; 100 m). The locality is distinctive by medium-heavy gleyish soil with clay particles of 18 – 39 %. In the area, there is located an agro-ecological climatic and research station. This station provides all the data concerning hydro-meteorological elements and plant cover characteristics required for numerical simulation on the mathematical model GLOBAL.

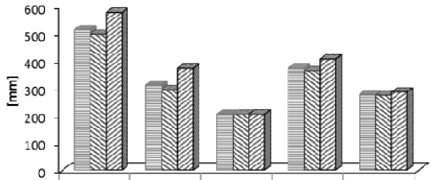
The model GLOBAL is a simulation mathematical model of soil water transfer which enables the calculation of moisture potential distribution or soil moisture in actual time (Majerčák and Novák, 1994; Pásztorová et al., 2011). The model was tried and verified for the monitored soil water storage to the depth of 0.8 m. After successful completion of the verification process, it was possible to launch numerical simulation of the course of ET_0 , ET_a , ET_d ($ET_d = ET_0 - ET_a$) and water regime components of the vegetal periods (VP).

In case the environment is moisture enough then $ET_a = ET_0$ and $ET_d = 0$. In case there is not enough water in a soil profile then $ET_a < ET_0$ which means the start of soil profile drying. In case $ET_a = 0$ then $ET_d = ET_0$. To assess the water storage available for plant cover, we conventionally use the following characteristic points of the moisture retention curve (soil-water content), wilting point (WP) representing the value of pF = 4,18, threshold point (TP) representing the value of pF = 3,3, field water capacity (FWC) representing the value of pF = 2,0 to 2,7. The simulation of the course of water regime components was executed to the depth of 3.0 m under the surface. Time-course of soil water storage was analysed to the depth of 1.0 m. Majority of field plants roots is located in this depth. Numerical simulation was carried out with 1-day step. The inputs of meteorological and plant cover parameters and the inputs necessary for the formulation of boundary conditions were adjusted accordingly. Average water storage (WS) into the depth of 1m, precipitation (P), ET_0 , ET_a and ET_d were calculated in this manner for particular vegetal period.

Results and discussion

Figure 1. shows average values of ET_0, ET_a, ET_d, WS and P in three periods of different length. The whole 38-years period (1970 - 2007), during which all the input data were obtained, was evaluated. Consequently, it was compared to the 30-year period between 1970 and 1999 and to the 8-year period between 2000 and 2007. The results have shown that from the long-term point of view ET_a is lower than ET_p by 40%. Between 1970 and 2007 this percentage was 35%. It is probably caused by increased precipitation, which was by 12% higher compared to the normal precipitation volume. Similarly, 80% of the precipitation is transpired back to the atmosphere by evapotranspiration. Between 2000 and 2007 this fraction was even 90%. In this period, ET_0 was higher by 16% and precipitation by 12% compared to the normal period. Average water storage in the root zone of the soil profile was slightly increased, by 12 mm. The same evapotranspiration deficit seemingly indicates that the rate of soil profile drying is the same. *Figure 2.* shows the sums of potential and actual evapotranspiration

and precipitation during the given vegetation periods. The figure shows development of ET0 and ETa as well.



	ET0	ETa	ETd	P	WS
1970-2007	514	310	203	372	276
1970-1999	497	294	203	363	273
2000-2007	576	372	204	406	285

Figure 1. Long-term ET0, ETa, ETd values and water storage in a soil profile to 1m depth.

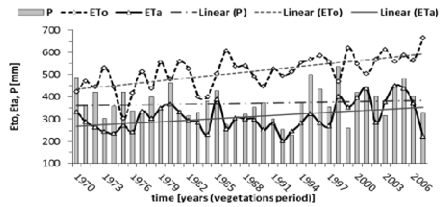


Figure 2. Course of P,ET0, ETa sums in the vegetation periods between 1970 - 2007 and the development trends of ET0 and ETa.

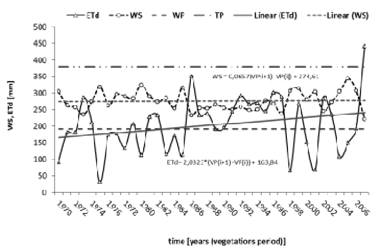


Figure 3. Course of WS and ETd during the vegetation periods between 1970-2007 and their development trends.

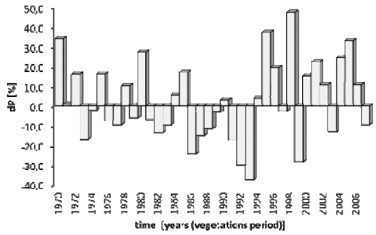


Figure 4. dP deviation of the precipitation total from the long-term precipitation total during the normal period between 1970-1999.

ET_0 and ET_a development trends have different gradient. From the beginning of the measurements in 1970 there is observed a rising difference between potential and actual evapotranspiration. Rising tendency of ET_0 indicates that more energy is radiated towards the surface. The totals of precipitations do not rise so sharply. Consequently, in the lowland areas the precipitations are not sufficient to cover water deficit created by the increased potential evaporation. As a result, evapotranspiration deficit rises. This deficit can be observed as increased drying of a soil profile. *Figure 3.* shows a development of average water storage WS in the root zone of a soil profile to the depth of 1m with regard to WP, TP and the totals of evapotranspiration deficit during the vegetation periods in question. The course of WS shows that the investigated area is dry. Average water storage during the vegetation periods was found between wilting point and threshold point. The development trend of the water storage is very slightly rising, i.e. 2.5m in 38 years. On the contrary, ET_d increased by 77 mm in the same period. Supposedly, the water in a soil profile in the investigated area is replenished from the groundwater level. Nevertheless, the impact of ET_d on the drying of a soil profile is obvious between 1986 and 1997. In this period, ET_d reached its maximum. Soil water storage in this period dropped below the long-term normal values. It was

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caused by the rainfall deficiency. Precipitation volume in that period was less then 17% under the normal volume in the years 1970-1999 (*Figure 4.*).

Conclusions

The **e**xamined locality of Milhostov is located in the central part of the East-Slovakian Lowland (VSN) and it is typical of VSN. Long-term average vegetal evapotranspiration amount is 310mm in the locality. Long-term average vegetal (april - september) precipitation amount is 372mm. Trend of temporal development in which the difference between potential and actual evapotranspiration increases was identified. Evapotranspiration deficiency rises. In terms of soil water regime it is adverse trend. Adverse consequences of such a trend are balanced by natural water transfer from the groundwater to the root zone in lowland conditions. The condition of soil drought creation will arise in case of significant groundwater decrease during vegetal period.

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INFLUENCE OF THE LANDSCAPE USE CHANGES TO THE DRY POLDER BEŠA AS A SPECIFIC GEOHYDROSYSTEM (THE EAST SLOVAKIAN LOWLAND)

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Abstract: Administratively the study area (cadastral territory of Beša village) belongs to the Košice region and Trebišov district. Polder Beša is a dry reservoir belonging to the largest in the Central Europe (volume 53 mil. m^3). It was built in 1965-1966 in the frame of the complex regulation of water regime on the East Slovakian lowland. Flowing and underground water in this area is represented by specific nature geohydrosystem (Torma, and Fazekašová, 2007). It was modified in 60th years of the last century for the purpose of fertilization of soils and enlargement of agroproduction areas in the region. Modifications influenced the natural configuration of the river network and the creation of new real and potential water surfaces, disappearance of wetlands, moors and the dead arms of rivers. They affected also the hydrophysical properties of soils, microclimate, land cover and the changes of the total structure of the landscape. Human activities in this region have caused irreversible changes in two ways. The first one influenced landscape structure directly, e. g. by building of the water canals and dams, the second one indirectly.

Keywords: landscape use, dry polder, geohydrosystem, Beša, Slovak Republic

Introduction

The aim of the paper is the mapping, analysis and evaluate spatial trends changes of the landscape use in the cadastral territory of Beša village during last fifty years with a view to especially of geohydrosystem Beša-dry polder. The study area belongs into Východoslovenská plain according to the geomorphological clasification of Slovakia (Mazúr and Lukniš, 1980). The total largely of region is 1 756 hectares, the flooded area of the polder is 1568 hectares. Since 1966 has been flooded eight times, mostly during spring month, last time it was in 2011. Hydrological situation in the given region has influenced the structure of landscape use significantly.

Materials and methods

The process of the evaluation of landscape use changes was as follows: formation of data landscape structure from six time horizons (1770, 1827, 1949, 1988, 2003, 2008) using software ArcView GIS 3.1. Operations: creation of the interpretative key, georeferencing, identification of the forms of landscape use, digitalization of the spatial data, verification of the data by field research, forming of a flexible chart database, multitemporal analysis, cartographic interpretation of the layers in the analog form. The result of this process was identification of eight groups of landscape use forms relate to hydrogeoregime of study area.

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Results and discussion

Polder Beša was built mostly on the less valuable hydromorphic soils with the permanent level of the underground water in the depth 70 cm under the surface (Vilček, 2011) This fact confirms also the multitemporal analysis of landscape use which was processed on the basis of cartographic material and aerial photographs from the period of 1770 – 2008 and field research (*Table 1, Figure 1*.). The change interpretation is presented by the means of landscape use forms (Feranec and Oťaheľ, 2001) with concentration on characteristics of its hydrogeosystems.

1 Landscape use form of forest and non-forest wood vegetation. The biggest proportion this group reached in 1770 (low lying forests 90% of the area). In 1827 there was a very intensive deforestation to receive agricultural land. Since 1949 the area of the forest cover was increasing and its proportion raised from 31% to 43% under the influence of successive processes.The level of the underground water has different height here, the lowest level under the surface occurs (of oak-hornbeam forests) 2 m at the surface, the closest to the surface it is of low lying forests (30 cm at the surface).

2 Landscape use form of permanent grasslands was the most spreaded in 1827 – 1949 (70%), in 1988 it was 45%, at present its proportion is 34%. It is presented mostly by the meadows and non-used, sometimes flooded permanent grasslands in the polder itself and to the S,SE and W from the village (underground water level is close to the surface or in the height 40 cm at the surface.).

3 Landscape use form of agricultural crops with an exception of year 1770, when the proportion of the group was the lowest, has a quite balanced representation in the rest of time horizont and oscillate in a proportion of 15 – 20%. At present it takes 17% (the level of the underground water is 2 m at the surface).

4 Landscape use form of sandy dunes presents locality with a small area(3.5 ha, 0.2%. It is a mining area for building sands (the level of the underground water is less than 2 m at the surface).

5 Landscape use form of aquatic ecosystems reached the largest area in 1827 (4%), at present it is represented by the net of different aquatics, but in the smaller area than in 19th century. They belong to the most important forms supporting the ecological stability of the area.

6 Landscape use form of built-up area is constituted of the settlements of rural type and areals for recreation. Its area has been increasing since 1770. It doubled till 2008 (2%). This form presents sealed territories regarding the water cycle.

7 Landscape use form of technical infrastructure, there are objects of agricultural farms and other engineering and technical objects in the open landscape (2%). They are sealed areas, but some of them produce contaminants of underground water (Čech; Krokusová; Kunáková, 2011).

8 Landscape use form of transport infrastructure. In past it was presented by the country road net, today the traffic density is higher. It is formed by important main roads, roads in the residential zone. In 2008 they took an area of 15 ha (1%). They are mostly sealed areas with production of water hydrogeosystems pollutants (Ivanová, 2006).

Table 1. Landscape use forms of study area in ha

Reclassified landscape use forms changes	1770	1860	1949	1988	2003	2008
Landscape use forms of forest and no forest	1387,1	3,4	211,1	544,0	559,2	743,6
Landscape use forms of permanent grassland	180,1	1107,0	1086,8	823,2	820,5	641,3
Landscape use forms of agricultural	161,3	379,9	343,6	299,0	286,2	284,3
Landscape use forms of dune	-	-	5,5	3,5	3,5	3,5
Landscape use of water and wetlands	-	236,5	62,3	26,6	25,9	22,6
Landscape use forms of settlement	17,9	20,2	32,8	35,3	35,3	35,3
Landscape use forms of technical infrastructure	-	-	0,1	10,1	10,5	10,5
Landscape use forms of transport infrastructure	9,7	9,1	14,0	14,3	15,0	15,0

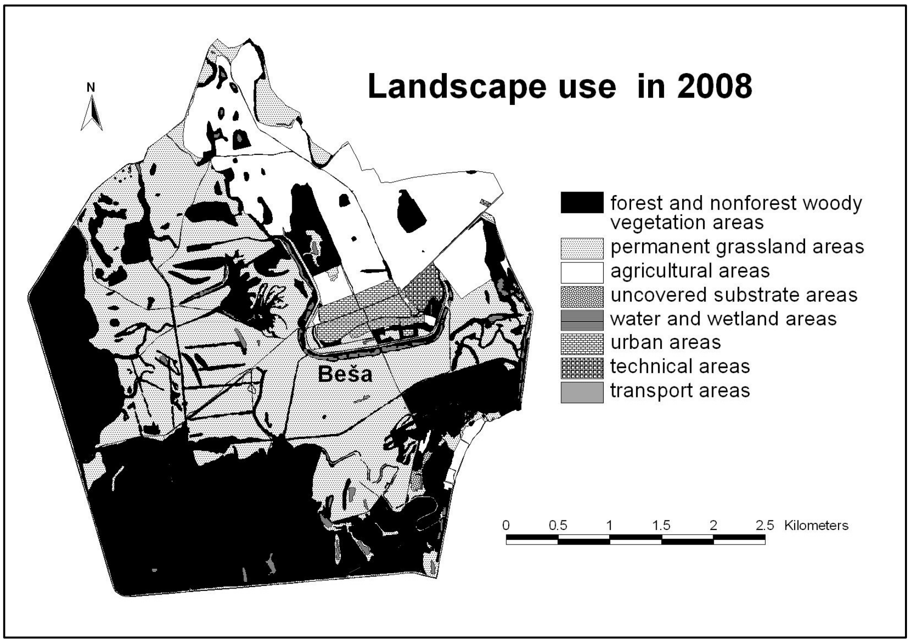

Figure 1. Landscape use of study area in 2008

Conclusion

Till the sixties of the last century the a territory of contemporary dry polder Beša was periodically flooded several times yearly. There was a natural water regime, which is conserved the unique conditions and kept suitable biotopes (network of canals, wetlands, dead arm of the river) for nesting and life waterfowl (including migrating species) and for hygrophil and water plants with a significant number of rare species. The rest part of the area was formed by agrogeosystems (mainly grasslean) used for extensive cattle breeding. At present days the polder is dry during the most part of

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a year. This situation is reflected in landscape use forms, which is shown by upper given multemporale analysis. Hydrological regime of the territory was artificially modified, what caused the extinction of the original habitats. At present the dry polder Beša has mostly retentive function in the period of flood situations, which extent and frequency is not possible to predict. Attenuation of the agricultural production (after 1989) conditioned significant regression of the original agrogeosystems by successive changes of vegetation and growth of technical infrastructure area. Functional delimitation of the territory influenced spatial dynamics of development in landscape use in polder itself, but also in the cadastral territory of the settlement (Black et al.,1998). During the last 60. years the fragmentation of the landscape was increased and its heterogenity too, but biodiversity of ecologically valuable territory decreased. Modification of the water regime in the natural hydrogeosystems did not bring expected results from the aspect of ecological stability and landscape protection.

Acknowledgements

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FLASH FLOODS ON SMALL FLOWS IN THE SLOVAKIA

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Abstract: Flash floods (floods from intense rains of very short duration) in small basins are one of the most significant natural hazards, which in the last years had negative effects across Europe. The affected river basins often absent rain gauge and water level gauge. Therefore, reconstruction of flash floods is often very difficult and loaded with many uncertainties. About the flash floods we still do not have sufficient information. Therefore, the description and analysis using rainfall-runoff models of each such flood events are extremely important for management of flood risk. In the present paper there are compared selected several historically documented extreme floods on small streams in Slovakia with approximately the same catchment area (from 31.24 to 37.86 km^2), but with different types of soils. First, floods of 29th June 1958 on the Upper Vah River in the Tatra National Park: on Koprovsky creek (31.24 km^2); on Rackova creek (35.51 km^2); and on Jalovsky creek in Jalovec (33.4 square kilometers); Second, flood of 20th July 1998, on Mala Svinka river at Jarovnice (34.39 km^2); Third, floods of 7th June 2011 in the Lesser Carpathians: on Gidra creek at Pila station (32.954 km^2) and on Parna creek at Horne Oresany station (37.86 km^2).

Keywords: flash floods, small basins, soil types

Introduction

The floods caused a lot of losses (millions of euro) in the whole Europe in last 15 years (Gyuricza and Birkás, 2000). The development of flood related losses in Slovakia in 1996–2010 is in *Figure 1*. The extremality of the year 2010 floods is shown. The share of the flash floods on the total losses was important.

The assessment of some of the recent flash floods from last years was published (Stastny and Majercakova, 2003; Blaskovicova et al., 2011). It evokes sometimes the opinion that the flash floods did not occur (at least so frequently) in Slovakia in the past and that they are consequence of the bad land management. The aim of the paper is to show, that the flash floods did occur even in forested catchments in the past, even before the heavy machinery was introduced in the forest management. There are three selected and documented flash floods compared that occurred in Slovakia on small streams with similar catchment area (from 31.24 to 37.86 km^2) (*Figure 2.*):

1. flood on 29 June 1958 on the upper Vah river in the Tatras National Park (TANAP): on Koprovsky creek (31.24 km^2), on Rackovsky creek (35.51 km^2), and on Jalovsky creek in Jalovec (33.4 km^2);
2. flood on 20 July 1998 on Mala Svinka creek in Jarovnice (34.39 km^2);
3. flood on 7 June 2011 in the Lesser Carpathians on Gidra at Pila (32.954 km^2) and on Parna creek at Horne Oresany (37.86 km^2).

All these catchments are forested, without agricultural management.

Materials and methods

There are several historical records indicating occurrence of flash floods in Slovakia. Thanks to a chapel and flood mark in Tiesnavy gorge near Stefanova we know about the flood on 11. 6. 1848, which killed 14 inhabitants of Stefanova village.

On 28.05.1925 the river Lubochnianka inundated out of its channel and damaged the road, rail road and broke down all the bridges down the Lubochnianka valley.

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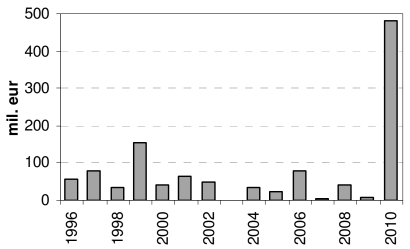

Figure 1. Flood related losses in Slovakia in 1996 – 2010

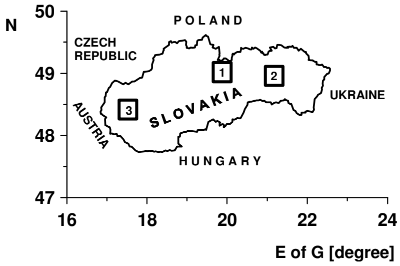

Figure 2. Location of the catchments: 1. Tatras; 2. Bachuren; 3. Lesser Carpathians.

Dub (1941) described the catastrophic flood on Vydrnanka creek in the flysh geological formation of Javorniky mountains which happened on 17.6.1939, and he assessed the peak flow of the flood to be 100 m^3s^{-1}, and specific yield reached 10 m^3s^{-1} km^{-2}.

Flood on 29. 6. 1958 in the Tatras region

The significant flood of approximately *100*-year return period did occur in the whole upper Váh basin in June 1958. According to Pacl (1959) the center of the flood was formed over the Tatra mountains built of crystalline basement (medium permeability, low to medium retention capacity). The peak flow reached 171 m^3s^{-1} on the Bela river (95 km^2) at Podbanske gauging station. Similar extreme floods occurred on Bela in 1934 and 1948. The water gauging stations were built on other small streams in the Bela catchment later. Out of them, the Koprovsky and Rackovy creeks have the area of about 35 km^2. The peak flows were estimated by Pacl to be 85 m^3s^{-1} on Koprovsky creek and 80 m^3s^{-1} on Rackovy potok. The Jalovsky creek at Jalovec station has also an area close to 35 km^2. The peak flow at Jalovec was estimated by Pacl (1959) to be 83 m^3s^{-1}. The peak specific yields reached 2.88/2.25/2.48 $m^3s^{-1}km^{-2}$ in the three catchments, respectively.

The Mala Svinka flood on 20. 7. 1998

The significant floods occurred in the catchments of Mala Svinka, Zehrica and the upper Torysa in July 1998 due to extreme storms The floods caused local natural disasters. The worst consequences were in the flysh basin of Mala Svinka (low permeability, medium retention capacity), small stream in the northern part of the Hornad basin. The catchment has the area of 34.4 km^2 at Jarovnice village and due to flood on 20 July 1998 as many as 48 people died, many of them children (Svoboda and Pekarova, 1998; Majercakova and Skoda, 1998). The highest elevation in the Mala Svinka basin is at the top of Bachuren (1081 m a.s.l.). The NLC model estimated flood peak flow reached 178.7 m^3s^{-1} at Jarovnice according to Svoboda and Pekarova (1998), and it represents the specific yield of 5.19 $m^3s^{-1}km^{-2}$, precipitation depth was 80 mm, the runoff coefficient was 0.68 and the flood runoff volume was $1.864.10^6$ m^3 of water.

Flood on 7. 6. 2011 in the Lesser Carpathians

The catastrophic flood situation developed on south-east slopes of the Lesser Carpathians on 7. 6. 2011 in the afternoon, that hit the upper parts of Vistucky creek, Gidra, Stefanovsky creek, Podhajsky creek and Parna creek. The flood waves damaged mainly the villages just below the slopes of the mountains: Pila, Casta, Dolany, Horne Oresany and Losonec. The Gidra and Parna creeks are in the southern part of the Lesser Carpathians in Western Slovakia. The upper parts of the streams flow through original beech forest ecosystems (medium permeability, high retention capacity), the only visible anthropogenic interventions are a small water reservoir on Parna and fish ponds on Gidra. The highest parts of the catchments reach 694m a.s.l. The runoff gauging stations on Gidra and Parna were established in 1956 by SHMI and the mean daily discharges are processed since 1961. During the flash flood in 2011 the water inundated out of the stream channel and the peak flows had to be assessed hydraulically. According to our field survey the peak flow of Gidra was estimated to be 44 m^3s^{-1}, what is specific yield of 1.36 $m^3s^{-1}km^{-2}$, and the peak flow of Parna was estimated to be 62 m^3s^{-1}, or 1.61 $m^3s^{-1}km^{-2}$.

Results and discussion

The development of the specific yield during the selected three floods is in *Figure 3*. It is important to take into account that those three catchments are situated in different geographical regions and the floods originated from different rainfall events. In spite of that, the comparison allows to notice some important aspects, as for example the extremely high peak specific runoff in Mala Svinka catchment was produced by the rainfall event of the shortest duration (ca 1.5 hour) in flysh geological formation. The runoff volume of the flood event at Jarovnice was 68% of the rainfall (*Table 1*).

The low runoff coefficient of the flood in the Lesser Carpathians is another surprising fact. It illustrates the very good drainage and water keeping properties of the karstic catchments. Despite it the flash flood in the Lesser Carpathians had catastrophic consequences in villages as Dolany, Casta and Horne Oresany, and in Pila village in particular.

The experience of the international comparison within the European project HYDRATE (Gaume et al., 2010) shows, that the specific yield of about 8–10 $m^3s^{-1}km^{-2}$ in catchments of the area of 30–40 km^2 is not extraordinary at all. In the Mediterranean region they can reach up to 10–50 $m^3s^{-1}km^{-2}$.

Table 1. Basic physico - geographic characteristics of the selected catchments, A – catchment area, L – length of the valley, P – rainfall depth during the flood, Td – rainfall duration during the flood, qmax – peak specific yield during the flood, Kr – runoff coefficient of the flood wave

Stream – station	A [km^2]	L [km]	Qa	Forest [%]	P [mm]	Td [hrs]	qmax [$m^3s^{-1}km^{-2}$]	Kr
Koprovsky potok	31.24	12.7	1.47	30	100	11	2.88	0.52
Rackova:	35.51	8.7	1.56	40	115	12	2.25	0.45
Jalovsky potok:	33.45	10.2	-	60	100	15	2.48	0.46
Mala Svinka:	34.39	13.8	-	50	80	1.5	5.19	0.68
Gidra	32.95	7.9	0.28	97	95	3.5	1.36	0.16
Parna	37.86	11.0	0.35	98	80	3.5	1.61	0.22

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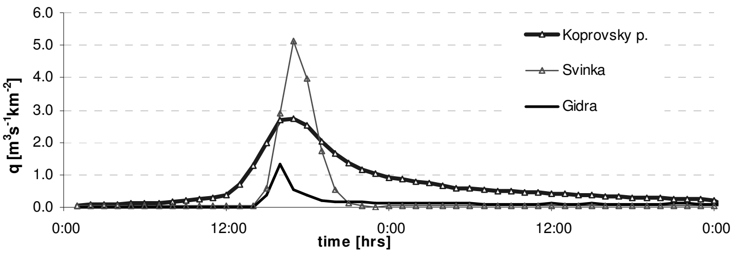

Figure 3. Comparison of the hourly specific yields of the extreme flood waves.

Conclusions

The analysis of the rainfall and runoff data of the particular floods on small streams gives us very valuable knowledge not only about the runoff formation in general, but also about the real possibilities of the flood protection. The analysed floods show us several matters. Even the healthy „water-effective“ vegetation cover of the forested and/or agricultural basin is not able to catch more than a small layer of precipitation (up to 10 mm). The next water keeping layer is the soil. Even the dry soil profile of the mean depth has a limited porosity usually below 150 mm. But, the infiltration rate of the dry natural forest or meadow soil is just a fraction of the rainfall intensity during storms and it decreases exponentially with time. The intensive 1-hour rain can result in catastrophic runoff in small basin saturated by antecedent precipitation and it can not be significantly mitigated by retention capacity of any vegetation cover and soil profile. The effective flood protection needs technical measures in such cases as sufficient water carrying capacity of the stream channels in the villages and dry polders/reservoirs above the villages.

Acknowledgements

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NUMERICAL SIMULATION OF THE ARTIFICIAL RECHARGES OF GROUNDWATER

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Abstract: Nowadays, the importance of artificial recharge of groundwater – used for short or long term underground storage – is increasing due to the growing demand for groundwater and to the continuous assurance of advantageous or at least acceptable agricultural conditions. The negative groundwater balance caused by the high amount of water extraction from porous medium, or the arid regions and the climate change need to develop efficient recharge facilities. In this study we focused on performance of the only Hungarian groundwater recharge system that is continuously working to reduce the effects of groundwater discharge in the surroundings of Borsodszirák village. At the site we analyzed the hydrodynamic effects on groundwater levels of the artificial recharge of groundwater using finite difference method based numerical simulations, highlighted the potential advantages and disadvantages what are hidden in the methods. Four model - systems were built with the same geological structure and boundary conditions, but which are differ in the amount of recharge and the production of the wells. In the simulations the aim of the hydrodynamic calculations was to determine the effects of the recharge to the water levels in each model – variants and compare the results, which scenario has the less harmful effect for the vegetation .

Keywords: artificial recharge, groundwater, numerical simulation

Introduction

In Hungary the main part of civil water supply is ensured from waterworks settled to subsurface water resources. The two-thirds of resources are in vulnerable geological environment, where the aquifers are not protected against surface contaminations. At sites of overexploitation the hydraulic heads in the aquifer are sinking endangering groundwater-related ecosystems. In this study we focused on the area of the Borsodszirák waterworks that is using artificial groundwater recharge to improve the quality and quantity of existing groundwater through the modification of the groundwater flow potential field to modify the subsurface pathlines of groundwater of high manganese, chloride and sulphate concentration and to enhance the groundwater resources. We were calculated with four different scenarios of pumping/ recharge rate and compare their effect to the groundwater-level. Due to the fact that the agriculture needs balanced water budget to assure the acceptable conditions for the growing of the plants it can be possible to use artificial recharge in the future not only in groundwater production but also in plant or crop production (Baser, 2004). We believe that all hydrogeological experiences gained from artificial groundwater recharge valuable information for agricultural engineers.

Materials and methods

The investigated area is at the North-East side of Hungary, in the valley of the rivers Sajó and Bódva. In the region the surface is flat, surrounding agricultural areas. The

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cover is Holocene flood plain clayey formation with 3 m average thickness. The waterworks was settled to the second layer – 4-5 m thick Pleistocene gravely aquifer – with 40 shallow depth pumping wells and 25 infiltration basins. Unfortunately the hydraulic connection between the riverbed sediments and the gravelly aquifer is very poor; therefore water resources are supplied by the artificial recharge-system based on the surface water of the Bódva–river. The river drift is sedimented in a horseshoe-shaped basin before utilization, and in case of necessity a artificial filtering and cleaning is performed before the water is stored into two 400 m^3 clear water tanks. The pretreated water is pumped into the artificial recharge system where the water is infiltrated into the gravelly aquifer and after a natural purification the groundwater is exploited using the production wells.
For the numerical three-dimensional groundwater-flow simulations through porous medium we applied Processing MODFLOW software, what is based on finite difference method. The extent of model-grid is 3km x 5km (*Figure 1.*) The clayey cover formation's horizontal hydraulic conductivity is $8.5 \cdot 10^{-4}$ m/d (Kovács et al., 2010). The aquifer is homogeneous and isotropic with a measured horizontal hydraulic conductivity of 90 m/d and an effective porosity of 0.2. The 25 infiltration basins are in direct hydraulic connection with the aquifer and treated as recharge cells (Pedretti et al., 2012). The pumping wells and infiltration basins are on *Figure 2*.

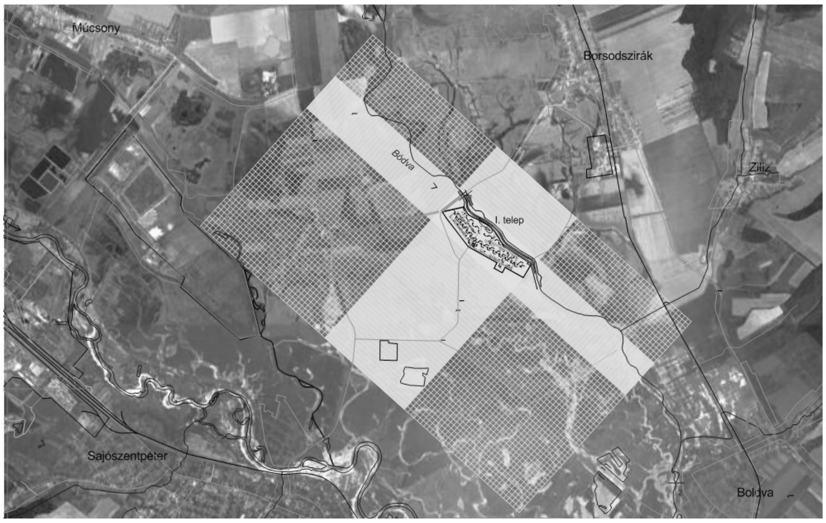

Figure 1. The mesh and the investigated area

At all model variants the production of the pumping wells are 8730 m^3/d. In the 1st case there are no infiltration basins, in the 2nd case 50% of the production assured by artificial recharge. In the 3rd variant artificial recharge reaches the 120% of the production (over-recharge). To determine the effects of the system a base model (4th variant) was calculated without any pumping wells.

Figure 2. The infiltration basins and wells

Results and discussion

The results of the numerical simulations - the calculated hydraulic heads – are plotted on *Figure 3*. The analysis of the different scenarios shows that the increase of artificial recharge reduces the drawdown on the well system and reduces the area of influence as well. Analyzing the water budget (*Table 1.*) we see that the river leakage is weak to compensate GW production, therefore the waterworks may only operate simultaneously to the artificial recharge system, otherwise regional sinking of the GW table will happen. Without artificial recharge the operation of the waterworks at the recent production rate became impossible. In case of the 3rd and 4th scenario the drainage effect of the river is dominant. The artificial recharge of 2280 m^3/d is possible even when no pumping is done, that causes maximum 2.7 m rise of the water table at the site center.

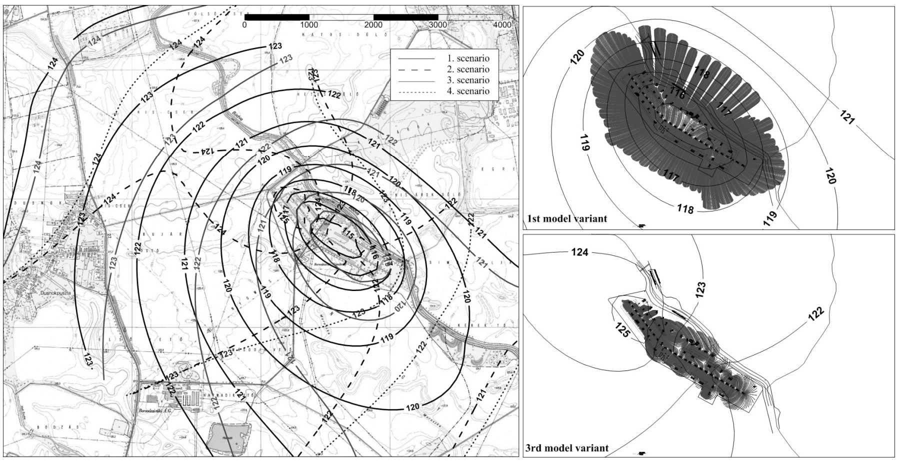

Figure 3. The calculated hydraulic heads (flow potential field) and 90 d pathlines to the wells (case 1. and 3.)

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Table 1. Water balances for the whole model domain

Model variants	Primer state		1. scenario		2. scenario		3. scenario		4. scenario	
Flow term	In	Out	In	Out	In	Out	In	Out	In	Out
	m^3/d		m^3/d		m^3/d		m^3/d		m^3/d	
Wells	No pumping		-	8733	-	8733	-	8733	No pumping	
Recharge	No infiltration		No infiltration		4282	-	10277	-	2282	-
River leakage	27	230	661	29	477	56	5	432	-	618
Head dep. boundary	1598	1395	8519	418	4719	689	1156	2273	1016	2680
Sum	1625	1625	9180	9180	9478	9478	11438	11438	3298	3298

Conclusions

The study performed proved that artificial recharge can be an important factor in keeping the groundwater budget even at large precipitation deficits. The groundwater model of the Borsodszirák area showed that there is a potential of rising GW table locally up to 2-3 meters and 0,2-1 m in a wider area even in gravelly aquifers. Considering the flow equation at sandy groundwater aquifers smaller artificial infiltration rates may lead to the same effects, therefore at dry periods due to climate changes the artificial recharge may compensate the overexploitation of subsurface aquifers. There is a need to test and apply artificial recharge on more sites to get more theoretical and experimental experiences (Várallyay et al., 1989) on the investigated topics in the future to assure the stability of groundwater related ecosystems in Hungary.

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EVAPOTRANSPIRATION OF CADMIUM TREATED MAIZE

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Abstract: Crop water loss determination may be carried out by using evapotranspirometers (ET). Although the shortcomings of evapotranspirometers are well known worldwide, there is no other instrument to measure the canopy evapotranspiration properly. The investigations were settled at Keszthely Agrometeorological Research Station in the vegetation period of 2011. In our study Thornthwaite type compensation evapotranspirometers were applied. The volume of the growing chambers was 4 m^3 each (surface area: 4 m^2, the depth of them 1 m). The pots were filled with soil column characteristic for the surroundings. The test plant was a short growing season maize hybrid (Perlona). In earlier evapotranspirometers a mechanic construction was applied producing daily total of water loss. Traditional equipments were automated at Keszthely Agrometeorological Research Station in 2011 providing facilities to monitor hourly evapotranspiration data. While our observations are preliminary ones, we concluded that the used very sensitive electronic sensors acted accurately. Results will be presented by deploying modifications of cadmium in evapotranspiration of maize canopy.

Keywords: evapotranspirometer, evapotranspiration, maize, cadmium pollution

Introduction

Determination of reference evapotranspiration (ET_o) is one of the most frequently cited processes of evaluating crop water use and irrigation necessity (Jensen et al., 1990). There are two ways in determination of ET_o; the calculation and measurement of the reference crop water loss. The FAO standard counting the ET_o is the well known Penman-Monteith equation (Allen et al., 1998). In rating 50 methods of calculation ET_o Grismer (2002) found that their assumptions, data demands, and results scatter on high extent. Although the accuracy of class "A" pans in ET_o measurement is controversial, its simplicity and low cost make them widely applicable in irrigation timing. Any method would be chosen to ET_o determination, they have to be tested and evaluated locally. Eventually the "A" pan is not accurate in timing irrigation nowadays.
Cadmium is a toxic element accumulating in different parts of the food chain (Bi et al., 2009). We focused on maize, because the crop's sensitivity to Cd was the highest among other plants (Wojcik and Tukendorf, 1999). Evapotranspiration in maize declined in Cd treated canopy (Kirkham, 2006).

Materials and methods

A field trial to study the influence of cadmium pollution on maize evapotranspiration was carried out at Keszthely, in 2011. The usual agronomic measures (plant protection, weed control) recommended for the location by the staff of the University of Agricultural Sciences, Keszthely, were applied. The test plant was the short growing season maize hybrid Sperlona. Of the two water supply treatments, the rainfed variant was sown in field plots (control, C). The other water treatment was the maize grown at "ad libitum" watering in evapotranspirometers (Et). The evapotranspiration was calculated as a residual term of the water balance. The growing chambers were metal containers with a volume of 4 m^3 (2×2 m in area, 1 m in depth), filled with a monolith

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from the surrounding areas, layered as in the natural state. Detailed methodology and construction of the equipment see in Antal (1968).
Traditional Et was renewed in 2010. The control system has been changed from mechanical to electronic. Two types of "pots", the water supplier or compensation pot and leakage pots were omitted. The compensation pot was replaced by an electronic switch connected to the water supplier tap directly (*Figure 1.*).

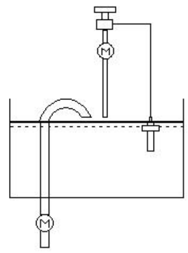

Figure 1. The reconstructed compensation system with float ring on the right and siphon (inverted U shape tube). M denotes flow meters

A data logger of HYGACQ V1.3 type was connected to each installation. The frequency of data sampling was 1 second. The logger calculates hourly sums and memorizes them. The collected hourly data can be loaded by PC using the WHYGACQ computer program. The program has a graphical surface providing a quick view about temporal variation of water supply.
The Cd concentration used for pollution was 10^{-5} M [$Cd(NO_3)_2 \times 4H_2O$]. A motorised sprayer (SP 415) was used to apply the pollutant in the field at weekly intervals.

Results and discussion

At non limited watering the size of reference evapotranspiration follows the changes in transpiration surface and radiation. Extremely arid season of 2011 (precipitation sum amounting to about half the average figure) resulted in high total water losses in maize. Yearly evapotranspiration sums in control and polluted maize totaled in 463.9 mm and 428.9 mm, respectively (*Figure 2.*). The greatest value of daily water loss was measured during tasseling in 9th July 2011 (7.1 and 6.7 mm in control and polluted crops). Cadmium pollution did not modify either seasonal variation or the date at which peak daily evapotranspiration loss was observed.
The seasonal evapotranspiration sum of Cd polluted maize significantly declined with 13% in 2011. Depression was the most pronounced in the second half of warm June and on some extremely hot days. In the beginning and in the end of the vegetation period the impact of Cd was moderate. The renewed Et permitted the hourly imitation of growing chamber's water compensation. This is the amount of additional water offered to soil and crops grown in the growing chamber. We handled the hourly distribution of compensation water for different radiation regimes separately. On cloudy days, both radiation and water replenishment were low and consolidated; the water loss of polluted maize hardly differed from control (data not shown).

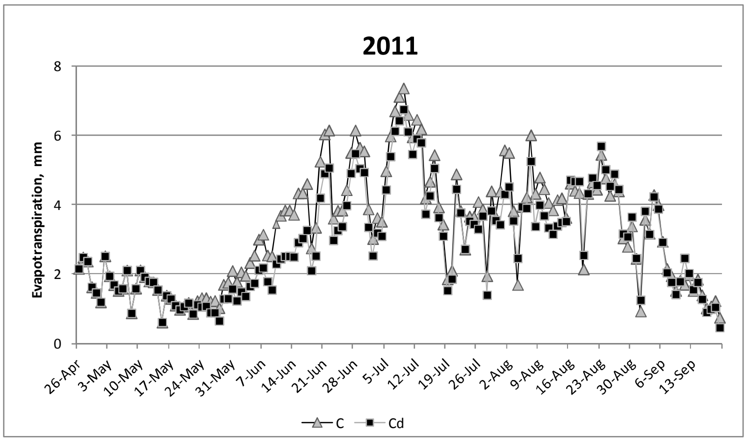

Figure 2. Seasonal variation of actual evapotranspiration in maize

The impact of Cd on evapotranspiration was the highest on clearsky conditions. Our sample day represents top water demand of maize during tasseling (*Figure 3.*).

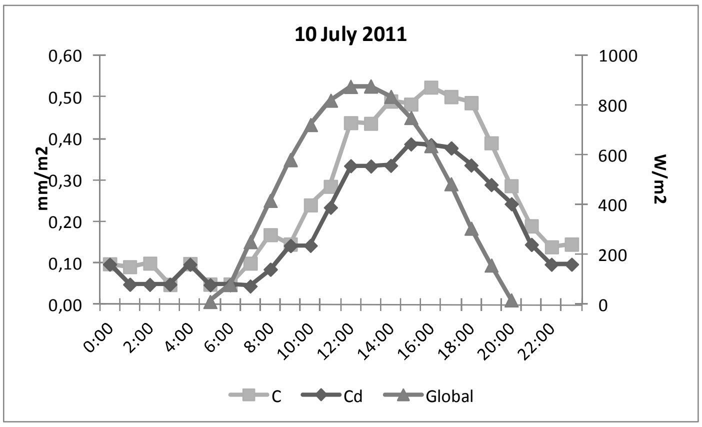

Figure 3. Diurnal variation in peak water uptake of maize during tasseling. Radiation intensity was expressed in total incoming (global) radiation (W/m^2).

Daily compensation water amounts totaled 5.99 and 4.45 mm/m^2 in control and polluted treatment, respectively. In our clear sky sample day decline in water use of polluted treatment reached the 30%. Decreased water use of Cd polluted maize was pronounced in accordance to earlier investigations of Fodor (2003).The time of largest system's water demand did not coincide with the highest solar angle; the peak water uptake was late about two to three hours. It means that the water demand follows better the air temperature curves then radiation figures. In spite of undisturbed radiation and "ad libitum" watering, the water consumption was more variable than the radiation curve

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calling the attention to other influencing environmental factors (air moisture, wind etc.). This small "noises" appeared parallel in the two treatments suggesting non physiological origin.

Peak maize water losses were measured at 16:00 DST, at the time of hottest air temperatures. The ascendant branch of evapotranspiration curve (before solar noon) was less steep than the descending branch in the afternoon.

Conclusions

Automation of mechanic Thornthwaite Mather type compensation evapotranspirometer had free scope for discussing crop-water system in more details. This type of observation allowed to follow hourly water consumption of evapotranspirometer's growing chambers precisely. In general the cadmium pollution declined with 13% the seasonal evapotranspiration of maize. The impact of cadmium was the highest during completely clear sky conditions (sometimes reaching the 30%).

Acknowledgements

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EFFECT OF WATER SUPPLY ON PLANT-PRODUCTION IN THE HAJDÚSÁG REGION IN 2002-2011

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Abstract: Our research objective was to determine the relationships between the water-supply parameters and yield of maize and winter wheat in different cropyears with special attention to the Hajdúság region. The experiment was conducted at the Látókép research site of University of Debrecen, in 2002-2011.
In the period of observation the weather conditions, the potential and actual transpiration have been analysed and significant differences were found between them**.** The experimental results proved that there are considerable differences between the cropyears in PET-AET (vegetations period of maize in 2003: 404 mm, in 2010 29 mm, in case of winter wheat in 2007: 376 mm, in 2008: 109 mm), in yield (maize in 2007: 7062 kg ha^{-1}, in 2008: 13987 kg ha^{-1}, winter wheat in 2010: 5804 kg ha^{-1}, in 2011: 10050 ha^{-1}).

Keywords: evapotranspiration, winter wheat, maize, cropyear, yield

Introduction

Frequent occurrence of meteorological extremities may increasingly affect plant-production (Jolánkai and Birkás, 2009). Varga-Haszonits (2003) found that the absolute extremes of climate change cause difficulties in crop production, because most crops are adapted to the average conditions. According to Lente and Pepó (2009), the water conditions of cropyear were the most important abiotic stress-factors in maize production. Estimating the response of plants to the moderate environmental change with modeling shows, that even the less sensitive C4 maize may answer negative changes in physiological processes (Anda, 2006).
The water-balance is determined by the precipitation and transpiration (Szász, 2005). The yield of plants was reduced significantly by water-stress (Bradford, 1994). In optimal water supply conditions the transpiration is principally determined by meteorological factors (Gardner, 1965).

Materials and methods

The field experiment was set up at the experimental site of the Institute of Crop Science, University of Debrecen, Centre for Agricultural and Applied Economic Sciences at Látókép. The soil of the experiment was calcareous chernozem. The study covers the data of the years 2002 - 2011. In the small-plot experiment there are four repetitions in a strip-plot design. Effects of different agro-ecological factors (soil water content in the beginning of vegetation periods, temperature, precipitation) in the vegetations period of maize (01/04 – 30/09) and winter wheat (01/10 – 30/06) were tested in the experiment. In the research we have applied uniform agrotechnics and nutrients' supply (maize: N=120 kg ha^{-1}, P_2O_5=90 kg ha^{-1} and K_2O=90, winter wheat: N=100 kg ha^{-1}, P_2O_5=70 kg ha^{-1} and K_2O=80 kg ha^{-1}).

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We determined Pearson-correlation coefficients, coefficient of determination (R^2) in connection with polinomial regression analysis. To analyse the ecological effects of each year we determined the potential evapotranspiration (PET) and the actual evapotranspiration (AET) values and their differences.
The daily PET was calculated by using Gábor Szász's method (mm day^{-1}).

$$PET = \beta \left[0{,}0054 \ (T + 21)^2 (1 - R)^{\frac{2}{3}} f(v) \right]$$

- T: average daily temperature (°C)
- R: saturation ratio of air humidity (e/E)
- β**:** coefficient of oasis effect (This refers to the increase in evaporation rates when water bodies, in this case stomata are surrounded by dry regions.)
- f(v): impact function of wind

For simplification of calculations the speed of wind was constant 2 m s^{-1}, f(v) = 1.
The AET was also calculated on a daily basis using the formula of Emánuel Antal.

$$AET = \frac{w + b}{1 + b} \cdot w \cdot PET \qquad w = \frac{NT - HV}{VK\min - HV}$$

- w: relative humidity in the root zone (mm)
- b: a coefficient allowing for the effects of plants (Crop coefficient describes the plant conditions that changes evapotranspiration.)
- PET: value of potential daily evapotranspiration (mm day^{-1})
- HV: unavailable water content (mm)
- VK_{min} : water holding capacity of the soil (mm)
- NT: actual water content of the soil (mm)

Results and discussion

In the period of observation we analysed the weather conditions, the PET and AET and we found significant differences in these parameters (*Table 1*).

Table 1. Characteristics of vegetation periods of maize (Debrecen, 2002-2011)

Year	Soil water content mm (04/01) (2 m)	(1 m)	Precipitation (mm)	PET mm	AET mm	PET - AET mm	Water-balance (Prec.-PET) mm	Yield kg ha^{-1}
2002	453	279	470	519	427	*92*	*-49*	10 819
2003	407	221	219	617	213	*405*	*-398*	7 500
2004	402	217	342	560	334	*226*	*-218*	13 179
2005	428	232	502	541	429	*112*	*-39*	12 907
2006	483	231	326	466	385	*81*	*-140*	12 197
2007	410	203	203	603	284	*319*	*-399*	7 062
2008	436	219	491	453	421	*32*	*39*	13 987
2009	450	229	168	608	219	*388*	*-439*	9 913
2010	472	234	590	424	395	*30*	*166*	9 424
2011	463	218	318	605	323	*282*	*-286*	12 388
Mean			**363**	**540**	**343**	**197**	***-196***	**10 938**

The precipitation in the vegetation period of maize was very variable in the Hajdúság region: for example in 2009 it was 168 mm, and in 2010 it was 590 mm.
The biggest difference was observed in maize in 2009: difference of PET and AET was 439 mm, when the vegetation period was more draught than average (precipitation 168 mm). In this year June was rainy (90 mm rainfall), so the yield was almost average.
During the past ten years the climatic water-balance was mostly in negative range. In 2008 the weather was rainy, the water-balance value was positive; the yield in that year was the best of the observed period.

Table 2. Characteristics of vegetation periods of winter wheat (Debrecen, 2002-2011)

Year	Soil water content (1 m) mm		Precipitation (mm)	PET mm	AET mm	PET -AET mm	Water-balance (Prec.-PET) mm	Yield kg ha^{-1}
	01.09	01.03.						
2002	222	220	337	409	242	*167*	*-72*	7 187
2003	205	221	280	430	153	*277*	*-150*	6 641
2004	160	219	377	389	174	*215*	*-13*	8 243
2005	152	233	424	412	222	*190*	*12*	7 752
2006	153	230	492	337	199	*138*	*154*	6 613
2007	165	203	207	477	101	*376*	*-270*	6 913
2008	187	219	485	331	221	*110*	*154*	6 346
2009	188	229	330	401	140	*261*	*-71*	9 487
2010	136	234	631	368	231	*137*	*263*	5 804
2011	207	218	341	443	168	*276*	*-102*	10 050
Mean			**390**	**400**	**185**	***215***	***-10***	**7 504**

The precipitation in the vegetation period of winter wheat was the least in 2007: 207 mm, while 2010 was extremely rainy (*Table 2*).
Difference of PET and AET varied between 137-376 mm in the past ten years, and the climatic water-balance was negative in six cropyears. The vegetation period was draughty in 2003 and 2007; the water-balance in these years have shown the biggest water-deficit. The yields in these years were less than average, but the extreme rainy years (2006, 2010) had negative effects on the yield, too.
Analysing the relationships between the yield and the difference of PET and AET we found negative correlation in maize ($r=-0.5549$), and positive in winter wheat ($r=0.4166$). The yield of maize was limited by the water-deficit in the most drought cropyears. In relation of yield and precipitation there was positive correlation in maize ($r= 0.4883$), and negative correlation in winter wheat ($r=- 0.4192$). The extreme rainy cropyear 2010 had negative effect on the yield of winter wheat.
The polinomial regression calculations showed the best curve function fit to the series of data (*Table 3*). In the case of maize the calculated yield by optimal water-balance was 12 645 kg ha^{-1} *(Figure 1)*, in the case of winter wheat it was 8 135 kg ha^{-1}.
The of the beginning of the function curve indicates that the water-deficit has great depressive influence on the yield.

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Table 3. R^2 values of the regressions between yield and some water supply parameters (Debrecen, 2002-2011)

	Climatic water-balance (Prec.-PET)	PET -AET	Precipitation
Yield of maize	0.61	0.44	0.46
Yield of winter wheat	0.48	0.54	0.39

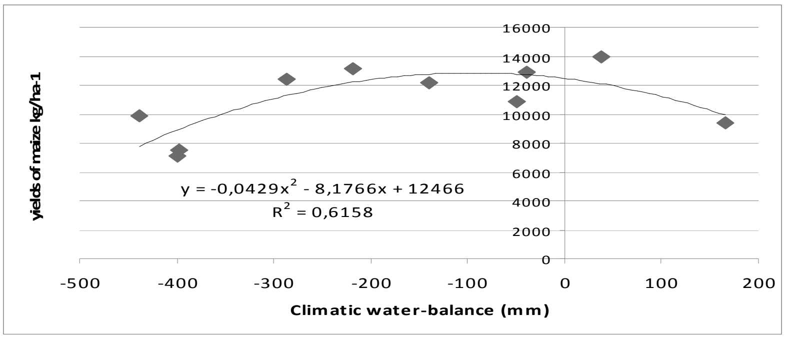

Figure 1. Connection between the yield of maize and climatic water-balance (Debrecen, 2012-2011)

Conclusions

Based on our results, it can be stated that there are significant correlations between the agro-ecological parameters of the cropyear and the yield of maize and winter wheat. There are fairly great differences between cropyears regarding the effects on crops. Although the extremely rainy cropyears have also negative effects on the yield of winter wheat and maize, the water-deficit caused much more decreasing in yields in the analysed years. In the case of yield and the difference of PET and AET there was a negative correlation in maize, and a positive one in winter wheat.

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EFFECT OF HYDROPHILIC TREATMENT ON WATER RETENTION OF SANDY SOIL

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Abstract: The attractive force on the soil – water interface depends on the adsorbed compounds in a three phase system. In this investigation we examined the effect of hygroscopic glycerol on the water retention of sandy soil. This effect may increase the water infiltration and decrease the deeper percolation. The glycerol is a main by-product of biodiesel production from plant oil. During the manufacturing process, some very valuable plant nutrients are concentrating in the hydrofoil glycerol phase, and feed it back into the soil permit of the sustainable production. If the glycerol treatment is increasing the soil water management, it may be usable for land improvement.

In our experiments a soil-filled tube was hanged on a digital scale. In the beginning the soil column was saturated, and then the solution could run out from the soil. In a long term measurement the mass – time data pairs were stored in the memory of a computer. Analysed the measured data the speed of the water leak from the soil column is calculable. There were three concentrations of contaminant, and three replications in all treatment level. Evaluated the stored data we found significant difference between the water retention of sandy soil and contaminant concentration.

Keywords: water conductivity, water retention, glycerol

Introduction

The most important features of soils are the water-holding capacity and the water conductivity properties. All of them are depending on the particle size distribution and the organic matter content. There are some papers about the statistical, mathematical analysis of the function between the soil organic matter and hydraulic properties of soil (Rawls et al., 1989; Dexter, 2004). There are a lot of results, to estimating the soil water retention and conductivity parameters from the mentioned soil properties (Gupta and Larson, 1979; Rawls and Brakensiek, 1989). There are some modeling methods for estimating the soil water retention and conductivity parameters, by measuring some other, relative easily measureable parameters (Rossi and Nimmo, 1994; Pachepsky et al, 1995; Nemes et al, 2003), but there are not too much papers reported about the direct measurement in function of organic treatment of these features of soils (Tamari et al, 1993; Emerson, 1995; Tester, 1989). De Jongi et al. (1983) measured the effect of organic matter on the gravitational water retention, and they fitted, two exponential functions, to the measured points, by logarithmic method. They reported about 20 percent decreasing effect of the 3% organic content, on water retention. Szegi et al. (2005) reported a very simple method, where some wet soil sample was put in a funnel, and their weight was measured in some given time. From the measured mass data the authors calculated the water content, and they estimated the effect of the organic treatments on water-holding capacity. In this paper we report the improvement of mentioned method and some results using the clear and glycerol treated soil.

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Materials and methods

The dry soil sample was filled into a plastic cylinder, it was 15 cm long and its diameter was 5 cm. The bottom of the cylinder was closed by a plastic disc, in the center of this disc there was a hole with a diameter of 4 mm, and in this hole we glued a 10 cm long plastic tube with an inside diameter of 3 mm. We put some coarse gravel (about 2-4 mm particle size) between the bottom plastic plate and soil sample, for promoting the water movement on this region of the tube. The top of this tube was covered by a thin plastic disc, but it was not closed hermetically, therefore it did not prevent the air movement, however it minimized the water loss by evaporation.
The filled cylinder was hanged on a hanging scale (OAHUS AV 4102 adventure pro) and the scale was connected to a computer. A computer program, developed for this measurement, continuously collected the weight data in every other second, and stored it on the hard disc of the computer. The bottom of the thin tube was under the water level of a water filled glass, using this solution, we could promote the dropping, and we could decrease the measurement error.
The hanging cylinders were filled by pumping from the bottom size, for filling we used water or 10 m/m % glycerol solution. At the beginning of the measurement the filled water level was over the soil level in the sample tube. Therefore in the first part of measurement we could measure the two phase water conductivity, and the second part, when the water level was under the soil level, we could measure the water retention of soil.
The test was made on a sandy soil from Fót.:

Table 1. The main attributes of used soil sample

Saturation percentage	KA	28.33
Lime content	$CaCO_3$ %	8 %,
	pH(H_2O)	8.2
Humus content	H %	1.4 %
Phosphorous content	AL-P_2O_5	95 ppm
Potassium content	AL-K_2O	120 ppm

All measurements were made in three replications. The collected data was evaluated by statistical analysis, and linear and non linear regression. For the data evaluation we used Microcal Origin 7.0 scientific software.

Results and discussion

Because of the total dry weight, and little differences in the amount of the water filling, there was difference between the measured data of the replications in given treatments. Fortunately the precision of measurement was increasing as the water content was decreasing, we used an additive constant of all data series, and we made all drying soil weight in same value. It means we shifted the curves, while the asymptotes were equal.
We calculated the average and the deviance of the three replications of shifted measured data; it can be seen on the *Figure 1.* In this figure, we can see that the measurement error in the first part of measurement was relative big, but later it was invisible. The explanation of this fenomenon is simple: this error is because of the manual

measurement; we could not measure the weight and the water content of the soil sample accurately, later the samples would become more alike.

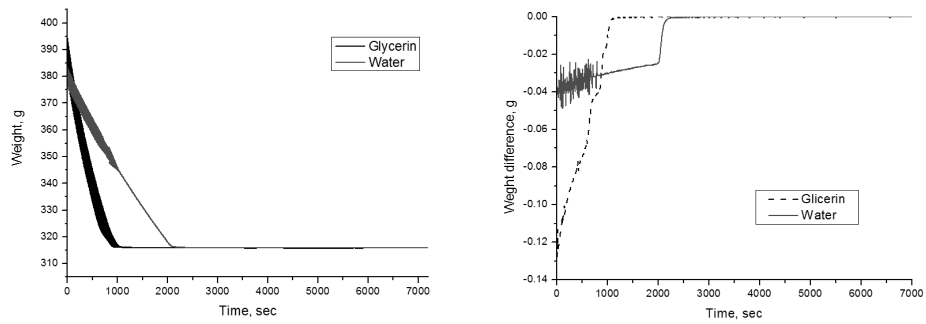

Figure 1. The shifted weight data with the error bars, and the derivative curves

In *Figure 1* can be seen the samples with glycerin treatment had higher weight, because we filled the same volume of fluid, and the density of glycerin solution was bigger. Another difference between the two treatments is the time when the nearly linear decreasing curves transform to an almost horizontal line. This value is at the glycerin solution about 1000 sec, and at the clear water it is about 2000 sec. The almost linear decreasing can be explained by the saturated water conductivity. It is not totally linear because the water level decreased while the water was moving down into the glass. We can see it in the whole curve but in every water level we can calculate it from the derivative curves.

For the further results we analyzed the first 200 second part of the curves and the three phase non linear part of the measured curves.

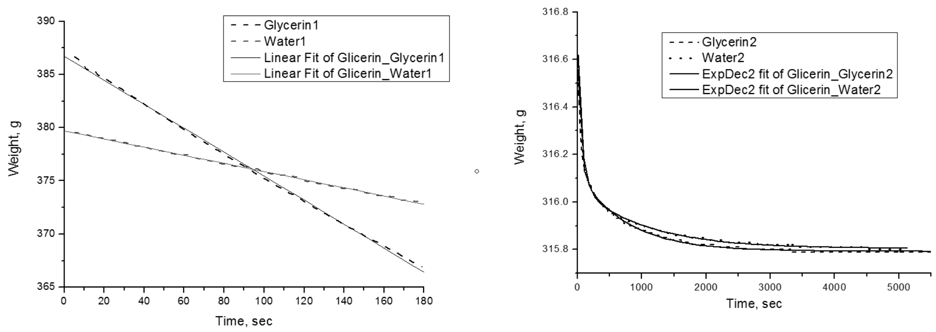

Figure 2. The two phase water conductivity and the water

In the first linear decreasing part of the curve, we made a linear regression to compare the two phases, conductivity at clear water and glycerin solution. In the *Table 2* we can see the ratio of slopes is about 3, it means that in the first part the conductivity of glycerin solution is three times bigger than the water conductivity. For now we have no explanation for that, it needs further investigation.

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Table 2. The linear correlation data of the first time of processes

Treatment	Y_0	Slope	R
Water	315.8	-0.038	-0.9993
Glicerin	386.7	-0.113	-0.9994

In the *Table 3* we can see the parameters of the fitted two part exponential equation:

$$Y = Y_0 + A_1 e^{-\frac{x}{t_1}} + A_2 e^{-\frac{x}{t_2}}$$ where Y= weight in g ; x= time in sec

Table 3. The exponential correlation of the non linear part of processes

Treatment	Y_0	A_1	t_1	A_2	t_2	R
Water	315.8	***0.23***	**1051**	0.53	**74.5**	-0.9997
Glicerin	315.8	***0.33***	**752**	0.55	**45.1**	-0.9994

This function combination means that there is a faster process, and a slower process. The A parameters in the different treatment support the conclusion that the results ot the faster process are almost the same, while in the slower process escapes about 1.5 times more water than glycerin treatment. It means that the soil can store about 1.5 times more water than the glycerin solution.

Comparing the fitted parameters we can see that the time constants of glycerin are smaller in both processes. It can therefore be concluded that the glycerin decreases significantly the water retention of the soil.

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VISUALISATION OF RAIN FACTOR FOLLOWING THE EXCEEDANCE TIME FOR AREA OF SOUTHWESTERN SLOVAKIA

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Abstract: The aim of this paper is to present values of rain factor in graphical form, which may be exceeded once per 100, 20 and 1 year. The data for this research were provided by Slovak Hydrometeorological Institute in Bratislava in digital form, for five meteorological stations situated in the southwestern part of Slovak republic. Rain factor was calculated following the methodology of Wischmeier-Smith (1978) with using new concept of data processing. Wischmeier-Smith methodology consider for the erosive effective rainfalls, those rainfalls which total amount is higher than 12,5 mm and the kinetic energy, at least one rain division is higher than 24 mm.h^{-1}. The new concept of data processing reposes the fact that selected rainfalls are not divided into rain divisions but each minute of rainfall is consider for separate rain division. The calculated values of rain factor were founded by creating of exceedance probability curves, which were constructed according to the method of moments. Rain factor values which may be exceeded once per 100, 20 and 1 year may be subtracted from created curves. These values did as base for creating of maps, with using GIS device. Concretely was used SPLINE interpolation method. These maps provide information about distribution and exceedance values of rain factor for southwestern part of Slovak republic. Created maps have significant meaning for prediction of rain factor values and also for anti-erosion measurements applied on agricultural soils in this part of Slovakia.

Keywords: rain factor, Wischmeier-Smith, exceedance probability, GIS

Introduction

Soil water erosion consider serious problem in the Europe Union. Almost 12.0% of all areas in Europe are endangered by water erosion and of course in Slovak republic is endangered as many as 43.3% of agricultural soils. These alarming numbers incite detailed research of water erosion factors. One of these factors is the rain factor R or rain erosivity. GIS devices help to creating the maps, which describe the spatial allocation of rain factor on the area of southwestern Slovakia for different exceedance time.

Materials and methods

Slovak Hydrometeorological Institute in Bratislava provided data about one minute precipitation for chosen meteorological stations situated in area of southwestern Slovakia. Totally were processed data from 5 meteorological stations for different time period. We used the methodology of Wischmeier-Smith (1978) which considers the erosive effective rainfall, those rainfalls, which are higher than 12.5mm and with intensity higher than 24.00 mm.h^{-1} in one rain division. The main different in this work is that each minute of rain was consider for individual rain division. The following equations were used for calculation of rain factor:

$$R = E * I_{30} \qquad [\text{MJ.ha}^{-1}.\text{cm.h}^{-1}] \qquad (1)$$

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Where:
R – rain factor [MJ.ha^{-1}.cm.h^{-1}],
E – rain kinetic energy [J.m^{-2}.mm^{-1}],
I_{30} – maximal 30-minutes rain intensity [cm .h^{-1}].

$$KE = (11,87 + 8,73 * \log_{10} I) * H_z \qquad [\mathrm{J.m^{-2}.mm^{-1}}] \qquad (2)$$

Where:
KE – kinetic energy of rain [J.m^{-2}.mm^{-1}],
H_z – pecipitation height [mm].

The values of exceedance were obtained from exceedance probabilty curves. These curves were constructed according to the method of moments which is preferably used in hydrology.

To creating of maps was used method based on Spline functions, which go out from interpolation by means of the most common cubic functions. It is a method of minimum curvature, which requirement is that interpolated surface must pass through the entry points and its curvature must be minimal (quadrate sum of the surface second derivation at each point must be minimal).

To simplify we could express how to create maps as follows:

The main principle is in the joining pairs of points by the segments of cubic curve (these are given by four points). From first four points is sum the cubic curve and the first two points are connecting into its segment. Then from the second to fifth point sums cubic curve and the other two points are connect into its segment etc. It is therefore of polynomial functions, on the edges linear (coherence of interpolated function and determinate number of its derivation). The surface is interpolated in parts and creates smooth surfaces. Alignment is determined by given tolerance and the number of iterations (Klimánek, 2008).

Results and discussion

Creating maps give information about distribution of rain factor, which can occur once per 100, 20 and 1 year in the area of southwestern Slovakia, which is one of the most important sources of agricultural soils in southwestern part of Slovak republic. The first created map shows the rain factor 100 annual values for chosen area. As we can see from the first map the highest values of rain factor can be found nearly the locality Dudince and the lowest nearly the locality Gabčíkovo which is situated in the lowest altitude in our republic. All created maps can be used as base for anti-erosion measurements of agriculture soils in mentioned area.

Other maps show values of rain factor which can occur once per 20 and 1 year. Showed values can be very useful for agricultural practice, because they can help to estimate the protection of soil in defined period, so the soil looses may decrease.

The above facts show that the use of our values will ensure better protection of soil against erosion. It also proposes the anti-erosion protection of soil for required level of protection of interested territory (e.g. protection of within the territory of town before the accumulation of eroded material).

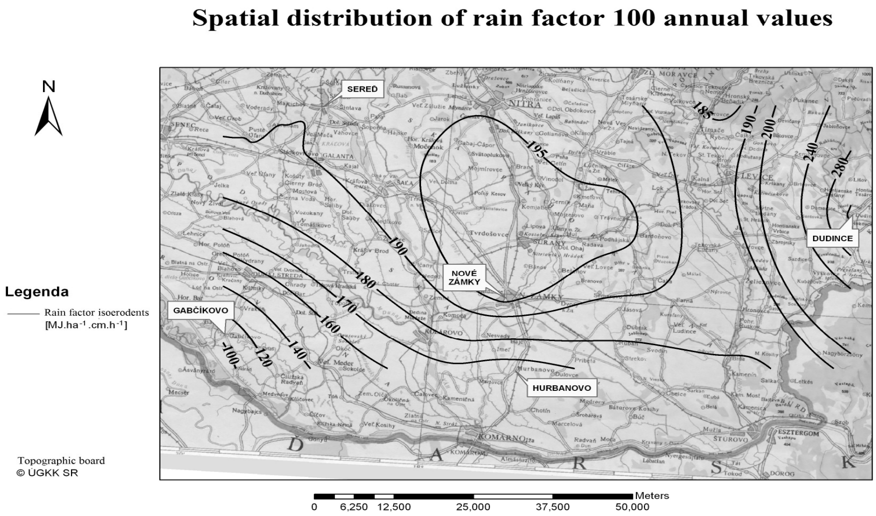

Figure 1. Spatial distribution of rain factor 100 annual values for area of southwestern Slovakia

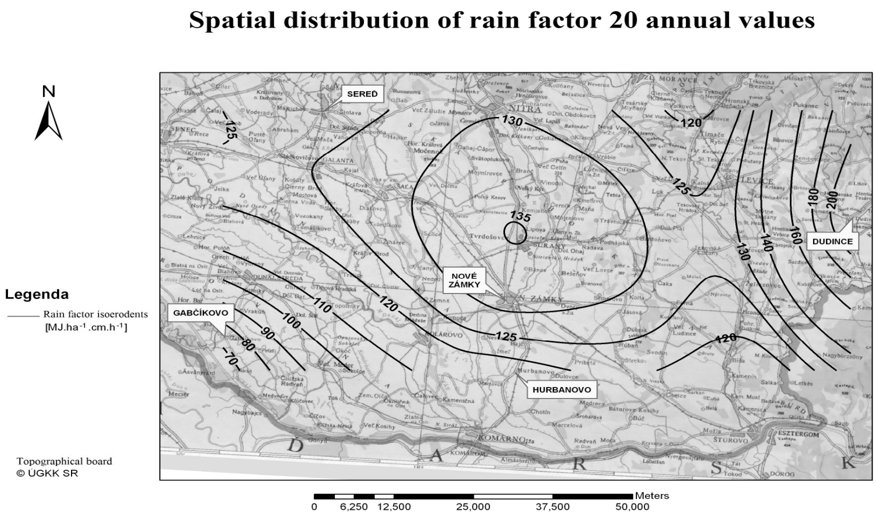

Figure 2. Spatial distribution of rain factor 20 annual values for area of southwestern Slovakia

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Spatial distribution of rain factor annual values

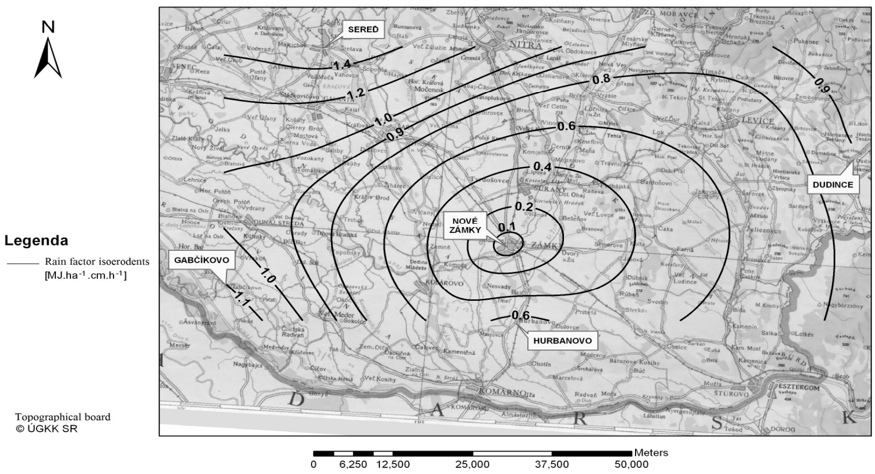

Figure 3. Spatial distribution of rain factor annual values for area of southwestern Slovakia

Conclusions

The used GIS devices provide one of the most suitable possibilities how to show spatial distribution of rain factor in the map form in the area of southwestern part of Slovak republic. Our established values can be considered for correct because new designed methodology of data processing abolish the individual mistakes (creating the rain divisions). This information is very useful for designing of anti-erosion measurement on agricultural soils, which are the most important sources for growing not only cereals but also for the other agricultural plants.

Acknowledgements

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EVALUATION OF CLIMATIC FACTORS INFLUENCING YIELD STABILITY USING LONG TERM STATISTICAL DATABASES

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Abstract: Although the crop production has a 10.000-year-long history and through this time agrotechnics developed significantly, there are still some factors that play important role in the formation of yield but cannot be changed by the grower. As the crop production is an out-door activity, so one of the most important among these factors is the climate. In open databases good number of the series of climatic factors and main crops' yield can be found. In this paper the correlation is observed between these climatic factors referring to temperature, precipitation and radiation and 11 main crops. That would be evaluated which of the factors has significant impact and how the produced biomass including cumulated greenwater depends on it.

Keywords: yield stability, climate, long term database, crop

Introduction

At the beginning of the human civilization, when mankind first tried cropping plants recognized that crop plants does not give the same yield in each year, and sometimes the differences could be very high. According to the level of that age, this variance was explained by some supernatural forces. The only thing that could be done against them was giving gifts to placate them. In the same time with progressing, more and more rational explications were found, until in nowadays, on the base of rationality, only scientific causes could be accepted (Jolánkai and Birkás, 2007; Jolánkai et al., 2008). In this way crop science and practice become reasonable. There exist numerous factors that having effect on yield (Tarnawa and Klupács, 2006; Berzsenyi et al, 2011) and among them there are some that could be influenced by the farmer and also some, that could not be. The first group is the set of elements of agronomic management the second group is the set of factors of environment (Várallyay et al., 1985). In the set of environmental factors there are some with more or less effect on yield (Klupács et al., 2010), but according to former observations, weather plays a significant role (Szöllősi et al., 2004). Even because cropping practice is not an indoor practice but mostly outdoor; the weather and climate has high impact on it (Láng et al., 2007).
As the yields still showing lower or higher fluctuation from the long term averages or trends, it should be more than useful to explore how it depends on each element of climate (Pepó, 2010).

Materials and methods

If changes in yields of main crops in last decades are studied, an upward tendency could be found. But that could also be detected, that there are some years when yield is under the trend line and also some when it is above it. In this study the yield of crops with the highest total area in Hungary were observed in the period of 1960 to 2000 (KSH).

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These crops are the following: wheat, maize, barley, rye, oat, peas, rape, sunflower, sugar beet, potato, alfalfa.
The yield of studied crops has given a close correlation with a linear trend in the observed period. Our aim is to find how the formation of yield under or above the trend depends on the cropping year's weather.
The following 32 parameters are collected by the Hungarian Meteorological Service (OMSZ):
Referring to temperature: average annual temperature, highest daily temperature in the year, lowest daily temperature in the year, highest mean temperature in the year, annual average of daily maximum temperatures, day with a maximum below 0 °C, day with a maximum above 25 °C, day with a maximum above 30 °C, day with a maximum above 35 °C, lowest temperature in the year, annual average of daily minimum temperatures, day with a minimum below 0 °C, day with a minimum below -10 °C, day with a minimum above 20 °C.
Referring to precipitation: annual total precipitation, annual precipitation as snow, maximal daily precipitation, daily precipitation above 0,1 mm, daily precipitation above 1 mm, daily precipitation above 5 mm, daily precipitation above 10 mm, daily precipitation above 20 mm, daily precipitation above 30 mm, daily precipitation above 50 mm, snowy days, frosty days, rain stormy days, sleety days.
Referring to radiation: total annual duration of sunlight, maximal daily sunlight radiation, daily duration of sunlight less than 20% of likely value, daily duration of sunlight more than 80% of likely value.
Statistical analysis was performed by using the MS Excel program packages. For each crop the trend was calculated and also the deviations from trend for each year. The connection between deviations and given year's climatic factors was analyzed. In that way 32 relations was given for each of 11 crops. The relation of these connections is showed by the Pearson's correlation coefficient ("r") that was calculated for each item. The absolute value of that coefficient refers to the role played by each meteorological factor in the formation of the deviation of the given yield from the trend.

Results and discussion

It can be state that the absolute values of correlation coefficients received are not so high, never more than 0.5. As there are so many results, a summary table is the best way to represent them. Four categories for the result were made with the following intervals: lowest ($0.1>|r|$), low ($0.2>|r|\geq 0.1$), moderate ($0.3>|r|\geq 0.2$), high ($|r|\geq 0.3$)
In *Table 1* that number of $|r|$ referring to climatic factors can be seen that falling into these categories by crops.
The weather parameters could be engaged in three big groups (temperature, precipitation, radiation). On *Figure 1* the rate of them can be seen as the referring correlation coefficient's absolute value falling in each categories. And also the trends and the fittings of trend lines are shown. On *Figure 1* that also can be seen, that temperature and radiation has more significant effect and precipitation has weaker correlation in average. It could be a surprise for first, but as there is no tool to change radiation in connection with field crops, and not much for defending crops from the extreme and fast changes in temperature, and as most of researches aim to explore and treat the effects of extremities of precipitation and soil water regime as well, it is not a

surprise for the second view. Most of tools and methods that can change the climatic milieu of arable fields are connected with water management, and as farmers usually use them that is the reason why precipitation seems to have less effect.

Table 1. The effect of climatic factors on crops by categories

r	high	moderate	low	lowest
wheat	2	4	10	16
maize	7	3	14	8
barley	3	5	7	17
rye	3	10	6	13
oat	2	4	12	14
peas	4	5	9	14
sunflower	1	5	16	10
rape	1	9	11	11
alfalfa	8	5	10	9
sugar beet	7	8	8	9
potato	3	8	11	10

On *Figure 1* that also can be seen, that trends have strong correlation, and as these are gained as averages, can be used as a base of compare, as a fictive reference crop (abbreviated as "φ"). If real crops' attributes are compared with that's of "φ", it can be seen, that cereals in ears', peas and oil crops' trend lines are very similar to "φ" precipitation trend line and other crops' trend lines are more similar to "φ" temperature trend line. According to these observations, here in Hungary, the yield of crops domesticated under our climate or similar to that are mostly formed by precipitation at first place; and the yield of crops domesticated under tropical or subtropical climate are primarily formed by the climatic factors connected with temperature.

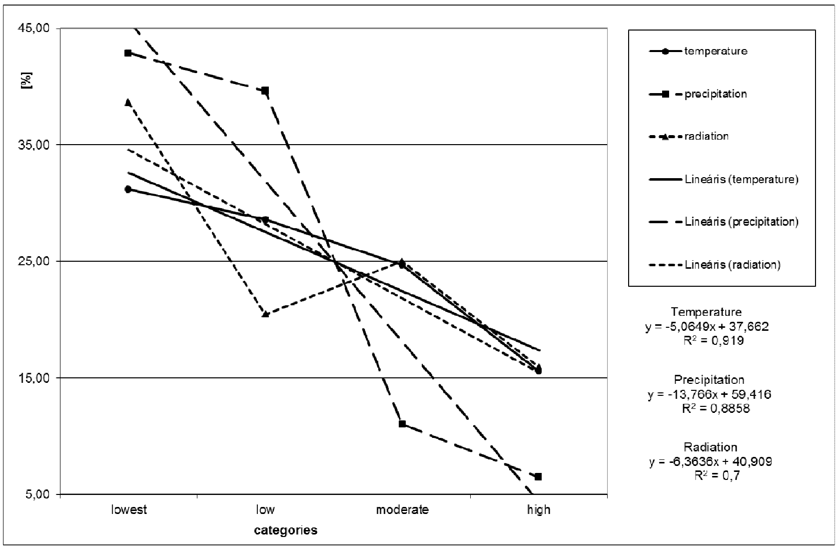

Figure 1. The average level of correlation by the main categories of weather parameters

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Conclusions

With higher "r" absolute value the connection is stronger, and the effect of weather parameter is bigger.

The variance in cereals in ears', peas' and oil crops' yield is primarily not depending on the changes in climatic factors. It is due to the good climatic adaptability of these crops as they can tolerate even extreme weather situations. However changes in agronomic management have effect hence they can play the main role.

The determinating effect of climate is much stronger for maize and potato. These cultures are more demanding, so mistakes in agronomic management occurs by not protecting from the effect of weather extremities. For these two crops it should be marked that the original gene center of them are the most far from Hungary, and also the climate of that area.

The strongest effect could be detected in the case of alfalfa and sugar beet. The reason of it for these two is different. The alfalfa is one of the most extensively cropped plant in Hungary. In this case there's no other factor than the climate to make significant effect on yield. The reason for sugar beet is almost the opposite. Farmers dealing with beet can solve on high level almost all the agronomical problems occurring hence climatic parameters rest as effecting factors.

After all, it can be stated that some of the climatic factors have great effect on crop production but the factors of agronomic management cannot be ignored. Researches and developments in agronomy play a significant role in the reduction of fluctuation in yield caused by climatic factors.

Acknowledgements

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DEVELOPMENT OF THE PRECIPITATION AND AIR TEMPERATURE DUE TO CLIMATE CHANGE

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Abstract: In recent decades the study of climate change has raised awareness. People felt the change especially with regard to air temperature and precipitation. Winters in our conditions compared to the past are longer and generally warmer, in the summer there are extremes of air temperature and an uneven distribution of precipitation. Storm precipitation change small streams to wild rivers and cause significant property damage. Therefore, in this paper, we devote to the expected forecast of the air temperature and precipitation development. The simulation of these two meteorological elements for the meteorological station of Slovak Hydrometeorolocical Institute (SHI) Kuchyňa on Záhorie was made by the CGCM 3.1 model for two scenarios - pessimistic A2 and optimistic B1. Differences between each scenario are significant at the end of 21st century. Generally, it can be state that with the rise of air temperature can increase also precipitation.

Keywords: climate change, precipitation, air temperature, modeling

Introduction

People may feel the climate change particularly in relation to air temperature and precipitation. Hot summer days in the absence of precipitation and successive torrential rains are repeated more frequently. That is why experts try to create prognosis for development of the meteorological elements in order to adapt to incoming changes. At present many workplaces in the world are working on the Global Circulation Models (GCMs), which provide climatic scenarios of various climatic parameters (Stehlová and Štekauerová, 2008). In the prognosis for development of meteorological elements we used a Coupled Global Climate Model (CGCM) 3.1.

Materials and methods

Mathematical model CGCM 3.1 is the latest version of the Canadian related model of the atmosphere and ocean circulation. The model uses heat and water flux adjustments obtained from uncoupled ocean and atmosphere model runs (of 10 years and 4000 years duration respectively), followed by an 'adaption' procedure in which the flux adjustment fields are modified by a 14 year integration of the coupled model. A multi-century control simulation with the coupled model has been performed using the present-day CO_2 concentration to evaluate the stability of the coupled model's climate, and to compare the modelled climate and its variability to that observed (Environment Canada, 2010). This is the first version of scenario based on CGCM 3.1 in Slovakia, which have not probably changed. Daily precipitation scenarios were constructed approximately by the methodology given in work for example Lapin et al. (2006). Reference range values were daily precipitation and daily average air temperature in the period 1961 – 1990 measured at meteorological station SHI Kuchyňa – Nový Dvor in Slovakia. Scenarios are calculated as the quotient of the average in the period to average in the period 1961 – 1990. By the regional modifications were used emission scenarios A2 and B1. Scenario A2 corresponds to the idea of a very heterogeneous world. The basic idea is to

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rely on them and to preserve local identity, respect local traditions. Population in the 21st century, continuously growing, economic development is strongly regional oriented, technological change and growth in gross domestic product is considerably slower than other group of scenarios. Scenario B1 corresponds to the idea of convergence world, population on Earth will reach its peak in the mid-21st century and then begins to decrease, rapid development of informatics, services, loading of clean and efficient technologies, reducing material intensity. The emphasis is on global solving of economic and social problems, environmental protection (Melo, 2004).
Using the CGCM 3.1 model was made the simulation of the average daily air temperature and daily precipitation for the station SHI Kuchyňa for the period 1961 – 2100 for both emission scenarios A2 and B1. Whereas as the reference period was selected thirty years 1961 – 1990, simulated data were also divided into three time horizons 2010, 2030 and 2075, which represents a thirty-year periods: 1996 – 2025, 2016 – 2045 and 2061 – 2090, which were compared.

Results and discussion

Used scenarios don’t represent the prediction of the given element on a given day, month and year, but have the same average total and approximately equal abundance in different intervals of occurrence. We decided to compare the measured and simulated average monthly values of the air temperature and precipitation for the period 1961 – 1990 (*Figure 1*), which we calculated from daily data.

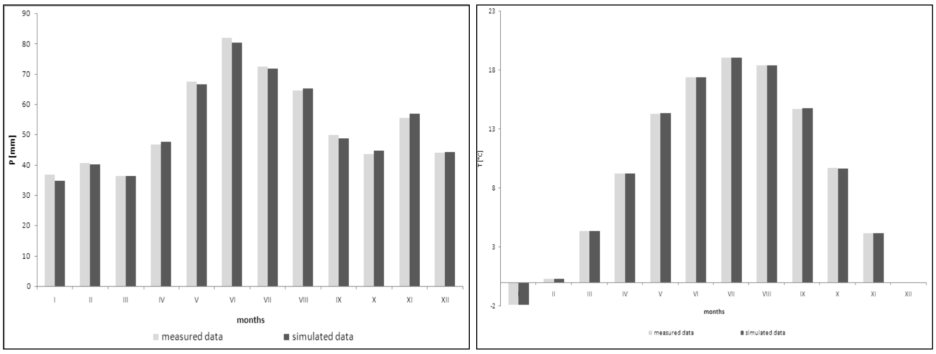

Figure 1. Comparison of average monthly precipitation (P) and air temperature (T) calculated from the measured and simulated data for the period 1961 – 1990 for the station SHI Kuchyňa

By comparison of measured and simulated average monthly values of air temperature in Kuchyňa station, we found that the biggest differences February (*Table 1*) - around 3 °C. The exception is the time horizon 2075 in a pessimistic scenario A2, where the biggest difference 4.63 °C was found in April.

Table 1. Differences in the measured and the simulated average monthly values of **air temperature** in time horizons 2010, 2030 and 2075 for the reference period 1961 – 1990 and the station Kuchyňa

	Air temperature (T)						
	1961-1990	1996-2025		2016-2045		2061-2090	
	measured data	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**
Unit	[°C]	[°C]		[°C]		[°C]	
Month		difference		difference		difference	
I	-1.87	2.93	2.09	2.68	2.35	4.12	3.12
II	0.31	3.30	3.11	3.02	3.28	4.57	3.78
III	4.38	2.12	1.54	2.31	2.54	3.88	2.57
IV	9.25	1.33	1.38	2.83	2.42	4.63	3.14
V	14.32	0.47	0.91	1.46	1.72	3.11	1.99
VI	17.39	1.87	0.80	2.07	1.51	2.99	2.29
VII	19.06	0.46	0.55	1.30	1.25	2.54	1.50
VIII	18.44	0.65	0.82	1.39	1.09	3.35	2.00
IX	14.74	1.11	0.83	1.65	1.56	3.00	2.17
X	9.70	1.43	0.97	1.65	1.66	3.34	2.50
XI	4.19	0.62	0.91	0.65	1.71	3.45	2.45
XII	0.02	0.70	0.59	1.15	1.28	3.51	2.78

Detailed numerical expression of precipitation differences in both scenarios to the real measured data from the period 1961 – 1990 provides Table 2. There are differences in the each scenario and observed time horizons. The maximum difference 31.68 mm between the simulated and measured average monthly precipitation should occur in the time horizon 2075 in November according to optimistic scenario B1. The biggest differences according to both scenarios are predicted in the last time horizon 2075.

Table 2. Average annual precipitation total and differences in the measured and the simulated average monthly values of **precipitation** in time horizons 2010, 2030 and 2075 for the reference period 1961 – 1990 and the station Kuchyňa

	Precipitation (P)						
	1961-1990	1996-2025		2016-2045		2061-2090	
	measured data	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**
Unit	[mm]	[mm]		[mm]		[mm]	
Precipitation total	**641.34**	**668.86**	**737.63**	**728.74**	**721.13**	**845.33**	**814.79**
Month		difference		difference		difference	
I	36.95	3.02	1.88	11.62	-1.04	19.62	29.18
II	40.63	-0.75	-5.70	4.65	-5.77	13.85	3.58
III	36.50	12.48	11.86	11.58	10.35	27.00	20.72
IV	46.77	6.63	12.34	19.91	8.56	22.62	18.68
V	67.56	7.17	15.70	13.56	19.71	29.05	24.55
VI	82.12	4.28	2.97	14.58	-2.63	19.10	3.02
VII	72.57	9.63	15.43	6.22	5.39	-4.84	0.53
VIII	64.69	-15.21	-1.64	-17.95	-8.33	-12.40	-9.60
IX	50.06	-3.01	19.29	13.92	23.61	22.16	24.01
X	43.62	-0.53	0.92	-2.34	-1.23	12.23	14.90
XI	55.72	1.94	17.91	9.97	22.39	28.56	31.68
XII	44.15	1.88	5.33	1.69	8.80	27.06	12.23

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Outputs of model document an increase of the average annual precipitation total in time horizons. There is more precipitation in pessimistic scenario (A2), only the 2010 time horizon predicts more precipitation in the scenario B1.

Conclusions

In this paper we dealt with impacts of climate change on the course of two meteorological elements, namely air temperature and precipitation in the area of Kuchyňa in Záhorie region in Slovakia. We wanted to point out differences between two scenarios, but also to compare the scenario outputs with the measured data of reference period 1961 – 1990. Outputs from global climate model CGCM 3.1 document the increase of air temperature and precipitation in the future in site. Depending on the human behaviour the air temperature can increase over 3 to 4 °C at the end of the century (more in A2 scenario, except a 2025 time horizon). Outputs from the model also present the increase of monthly precipitation total to the end of the century, but there are some months (especially August in all simulated periods) when simulated precipitation decreases. According to both scenarios the average annual precipitation total increases mainly in second half of century.

Prognosis of development of meteorological elements doesn't need be exact, but it is important in view of preparedness of population, whether on the flood or the extreme dry periods in the future.

Acknowledgements

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TRENDS IN WATER RESOURCES QUALITY REGARDING TO AGRO-ECOSYTEM ALONG GABČÍKOVO – TOPOĽNÍKY CHANNEL

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Abstract: Groundwater (GW) and surface water (SW) are two interrelated components of the hydrological cycle and changes on either of these components will certainly affect the quantity or quality of the other. In this study the interaction between GW and SW, along the Gabčíkovo – Topoľníky Channel, as green water resources was investigated and the trends of the quality of GW-SW system were analyzed. The study area lies at the Danube Lowland in the east half of the Rye Island (Žitný Ostrov), which is one of the most productive agricultural areas of Slovakia. For this reason it is very important to deal with the quality of water resources at this region and their impact on biomass production and soil salinization. In the analysis several indicators of water quality (e.g. pH, NH_4^+, Cl^-, NO^{2-}, NO^{3-}, SO_4^{2-}) for selected time period according to the available data were examined. The results of this study can be taken as basis information for further research in this area, e.g. as input data to integrated surface-subsurface numerical models linked to the agro-ecosystem.

Keywords: water resources quality, groundwater – surface water system, agro-ecosystem

Introduction

Water is one of the most important natural resources, it is essential for drinking water supply, industry, and also for biomass production and agriculture. In Slovakia, groundwater is the dominant resource of drinking water, therefore it is very important to save and care about its quality. In this paper the interaction between GW and SW regarding to the agro-ecosystem and the trends in water resources quality in the locality of the Gabčíkovo-Topoľníky Channel was analyzed. The study area lies at the Danube Lowland in the east half of the Rye Island (Žitný Ostrov), which is one of the most productive agricultural areas of Slovakia. Its average slope is about $2{,}5.10^{-4}$ and there was one of the reasons for building channel network there (as a drainage system). Gabčíkovo-Topoľníky channel is one of the largest channels of this network. Its length is about 30 km, channel width ranges from 8 m to 17 m. The Rye Island is the biggest river island in Europe, with an area of almost 1900 km^2. Under its surface is the richest water reservoir of Slovakia and also of Eastern Europe: according to the Water Management Balance (WRI, 2005) there are 10 milliard m^3 of drinking water, what means $18m^3.s^{-1}$ of available groundwater resources. For this reason it is very important to deal with quantity and quality of water resources at this region and their impact on biomass production. In the past years many studies were dealing with this topic in this area, e.g. Dulovičová and Velísková, 2010; Onderka et al., 2008; Baroková and Šoltész, 2011. As Rye Island is one of the most productive agricultural areas of Slovakia, several works were devoted to the monitoring of soils and soil water regime in this locality, e.g. Kováčová, 2007; Štekauerová et al., 2009.

As under the Rye Island there are extensive supplies of groundwater, its whole territory is a protected water management area, so the application of nitrogenous fertilizers is strictly limited by law. On the other hand, fertilizers are the substance containing nutrients nourishing plants, maintaining or improving soil fertility and positively affecting the yield or quality of production. During the years of intensive socialist

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agriculture, the amounts of commercial fertilizers applied in the Slovak Republic were gradually growing. They reached their peak in the late 1980s and early 1990s (250 kg of pure nutrients/ha). Upon the changes taking place after 1989 in the agricultural sector (land restitutions, price increase, intensification decrease, legislation measures), the consumption of commercial fertilizers in agriculture fell significantly. During 1990-2000, the consumption of nitrogenous fertilizers dropped by more than 60% (-58 kg p.n./ha), the consumption of phosphate fertilizers fell by 89% (-61,7 kg p.n./ha) during that period and the consumption of potash fertilizers fell by 92.5 % (-73.2 kg p.n./ha). Since 2000, moderate increase in fertilization has been observed again (www.enviroportal.sk). On *Figure 1* the fertilizers consumption in Slovakia between years 1990-2009 is presented.

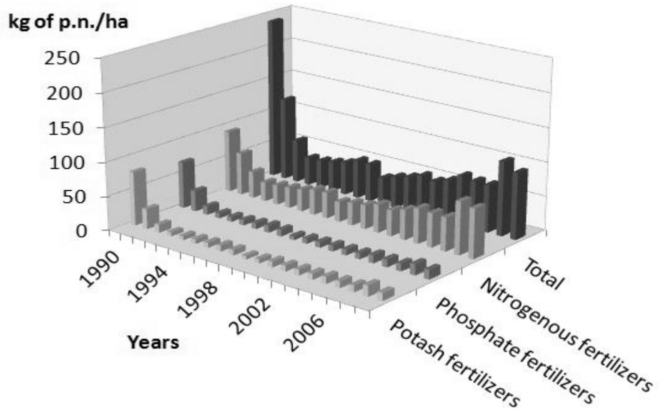

Figure 1. Fertilizers consumption in Slovakia between years 1990-2009

Materials and methods

The quality of SW and GW was evaluated separately in this study. The quality analysis of GW and SW resources along Gabčíkovo-Topoľníky Channel was performed by using data from the monitoring network of the SHMI. Other data were obtained from Reports on water management in the Slovak Republic and State of the Environment Reports of the Slovak Republic published by the Slovak Environmental Agency. Some of them are from own field measurements or from monitoring data of IH SAS. For the preparing and evaluation of the data, standard statistical methods were applied.

Results and discussion

After the collection of data, the trends in GW and SW quality as green water resources were analyzed. Several indicators of water quality (pH, NH_4^+, Cl^-, NO_2^-, NO_3^-, SO_4^{2-}) along Gabčíkovo-Topoľníky Channel were examined. The samples of SW were taken in the profile Kutniky and the samples of GW were taken from five drill holes around this locality. Water quality data were available from the period 1991-2006; indicators NH_4^+, NO^{2-}, NO^{3-} in SW were available from 1993-2006. The frequency of water sampling was variable. Generally, SW samples were taken once a month; GW samples were taken two times per year, but in one of the drill holes monthly sampling was provided. As the samples were taken on different dates and with various intervals, it was not possible to make direct comparison between the indicators of water quality. Instead of that, basic statistics and the trends of these indicators were compared.

In *Table 1* the minimum, maximum and average values of selected indicators of SW and GW quality are shown. The values of pH are comparable in both of the analyzed water resources, even though in the case of maximum, value in SW is softly higher than in GW. On the other hand, in the case of minimum, pH value in SW is softly lower than in GW. It means that oscillation of these indicator values has wider range in SW than in GW. The average amounts of NH_4^+, Cl^-, NO_2^- and NO_3^- in SW are generally higher than in the GW, except SO_4^{2-} that is higher in GW. Generally, the variation of all the quality indicators during the year shows lower values in the summer seasons.

Table 1. Water quality indicators in SW and GW along Gabcikovo-Topolniky Channel

		Kutniky SW	Vrakun 1 GW	Vrakun 3 GW	Vrakun 4 GW	Mliecany 1 GW	Mliecany 4 GW	GW Total
pH [-]	average	7,79	7,76	7,73	7,71	7,59	7,42	7,64
	min	6,10	7,49	7,45	7,00	7,01	6,75	6,75
	max	8,40	7,91	7,97	7,91	7,90	7,70	7,97
NH_4^+ [mg.l^{-1}]	average	0,42	0,07	0,08	0,14	0,07	0,07	0,08
	min	0,01	0,01	0,01	0,01	0,001	0,001	0,001
	max	1,96	0,43	0,53	0,55	1,26	0,44	1,26
Cl^- [mg.l^{-1}]	average	31,60	6,40	8,97	27,30	17,80	33,08	18,71
	min	13,70	3,45	5,65	15,91	10,50	20,34	3,45
	max	60,80	17,70	19,50	40,90	28,78	83,72	83,72
NO_2^- [mg.l^{-1}]	average	0,27	0,02	0,02	0,02	0,01	0,03	0,02
	min	0,02	0,01	0,00	0,005	0,005	0,005	0,005
	max	1,23	0,06	0,06	0,05	0,20	0,36	0,36
NO_3^- [mg.l^{-1}]	average	10,87	1,99	1,83	1,03	12,69	30,78	9,66
	min	1,99	0,01	0,01	0,005	1,60	16,30	0,01
	max	24,30	5,40	20,50	2,50	30,70	48,00	48,00
SO_4^{2-} [mg.l^{-1}]	average	55,69	19,27	33,33	134,39	58,94	110,87	71,36
	min	32,20	3,79	19,20	76,80	34,60	53,80	3,79
	max	99,20	50,00	99,60	200,00	129,08	327,30	327,30

The trends in water resources quality during the study period can be summarized as follows: indicators pH, NH_4^+, Cl^- and NO_2^- in the samples of SW has a descending trend, while NO_3^- and SO_4^{2-} has an ascending trend. In two of the GW sampling wells all the examined indicators have similar trends as in the samples of SW. In three of the sampling wells some of the indicators (pH, Cl^- and NO^{3-}) had diverse trend as in the case of SW. In general, the results of the analysis of the indicators of GW quality are comparable to those that showed up in the SW. On *Figure 2* an example of NO_3^- amounts in SW and GW during the study period are shown in comparison to the nitrogenous fertilizers consumption in Slovakia. As can be seen, the course of NO_3^- amounts in SW and GW is similar. The indicators has increasing and almost parallel trend in both water resources. The trend of the fertilizers consumption is also increasing, but the trendline is steeper.

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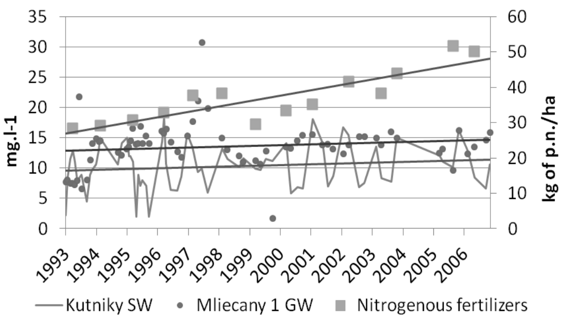

Figure 2. Example of comparison of NO_3^- amounts in SW and GW to nitrogenous fertilizers in Slovakia

Conclusions

In this study the interaction between GW and SW, along the Gabčíkovo – Topoľníky Channel, as green water resources was investigated and the trends of the quality of GW-SW system were analyzed. It was shown, that the variation of all the quality indicators during the year has lower values in the summer seasons. In general, the results of the quality data analysis of GW are comparable to those that occurred in the SW. The results of this study can be taken as basis information for further research in this area, e.g. as input data to integrated surface-subsurface numerical models linked to hydrological problems of the agro-ecosystem.

Acknowledgements

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SYSTEMS

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WATER AS A TRANSFER MEDIUM OF AGRO-ECOTOXIC SUBSTANCES

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Abstract: Toxic substances of agricultural origin may be transferred by polluted water into the food chain, and toxins may be dissolved in agricultural liquid products. Toxin containing products may cause health hazard. A quantitative and complex *in vitro* biotesting system proposed by us is based on the detection of changes in biophysical parameters of the living tissue as biosensor that enable to model pathologic processes and can reveal functional impairment caused by toxin exposure in different organs in an early, reversible stage. The effect of methylmercury on rat brain slices will be demonstrated.

Keywords: polluted water, biotesting system, rat brain slices, heavy metal, methylmercury

Introduction

Waters in urban and non-urban areas are vulnerable to contamination by pesticides, mycotoxins, heavy metals and other chemicals. Patterns in pollutant contents may vary depending on contaminants with different source inputs and processes of formation and degradation. Understanding the sources, fate, and quantity of chemicals in water, in conjunction with assessment of effects, not only forms the basis of risk characterization, but also provides critical information required to make regulatory decisions. Adequate assessment of potential risks for many contaminants in drinking water is currently limited by a paucity of toxicological information (Ritter et al., 2002). For example, mycotoxins have been investigated in food and feed products for decades but rarely in the environment, especially in surface waters. These toxins, however, were detected e.g. in a number of rivers (Bucheli et al, 2008). Data suggest that the greatest agro-ecological toxin concentrations (pesticides, mycotoxins and others) in water streams may be observed during spring snowmelt conditions (Kolpin et al., 2010). Toxic substances of agricultural origin may be transferred by polluted water into the food chain (mediated e. g. by fish), and toxins may be solved in agricultural liquid products like juices (Mateo et al., 2009). Pollutants directly or indirectly transferred by water may cause health hazard. For a sound risk assessment new approaches and methods are needed that may reveal and quantify health risks in case of long term low dose ecotoxin expositions. Biosensors based on recording of biophysical parameters of living tissues in order to detect harmful changes caused by toxic agents can create useful biotesting tools. The biotesting tools proposed by us is a complex *in vitro* monitoring system. The usefulness of the *in vitro* biosensor testing tools will be demonstrated revealing the effect of methylmercury salts (MeHg) on brain slices of pre- and postnatally treated rats. MeHg is a prominent environmental neurotoxicant, which targets primarily the central nervous system. In the aquatic environment, MeHg is accumulated in fish, which represent a major source of human exposure (Farina et al., 2011). Exposure on developing brains remain a major health risk because human exposure to MeHg today is primarily through consumption of MeHg-contaminated fish and seafood. Adverse health effects are increasingly associated with adult chronic low-level MeHg exposure.

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Materials and methods

The effect of MeHg-chloride on the excitability of developing cortical neurons was tested. MeHg-chloride was administered in the drinking water (0,375 mg/kgbw/day) to pregnant rats during gestation and suckling period and the offspring were investigated. Some of the treated animals were grown up without any further MeHg-chloride application, and their offspring (second generation) were also studied. The biophysical characteristics of the neuronal membranes as well as the synaptic responses evoked by electrical stimulation of the corpus callosum were measured in brain slices, according to methods in paper Világi et al. (1996). Slices prepared from the somatosensory cortex of 4-week-old rats (8 in each group) were analyzed using sharp electrode intracellular micro-electrophysiological recording technique.

Results and discussion

A quantitative and complex *in vitro* biotesting system was worked out. The proposed testing system is based on the detection of changes in biophysical parameters of the *in vitro* surviving tissue as biosensor that enables to model pathologic processes and can reveal functional impairment caused by toxin exposure in an early, reversible stage. The proposed electrophysical biotesting methods may be applied in different exposition paradigms, and model different processes of physiology and pathology.

Processes for biotesing

Testing of basic excitability of nervous tissue (changes in biophysical parameters of evoked biopotentials);
Modelling of pathologic processes (development of epileptiform seizure activity)
Multitoxic effects (simultaneous exposition to more toxins)
Changes in plasticity processes (modification of short term- or long-term synaptic activity)

Biotesting of different exposition schemes

Effects of low dose, long-term exposition to toxins
Anomalies of developing nervous system caused by toxin exposition of pregnant rat
Monitoring of changes in several generations after toxin exposition
Accidental model: effect of high dose acute exposition

The highlighted processes were analyzed and exposition schemes were applied in the MeHg-chloride experiments.

Long-lasting treatment with low doses of MeHg-chloride caused a slight 6% decrease in the resting membrane potential and 13% decrease in the amplitude of spikes together with an enhanced excitability. Threshold voltages necessary to evoke spikes and excitatory postsynaptic potentials (EPSPs) decreased by 15% (*Figure 1.*, *Table 1.*).

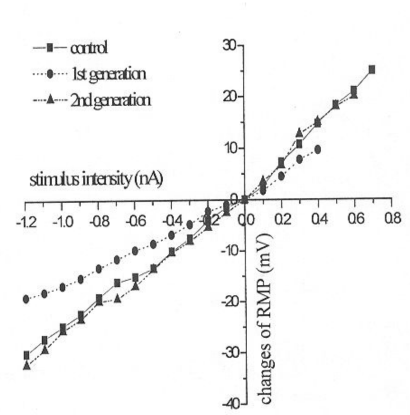

Figure 1. Resting membrane potentials (RMP) in the first and second generation rat cortex slices after prenatal and postnatal MeHg-chloride exposition

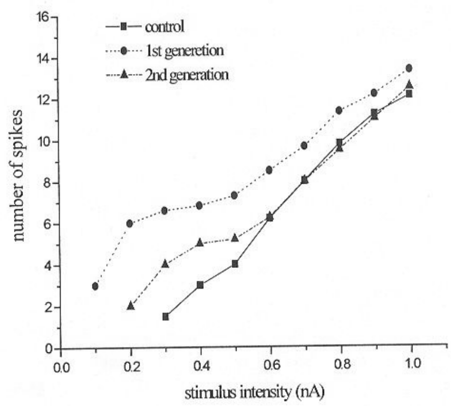

Figure 2. Spike numbers in the first and second generation rat cortex slices after prenatal and postnatal MeHg-chloride exposition

Stimulation with the same intensity evoked more spikes in MeHg-treated rats than in controls (*Figure 2., Table 1.*). These changes indicated a higher neuronal excitability following MeHg-chloride exposure. The altered membrane characteristics in the 4-week-old MeHg-chloride treated animals might be the consequence of the abnormal developmental processes taking place in the presence of MeHg-chloride which may alter the biophysical parameters and thus the normal neuronal excitability. Besides this, the acute toxic effect of Hg^{2+}, which was present in the brain at the time of investigations, has to be taken into consideration. The untreated offspring (second generation) had normal neuronal characteristics.

Changes in biophysical parameters (resting membrane potentials, spike amplitudes, resistance, spike numbers, EPSP threshold and spike threshold) were summarized in *Table 1*. Significant changes in highlighted line are signed with asterisks.

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Table 1. Biophysical parameters of first and second generation rat cortex slices after prenatal MeHg-chloride exposition

	Resting potential (mV)	Spike amplitude (mV)	R_{in} (Mohm) (-0.4 nA)	Spike number (+0.8 nA)	EPSP threshold (V)	Spike threshold (V)
Control	73.2±3.7	92±5.8	25.5±1.1	10.0±1.78	4.1±0.8	6.6±2.7
First generation	69.2±4.3	80±6.2 *	19.7±2.8 *	12.8±2.45 *	3.5±0.3	5.4±0.6 *
Second generation	74.6±1.0	87±4.4	25.4±3.6	9.5±0.6	3.9±0.8	6.1±0.6

Conclusions

A quantitative and complex *in vitro* biotesting system proposed by us is based on the detection of changes in biophysical parameters of the living brain tissue as biosensor that enable to model pathologic processes and can reveal functional impairment caused by toxic agro-chemical agent exposure in nervous system in an early, reversible stage. It is impossible to keep the toxins of environmental origin completely out, but it is possible to reveal the harmful mechanisms for an effective risk characterization. The harmful effect of ecotoxic MeHg on rat brain slices – as *in vitro* surviving, biotesting living tissue – was demonstrated. Quantified functional changes of biophysical parameters were measured and underlying mechanisms were revealed after exposition to the ecotoxic compound. Modification of bioelectric properties and parameters as biomarkers may characterize adverse effects of MeHg or other chemicals transferred by aqueous media. Our *in vitro* biotesting methods may more directly assess and quantify developmental neurotoxicity. The ecotoxicological effects of long-term, low-level exposures to different dissolved agrotoxic agents or mixtures of agrochemicals are yet poorly understood and have to be further investigated. Our new approach can provide data for an effective risk assessment of food-borne diseases or diseases of environmental origin.

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THE ROLE OF MICRORELIEF MEASUREMENTS IN PRECISION AGRICULTURE

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Abstract: Micro relief measurements are providing information on the small scale differences concerning relief within field. Precision agriculture measurements nowadays can be carried out by sub-inch accuracy, therefore micro relief measurements have provided accurate information on the surface of our experimental research field near Mosonmagyaróvár, Hungary. Within field differences on yield permanently appears in the experimental field. Yield is determined by various factors, such as nutrient replenishment, soil chemical and physical properties etc. Subsurface water resources such as soil moisture and groundwater or in other words inorganic green water and its regime have also significant role on yield. Available water for the vegetation – being "blue" or "green" – therefore determines the success of plant production. Surface of the cultivated field in every case has differences in height above the sea level being large or small, as plain agricultural field does not exist. High accuracy micro relief measurements provided additional data for the existing geographical information system (GIS). Comparing the three dimensional (3D) surface map with the experimental on-field measurements such as plant height differences during the vegetation period, maize grain yield and moisture content at the time of harvest showed that micro relief measurement play a significant role in precision (site-specific) agriculture. Data about the surface with this accuracy also helps to understand the subsurface water regime of the cultivated fields.

Keywords: micro relief, water regime, green water, precision agriculture, GPS

Introduction

Micro relief – which means irregularity of the land surface, causes variations in elevation. During plant production process tillage induces soil elevation differences, which causes variations on soil surface storage capacity (Planchon et al., 2002). Within field differences such as soil chemical and physical parameters highly affects the successfulness of plant production. A relatively new approach in plant production practice called precision or site specific agriculture focuses on these differences in order to treat the variability on small scale. Different measurements on diversity in soil parameters such as tillage force (Neményi et al., 2006), soil moisture (Milics et al., 2006) or soil electrical conductivity (Milics et al. 2011) proved that even in a relatively small agricultural land, large differences can occur in soil properties, therefore in yield. Yield is also influenced by external factors such as precipitation (Balla et al., 2011) and fertilizer – mainly nitrogen – supply (Kovács et al., 2011). Fertilization modifies yield, at the same time it is one of the most crucial economic question of precision plant production (Sulyok et al., 2011; Takácsné György, 2011).

Yield is influenced by soil properties, on the other hand improper cropping pattern and agrotechnics as parts of the irrational land use practices seriously affects the soil formation and processes (Várallyay, 2010). Soil moisture as an important source of water is crucial for plants, however in case of improper agrotechnics micro relief differences can cause local and spatial water redundancy, which affects yield on the local scale.

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Materials and methods

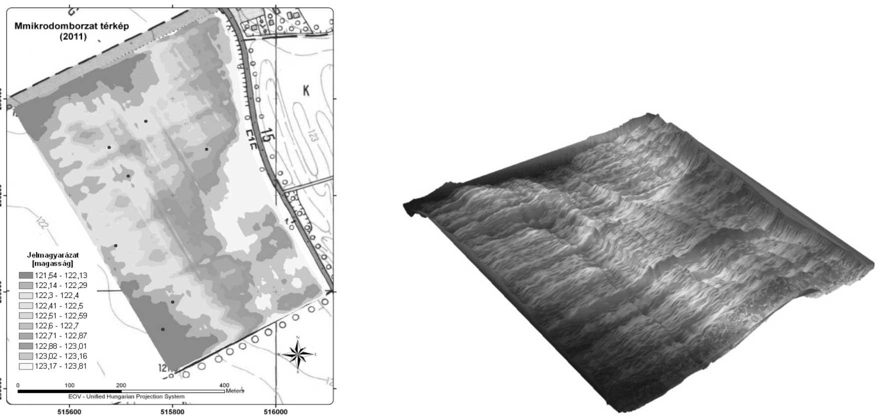
The experimental site, where the research was carried out is located near Mosonmagyaróvár, Hungary. It belongs to the Institute of Biosystems Engineering, Faculty of Agricultural and Food Sciences, University of West Hungary. The experimental site is situated in a 23.52 hectares large agricultural field on which precision agriculture has been applied since 2001. The MEPAR (Agricultural Parcel Identification System) code of the field is K2XEW-8-08.

The area is an agricultural alluvial plain of the Leitha River. The field can not be characterized by one soil profile, as a buried riverbed (former Leitha) crosses it. The humus content in the upper 20 cm layer is between 1,4-2,8% in this alluvial soil.

Micro relief measurements were carried out in 2011.04.19. High accuracy RTK GPS data were collected in order to receive precise information about the surface of the investigated field. Number of total collected data was 29039. At the same time volumetric soil moisture content was measured by means of TDR-300 equipped with 20 cm rods, DGPS system was used in this case. Total number of data was 643. Micro relief map and volumetric water content map was created by means of IDW interpolation (Morschhauser and Milics, 2009) using ArcGIS/ArcMAP 9.2 software. Samples in order to measure soil moisture content by gravimetric method were also collected on the same day, location data was collected by handheld GPS. On 2011.06.17 during a survey, heights of maize were measured, especially in areas where extreme low plants occurred. Yield measurements were carried out by means of precision (site-specific) data collection system (AgLeader Technology), therefore spatially accurate information was collected from all measurable data.

Results and discussion

High accuracy height measurements provided data for creating micro relief map of the investigated field (*Figure 1.*).



a, *b,*

Figure 1. a, Micro relief map; *b*, Three dimensional map of the micro relief

Volumetric soil moisture data measured in field circumstances and soil moisture content measured in laboratory drying chamber showed high correlation (R^2=0.89; n=24).

In the field level relief and volumetric soil moisture content data showed weak correlation (R^2=0.38; n=235159). This is due to the difference of number of samples collected by on-line and off-line methods as well as interpolation. Subsurface soil parameter differences also caused uncertainty in the whole field. Due to the buried river bed (former Leitha River) crossing the investigated field different soil types can be found here, therefore in some areas micro scale basins caused depression in values of soil moisture, yield and electrical conductivity, however in some cases the effect was the opposite (*Figure 2.*). A slope in the field also influences the data.

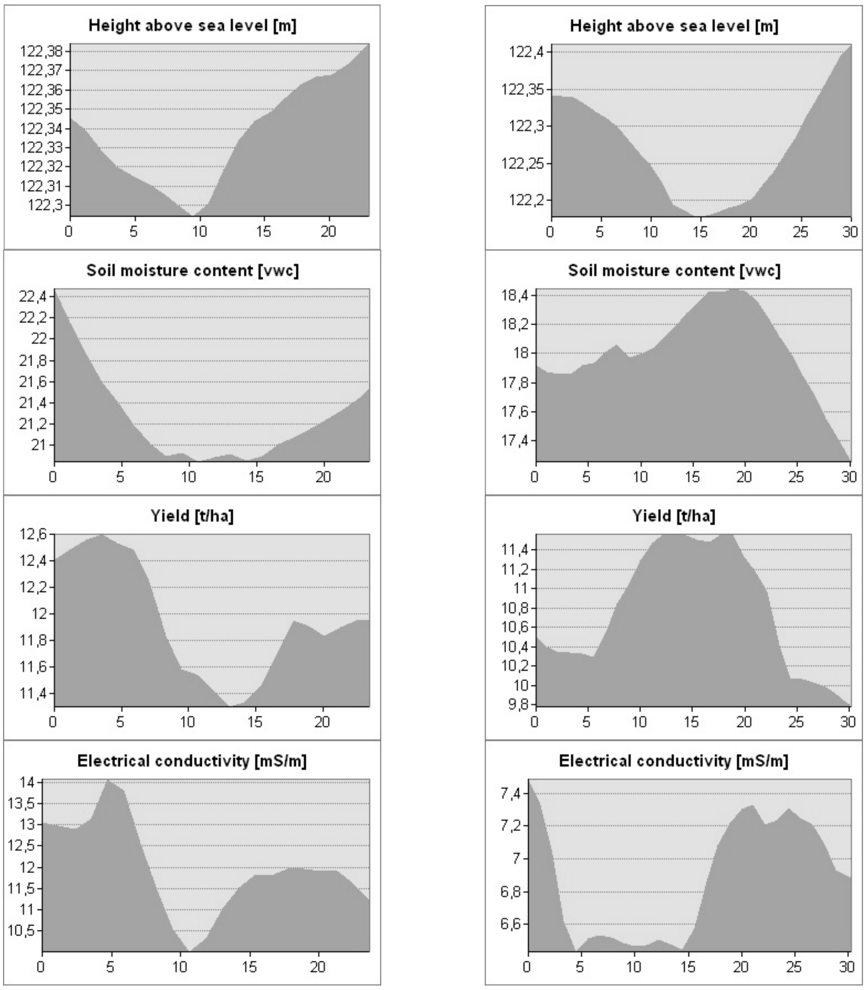


Figure 2. Cross section of two choosen area showing different measured values

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Conclusions

Micro relief measurements can be carried out relatively easily in precision agriculture with a high accuracy RTK GPS system. The local micro scale endorheic basins in unfavourable precipitation conditions can collect relatively large amount of water, therefore pressure on plants will cause hold on their growth. Depending on the subsurface soil properties this effect can be favourable and result higher yield than yield of the surrounding area. Direction of tillage could be also visualized on the micro relief map where micro scale runoff channels visible on the whole field. Micro relief map visualized the differences appearing in the field concerning elevation. Further research, however is needed in order to understand the effects that micro relief differences cause in precision agriculture and in green water regime.

Acknowledgements

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THE EFFECT OF WATER SUPPLY ON THE NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

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Abstract: The plant chlorophyll content is in close correlation with the level of nitrogen supply of plants; therefore, nitrogen need and the nitrogen rate to be applied can be determined by the indirect measurement of chlorophyll content. The leaf chlorophyll content can be easily measured indirectly by using non-destructive, optical measurement tools that express the relative chlorophyll content in indexes. Normalized Difference Vegetation Index (NDVI) is also an index like this, which is calculated on the basis of the intensity of red and infrared rays reflecting from the surface of plants.
During our examinations, we analyzed the effect of water supply on the value of NDVI in sweet maize populations. Based on our results, we concluded that NDVI increased in parallel with the growth of sweet maize, independently of the extent of water supply. The NDVI values of maize populations with different water supply significantly differed from each other and the largest difference was observed at the 9-10-leaf stage. Our results showed that the extent of water supply of plants affects the measured NDVI value; therefore, during the determination of nitrogen need on the basis of NDVI values, it is also important to consider the differences between NDVI and water supply.

Keywords: Normalized Difference Vegetation Index (NDVI), water supply, chlorophyll content

Introduction

The quantity of the chlorophyll molecules which play a role in the photosynthetic apparatus make it possible to conclude to the physiological and overall crop conditions (Carter, 1994). This quantity can be easily measured with non-destructive, optical measurement devices (Hong et al., 2006). Optical measurements are based on the principle that chlorophyll molecules absorb red rays of light, while they transmit infrared rays. Therefore, based on the intensity of rays transmitted or reflected from leaves, it is possible to create indexes that are in close correlation with the chlorophyll content of leaves (Plant, 2001; Zhang et al., 2009).
The Normalized Difference Vegetation Index is a widely used index without dimension that expresses the photosynthetic activity of a given area. The value of the NDVI is determined as the ratio of the difference and sum of the intensities reflected by the vegetation in the near infrared and the visible red radiation range (Roderick et al., 1996). NDVI is in close correlation with the chlorophyll content of the crop population, as well as its level of nitrogen supply and its yield (Teal et al., 2006; Cui et al., 2009; Gianguinto et al., 2011).
By performing the indirect measurement of the chlorophyll content, the level of nitrogen demand and the amount of nitrogen fertilizer to be applied can be determined (Freeman et al., 2007; Xiong et al., 2007). The water supply of crops significantly affects the photosynthetic activity and chlorophyll content (Debreczeni, 1983; Shangguan et al., 2000; Bloch et al., 2006;). Based on our hypothesis, water supply has an influence on the NDVI value, too.

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Material and methods

The examinations were carried out in the show garden of the Horticultural Institute of the University of Debrecen on chernozem soil on 8.4 m^2 plots. Tests were done on 60 crops per plot, using three sweet maize hybrids (GSS 1477, GSS 2259, Overland). During the treatments, three replications were applied per hybrid. Sowing was carried out 6 cm deep with a sowing gun on 19/05/2011, row spacing was 70 cm and plant-to-plant distance was 20 cm. Harvesting took place between 16-18/08/2011 in accordance with the heat sum demand of the hybrids.

In the different water supply treatments, the quantity of the applied irrigation water was determined on the basis of the daily data of weather stations located in the test area. In the 'irrigation 1' treatment, the amount of replenished water was determined as the evapotranspirational loss estimated on the basis the Shuttleworth-Wallace method (1985), while in the 'irrigation 2' treatment, only half of this amount was applied with dripping irrigation.

The relative chlorophyll content of the foliage was measured with the *GreenSeeker Model 505* meter. This device expresses the relative chlorophyll content of the foliage in NDVI values which is calculated on the basis of the reflectance of 660 nm wavelength rays, using infrared light (770 nm) as reference (NTech Industries Inc., 2007).

The difference between treatments were evaluated with one-way ANOVA, using Duncan's or Games-Howell simultaneous mean value comparison tests as a supplement, depending on wheter the Levene's test showed the identity or difference of the variance of the examined variables. The average difference was expressed in percentage in all cases: $MD_{(\%)} = \sum[(M_x – M_y)/(M_y/100)]$, where $MD_{(\%)}$ = mean difference, M_x = mean of results measured in the x treatment, M_y = mean of results measured in the y treatment.

Results and discussion

Based on the measurement results, it was established that the NDVI value significantly changed depending on the level of water supply. The difference between treatments was the most expressed at the 9-10-leaf stage, since the mean difference (MD%) was the highest at this stage of development. The full irrigation dose (Irrigation 1) resulted in significantly higher NDVI values at all three development stages in comparison with the non-irrigated populations, while the half dose (Irrigation 2) resulted in the significant increase of the NDVI value only at the 6-7 and 9-10-leaf stage *(Table 1.).*

Table 1. Changes of NDVI values at different development stages per treatment

	6-7-leaf		9-10-leaf		13-15-leaf	
Non-irrigated	0,491	B	0,681	C	0,791	B
Irrigation 2	0,526	A	0,769	B	0,791	B
Irrigation 1	0,530	A	0,803	A	0,815	A
F value	3,2*		97,2***		8,8***	
MD%	5,3		11,7		2,0	

***p<0.001, *p<0.05; MD% - mean difference

The effect of water supply on the NDVI values was shown to be different in the case of the different hybrids. The full irrigation dose (Irrigation 1) resulted in significantly higher NDVI values in the case of all three hybrids, while the half dose (Irrigation 2) resulted in significantly higher NDVI value only in the case of the OVERLAND hybrid in comparison with the non-irrigated treatment. Based on the mean difference (MD%), the difference between different treatments was the highest in the case of the GSS 2259 hybrid (*Table 2.*).

Table 2. Changes of NDVI values in the case of different hybrids per treatment

	GSS 1477		GSS 2259		OVERLAND	
Non-irrigated	0,663	B	0,658	B	0,643	B
Irrigation 2	0,682	AB	0,693	AB	0,710	A
Irrigation 1	0,708	A	0,716	A	0,725	A
F value	$2,3^{+}$		3,6*		7,2***	
MD%	4,5		5,8		5,1	

***p<0.001, *p<0.05, $^{+}$p<0,1; MD% - mean difference

NDVI values increased in parallel with the growth of sweet maize during the growing season. Based on the mean difference values, the difference in NDVI measured at the different stages of development was the most expressed in the non-irrigated treatment. In the non-irrigated populations there was a significant increase of NDVI at the 13-15-leaf stage, significant NDVI increase could only be observed until the 9-10-leaf stage in irrigated populations (*Table 3.*).

Table 3. Changes of NDVI values at different development stages per treatment

	Non-irrigated		Irrigation 2		Irrigation 1	
6-7-leaf	0,491	C	0,526	B	0,530	B
9-10-leaf	0,681	B	0,769	A	0,803	A
13-15-leaf	0,791	A	0,791	A	0,815	A
F value	341,6 ***		265,7***		433,0***	
MD%	38,7		33,2		35,5	

***p<0.001; MD% - mean difference

Conclusions

Based on the obtained results, it was established that water supply affects NDVI values and that the effect of water supply on NDVI values also depends on the genetic potential of the crop.

Based on these findings, it was concluded that it is practical to consider the correlations between the level of water supply and NDVI values in the determination of nitrogen need on the basis of NDVI values.

Acknowledgements

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THE ECOTOXICOLOGICAL EFFECTS OF DON TOXIN ON MAIZE GERMINATION

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Abstract: Globally, *Fusarium graminearum* (teleomorph *Gibberella zeae*) is an important plant pathogen that attacks a wide range of plant species, including many important crop plants such as maize (*Zea mays*). *F. graminearum* infection reduces both yield and quality of the maize. This fungi is capable to produce several mycotoxins, one of them, the most important is the deoxynivalenol (DON, vomitoxin). Biogas fermentation might be a potential method for the utilization of the infected maize as an alternative raw material. In our experiments *F. graminearum* (producing DON toxin) free and infected maize-grits have been added to the same raw material mixtures. Results showed that *Fusarium* can not be detected in the end product after 30 days mesophilic anaerobic digestion. The liquid end product of biogas fermentation can not be analyzed for DON toxin content by ELISA and HPLC methods. Therefore we carried out anaerobic hydrolysis model experiments for the DON toxin determination. In this publication the effect of DON toxin contaminated hydrolysed end-product on the germination of maize has been investigated in the case of the pot germination assays.

Keywords: biogas, *Fusarium graminearum*, deoxynivalenol, seed germination assay

Introduction

In the recent 30 years most crop losses are caused by *Fusarium* head blight and ear rot in the regions of the grain area (Hornok, 2001). *Fusarium graminearum* Schwabe (teleomorph: *Giberella zeae*/Schwein/Petch) is the most important pathogenic filamentous fungi (Kövics, 2000). Infections and symptoms of *Fusarium* can be observed in all developmental stages of maize (Del Fiore et al., 2010). The presence of fungi degrade the quality of the maize, they produce mycotoxins which has harmful effects on both livestock and human health (Eifler, 2011; Placinta et al., 1999). In our experiments *Fusarium graminearum* is selected, because this is the most important pathogen in Hungarian climate. The in vivo experiments have shown that one of the most common trichothecenes is the deoxynivalenol (DON, vomitoxin) (Szécsi, 1994). Alternatively, *Fusarium* and mycotoxin contaminated maize can act as a base material for biogas utilization. However, the toxin content should be examined in the fermentation end product. The advantage of pot germination is that the toxic effect is more visible in the seed germination and development of young plants, because pathogens cause developmental abnormalities or changes in the revenue of the crop (Radulescu and Negru, 1971). The toxic effect is indicated in the lack of germination, reduced seedlings or any change in growth (Gong et al., 1998; Nagy and Tamás, 2008).

Materials and methods

Because of the physical properties of the end product of biogas fermentation, DON toxin content can not be analyzed by analytical methods. Therefore we carried out anaerobic hydrolysis model experiments for the DON toxin determination. The anaerobic hydrolysis was made at mesophilic temperature (38 °C), for 4 days, in a half litre glass jar with gas bag in laboratory incubator shaker (Heidolph Unimax 1010). The experimental settings were the followings:

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- control: 250 ml sterile deionised water and 12.5 g of maize grits, and
- the test: 240 ml sterile deionised water, 12.5 g of maize grits and 10 ml *Fusarium graminearum* inoculum.

The medium was inoculated with 6.4 x 10^7 conidia of *F. graminearum*. Inoculum was carried out on Papavizas selective medium (pH 5.2) (Szécsi és Mesterházy, 1998) and we used *Fusarium graminearum* strain (NCAIM F.00970). The medium consisted of 15 g peptone (Biolab), 1 g KH_2PO_4 (VWR), 0.5 g $MgSO_4.5H_2O$ (VWR), 0.5 g bile salts (Biolab) 20 g agar (VWR), 0.5 g pentachloronitrobenzene (PCNB, Sigma), 50 mg chlortetracycline hydrochloride (AppliChem), 100 mg streptomycin sulfate (AppliChem) per liter. 250 ml of the medium was dispensed in a glass tube, inoculated with macroconidia of *Fusarium* and incubated with shaking (190 r.p.m.) at 25 °C for 7 days under aerobic conditions.

The deoxynivalenol concentration was determined from the maize and the hydrolyzed products at the Regional Biogas Plant Central Laboratory of Nyírbátor with enzyme-linked immunosorbent assay (ELISA) method. DON concentration was determined using the Ridascreen Fast R5902 DON ELISA kit (R-Biopharm Hungary Kft.) according to the manufacturer's instruction.

For each pot experiments, 1 kg quartz sands (Scharlab), LG 33.95 maize hybrids' seeds and the hydrolysed products were used. The infected and *Fusarium* free hydrolysed products were separated into two phases (suspension and liquid phase) with centrifuge (1500 g for 15 min). In this way 4 treatments were used in pot experiment. In the control case deionised water was used. We determined the optimal water quantities and every day it was corrected with sterile deionised water. The seeds were planted 3-4 cm deep (20 seeds per pot). The germination was at room temperature for 22 ± 2 °C, in all cases 6 days. After the germination time we measured the length of developed roots.

Results and discussion

Before the anaerobic hydrolysis we determined the cell number on the Papavizas medium. *Figure 1a* shows the macroconidia of *F. graminearum*. After the 4 days incubation period, we could not detect the presence of the mould. The macroconidia are not visible in the hydrolysed end-product, due to the enzymatic degradation of maize (*Figure 1b*). In the treatments, concentration of DON did not change in the control case (*Table 1*). Concerning the DON concentration there were no differences between treatments in the model experiments.

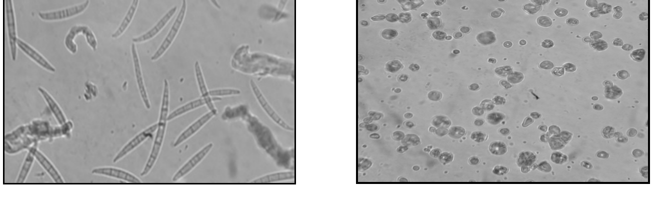

Figure 1. Microscopic view of *Fusarium graminearum* (40x) (a), and enzymatic degradation of maize (40x) (b)

Table 1. DON concentration (μg/kg)

Sample	DON toxin (μg/kg)
Input maize	1.08
Control liquid phase	1.05
Fusarium liquid phase	1.18

Regarding germination ability, more maize germinated in the control liquid phase, than in the control. In the case of the control suspension and the *Fusarium* liquid phase treatments the germination rate was the same as in the control. In case of *Fusarium* suspension 6% less seedlings was observed compared to the control (*Figure 2*).

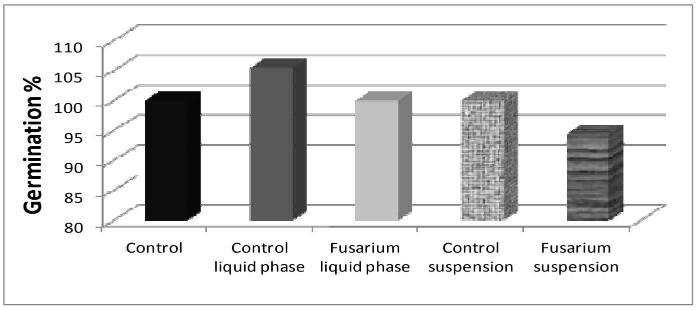

Figure 2. The effect of hydrolysis end-product on the germination

Based on the classification of the average root lengths (Németh, 1998) the control liquid phase and the suspension stimulated the germination of maize. The *Fusarium* suspension's effect was less significant. Due to the effect of *Fusarium* liquid phase, the root lengths were reduced, although this treatment is non-toxic based on the toxicological assessment category (*Table 2*). It is assumed that the higher content of DON toxin inhibits the germination.

Table 2. The qualification the average root length in the percentage of the control (%)

Sample name	The average root length in the percentage of the control (%)	Qualification
Control	100.0	non-toxic
Control suspension	142.1	stimulating
Fusarium suspension	122.0	stimulating
Control liquid phase	135.0	stimulating
Fusarium liquid phase	116.6	non-toxic

General statistic test and the variance analysis of Tukey were also carried out between treatments (*Table 3*). Significant difference was found between the control, and the control liquid phase, the control suspension. The reason for this is probably that the presence of nutrients, coming from maize grits. Significant differences were not determined among the infected and *Fusarium* free treatments. In summary, the results showed minimal inhibitory effect of DON toxin on the maize germination.

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Table 3. General statistics of root length in germination assays (cm)

Sample	Median	Modus	Mean	Standard deviation
Control	12.35	13.60	12.09 [a]	3.99
Control suspension	18.8	18	17.18 [b]	4.76
Fusarium suspension	14.00	14.70	14.75 [ab]	4.86
Control liquid phase	17.00	15.20	16.33 [b]	5.29
Fusarium liquid phase	13.45	15	14.10 [ab]	3.26

* the same alphabetical index signs no significant difference ($P < 0.05$)

Conclusions

Although the fungus destroyed in the biogas production, the DON toxin remained in the end-product and after utilization on lands the toxin can effect the germination of maize. The hydrolyzed product was observed to possess small inhibitory effect on germination in the case of *Fusarium* and DON-containing liquid phase. Further study is needed to identify the effect of DON toxin on the germination with germination tests using different concentrations of standard DON toxin. Since in this present study the *F. graminearum* was dead during the investigation, therefore other aerobic and anaerobic model biogas experiment should be tested on mesophilic and thermophilic conditions, in which the necessary nutrients are provided for the fungus by meat meal.

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IMPACT OF HYDROPHYSICAL SOIL PROPERTIES ON SOIL BIOLOGICAL ACTIVITY AND SUSTAINABILITY OF THE SOIL ECOSYSTEM

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Abstract: Soil is the largest potential water reservoir that is labeled as the green water and a shortage of water resources has become a major concern for sustainability procuration and soil protection. Biological element of the soil plays a key role in the soil ecosystem and its activity significantly contributes to improvement of the soil quality and health. Its activity is the result of a combination of the biotic, chemical and physical processes in the soil. The aim of this work was to monitor and to evaluate the development of hydrophysical and biological properties of soils within the time and spatial scales under the different management systems. The study was carried out in two model areas in the marginal areas of the northeastern Slovakia during 2008 - 2010 (48º 57'N, 20° 05'E; 49º 16'N, 20° 46'E). Physical (bulk density, porosity, maximum capillary capacity, soil moisture) and biological (soil enzyme activity, soil respiration, microbial biomass carbon) soil properties were monitored and statistically evaluated. Reported indicators of the soil biophysical parameters reached comparatively better values in ecological farming systems. Statistical testing found significant effects of soil moisture on urease activity, acid phosphatase and soil microbial biomass. The result of the research showed that different farming systems play an important role in the soil ecosystem sustainability. One of the important environmental factors affecting the biological activity of the soil is water and moisture availability.

Keywords: agro-ecosystem, soil managements, soil

Introduction

Human agricultural activity leads to very strong changes in the soil and the knowledge of the moisture conditions and their management is one of the main possibilities that allow raising significantly the fertility and quality of soil. Soil is the largest potential water reservoir that is labeled as green water and the shortage of water resources has become a major concern for sustainable crop production and soil protection (Farkas et al., 2009). Biological element of the soil plays a key role in the soil ecosystem and its activity significantly contributes to the improvement of the soil quality and health. Its activity is the result of combination of the biotic, chemical and physical processes in the soil (Gomboš and Pavelková, 2011; Igaz et al., 2011). Water and moisture availability is a significant stress factor of soil and ecosystem in relation with yield quality and quantity. Water surplus or water deficiency could cause the changes in mass and energy regime of soils and in their biochemical cycles (Várallyay, 2009; Klupács et al., 2010). Soil management changes soil structure and has an important effect on soil water, heat and nutrition regimes. Structural degradation, mechanical disturbance, soil erosion has also damaging impact on soil water and soil aeration. Considering all these factors, Farkas et al. (2009) concluded, that it is essential to develop and put in practice sustainable and conserving soil management systems for increasing crop yields and limiting the devastating consequences. One of the ways of optimizing green water and its use is soil and water conservation, favorable tillage practices and crop management (Ringersma et al., 2003).

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Materials and methods

The research project was carried out during years 2008-2010 in production conditions in two investigated areas Liptovská Teplička (48° 57' N; 20° 05' E) and Plavnica (49° 16'N, 20° 46'E), situated in marginal region of north-eastern Slovakia. Liptovská Teplička has applied ecological farming system. There is the largest area of cambisols mostly moderate and strongly skeletal. Plavnica has applied low input farming system. The soil conditions are relatively homogeneous, represented by cambisols and fluvisols, moderate or poorly skeletal (Michaeli and Ivanová, 2005).

The soil samples for physical and biological soil properties determinations were in springtime in connected coppice, on 12 permanent research sites, from the depth of 0.05 to 0.15 m. We studied and evaluated the bulk density [t m^{-3}], porosity [%], maximum capillary capacity [%] and soil moisture [%] in Kopecky physical cylinder with a capacity of 100 cm^3 (Fiala et al., 1999). Monitored biological soil characteristics were following: the activity of acid and alkalic phosphatase [µg $P.g^{-1}.3\ hour^{-1}$], urease [mg NH_4^+ - $N.g^{-1}.24\ hour^{-1}$], catalase [ml $O_2.g.min^{-1}$], basal soil respiration [µg $CO_2.g^{-1}$] and microbial biomass carbon [µg $C.g^{-1}$]. The activity of phosphatases was assessed according the Chazijev‘s method modified by Grejtovský (Grejtovský, 1991). For urease activity assessment, method modified by Galstjan in Chazijev and activity of catalase by Chazijev (Chazijev, 1976) was used. Soil basal respiration was assessed by Isermeyer method (Alef and Nannipieri, 1995) and microbial biomass carbon was determined by microwave irradiation method (Islam and Weil, 1998). The obtained data were statistically processed using the analysis of variance from StatGraphic package.

Results and discussion

Quantifiable biophysical indicators play an important role in the assessment of the sustainability of soil ecosystem. Bulk density, as an integral value of the soil texture, humus content and anthropogenic impacts on soil is the most susceptible to changes in the soil environment. The research has shown that the values of soil bulk density on localities with ecological farming system reached comparatively better values than the average values for the given soil type and class (0.85 to 1.35 $t.m^{-3}$). The values of bulk density on localities with low input farming system reached critical levels (1.30 to 1.58 $t.m^{-3}$) and some sites have slightly exceeded the critical levels. Porosity corresponded with bulk density. Maximum capillary capacity is relatively unstable hydrophysical parameter and represents the amount of water in its natural state that soil is able to sustain for a long time in the capillary pores after previous saturation. The values of the maximum capillary capacity during the period varied in the range from 25.59 to 43.90 % in ecological system and from 31.17 to 37.89 % in the low input system. The observed soil biological parameters (soil enzymes activities, basal respiration, soil microbial biomass) reached higher values under ecological farming system compared to low input farming system. These parameters determine the soil quality and are influenced by the composition of plant community, soil organic matter content, soil moisture and temperature. These conclusions are consistent with the results of some authors (Brookes, 1995; Líška et al. 2008; Kotorová and Kováč, 2011).

Higher biological activity on soils was found at the localities with ecological farming system. Analyses of variance (*Table 1*) confirmed the statistically significant effect of tested factors (year, locality) on bulk density, total porosity, maximum capillary capacity, soil moisture, capillary porosity, non-capillary porosity, the activity of urease, basal soil respiration and soil microbial biomass. Locality and year had significant effect on the activity of catalase and acid phosphatase, but no-effect on the activity of alkaline phosphatase.

Table 1. Analysis of variance of soil physical and biological parameters

Parameter	Min.	Max.	Mean	Standard error	P significance
Bulk density [t m^{-3}]	0.88	1.55	1.28	0.0148	++
Porosity [%]	41.46	66.84	51.81	0.5567	++
Capillary porosity [%]	27.43	38.21	32.56	0.4025	++
Non-capillary porosity [%]	1.87	23.41	13.60	0.7005	++
Maximum capillary capacity [%]	31.19	42.98	35.73	0.4827	++
Soil moisture [%]	16.10	31.95	25.11	0.8486	++
Urease [mg NH_4^+ - N.g^{-1}.24 h^{-1}]	0.137	0.617	0.376	0.0081	++
Catalase [ml O_2.g.min^{-1}]	0.763	2.344	1.589	0.0566	+
Acid phosphatase [μg P.g^{-1}.3 h^{-1}]	157.611	310.589	229.264	2.3756	+
Alkaline phosphatase [μg P.g^{-1}.3 h^{-1}]	180.419	265.914	222.372	9.7875	-
Basal soil respiration [μg CO_2.g^{-1}]	57.125	153.515	89.019	1.6196	++
Soil microbial biomass [μg C.g^{-1}]	72.705	492.765	259.046	10.9220	++
Count	144				

$^{++}$P< 0.01 $^{+}$P< 0.05

As it is clear from the values of correlation coefficients (*Table 2*), the effect of bulk density, total porosity and non-capillary porosity on soil enzymes activity and soil microbial biomass were significant till statistically significant. The effect of soil moisture on activity of urease, acid phosphatase and soil microbial biomass were significant.

Table 2. Correlation coefficients (r) for relationship of soil physical and biological parameters

Parameter	Urease	Acid phosphatase	Alkaline phosphatase	C_{res}	C_{mic}
Bulk density	**-0.778**$^{++}$	**-0.715**$^{++}$	**-0.663**$^{++}$	-0.134^{-}	**-0.429**$^{+}$
Porosity	**0.776**$^{++}$	**0.715**$^{++}$	**0.662**$^{++}$	0.142^{-}	**0.428**$^{+}$
Capillary porosity	0.210^{-}	0.231^{-}	0.279^{-}	-0.177^{-}	-0.084^{-}
Non-capillary porosity	**0.578**$^{++}$	**0.578**$^{++}$	**0.450**$^{+}$	0.269^{-}	**0.477**$^{+}$
Maximum capillary capacity	0.183^{-}	0.219^{-}	0.223^{-}	-0.125^{-}	-0.013^{-}
Soil moisture	**-0.344**$^{+}$	**-0.472**$^{+}$	-0.300^{-}	-0.069^{-}	**-0.458**$^{+}$

$^{++}$P< 0.01 $^{+}$P< 0.05

Conclusions

On the basis of the research results reported in the production conditions under different farming systems and at the similar soil-ecological conditions were found out that in soil with ecological farming system, in the structure that are dominated by perennial fodder crops, as well as sufficiently high doses of organic fertilizer, positive changes of soil physical properties and comparatively with the average values for the given soil type

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and class are observed. The values of physical properties on localities with low input farming system have reached critical levels and some sites have slightly exceeded the critical levels. Observed soil biological properties reached higher values under ecological farming system than under low input system. Soil biological parameters play an important role in soil quality and are influenced by soil moisture, temperature, content of soil organic matter and plant composition. Statistical testing found out significant effects of soil moisture on urease activity, acid phosphatase and soil microbial biomass. It was also found out statistically significant that there was the effect of bulk density, total porosity and non-capillary porosity on soil enzymes activity and soil microbial biomass. Different farming systems play an important role in the soil ecosystem sustainability. One of the important environmental factors affecting the biological activity of the soil is water and moisture availability.

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DOES THE DROUGHT AFFECTS ON THE REPRODUCTIVE CHARACTERISTICS OF GOATS IN ORGANIC BREEDING?

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Abstract: Aim of research was to determine whether drought affects on reproduction of goats in organic production. The research was conducted on organic family farm that has long engaged in organic farming goats in Slavonia (locality Valpovo). The research included 22 goats Alpine breed during the two test years (2009 and 2010). Goats were about 4 years old, and in the third and fourth gravidity. Goats grazed on the organic pasture, and upon returning to the barn they consumed meadow hay (*ad libitum*) and 200 g of corn. Goats were reared according to Regulation of organic farming and mentioned feeds were produced in their own farm according to organic standards. Analyzing the weather conditions, it is evident that in year 2009 in the studied locality may be considered as a dry in comparison with year 2010 as rainy. During pasture season average monthly temperatures in year 2009 were higher by 2.0ºC, while average precipitations were lower for 437.0 mm in comparison with year 2010. Goats were mated during the both years in August, when with them stayed buck in the pasture and goats were kidding in February. During the dry year (2009) was determined significantly longer interval between kidding (372:358 days), smaller number of kids per goat (1.41:1.64) and liveborn kids (1.27:1.59), less litters with twins (11:13) in comparison with year 2010. Goat kids birth weight were also significantly less during the dry year in comparison with rainy year (3.67:3.86 kg). The reasons for these changes can be found in the dry period of the year that is reflected on the depletion of plant communities in the pasture and consequently lower intake of essential nutrients, as well as poor preparation of the goats for mating, and subsequent development of the fetus.

Keywords: goat, reproductive characteristics, drought, organic breeding

Introduction

Climate changes increasingly affecting on agriculture crop production, horticulture and animal husbandry (Köles et al., 2011). Particular importance has the appearance of dry periods that have a significant impact in expressing productivity, maintenance of reproduction and animal health. Organic agriculture is a general trend in the world and in recent years has been great interest in it (Seregi et al., 2008). Particular importance in organic production has climatic conditions, with regard to ecological farming is based on keeping the animals outdoors and on the greater use of pasture. Goats and sheep are very suitable for breeding in organic production (Antunović et al., 2007) and sustainable agriculture (Laczo et al., 2007; Pajor et al., 2007; Póti et al., 2007). Fertility of goats was the highest in the autumn and in spring when is the best offer of food follows kidding. On expression of the goat fertility significant impact have a weather conditions (temperature, precipitations, relative moisture) and feeding. Moisture and temperature changes in the course of the growing season affect changes of the grassland botanical composition and nutrients uptake (Karalić et al., 2007) i.e. forage quality that will be reflected in animals health and productivity (Antunović et al., 2001). One of the costs of drought is the reduction in kidding performance (McGregor, 2005). There are very few papers that explore reproductive characteristics of goats in organic production (Antunović et al., 2007) as well as the influence of climatic conditions - drought. Aim of research was to determine whether drought affects on reproduction of goats in organic production.

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Materials and methods

The research was conducted on organic family farm that has long engaged in organic farming goats in Slavonia (locality Valpovo). The research included 22 goats Alpine breed during the two test years (2009 and 2010). Goats were about 4 years old, and in the third and fourth gravidity. Goats grazed on the organic pasture, and upon returning to the barn they consumed meadow hay (*ad libitum*) and 200 g of corn. Goats were reared according to Regulation of organic farming and mentioned feeds were produced in their own farm according to organic standards (NN, 13/02). Goats were mated during the both years in August, when with them stayed buck in the pasture and goats were kidding in February. During the both years war followed interval between kidding, the number of kids per goat (litter size), number of kids born alive, number of kids per litter and birth weight kids. The results were statistically evaluated by using LSD test (Statistica, 2008). Differences were considered as significant at the level of 0.05 or less.

Results and discussion

Analyzing the weather conditions (*Table 1.*), it is evident that in year 2009 in the studied locality may be considered as a dry in comparison with year 2010 as rainy. During pasture season (from April till November) to average monthly temperatures in year 2009 were higher by 2.0°C, while average precipitation were lower for 437.0 mm in comparison with year 2010.

Table 1. Weather conditions in the years of investigation on the mentioned locality (Meteorological and Hydrological Service, 2011)

Months	Year					
	2009			2010		
	Temp., °C	Prec., mm	Rel. moist., %	Temp., °C	Prec., mm	Rel. moist., %
April	14.0	12.6	64	11.8	68.7	73
May	17.8	71.4	67	16.1	164.0	74
June	19.3	77.7	71	20.0	201.3	76
Julay	22.5	23.5	65	22.7	44.1	73
August	22.3	38.6	68	20.8	69.1	75
September	18.5	10.8	68	15.0	116.1	83
October	11.1	70.7	77	8.6	86.3	82
November	7.6	63.0	86	8.4	55.8	84
December	2.9	87.9	86	0.1	75.2	84
Mean	*12*	*579.9*	*74*	*10.8*	*1105.3*	*79*
*Pasture season**	*17.0*	*368.0*	*70.8*	*15.0*	*805.0*	*77.5*
Average (1975-2010)	*11.0*	*706.4*	*81*	*11.0*	*706.4*	*81*

Temp. - Temperatures; Prec. - Precipitations; Rel. moist. - Relative moisture; *from April to November

During the dry year (2009) was determined significantly longer interval between kidding (372:358 days) and lower birth weight of goat kids (3.67:3.86 kg) in comparison with year 2010 (*Table 2.*).

Table 2. Duration of kidding interval in goats and birth body weight of kids

Indicators	2009		2010	
	Mean	SD.	Mean	SD.
Kidding interval, days	372.05[a]	12.80	358.19[b]	12.19
Birth body weight of kids, kg	3.67[a]	0.20	3.86[b]	0.22

[a,b] (P<*0.01); SD standard deviation*

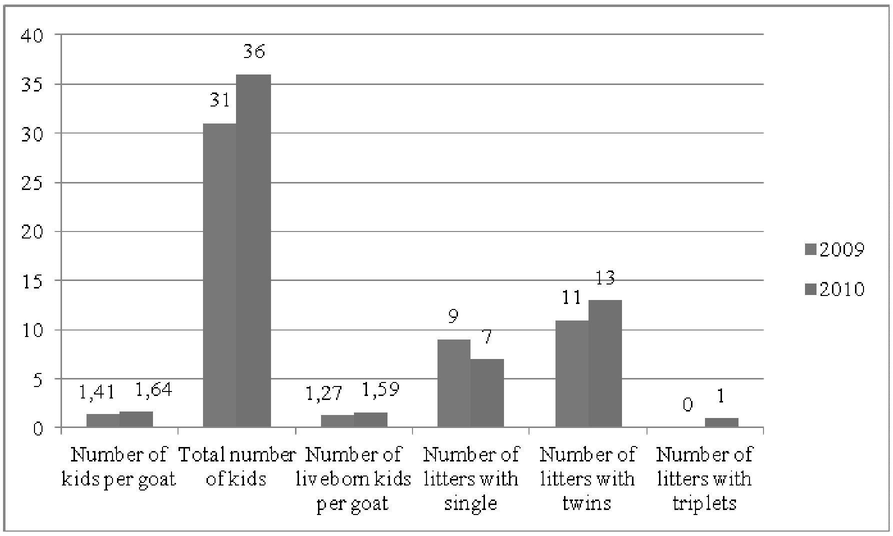

Figure 1. Reproductive characteristics of goat during investigation years

Figure 1. shows the reproductive characteristics of goat during investigation. During the rainy year (2010) were determined higher total number of kids (36:31), the average number of kids per goat (1.64:1.41) and liveborn kids (1.59:1.27), as well as higher litters with twins (13:11) and litters with triplets (1:0). The reasons for these changes can be found in the dry period of the year 2009 (especially during the pasture season) that is reflected on the depletion of plant communities in the pasture and consequently lower intake of essential nutrients, as well as poor preparation of the goats for mating, and subsequent development of the fetus. In organic breeding, but during climatic normal year in investigation in Croatia Antunovic et al. (2007) determined shorter kidding interval of goats (356 days), higher average birth weight of kids (3.87 kg) and higher number kids per goat (1.7). Reproductive performance of goats is affected by the live weight of does at mating time and the change in live weight at mating (McGregor, 2005). With rangeland goats Henzell (1982) reported that drought increased mean kidding interval from 221 days to 337 days. In investigation McGregor (1995) determined that nutritional stress during the first 50 days of pregnancy will result in increased abortions in pregnant does, as well as does fed to lose weight during mid

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pregnacy (from 50 to 90 day), had a foetal loss of 21%. Lower birth weight Hungarian Native goats kids (female 2.8 and male 3.4 kg), but and higher litter size (1.92) in goat from sustainable production in Hungary determined Laczo et al. (2007).

Conclusions

Based on the results we can conclude that it is determined significant effects of the drought on the reproductive characteristics of goats and birth weight of kids in organic breeding.

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INVESTIGATION OF THE ENVIRONMENTAL CHANGES PRODUCED BY HUMAN ACTIVITY ON EXAMPLE OF A KARST LAKE WITH THERMAL SPRING-WATER

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Abstract: Nowadays natural habitats are imperilled because of human landscape-transformer processes and negative effects of climate change. Watery habitats belong to the most vulnerable lands because low rate of anthropogenic effects can lead to significant and fast changes in these places. Although we can characterize Carpatian Basin with high mosaicity, it is need to be managed in its entirety without borders. The international realization of this is supported by the Hungary-Romania Cross-Border Co-operation Programme of the European Union. Conditions of Püspökfürdő (karst lake with thermal spring-water, Pârâul Pețea reserve, Oradea, NW Romania) and anthropogenic effects in dynamics of environmental processes are examined in this project. Paleoecological analysis, soil- and wather-chemical measurements and geological examinations are carried out in the area. Based on laboratory measurements and field studies we are able to do comparative analysis, prepare parameter-maps and examine the evolution of the area. Aims of our work are to classify ecological potential, to define the rate of degradation and to determine ecological function of the natural habitat. Results give possibility to sustainable development of tourism investments and operation in case of Püspökfürdő, what assists the improvement of ecological status of the lake, because Pârâul Pețea reserve is touched by anthropogenic effects in higher degree. In this paper we present a part of examinations of water chemistry.

Keywords: Pârâul Pețea reserve, thermal spring, water chemistry, anthropogenic effect

Introduction

Research focusing on the recent processes of karst areas is still current and of particular importance. Such research is justified by the changes in the state of karst environment and its sensitivity; the latter is due to special karst features such as the special wildlife, hydrological system, morphological elements and their sensitivity. In karst areas, water quality is a cardinal issue, as it is a link between the elements of the karst system. Nowadays, however, preserving the quality of our waters has become an increasing challenging task. With the contamination of waters usage possibilities are also reduced. However, the growing population and limited supplies require the preservation of the available resources in their original state (Samu, 2011).

Materials and methods

The Pârâul Pețea reserve is located in Băile 1 Mai spa (Püspökfürdő), 9 km southeast from Oradea, Romania, and was declared in 1932 around the hypothermal lake formed by some extensions of the brook (total length 1.5 km, *Fig.1*, a). It is situated within the borders of Băile 1 Mai spa, with a hospital, a hotel, a public pool and drainage facilities as nearby potential pollution sources on the left bank, and agricultural activities (possibly implying the use of pesticides) on the right bank (Gagiu and Venczel, 2008).
The reserve has roughly two zones: first (A), a pond with thermal, underwater springs, having a depth of 0,1 - 3 m and an average temperature between 35 °C by the springs and 25 °C near the shore (Paina, 1978). The second zone (B) is an elongated pond

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formed by another diverticulum of the rivulet (in 2002 it was excavated and cleaned of excessive mud and organic debris threatening to overload the biotope). Aquatic vegetation is abundant, consisting of species of *Potamogeton*, *Typha*, *Phragmites*, *Lemna*, *Butomus*, *Alisma*, *Spirodela*, *Cabomba*, *Elodea*, and the local endemic morph *Nymphaea lotus* L. var. *thermalis* (Tuzson, 1908).

Water samples were collected from 20 cm under the water surface (glass and PET bottle, 2 x 0,5 litre). Every sampling point was appointed by EOV coordinates (153 points). Electrical conductivity (EC) and pH were measured on the scene. Conserving was carried out by a high purity nitric acid (pH 3) and samples were stored in 4°C. Chemical data were measured by Hungarian standard on studied water samples. Magnesium, natrium, potassium, calcium contents were determined by atomic absorption spectrophotometry (MSZ 1484-3:2006. (6.)). Nitrate (MSZ 1484-13:2009. (5.2.)) and phosphate (MSZ 448-18:1977.(6.1.)) contents were measured by UV-VIS spectrophotometry. pH and EC measurements were carried out strength of MSZ 1484-22:2009 and MSZ EN 27888:1998. Carbonate content was determined by volumetrical analysis (MSZ 448-11:1986).

Results and discussion

Parameters show that the eastern arm of the studied area (right side in the picture) is differed from other parts absolutely. Causes of differences are (1) another spring water feed the rivulet - water with other dissolved compositions; (2) intensive agricultural activity on areas next the rivulet; and (3) rivulet-water moves slowly because the water of main thermal spring backs up the water of eastern arm. The pH is lower (~ pH 7) in the main spring and in the flow out water of public pool but pH is higher at the fields are grown thickly by vegetation (pH (*Figure 1*, b)). EC, Ca^{2+}-, Mg^{2+}-, K^{+}-, Na^{+}- and carbonate-concentrations are highest in the water of main spring, in the flow out water of public pool and in some spots on the middle of the studied area (*Figure 1*, c). We suppose that there are “runaway springs” in the latter case. The presumable springs are located on Mg-concentration map best of all (*Figure 1*, d). There is minimum of the K-concentration where vegetation is the thickest because K is macro-nutrient element. Phosphate-concentration is zero in the water on the all field but area of intensive agricultural activities (eastern arm of the studied area) and forest covered area (left side in the picture) where we could experienced some flow. We established that anthropogenic pollutants come to the water from cultivated fields but ones (come from herbicides, pesticides, muck-heaps and digged toilets) can accumulate in the sediments. Nitrate-concentration is the highest next the hospital.

The main aquifer systems in the area are located in holocene, pleistonce, pliocene (cold), lower cretaceous and triassic deposits (thermal - 35 °C -120 °C). The pH level of water is in the range of 6,3-8,15. The EC of geothermal waters in the aquifer is relatively low in Oradea perimeters. The high water hardness of Oradea aquifer is a consequence of the presence of limestone and dolomite in the triassic aquifer. Major dissolved cations are calcium (134-275 mg l^{-1}) and magnesium (32-71 mg l^{-1}). The waters from thermal aquifer of Oradea can be classified as sulfate-bicarbonate-calcium-magnesium type. (Roba, 2010). Flow paths of spring water are short, so the contact time with carbonate rocks is short too and the dissolvable substance concentrations are less on the area of Püspökfürdő.

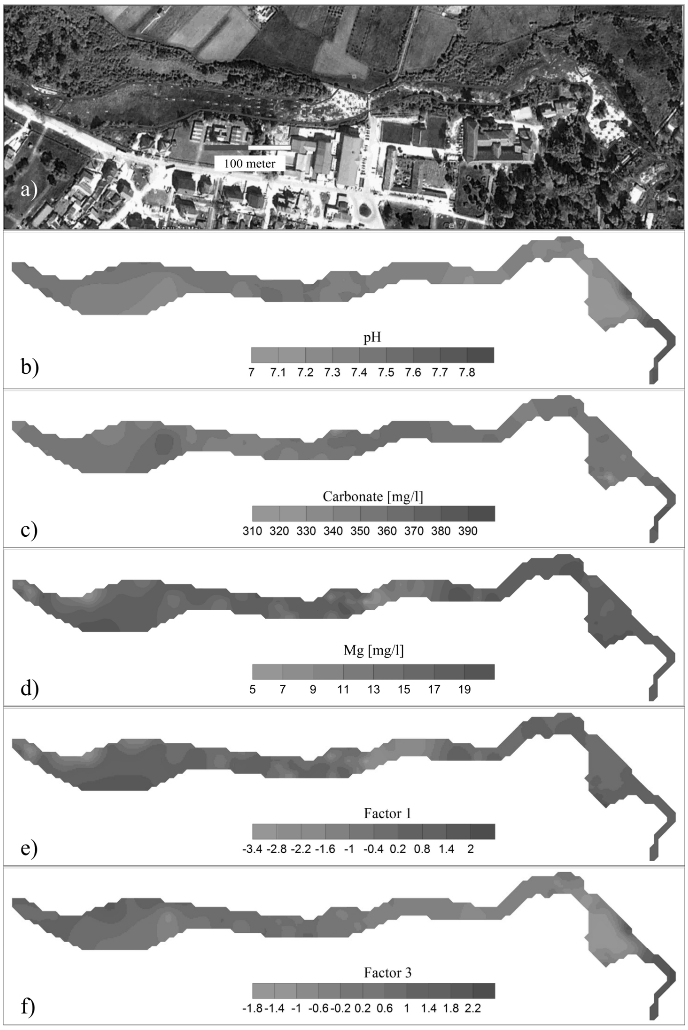

Figure 1. Picture of studied area (a) and distribution maps of pH (b), carbonate (c), phosphate (d), Factor 1 (e) and Factor 3 (f)

Kaiser-Meyer-Olkin examination was the first step of statistical analysis. We established that there are not strong relations between the pair of variables (0.594) so variables are suitable to factor analysis, but Bartlett examination show that there is latent structure among parameters. K, Mg and Ca are correlated to a certain extent. Results of communalities show r>=0.5 between factor and original variation with the except of nitrate. Na has very strong communalitie (0.970) so we removed it from variables. The first three factors wrote down variables in 65.953%. System was

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interpreted by first factor in 27.142%, second factor in 20.835%, third factor in 17.976%. Factors transformed variables well on the basis of the khi-square (value <20, level of significance ~ 0.5). We were considering those parameters which were more than |0.250| to factors (Extraction Method: Maximum Likelihood, Rotation Method: Varimax with Kaiser Normalization, Rotation converged in 4 iterations.). Factor 1 contained Ca (0.712), Mg (0.851) and K (0.936). This group characterized compounds of carbonate rocks and flow up thermal spring water (*Figure 1*, e). Factor 2 contained EC (0.893), phosphate (0.795) and carbonate (0.510). Anthropogenic effects are reflected by phosphate (vegetation, eutrophication, muck-heaps, agricultural activities etc.). Influence of carbonate is minimal on the factor. Factor 3 contained Ca (-0,255), EC (-0,268), phosphate (0,352), pH (0.857) and nitrate (-0,522). pH was grown by this factor best. Consequently there was an effect what influenced pH only, so pH was independent of carbonate rock and factor which influenced EC. This effect was not anthopogenic, because Factor 3 opposited to nitrate, although nitrate belong to Factor 3 in slighter degree (*Figure 1*, f).

Conclusions

Collective analysis of parameters back up the previous results and different effects are outlined by its: main spring, "runaway springs", intensive agricultural activity, vegetation influences, waters come from another places (springs with other compounds and pool water).

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FOOD SAFETY – WATER MANAGEMENT

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Abstract: Water is one of the holders of the food safety risk sources, which includes the chemical and the biological risks as well. From this point of view in agricultural production the Salmonellosis, the Champhylobacteriosis and the Leptospirosis is prominent in leafy vegetables and drinking water by zoonosis. The chemical risks (nitrate, pesticide residues, heavy metals, liquid manure, sewage and sewage sludge) predominate in the surface water level and the ground water level. In the presentation we showed examples: the different places (flood plain, utilization of sewage in plant production, pesticide residues in the soil) of this mentioned risk sources where they predominate. The change of the heavy metal status of the riparian zone in the soil-plant chain, atrazine accumulation in National Uniformed Long-term Fertilization Experiment was also showed. According to our results the Zn-content of five-leaf stage corn increased significantly on floodplain soil, but the effect moderated in the grain fill period. This is only 1.5 times higher than the 3 times higher young period content compared to the control. In the lower soil layers (150-300cm) the measured atrazine accumulation would be dangerous for the products made from the plants (pumpkin and pumpkin oil), which roots take up water from these lower layers as well.

Keywords: food safety, chemical and biological risk sources, river contamination

Introduction

Food safety in its new interpretation spread from the farm to the table is affected by more different risks which origins could join to water management. From *Table 1.* the different sources of food safety risks the chemical and the biological can influence the food safety, but in different rate. These sources of risks spread from bacteria to ionizing radiation. Most of them could not link directly to the water management of course, but some of them in our environment either food safety or public health point of view mean considerable risk factors by the water mediation. The following biological risks are the most important ones because of the known physiological effects (Molnár, 2002).

Table 1. Biological and chemical risk sources (Molnár, 2002)

	Sources (contaminations)
Biological	Bacteria, Yeast, Fungii, Pathogens,Viruses, GMO
Chemical	Additives, Aerosol, Enzyme derivative, Gases, Iionizing radiation, Toxins, Detergents, Heavy metals, Pesticide residues, Precervative residues

The effect of the genetically modified plant belongs to this group as well. But in this topic there is sharp opposition even among the researchers about the possible dangers. From the ***biological risks*** the salmonellosis, champhylobacteriosis and the leptospirosis belong to the zoonisis influenced by animals. One of the most important is the salmonellosis caused by the Salmonella bacteria multiplying in the small intestines and after a short latent period in most of the cases it is symptomless bacteria evacuation or it causes acute gastro-enteric problems. From the food safety point of view the soil surface waters, digged wells, and the rodents, birds, wide animals living in our environment also mean dangers. The human salmonellosis presents in the form of food poisoning. In most cases the strarting point is the intensive pig/pork and fowl raising, but especially the poultry so therefore either in EU or in USA there are different programs to decrease/reduce salmonellosis. The effectiveness of these is conspicuous in

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slaughterhouses and in egg production. The proper microbiological quality of the applied technological water is also essential. In the last decade the local food production has prospered, and there could happen that water does not get from the piped water supply, rather than from the digged wells, where the continuous control is as essential as in piped water (Győri, 2011b).

The champhylobacteriosis could spread with differently contaminated natural waters, but in this case the pathogen resistibility to environmental factors is low. Pathogens of leptospirosis are fit for life in puddles, lakes and low water output waterflows. Hereby mostly in summer warm times bathing in these waters can mean danger/risk for the human body (Nagy et al., 2002; Pucket, 2005; Szeitzné, 2008). Next lists the *chemical risk sources*: Nitrate, pesticide residues (soil surface water, lower layer); Heavy metals (dissolved, unsolved); Liquid manure (biological, chemical); Sewage, sewage sludge. The different compounds have different effects in the soil layers, and with the water management their effect shifts in time. These dangers appear in several places due to either natural phenomena or anthropogenic impact. With flood or inland water contaminations with different origin can get far or they can transform such a condition which is directly dangerous for the food safety. Their long-term risks were shown in the results of the contamination at Tisza River in 2000. In this research we examined the condition of the area along Tisza River at Tivadar, Vásárosnamény, Rakamaz, Tiszacsege and Tiszakürt.

Materials and methods

In our study the Salmonellosis, the Champhylobacteriosis and the Leptospirosis have been evaluated in leafy vegetables and drinking water by zoonosis. The chemical risks (nitrate, pesticide residues, heavy metals, liquid manure, sewage and sewage sludge) were observed in the surface water level and the ground water level. In our study we showed examples: the different places (flood plain, utilization of sewage in plant production, pesticide residues in the soil) of this mentioned risk sources where they predominate. The change of the heavy metal status of the riparian zone in the soil-plant chain, atrazine accumulation in National Uniformed Long-term Fertilization Experiment has been examined on the experimental data range from 1967-2001 (Debreczeni and Németh 2009). Regading flood or inland water contaminations with different results of the contamination at Tisza River in 2000 have been studied. The condition of the area along Tisza River at Tivadar, Vásárosnamény, Rakamaz, Tiszacsege and Tiszakürt was evaluated.

Results and discussion

Having analysed the samples following the Lakanen-Erviö method to determine the element content available for plants, we have found that there were data above the officially allowed limits only in case of Zn concerning samples taken from the upper 10 cm layer (*Table 2*.).

Based on the data groups, it should be taken also into consideration that time to time we have to note what kind of changes can be recorded concerning the amount of each element. This can be assured only by repeated sample taking and analysis.

Table 2. Element content in floodplain soils following the Lakanen-Erviö method (Hungary, Vásárosnamény, 2000)

	Cd	Cu	Pb	S	Zn
cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0-3	0.944	39.7	64.9	475	65.9
3-7	0.964	53.5	85.4	569	97.0
7-10	0.814	39.4	43.4	340	68.8
limit value "C1"	-	90.0	70.0	-	40.0
limit value "C2"	-	140	150	-	80.0
limit value "C3"	-	190	300	-	160

These data remind us that due to floods of river Tisza any place of sample taking contains also debris settled from alluvial deposit which may have significant effect on the plants cultivated there. From food safety point of view, it is especially true in case of Cd and Pb. However, corn at its five leaves development stage - which is its most sensitive phenological phase - has four-five times higher Zn values on the flood plains than on control fields (*Table 3*.). This also verifies the statement taught already in the agro-chemistry for a long time past that corn belongs to the group of plants which needs a lot of Zn. Data analysis of sweet corn field samples from flood plain at Rakamaz (Hungary) verify that the harvested corn neither from Cd nor from Cu did not contain significantly higher values than corn cultivated on the control fields out of flood plain, even Zn values are higher only by one and a half.

Table 3. Element content of five leaves corn (Vásárosnamény), and sweet corn (Rakamaz)

sample site	Cd	Cu	Pb	Zn
near the pasture in the flood-plain 500m far from the river	0.343	5.89	1.80	68.3
100m far from the river	1.28	10.3	2.80	89.2
300m far from the river	0.667	10.2	2.19	123
control	0.380	11.1	2.14	22.9

	Cd	Cu	Pb	Zn
flood-plain	0.101	1.20	<0.1	24.8
control	0.0801	1.33	<0.1	16.9

However, plants from flood plain have different utilisation purposes (arable crops, fruits, medicinal (drug) plants) so analysis of medicinal (drug) plants can be especially important from plants grown or cultivated on flood plain (Győri, 2011a). Movement and accumulation of pesticides and their residues in the different soil layers and later their absorption together with nutrients may be closely connected to water utilisation. This peculiar accumulation may be in close relation with the precipitation penetrating from the soil surface but it cannot be excluded that it is the consequence of water movements (horizontal and vertical), having taken into consideration features of the soil type of the given field (humic gley soil, “wiesenboden” cultivated by monoculture).
This later conclusion may be underlined by data presented in *Table 4*. These analytical data were recorded on a field, which was used as pasture from time immemorial.

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Table 4. Soil analysis data of field used as pasture

Analysed active ingredience	LOQ [mg/kg]	Detector	Bakonszeg pasture Results [µg/kg]				
			B1 0-20 - BO5/11/895	B8 0-20 - BO5/11/907	B15 0-20 - BO5/11/919	B1 100-130 - BO5/11/900	B1 200-235 - BO5/11/904
a-HCH	0,0005	ECD	<LOQ	1,52	1,71	<LOQ	<LOQ
b-HCH	0,0005	ECD	8,51	8,41	10,72	7,59	8,37
Heptachlor	0,0005	ECD	<LOQ	<LOQ	0,21	<LOQ	<LOQ
Heptachlor-	0,0005	ECD	0,77	0,76	0,98	0,72	<LOQ
Aldrin	0,0005	ECD	<LOQ	<LOQ	0,21	<LOQ	<LOQ
Endrin-	0,0005	ECD	0,29	<LOQ	0,46	0,17	<LOQ
Endrin-	0,0005	ECD	0,25	<LOQ	0,21	<LOQ	<LOQ
Endosulfane-	0,0005	ECD	0,94	0,75	0,99	0,63	1
pp-DDE	0,001	ECD	1,35	0,74	1,48	0,34	<LOQ
pp-DDT	0,001	ECD	1,58	0,54	1,63	0,02	<LOQ
Metolachlor	0,005	MS	<LOQ	<LOQ	<LOQ	<LOQ	44

There are different and well detectable amounts of active ingredients in the different soil layers. Having compared these data with data from an arable field, it can be concluded that concentration of certain products is much more higher, but these products can be found also in the deeper layers.

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THE USE OF BY-PRODUCT OF GREEN ENERGY IN AGRO-ECOSYSTEM

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Abstract: The green development is in the focus of environmental protection, which has outstanding importance for agriculture as well. One of the most important expectations regarding the green agriculture is the minimization of industrial chemicals applications, and in line with this, to provide the production on the same or higher level. One possible way to minimize chemicals may have the use the by-products of biogas-factories. With use of fluid by-product we are able to decrease the amounts of chemical fertilizers. The crop plants take out huge amounts of nutrients from soils. To get the same yield – in quality, and quantity - it is necessary to replace the minerals that were harvested by plants.

The physiological effect of fluid by-product was examined, which was originated from the biogas-factory located in Biharnagybajom (Eastern-Hungary). The fluid by-product contains several essential elements therefore it can be suitable material to substitute the industrial chemicals. Sunflower (*Helianthus annus* L. cvs. Arena) seedlings were used in our laboratory the experiments. The effects of fluid by-product were different depending on the plant variety and the concentrations of fluid by-product. Dry matter accumulation of shoots and roots of sunflower and the contents of elements were measured of the plants that were grown on nutrient solution.

By the examination of several physiological parameters we came to the conclusion that the fluid by-product of biogas factory can be suitable material to replace the industrial chemicals.

Keywords: biogas, crop nutrition, land use, industrial side – products

Introduction

Biogas is produced in different environments e.g. in landfills, sewage sludge and biowaste digesters during anaerobic degradation of organic material. Methane, which is the main component of biogas, is a valuable renewable energy source, but also a harmful greenhouse gas if emitted into the atmosphere (Wellinger and Linberg, 2000).

In order to achieve sustainable development, comprehensive utilizations of renewable resources, efficient energy production and the reduction of energy consumption have become our major tasks (Kabasci, 2009).

The aim of this study was to examine the plant physiological effect of fluid by-product of biogas factory. This by-product contains some useful elements for plants. So, it may have positive effect on the growth and development. The application as alternative nutrient supply may reduce the usage of chemical fertilizer and the eutrophication and pollution of surface and groundwater will be reduced.

Materials and methods

Sunflower (*Helianthus annus* L. *cvs. Arena*) seedlings were used in the experiments. The seedlings were transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1 mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 10 µM $ZnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. Iron was added to the nutrient solution as Fe(III)-EDTA at a concentration of 10 µM. The different treatments were the following: distilled water

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(absolute control: distilled water, control: nutrient solution, 8.55ml from fluid by-product, 17 ml from fluid by-product and 85 ml from fluid by-product. The seedlings, 12 for each basic treatment, were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 ^{o}C, relative humidity of 65–70% and a photosynthetic photon flux of 300 μmol m^{-2} s^{-1}) in controlled environmental room. The volume of experiment pots were 1.7 L, with one pot containing 4 plants. The element contents of materials were determined using an OPTIMA 3300DV ICP-OA Spectrophotometer. The dry weight of shoots and roots were measured with the use of thermal gravimetric analysis, after drying at 85 C° for 48 h. The examined biogas fluid by-product originated from Biharnagybajom, Eastern-Hungary.

Results and discussion

The examined material was supplied in large quantity by the above-named company. These materials contain lots of useful element for plants (e.g. calcium, iron, potassium, magnesium etc.) and its toxic elements are considerable (*Table 1.*).

Table 1. Contents of examined elements (Al, Cd, Cr, Ni, Sr, Ca, Fe, K, Mg, P) in fluid by-product of biogas factory (mg kg^{-1})

Toxic elements					Essential elements				
Al	Cd	Cr	Ni	Sr	Ca	Fe	K	Mg	P
109	0.12	0.39	<1	6.4	1,411	157	2,651	433	448

Potassium is a cation that appears in the largest quantities in plants. Potassium plays a very important role e.g. in the frost tolerance of plants (Wyn Jones et al., 1979). Other important elements include magnesium. In green leaves, a major function of magnesium, and certainly its most wide-known function, is its role as the central atom of the chlorophyll molecule (Michael, 1941).

The investigated material contains some toxic elements beside the useful elements. The toxic effects of aluminium are primarily root-related (Taylor, 1988). The root system becomes stubby as a result of inhibition of elongation of the main axis and lateral roots (Klotz and Horst, 1988).

The roots can uptake the examined elements, and since they have significant role in the main physiological processes of plants their amounts were measured in the shoots, and in the roots (*Table 2.* and *Table 3.*).

Larger concentrations from the investigated elements were measured in the roots than in the shoots. The elements localized in the roots and the root-to-shoot transfer was retarded. The content of Al was approximately 3folds higher in the roots of control plants than in the shoots. This value was 76 times higher when 8.5 ml fluid by-product was added to the nutrient solution and 118 folds in the 85 ml by-product treatment. The amount of Cr increased parallel to the increased by-product quantity. The highest content Fe was measured in the 85 ml treatment. The amount of K decreased in all treatments comparison to the control roots.

Table 2. Concentration of examined elements (Al, Cr, Fe, K, Mg, P) in the shoots of sunflower seedlings (mg kg^{-1}) effecting by fluid by-product of biogas factory

Elements	Treatments				
	Abs. control	Control	8.5 ml	17 ml	85 ml
Al	7.51	10.2	10.2	196	9.85
Cr	0.235	0.357	0.262	0.395	0.424
Fe	75.9	140	132	137	94.8
K	6,59	56,25	61,923	55,799	53,053
Mg	2,774	3,827	3,545	3,361	4,3
P	2,917	6,954	9,595	8,765	7,999

Table 3. Concentration of examined elements (Al, Cr, Fe, K, Mg, P) in the roots of sunflower seedlings (mg kg^{-1}) effecting by fluid by-product of biogas factory

Elements	Treatments				
	Abs. control	Control	8.5 ml	17 ml	85 ml
Al	89.3	33.3	781	905	1,166
Cr	0.657	0.819	2.53	2.75	3.92
Fe	300	370	1,184	1,428	1,940
K	5,311	79,977	44,12	49,022	22,218
Mg	394	1,203	981	1,001	1,428
P	2,809	9,484	9,273	10,742	9,131

Differences were observed in the dry matter accumulation during the experiment. The results are shown in *Table 4*.

Table 4. Effects of fluid by-product of biogas factory on the shoots/ roots ratio of sunflower seedling (g $plant^{-1}$)

Treatments	Shoot (g $plant^{-1}$)		Root (g $plant^{-1}$)		Shoot/root	
	Mean	S.D	Mean	S.D.	Mean	S.D.
Abs. control	0.044	0.010	0.018	0.010	2.444	0.069
Control	0.433	0.090	0.103	0.020	4.203	0.050
8.5 ml	0.513	0.090	0.105	0.030	4.885	0.060
17 ml	0.564	0.120	0.107	0.040	5.271	0.070
85 ml	0.422	0.090	0.038	0.010	11.105	0.075

The dry matter accumulation of shoots increased in all treatments comparison to the control. The dry matter of shoots increased with 30% in the 17 ml treatment, this value was 18% in the 8.5 ml treatment. The dry matter accumulation of roots increased with 2-3% in the 8.5 ml and 17 ml treatments and decreased with 24% in the 85 ml treatment. The shoots/root ratio was the highest when 85 ml fluid by-product was

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applied. This value also increased in the 8.5 and 17 ml treatment comparison to the control. The ratio of shoot to root growth varies widely between plant species, during ontogenesis of plants, and it strongly modified by external factors. When parts of the shoots are removed, plants tend to compensate this by lower root growth and returning to a ratio characteristic for the species. However, there is some controversy as to whether this reflects functional equilibrium between roots and shoots (Klepper, 1991).

Conclusions

The investigated fluid by-product contains some essential and harmful elements. The plants can absorb these elements and may cause different effects on the development and growth of plants. Most of investigated elements are localized in the roots and not transferred into the shoots. The dry matter accumulation of shoots increased in all treatment comparison the control. The dry matter of roots increased in the 8.5 ml and 17 ml treatments. The shoots/root ratio was the highest when 85 ml fluid by-product was applied.

Finally, the fluid side-product can be suitable for replacing the expensive mineral fertilizers. Therefore we keep that the side-product of newly emerged biogas factories can be useful tools of suitable agriculture from environmental aspects too.

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NEW SZÉCHENYI PLAN

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"FLOODS" NATURE RESERVE (CENTRAL BOHEMIA, CZECH REPUBLIC): VEGETATION SURVEY

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Abstract: "Small floods" belongs to the "Floods" Nature Reserve and is an important biological locality. It is situated in the Central Bohemia District (area about 8 ha | altitude 370 m), 5 km to the west of the city of "Kladno" and includes a water basin and adjacent zone. The area originates in a depression of undermined ground from an extension of "Turyňský" Pond on the "Kačák" Brook. The researched area is typical with its wetland and swamp plants. The dominant species, *Carex gracilis,* occurs in very wet places. In the inflow area of "Kačák" Brook there are marshlands with the dominant, *Carex acutiformis*. Reeds communities are the most extended phytocoenose on the shore of the basin, further from the water level there is *Phragmites australis* accompanied with the species, *Carex* sp., *Typha* sp., *Urtica* sp. During the vegetation period of 2006 - 2010, more than 180 vascular plant taxa were determined there. The authors found some severely endangered and endangered species of the Czech Republic´s flora, the former include, i.e. *Malus sylvestris*, *Scilla bifolia*; the latter include *Aguilegia vulgaris*, *Aster amellus*, *Dactylorhiza majalis* and *Iris pseudacorus*. Ruderal species and water and swamp taxa have also been determined there.

Keywords: wetland, management, endangered species

Introduction

There are currently about 800 nature reserves in the Czech Republic. The "Floods" Nature Reserve has major significance as a waterfowl migration stop and nesting place. 176 species of birds have been found there, including 131 of protected ones, the Floods NR (nature reserve) is an important place for migration stops of some wading birds and birds of prey, plovers, anseriform species, finfoot and small migrating song birds (Lorenc, 1989). The area was declared a nature reserve in 1985. It is an extensive wetlands complex situated between the municipalities of "Kamenné Žehrovice", "Srby u Tuchlovic" and "Tuchlovice" and occupies an area of 2.5 km^2. The undermined territory, as a result of underground coal extraction, gradually sank and was flooded by water (spontaneous filling of the wetland took place - anthropogenic factor), due to this development, sluice gates are missing here and the bottom cannot be cleaned; this specific succession (Lindborg and Eriksson, 2004) leads to the settling of numerous harmful substances. As a result of specific management, which has been applied in this territory during the existence of the nature reserve, valuable wetland communities that can no longer be found in the surrounding landscape, which is used for agricultural purposes (Frackleton and Watkinson, 2002), have developed here. Exclusion of agriculture, especially the exclusion of the use of herbicides and mineral fertilisers, industry and tourism, has had a favourable effect on the spontaneous re-naturalisation of the landscape and on the presence of rare and endangered species of plants and animals (Weiner, 1990; Schwinning and Weiner, 1998).

Main objectives: Overall assessment of the vegetation in areas of the "Floods" Nature Reserve. | Approximate site characteristics of certain areas using Ellenbergs' indication values by particular species. This includes the relationships concerning light, temperature, continental characteristics, humidity, reactive and soil nitrogen. The

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presence of protected and endangered species as well as invasive species was also assessed. Finally, advisable management for the studied areas has been suggested.

Materials and methods

The studied area reaches from N50°8'49.669" to N50°8'8.645" and E14°0'31.012" to E14°1'20.624". The floristic part was chosen in the field by inventory methods (Kubát et al., 2002) common in Central-European field botany (the area of "Small Floods" and the area of "Big Floods" - *Fig. 1*). The phytosociological part was worked out with the help of the work processes of the Zürich Montpellier School of Phytosociology (analysis, synthesis, typization of vegetation) - collecting phytosociological relevés (Rosenthal, 2003). We compared the results concerning the vegetation with previous surveys.
The topography of the nature reserve is moderately undulated with the maximum altitude being 380.0 m. The geological bedrock consists of younger Paleozoic feldspathic sandstone. In the vicinity of the basin there are developed alluvial deposits and on these there is gley soil; there are brown soils and cambisols on higher parts of the banks. The average annual temperature is 8.5 °C and there are more than 40 summer days per year here. The average total annual precipitation is 515 mm.

Figure 1. Aerial photo of the wetlands in "Floods" Nature Reserve - the area of "Small Floods" and the area of "Big Floods".

Results and discussion

In this area more than 190 species were identified mainly in the wetland and water community of *Lemnetum minoris*. There were 12 taxa of protected plants of various categories found. The authors have discovered and confirmed the presence of several highly endangered and endangered species of the Czech Republic's flora, the former include, i.e. *Malus sylvestris*, *Scilla bifolia*, *Dactylorhiza majalis* and others.

Figure 2. Nature reserve “Floods” Nature Reserve - the locality, “Small Floods”, with the valuable communities, *Lemnetum minoris* and alliance with the dominant, *Carex acutiformis*.

Plant communities are constantly evolving, depending on the subsidence and changes caused by land drops, activities of waste water treatment plants in the surrounding villages and the suspension of activities of industrial enterprises (dairies). The water community that has developed is the *Lemnetum minoris* community amongst rushes and in quiet bays. This indicates water enriched with nitrogen. The banks are accompanied by reed vegetation. Heavily waterlogged areas are dominated by *Carex gracilis*, the inflow part of "Small Floods" is covered by wetland meadows with *Carex acutiformis*.

In comparison with the previous surveys (in 1989 and 1997), there are generally widespread species such as *Acorus calamus*, *Anthoxantus odoratum*, *Betula pubescens*, *Carduus crispus*, *Cerastium arvense*, *Cornus alba*, *Cornus sanguinea*, *Eleocharis palustris*, *Lonicera nigra*, *Lonicera tatarica*, *Molinia caerulea*, *Physocarpus opulifolius*, *Ribes aureum*, *Succisa pratensis*, *Symphoricarpos albus* and others present in the area of interest. As opposed to the previous surveys, particularly ruderal species appeared such as *Papaver argemone*, *Hesperis matronalis*, *Chenopodium glaucum*, *Inula salicina* and others.

Reed is the largest community populating the pond bank; in places further from the water level the reed is accompanied by *Carex* sp. *Typha* sp. and *Urtica* sp., in the

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direction towards the water there is a depletion of vegetation. A well-developed community that occurs in the inlet area of the "Small Floods" and along the Kaňák stream is association *Phalariridetum arundinaceae*. In some places *Phalaris arundinacea* forms very dense vegetation, in which other species penetrate only to a small extent. The northern part of the monitored area shows the insular development of a community with the dominant, *Equisetum palustre*.

Conclusions

During the vegetation period of 2006 - 2010, more than 180 vascular plant taxa were determined there. The authors found some severely endangered and endangered species of the Czech Republic's flora, the former include i.a. *Malus sylvestris*, *Scilla bifolia*, *Aguilegia vulgaris*, *Aster amellus*, *Dactylorhiza majalis* etc. The occurrence of very well preserved and biologically valuable communities with dominat *Carex acutiformis* and *C. gracilis* were confirmed there. The plant communities just mentioned are severely endangered by the expansion of *Phragmites australis*, as well as by the process of being overgrown with *Phalaris arundinacea* and *Urtica* sp.

Acknowledgements

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SITE-SPECIFIC NUTRIENT REPLENISHMENT BASED ON ECONOMICAL CALCULATIONS

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Abstract: The effect of fertilization on yield have long been studied and researched. As a result, many researchers proved that fertilization plays very important role on yield. The yield affects the value of production trends, the nutrient supply and the costs, since it is the most expensive intervention in the cultivation of corn. Therefore both have a significant role on realization of income. This study examines the fertilization conditions in economic contexts of growing maize. The experiments were carried out in the 15.3 hectares experimental field belonging to University of West Hungary, Faculty of Agricultural and Food Science. NK Furio and DK 440 corn hybrids were planted during the research. Based on the fertilizer reaction functions, income functions were determined. Using the data provided by the models, for each treatment unit the profit map was created by means of ArcView/ArcMap 9.2 software. Based on our calculations we can conclude that the fertilizing recommendation system suggested higher amount of fertilizer than the economically optimal.

Keywords: site-specific nutrient replenishment, profit map, profit optimization

Introduction

Precision or site specific agriculture is one possibility for farmer to fulfil the high requirements that market dictates nowadays.

Berzsenyi and Győrffy (1995) during their research have proved that yield is highly depending on two influencing factor: nutrient replenishment (by 30.7%) and genotype (30%). The role of genotype has been also emphasized by Sárvári (1982).

Research concerning precision (site-specific) agriculture have been started in Hungary by Hungarian Academy of Sciences and its Research Institutes in the late 90s (Győrffy, 2000). Economical questions of the technology were investigated among others by Lowenberg-DeBoer (1996). Available Hungarian literature primarily focuses on precision plant protection issues, such as return of investment and efficiency of the technology (Takácsné-György et al., 2008; Lencsés and Takácsné-György, 2008; Takácsné-György, 2011).

Unfortunately in Hungary there are very few publications dealing with economy of nutrient replenishment. Most of the published works are investigating the return of investment (Smuk et al., 2009; Smuk et al., 2011). Research on this issue is in focus at the Institute of Biosystems Engineering, Faculty of Agricultural and Food Sciences, University of West Hungary (Neményi et al., 2006).

In this paper authors draw attention to the fact that up-to-date plant production requires complex approach which requires economical knowledge in order to produce profit for the agricultural enterprises.

Authors in this research were examining ecological issues of maize production in the year of 2002. Economic circumstances (profitability) were mapped in a special profit-map (Smuk et al., 2010). Parallel to these calculations optimal amount of fertilizer (nitrogen) in the given economic circumstances were calculated, where profit would have been the maximum.

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Materials and methods

Calculations carried out for the 15.3 ha research field located at N 47° 54' 19.71" E 17° 15' 0.807" belonging to the University of West Hungary, Faculty of Agricultural and Food Sciences, cultivated by Institute of Biosystems Engineering.

The field is located in an alluvial plain. The area is humus alluvial soil; in the upper soil layer humus content varies between 1.4-2.8%. The differences in humus content show the same pattern as all other properties. In the areas where humus content is lower sand fraction significantly increases, on the other hand where humus content is higher clay and silt fraction increases. Nutrient replenishment was carried out by an AMAZONE ZAM 1500 Tronic type fertilizer. In order to carry out the variable rate application dGPS signals were used during the fertilizer replenishment work in the 63 experimental units. For the determination of the fertilizer dose ProPlanta model was applied. In the same field a four and a three ha area was used as a control, therefore in this two area conventional plant production methods were applied.

In order to calculate the profit maximum, our assumption was that the maximum of a quadratic function can be found in its derivative; therefore profit functions were determined first for the given year, and then the derivation of these functions gave the profit maximum. Based on the regression equations mathematical models were used in order to define the production value (Pv), the total cost (Tc) and the profit (P) functions, which are as follows:

$$Y_{Pv\ 2005} = -8{,}9362x^2 + 1901{,}1x + 126074 \qquad (1)$$

$$Y_{Pv\ 2006} = -2{,}8132x^2 + 823{,}49x + 169055 \qquad (2)$$

where „Y_{Pv}" is the production value in Ft ha^{-1}, and „x" is N agent in kg ha^{-1}.

$$Y_{Tc\ 2005} = 399{,}55x + 87274 \qquad (3)$$

$$Y_{Tc\ 2006} = 423{,}91x + 103823 \qquad (4)$$

where „Y_{Tc}" is the total cost of production in Ft ha^{-1}, and „x" is N agent in kg ha^{-1}.

$$Y_{P\ 2005} = -8{,}9362x^2 + 1501{,}6x + 38799 \qquad (5)$$

$$Y_{P\ 2006} = -2{,}8132x^2 + 399{,}57x + 65232 \qquad (6)$$

where „Y_P" is the profit in Ft ha^{-1}, and „x" is N agent in kg ha^{-1}.

Results and discussion

Variable rate applications were carried out based on ProPlanta fertilization advisory system. According to the application, significant differences occurred in the field. Nutrient replenishment doses based on input data including soil sampling and yield measurements were calculated for nitrogen (N), phosphorus (P) and potassium (K). Doses were calculated according to the needs of the different areas. The average of applied nutrients for the field was lower than in earlier years, however spatial differences compensated this.

Table 1. Data of nutrient replenishment and yields in the averages of investigated area.

Year	Plant	Average yield ($t\ ha^{-1}$)	N ($kg\ ha^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O ($kg\ ha^{-1}$)
2005	Corn *(Zea mays L.)*	9.85	119.5 (12.13)	17.13 (1.74)	139.2 (14.13)
2006	Corn *(Zea mays L.)*	10.84	105 (9.69)	21.3 (1.95)	120 (11.07)

*The values indicated in brackets are specific agent amounts (kg agent t^{-1} yield)

As it can be seen in *Table 1.* in 2006 amount of applied specific agent has been significantly decreasing due to variable rate application as well as favourable meteorological conditions. By applying precision agriculture technology applied nutrient was reduced at the same time yield has increased. It can be stated that efficiency of plant production was increased by applying site-specific agriculture technology. A question occurs at the same time: how does profitability related to increased efficiency?

Profit function was calculated for the year of 2005 (*Figure 1.*). It can be seen that production value and profit has their maximum in different amount of N fertilizer. It can be concluded that increasing N doses could be utilized by the plant (although in smaller and smaller portion, *Mitscherlich law*), this in not profitable (*Gossen II. law*). In case $\partial(1)$ and $\partial(5)$ is calculated edge values will be the results. These are 106 and 84 kg ha^{-1} N fertilizer for (1) and (5) respectively.

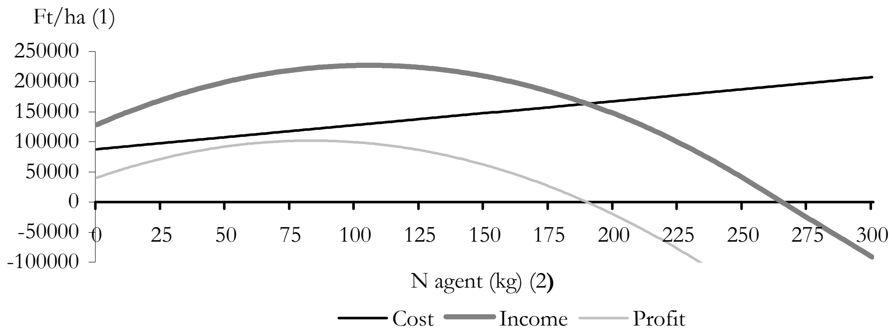

Figure 1. Profit curve of DK 440 Mosonmagyaróvár 2005. (1) Ft ha^{-1}, (2) N agent (kg ha^{-1}), (3) Total Cost, (4) Production Value, (5) Profit.

In case we compare the calculated value with *Table 1.* data, it can be concluded that nutrient replenishment for 2005 was well over the achievable maximum yield. Knowing the yield functions, with much less N fertilizer more profit could be earned.

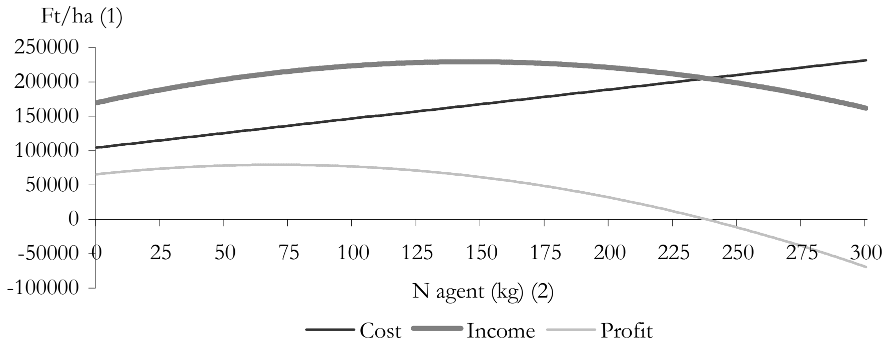

Figure 2. Profit curve of NK Furio Mosonmagyaróvár 2006. (1) Ft ha^{-1}, (2) N agent (kg ha^{-1}), (3) Total cost, (4) Income, (5) Profit.

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In case we calculate $\partial(2)$ and $\partial(6)$ the edge values will be at (2) 146 kg ha^{-1}, and at (6) 71 kg ha^{-1} N fertilizer agent (*Figure 2.*). Comparing the data to *Table 1.* it is clear that the advisory system has achieved a better result; however the recommendation is still the double as the needed amount would be. This does not mean that the advisory system has failed; because the fertilizer reaction functions differ in case genotypes are differ, therefore standardization is necessary in order to make calculations easier.

Conclusions

Reduced amount of N application decreases the possibility of eutrophication and N leaching; therefore utilization of nutrients is better. According to our measurements and calculations we can state that nutrient replenishment plans can be further developed in case a hybrid is well known. As a result of the application of this technology significant savings can be achieved, furthermore environmental load will be reduced. It is important therefore to apply precision agriculture technology. More precise data collection has to be carried out, and advisory systems have to be refined.

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METABOLIC CHANGES IN A *VRN-1* MUTANT WHEAT LINE

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Abstract: Wheat is one of the main food crops grown worldwide and is of great economic and nutritional importance. Winter cereals require cold acclimation to reach their maximum freezing tolerance and vernalization for the initiation of the transition from the vegetative to the reproductive phase. In cereals, the vernalization response is mediated by stable induction of the floral promoter *VERNALIZATION-1* (*VRN-1*), which initiates reproductive development at the shoot apex. To understand the metabolic changes underlying these processes we used a diploid wheat (*Triticum monococcum*) mutant, *maintained vegetative phase* (*mvp*), that carry a deletion encompassing *VRN-1*. Samples were collected from wild-type and mutant leaves and crown tissues two weeks after cold treatment at 3°C (vegetative phase), when the shoot apex developed double ridges (competent to flower), and when the spikelet is formed (reproductive phase), and from non-treated controls. Metabolites were measured by GC-MS. Preliminary results show differences in valine contents of cold-treated wild-type and mutant shoots, and in cinnamic- and linolenic acid contents of cold-treated wild-type and mutant crown tissues. Cinnamic acid is a precursor of salicilic acid while linolenic acid is a precursor of jasmonic acid. Thus the differences in the amounts of these compounds between the wild-type and the never-flowering *VRN-1* mutant may indicate an important metabolic flux underlying the transition from vegetative to reproductive phase in wheat.

Keywords: freezing tolerance, metabolite profiling, vernalization, wheat

Introduction

Cereals are significant sources of food and animal feed, constituting over 50% of worldwide crop production. To maximize yield, it is essential to tailor the life cycle of cereals to the agro-environments in which they are grown. The transition from vegetative to reproductive growth is a critical developmental switch and a key adaptive trait in both crop and wild cereal species that ensures that plants set their flowers at an optimum time for pollination, seed development, and dispersal. Adaptability to a wide range of environments has been favoured by allelic diversity in genes regulating growth habit (*VRN* genes) and photoperiod response (*PPD* genes) (Distelfeld et al., 2009). Differences in the *VRN* genes divide the temperate cereals into winter and spring classes. Winter cereals are planted in fall and require long exposures to cold temperatures to accelerate flowering (vernalization requirement), an adaptation that prevents the exposure of sensitive floral meristems to freezing winter temperatures. Natural variation in vernalization requirement in the temperate cereals is mainly associated with allelic differences in the *VRN-1*, *VRN-2*, and *VRN-3* vernalization genes. *VRN-1* encodes a MADS-box transcription factor with high similarity to *Arabidopsis* meristem identity genes *APETALA1*, *CAULIFLOWER*, and *FRUITFULL*, which regulate the transition of the vegetative shoot apical meristem to the reproductive phase (Greenup et al., 2009). In diploid wheat, radiation-induced deletions in the *VRN-1* gene result in plants that never flower, suggesting that this gene is essential for flowering in this species (Shitsukawa et al., 2007). To understand the metabolic changes underlying the transition from vegetative to reproductive phase we used a diploid wheat (*Triticum monococcum*) mutant, *maintained vegetative phase* (*mvp*), that carry a deletion

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encompassing *VRN-1* (Dhillon et al., 2010). Here we report differences in metabolite content of wild-type (WT) and mutant (VRN-1) leaves and crown tissues two weeks after cold treatment at 3°C, when the shoot apex developed double ridges, and when the spikelet is formed compared to non-treated controls.

Materials and methods

Plant growth conditions

After germination for 6 days (1 day 22°C, 3 days 4°C, 2 days 22°C) the seedlings were grown in wooden boxes (42 x 31 x 18 cm) in a 2:1:1 (volume) mixture of garden soil, humus and sand for 28 days in a growth chamber (Controlled Env. Ltd., Winnipeg, Canada) at 20/17°C day/night temperature and 75/70% relative humidity, with 16 h illumination at 260 µmol m^{-2} s^{-1}. Cold treatment was carried out at 3°C until the appearance of the spike primordia without changing the other growth conditions. Sampling was done at the end of the growth at 20/17°C, after 14 days at 3°C (apex was still in vegetative phase), after 23 days at 3°C (double ridge phase of the apex, start of vegetative/generative transition) and after 35 days at 3°C (spike primordia).

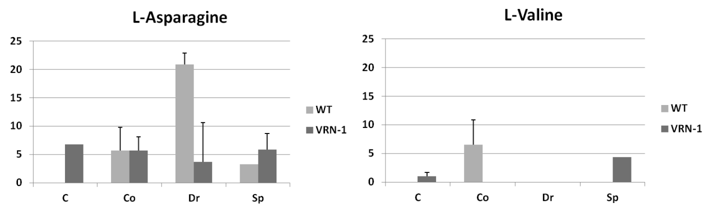
Metabolite profiling

Extraction, derivatisation and analysis of metabolites were carried out as described by Schauer et al. (2004) using a quadrupole-type GC-MS system (Finnigan Trace/DSQ, Thermo Electron Corp.). The chromatograms and mass spectra were evaluated using the XCALIBUR software (Thermo Electron Corp.) and the NIST 2.0 library. Principal Component Analysis (PCA) was carried out with the Multibase Excel Add Ins program installed from the Numeric Dinamics web site (http://www.numericaldynamics.com).

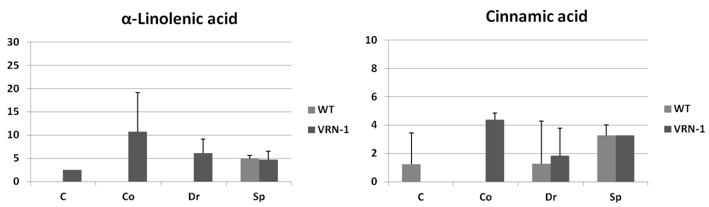
Results and discussion

Metabolite profiling was performed on soil-grown plants sampled from four different stages. Leaves and crowns were harvested from eight plants in three parallels from 28-day-old plants grown at 20-17°C (control) and after cold treatment at 3°C in vegetative and double ridge phases and when the spikelet was formed. All four stages were analysed by metabolite profiling, yielding a total of 48 datasets. In each sample 31 metabolites were identified including the amino acids asparagine, aspartic acid, glutamine, proline, threonine, serine and valine, the carbohydrates fructose, galactose, glucose, inositol, maltose, mannose, melibiose, turanose, raffinose, ribose, sorbitol, and sucrose, the carbonic acids cinnamic acid, galactonic acid, glutaric acid, iso-citric acid, linolenic acid and malic acid, and six compounds with unknown specification. Thus our final dataset included 1488 data. Averages and standard errors were calculated from parallels and plotted on bar charts. We found that the cold treatment significantly increased the amounts of fructose, galactose, glucose, melibiose, raffinose, turanose, sucrose and malic acid both in leaves and crowns and the asparagine, aspartic acid, proline, threonine and valine contents in crowns in WT as well as in VRN-1 plants. In the moderately freezing-sensitive *Triticum aestivum* cv. Chinese Spring wheat variety, Kovács et al. (2011) found a gradual increase in amino acid content during a 3-week cold acclimation period in whole shoots (crowns and leaves). By the separate examination of the crowns and leaves it turned out that, in general, in the spring wheat *Triticum monococcum*, the amounts of amino acids were increased only in crowns but not in leaves. We collected samples after 14-, 23- and 35-day cold treatment and found a significant increase in aspartic acid content of leaves only after 35 days both in WT and VRN-1 plants and in valine and asparagine content of WT after 14 and 23 days, respectively (*Figure 1A*). In contrast, amounts of cinnamic acid and linolenic acid were increased only in the mutant crowns after 14 days (*Figure 1B*). These finding indicate that VRN-1 influences the cold-induced valine accumulation in vegetative stage and asparagine accumulation at the start of vegetative/generative transition in shoots. Furthermore, VRN-1 is involved in conversion/catabolism of cinnamic acid and linolenic acid. Since cinnamic acid is a precursor of salicilic acid while linolenic acid is a precursor of jasmonic acid the differences in the amounts of these compounds in WT and VRN-1 crowns suggest implication of these stress hormones in transition from vegetative to reproductive phase in wheat. Accumulation of carbohydrates at low temperature leading to improvement in cold tolerance of plants including winter wheat is a known phenomenon (Zheng et al., 2011). Our result indicates that this phenomenon is independent of VRN-1 action.

A)



B)



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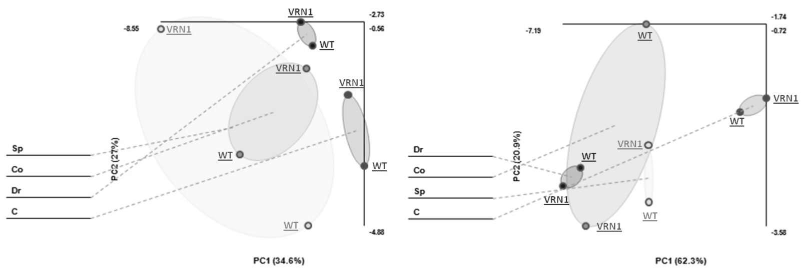

Figure 1. Metabolite differences in leaves A) and crowns B) of WT and VRN-1 mutant in control (C), and after cold treatment in vegetative (Co) and double ridge (Dr) phase and when the spikelet is formed (Sp). C) The result of PCA analysis of shoots (left) and crowns (right) data.

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Principal Component Analysis (PCA) was used to determine the main contributions to variation in the data. *Figure 1C* shows that the metabolite profile of WT and VRN-1 mutant was very similar both in leaves and crowns in control and double ridge phase and also in crowns when the spikelet was formed. The cold treatment resulted in alteration of metabolism in a different way in WT and VRN-1 leaves and crowns. At spikelet formation, the metabolite content of WT and VRN-1 was very different. In WT, the metabolite content at spikelet formation in leaves was altered compared to the double ridge phase, while in the VRN-1 mutant the alteration was minimal during the same period of time. This finding is in correlation with the lack of vegetative/reproductive transition in the VRN-1 mutant.

Conclusions

The *VRN-1* gene, which is essential for flowering, influences the cold-induced accumulation of valine in vegetative stage and accumulation of asparagine at the start of vegetative/generative transition in shoots. In VRN-1 mutant, cinnamic acid, a precursor of salicilic acid, and linolenic acid, a precursor of jasmonic acid, accumulate in crowns suggesting implication of these stress hormones in vegetative/generative phase transition in wheat.

Acknowledgements

We thank Ferenc Marincs for help with the PCA analysis. This work was supported by TÁMOP-4.2.2/B-10/1-2010-005 to the University of Pannonia and by the National Office for Research and Technology, NKTH-OTKA CNK80781 to the Agricultural Research Institute, Centre for Agricultural Research and CNK80936 to the Agricultural Biotechnology Center.

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TRANSPIRATION OF PLANTS UNDER THE CONDITIONS OF CONTROLLED WATER REGIME

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Abstract: The aim of the submitted contribution is to analyze plant evaporation during the transition from the stress conditions to the moisture optimum conditions. Moisture conditions shall be specified by water storage to the depth of 1 m, which shall be determined by numerical simulation on the mathematical model GLOBAL. Moisture aspects shall be specified by hydrolimits of "field water capacity", "threshold point" and "wilting point". Daily course of water storage in the chosen vegetation periods during the 38-years period (1970 - 2008) shall be specified by the regulation of groundwater level. Consequently, these courses will be compared to the usable water capacity and calculated courses of actual transpiration.

Keywords: transpiration, soil water storage, ground water level, hydrolimits

Introduction

Vegetation cover forms an important interactive link with unsaturated soil zone within the hydrological cycle. During a vegetation period, plants go through different phonological phases. During these time-limited phases, plants have different requirements for water content available in soil. If the available water content is not sufficient in these critical phases, plants` growth and development is retarded. One of the indicators of optimal water provision for plants is their transpiration potential. This state is reached when the soil water storage (WS) is on the upper level of available water content (AWC), within the interval of field water capacity (FWC) and point (TP). If the water content drops under this level, plants react to new stress conditions by lowering transpiration intensity or its total cessation (Fazekašová et al., 2011).

The unsaturated soil zone can be considered a third water source. It supplies the biosphere with water, interacts with atmosphere and ground water. From this point of view, precipitations are the main source of water flow at its upper level and ground water at its lower level. During dry periods, this capillary flow from ground water level (GWL) is a key element in plants`struggle for survival under extreme conditions (Šútor et al., 2011). GWL control during this period enables us to enhance the moisture conditions in soil and thus prevent the formation of extreme conditions and associated impact (Štekauerová et al., 2009).

In this contribution, transition of the soil moisture from state of drought to the state optimal moisture level by GWL control using defined variants was simulated. In the mathematical model GLOBAL, defined GWL values were used as a boundary condition (Majerčák, 2011).

Materials and methods

Analysis of the plant evaporation during soil moisture transition state from the state of drought to the state of moisture optimum was carried out with regard to the winter wheat. Therefore in the 38-years period there were chosen three growing seasons (GS) of the years 1973, 1986 and 2007. This selection takes into consideration the number of

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extremely dry days, when the soil water storage almost reached the wilting point (WP). The back process of gaining the optimum moisture state was simulated by the mathematical model global. As the inputs were used the data measured in Milhostov area, located on the Eastern-Slovakia Lowland (ESL) near the town of Trebišov. This area is characterized by the heavy clay-loamy soils of gley fluvisol type.

Moisture changes in the unsaturated soil zone to the depth of 1 m were applied by the change of boundary condition. In these simulations, boundary condition was represented by 4 groundwater levels (GWL_{real} – real course, GWL_{100} – lower level of bilanced layer, GWL_{90} – existing regulatory drainage, GWL_{60} – long-term minimum). In all of the variants, with the exception of GWL_{real} the levels were set at the defined levels during all the years in question. Consequently, daily development of water storage (WS) to 1m depth and daily total of transpiration (E_t). The aim of the evaluation was to quantify the impact of set GWL on plants` transpiration potential rate by means of the calculated soil water storage.

Results and discussion

Figure 1. represent the daily developments of water storage to 1m depth with marked hydrolimits FWC, TP, WP and daily totals of actual (E_{ta}) and potential (E_{t0}) transpiration during the monitored vegetation periods of the given years.

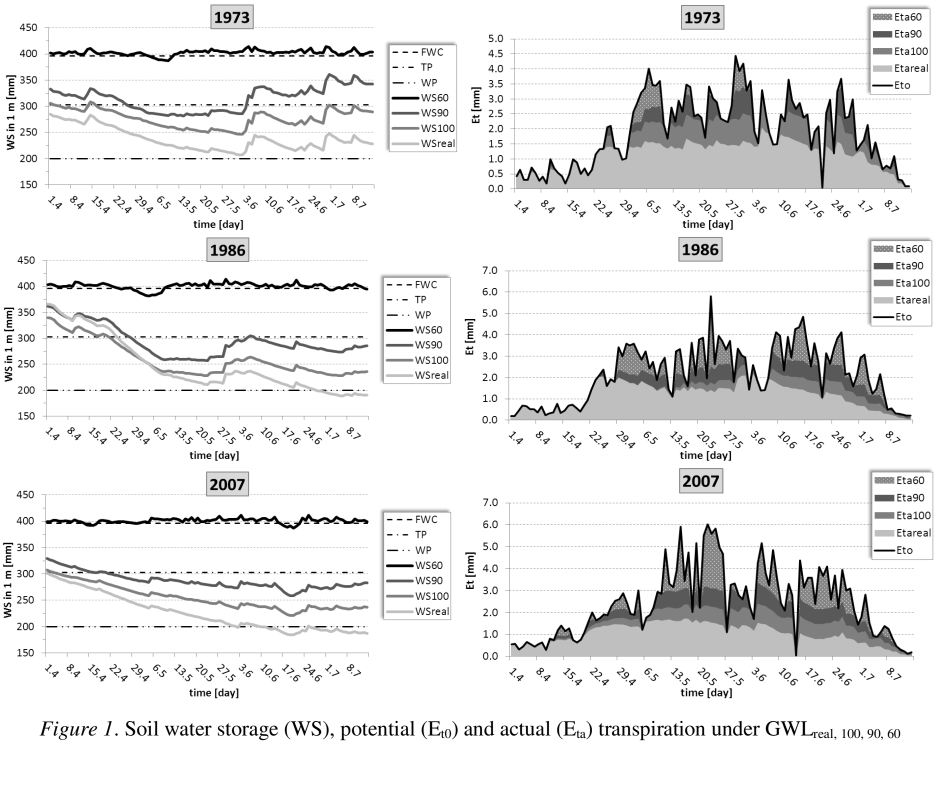

Figure 1. Soil water storage (WS), potential (E_{t0}) and actual (E_{ta}) transpiration under $GWL_{real,\ 100,\ 90,\ 60}$

The length of the period (105 days) is determined by the length of the period during which the wheat growing on the farmland actively transpires. GWL control in the individual variants showed an important interaction with the balanced soil layer. Average growth of WS at the selected $GWL_{100, 90, 60}$ compared to WS_{real} was this: 1973 (39.30; 77.20; 165.11) [mm], 1986 (12.12; 46.30; 152.82) [mm] a 2007 (29.54; 61.41; 175.51) [mm]. Similarly, the interaction with unsaturated soil zone and vegetation cover was shown. In this case, the rise in E_{ta} is significant compared to the actual state. Percentually, rate of reaching E_{t0} increased with the variants $GWL_{real, 100, 90, 60}$: 1973 (60, 83, 94, 100) [%], 1986 (54, 63, 80, 100) [%] a 2007 (43, 61, 78, 100) [%].
Figure 2. represents a positive impact of the increased soil water storage on the E_{ta} increase, under the effect of controlled GWL. With the increase in GWL, cumulative lines of the sum of E_{ta} values approach to E_{t0} and in GWL_{60} they are identical. In practice it means that plants react to drought by lowering their transpiration until the soil moisture conditions are optimal again, near FWC. This reduction in transpiration can be critical during the important phenological phases of the crop with regard to the economical revenues.

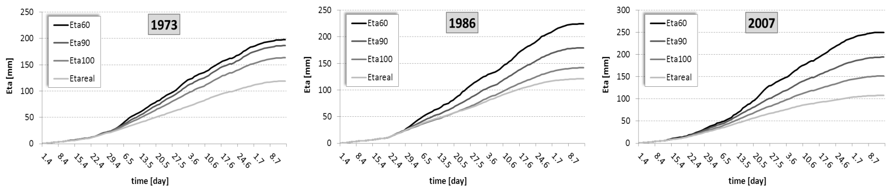

Figure 2. Cumulative lines of E_{ta} under $GWL_{real, 100, 90, 60}$

Table 1. shows the average values of transpiration deficit (E_{tD}) and percentage of reaching the AWC from the average values of WS for all the variants.

Table 1. Transpiration deficit E_{tD} and percentage achieving the AWC under individual GWL variants

GS	GWL_{real}		GWL_{100}		GWL_{90}		GWL_{60}	
	E_{tD} [mm]	WS_{AWC} [%]	E_{tD} [mm]	WS_{AWC} [%]	E_{tD} [mm]	WS_{AWC} [%]	E_{tD} [mm]	WS_{AWC} [%]
1973	78.38	19	34.17	39	11.19	59	0.00	103
1986	103.73	24	82.84	31	45.27	48	0.00	102
2007	142.44	13	98.39	28	55.92	44	0.00	102

Conclusions

The aim of the contribution was to evaluate the impact of soil moisture on the water content transpired by plants. The results showed the high dependency between the soil water storage and the total of transpiration during the investigated vegetation periods of the years 1970, 1980 and 2007. From the cumulative lines it is clear that the sum of E_{ta} is rises to the E_{t0}. Transpiration potential was reached if the soil water storage oscillated around FWC. This state of WS was gained after GWL was modified to the level of long-term minimum of 0.6 m. The sums of other variants of the regulation GWL, 1 m

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under the balanced soil layer and 0.9 m (existing regulatory drainage), gradually approached E_{t0}. For the production process it is important that the plant cover should reach or at least approach to its transpiration potential. This, in a certain way, represents optimal soil moisture state. Otherwise, plants suffer from water deficit or even drought. The results of the modelling has confirmed the effect of GWL control by way of the boundary condition used in the model GLOBAL. At the same time, mutual interactions between the investigated subsystems within the system “atmosphere – vegetation cover – unsaturated zone – ground water level” were analysed.

Acknowledgements

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RESPONSE OF *ARABIDOPSIS THALIANA* TO STRESS BY ZINC AND CADMIUM

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Abstract: Increasing heavy metal contamination of the groundwater is a growing risk concerning food production and environmental protection. On the other hand, trace element deficiency became obvious in several crop production systems. Consequently, solutions are searched for the sustainable supply of trace elements to crops and at the same time avoiding their exposure to toxic levels of heavy metals. In order to produce safe food with eligible nutritional value, the levels of zinc should be increased while the level of cadmium should be decreased in crop plants. This is a challenge because zinc and cadmium often occur together as contaminants. Plants absorb and distribute toxic heavy metals through their transpiration stream, using the same mechanisms as in mineral nutrition: uptake by the roots, translocation by long-distance transport in the xylem, and accumulation in below- and above-ground organs. Our study aimed at quantifying the effects of environmentally realistic concentrations of zinc and cadmium. We studied the stress reactions in wild type, transgenic and mutant *Arabidopsis thaliana* plants under zinc and cadmium excess focusing on changes of enzyme activities related to the antioxidant defense system.

Keywords: Zinc, cadmium, Arabidopsis thaliana

Introduction

Cadmium and zinc occurs naturally in the earth's crust. Most zinc and cadmium enters the environment as results of human activities. Plants take up these heavy metals primarily through the roots. Cadmium belongs to the same group of transition metals as zinc and therefore it may be speculated that it enters plants in the same manner and at similar velocities as zinc (Hassan and Aarts, 2011; Pence et al., 2000). Cadmium and Zn are chemically similar. Cadmium is thus able to mimic the behavior of the essential element Zn in its uptake. It has been known for decades that Zn is a competing ion for Cd and depresses Cd uptake (Mengel and Kirkby, 2001). However, unlike Zn, Cd is toxic both to plants and animals. The basic cause of the toxicity probably lies in the much higher affinity of Cd for thiol grouping (SH) in enzymes and other proteins (Mengel and Kirkby, 2001).

Zinc, plants and the environment: Zinc is found in the air, soil, and water and one of the most mobile heavy metal in surface waters and groundwater. It is present as soluble compounds at neutral and acidic pH values. Concentrations of water-soluble Zn is typically low in bulk soil solution even in Zn contaminated soils, between 0.4 nM and 4 μM (Barber, 1995; Broadley et al., 2007) The importance of zinc in plants is principally as metal component of a number of enzymes. (Broadley et al., 2007; Outten and O'Halloran, 2001). Zinc also plays a role in the synthesis of tryptophan which is a precursor of indoleacetic acid (IAA), therefore shortage of zinc disturbs the IAA mediated regulations (Broadley et al., 2007).

Zinc deficiency and excess in plants: Several symptoms of zinc deficiency have already been reported for example development of bronze tints, auxin deficiency like responses such as internode shortening, epinasty, and reductions of leaf size. Zinc deficiency is

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more common in crops produced on high pH-soils. Therefore significant part of the world's arable land considered as zinc deficient (Broadley et al., 2007). High soil zinc concentrations cause retarded growth, reduced yield and chlorophyll degradation.

Cadmium, plants, and the environment: Cadmium is relatively mobile in surface water and ground-water systems. Cadmium enters into the surface and ground waters via waste water of industry and households. Fertilizers (especially phosphate fertilizers) often contains small amount of cadmium. Cadmium flux into plants is strongly influenced by soil Cd concentration, pH values and organic matter levels. Cadmium excess in plants: Low Cd concentration also considered as risk if the soil pH is under 6.5. Plants grown on soil with high concentration of cadmium show visible symptoms of injury namely chlorosis on leaves, browning of root tips and finally death. Increased cadmium concentration seriously affects the photosynthesis (Nagajyoti et al., 2010).

The present study aimed at quantifying the effects of environmentally realistic concentrations of zinc and cadmium in the model plant Arabidopsis thaliana. It is well known that excess of heavy metals will cause the generation of reactive oxygen species (ROS) inside plant tissues. The most common response of plants to ROS is the increase of the antioxidant enzyme activities. To better understand the plant's stress reactions, changes in glutathione S-transferase (GST) activities in transgenic *Arabidopsis thaliana plants* exposed to excessive Zn and Cd concentrations were measured.

Materials and methods

Arabidopsis thaliana plants (ecotype: Col-5) were transformed with cDNA clone overexpressing Zea mays GSTF4 gene (EMBL: U12679 / X79515; Uniprot: P46420) under the control of cauliflower mosaic virus 35S promoter. cDNA were introduced with floral dip transformation method using the hygromycin phosphotransferase (hpt) gene as selectable marker. The fourth transgenic generation (T4) were selected for homozygosity and used for further experiments.

Heavy metal treatment: Arabidopsis plants were grown on soil which was irrigated once with tap water containing 20 or 30 µM CdSO4 at rosette stage. The plants were illuminated with Megaman plant lamp (W1511P) for 16/8 photoperiod (16-27 µmol m-2 s-1) Digital photos were taken in every 15 minutes with a webcamera. Zn treatments were carried out in soil and also in hydroponic system (Tocquin et al., 2003). For hydroponics seeds were sown on 0.55% agar-filled punched tubes and grown on a Flora nutrient solution (General Hydroponics, Biopole, France) containing 0.02 µM or 1500 µM ZnSO4. The hydroponic system consisted of one liter capacity containers with a nontransparent plastic lid containing holes for placing agar-filled tubes with seeds. The soil grown plants were treated with water containing 150 µM and 1500 µM ZnSO4 as described by Cd treatment.

Enzyme activity assays: Cell-free extracts of leaves were prepared and its enzymatic activities of glutathione S-transferase (GST; EC 2.5.1.18) were determined spectrophotometrically (Habig et al., 1974). Chlorodinitrobenzene (CDNB) was used as model substrate.

Statistical analyses: Statistical analyses of data (four replicates) were conducted using the Statistica software (Version 6.1, Statsoft Inc., Tulsa, OK, U.S.A.).

Results and discussion

The cadmium effects on plants were examined in pot experiment. Our experiments revealed that cadmium causes chlorotic lesions on plant leaves but the plant development were not affected. No visible differences were observed between transgenic and wild-type plants. Interestingly the light intensity was a key factor for the chlorotic reactions. The lesions developed on the plants that were grown under 27 µmol m-2 s-1 light intensity, while no lesions were observed under 16 µmol m-2 s-1 light intensity at all.

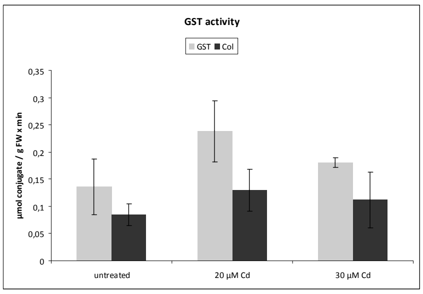

Figure 1. The induction of glutathione S-transferase activity in $CdSO_4$ treated (20 µM and 30 µM) gstf4-transgenic (GST) and wild-type (Col) *Arabidopsis thaliana* plants. Mean values ± SEM are shown (n=3).

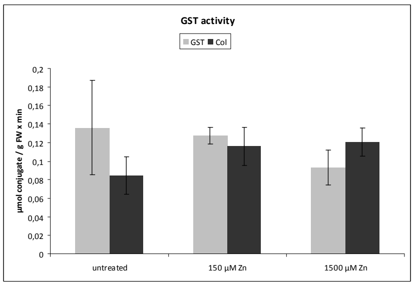

Figure 2. The induction of glutathione S-transferase activity in $ZnSO_4$ treated (150 µM and 1500 µM) gstf4-transgenic (GST) and wild-type (Col) *Arabidopsis thaliana* plants. Mean values ± SEM are shown (n=3).

In order to assess the cadmium effect on the plant's detoxification system, the enzyme activities of glutathione S-transferase were measured in the treated and untreated plants. Glutathione S-transferases (GST) are considered to play an important role in heavy metal stress (Lyubenova and Schröder, 2011; Schröder, 2001). It was found that the GST activity were higher in gstf4-transgenic plant in all cases. Cadmium caused increased GST activity in transgenic Arabidopsis which was higher in 20 µM cadmium treatment (*Figure 1*).

The effects of zinc were characterized in a hydroponic system. We tested ZnSO4 and ZnCl2 but their effect on plants were consistent. No phenotypic differences were observed between the stress reaction of the transgenic and wild-type *Arabidopsis thaliana* plants. High concentration of ZnSO4 (1500 µM) slowed the plant growth,

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shortened the internodal segments and the leaves became yellow, however intensive hairy root development were observed. The soil grown plants did not show these intensive symptoms. Only slight yellowing was observed on leaves in case of 1500 µM Zn treatment. The glutathione S-transferase activity were not affected significantly by zinc treatment (*Figure 2*).

Conclusions

Plants absorb and distribute toxic heavy metals through the transpiration stream inside the plant, with the same mechanisms used in mineral nutrition (Memon and Schröder, 2009).

Therefore plants can be used to remove, sequester, and chemically decompose environmental pollutants like heavy metals and their derivatives. This method has become one of the most rapidly developing methods of environmental restoration. The efficiency of plants as detoxifiers, filters and traps has been proven in cleaning up soils and waters polluted with crude oil, explosives, landfill leachates, metals, pesticides, and solvents (Kőmíves and Gullner, 2000). Our above mentioned results contribute to the knowledge about the stress reaction of plants under heavy metal stress that can be useful both for food production and phytoremediation.

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RAINFALL USE EFFICIENCY OF WINTER WHEAT GROWN IN DIFFERENT FARMING SYSTEMS

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Abstract: Wheat grain yield, yield structure components and the rainfall use efficiency of winter wheat were analyzed in two different farming systems of a long-term field experiment conducted from 1999 till 2008 in Dolná Malanta (Slovakia) on a haplic luvisol soil. The rainfall use efficiency of winter wheat is providing a measure for the adaptation of a cropping system to climate and external inputs. Higher grain yield and more favorable yield structure components of wheat were achieved in the integrated cropping system (compared to the ecological system) and by fertilization. Also rainfall use efficiency was higher in the integrated cropping system and with fertilization presumably due to increased resource availability. In the drier growing seasons the rainfall use efficiency was generally higher than in those with average rainfall as with increasing rainfall the relative importance as limiting factor might change from rainfall to nutrient availability.

Keywords: wheat, rainfall use efficiency, cropping system, fertilization

Introduction

The external inputs differ strongly between farming systems. In conventional systems high external inputs are used (e.g. synthetic fertilizers and chemical plant protection products). Contrary to that, external inputs are reduced or prohibited in organic agriculture to promote ecosystem health. Integrated agriculture lays in between using natural regulation processes and external inputs. Cropping system is affecting the yield (Mäder et al., 2007) and bread-making quality of wheat (Váňová et al., 2008). Rainfall use efficiency is providing a measure for the adaptation of a cropping system to climate and external inputs. The water use efficiency of a crop can be affected by cropping system as shown by Álvaro-Fuentes et al. (2009) for barley grown under rotation and monoculture. Input of fertilizers has a positive effect on the yield stability of agricultural systems and increases the production sustainability (Hao et al., 2007). Nitrogen addition is increasing rainfall use efficiency as showed for several natural arid and semiarid grassland ecosystem sites in Inner Mongolia by Bai et al. (2008). Aim of the study was to assess the effects of cropping system, fertilization and year on yield and yield structure components of wheat and on the the rainfall use efficiency of wheat.

Materials and methods

A rotation and cropping system experiment was performed at the Research Experimental Station of the Slovak University of Agriculture in Dolná Malanta from 1999-2008. The continental climate is characterized by warm and dry summers and mild winters (long-term average temperature and rainfall: 9.7°C rsp. 561 mm, average rainfall during wheat growth: 434 mm). The soil type is a Haplic Luvisol developed at proluvial sediments mixed with loess.

Experimental factors were cropping system and fertilization. The course of the crop rotation of the two cropping systems “Ecological (ECO)” and “Integrated (INT)” is summarized in *Table 1*. The fertilization treatments were “fertilized (+fert)” and

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“unfertilized (-fert)”. The +fert treatments were based in both cropping systems on 40 t of manure which was applied before maize. The INT system received additionally synthetic fertilizers. The amount applied was based on soil testing and fertilizer recommendations. The crop management data for winter wheat are summarized in *Table 2*. Grain yield and yield structure components (n ears m^{-2}, n kernels m^{-2}, thousand grain weight (TKW) (g)) of the winter wheat growing in the third year of the crop rotation course were evaluated in four repetitions. So the pre-crop before wheat was lucerne in the ECO system and peas in the INT system.

Rainfall use efficiency (RUE) which is the ratio of yield or yield components to rainfall was calculated by dividing the assessed parameter by the rainfall during growth (from sowing till harvest) as presented by Chiroma et al. (2008). RUE does not take into account the changes in soil water storage. Commonly the water-use efficiency is calculated as the ratio of yield to evapotranspiration (calculated from rainfall and the chance in soil water storage) (López and Arrúe, 1997). Anyhow, Zaongo et al. (1994) have criticized this concept for not adequately defining the use efficiency of rainwater.

Table 1. Crop rotation of the two cropping systems.

Year	Cropping system		
	Ecological (ECO)		Integrated (INT)
1	beans + lucerne		winter wheat
2	lucerne		peas
3	winter wheat		winter wheat
4	peas		maize
5	maize		spring barley
6	spring barley		lucerne (3 years)

Table 2. Crop management data for winter wheat (1999 – 2008).
Nitrogen, phosphorus and potassium were applied solely in the integrated system.

Year	Sowing date	Harvest date	Rainfall (mm)	Average temperature (°C)	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
1999	23/10/98	20/07/99	435	8.1	23.8	15.0	31.6
2000	28/09/99	3/07/00	301	9.5	25.3	5.0	18.3
2001	29/09/00	20/07/01	408	10.4	29.0	5.8	23.3
2002	4/10/01	6/07/02	310	9.0	44.2	15.8	16.6
2003	9/10/02	30/06/03	264	7.7	34.2	21.6	26.6
2004	2/10/03	21/07/04	450	8.2	39.8	19.1	16.6
2005	1/10/04	19/07/05	398	8.2	49.2	22.5	10.0
2006	7/10/05	20/07/06	522	7.9	58.3	22.5	0.0
2007	2/10/06	2/07/07	347	10.0	58.0	28.3	56.6
2008	9/10/07	28/07/08	467	8.9	57.5	28.3	21.6

Results and discussion

The three factors cropping system, fertilization and years affected the recorded parameters grain yield, number of ears m^{-2}, number of kernels m^{-2} and thousand kernel weight (TKW) (*Table 3*). There were interactions between the factors (except for number of ears m^{-2}). Generally, the grain yield was increased in the cropping system INT by 0.89 t yr^{-1} (by 17%) (compared to ECO). Fertilization increased the grain yield by 0.43 t yr^{-1} (by 7.9%) compared to no fertilization. There was a significant three-way interaction between cropping system, fertilization regime and year insofar that in some years the effects of cropping system and fertilization were observed whereas in other years (e.g. 2008) no differences between the treatments could be found. Ear number m^{-2} was significantly higher in the integrated cropping system compared to the ecological one (by 7.8%). Fertilization increased the n ear m^{-2} significantly by 7.1%. Kernel number and TKW were generally higher in the INT system (by 12.1% compared to ECO) and with fertilization (by 5.3% compared to no fertilization). TKW was significantly increased with fertilization by 2.5% and in the INT system (by 3.6%) (except for the years 2001 and 2007 when the TKW was higher in the ECO system).

Table 3. Main effect means and analysis of variance (probability levels) results for the effects of Cropping System, Fertilization and Year on grain yield, number of ears and kernels m^{-2}, thousand kernel weight (TKW) and the rainfall use efficiency (per mm of rainfall) for these parameters.

	Agronomic parameters					**Rainfall use efficiency**			
	Grain	Ears	Kernel	TKW		Grain	Ears	Kernel	TKW
	(t ha^{-2})	(n m^{-2})	(n m-2)	(g)		(kg ha^{-1} mm^{-1})	(n m^{-2} mm^{-1})	(n m^{-2} mm^{-1})	(g m^{-1})
Cropping system (CS)									
INT	6.12^{a}	583^{a}	14778^{a}	41.7^{a}		16.1^{a}	1.56^{a}	39.1^{a}	0.111^{a}
ECO	5.23^{b}	540^{b}	13186^{b}	40.2^{b}		13.8^{b}	1.45^{b}	35.2^{b}	0.107^{b}
Fertilization (F)									
+fert	5.90^{a}	574^{a}	14344^{a}	41.4^{a}		15.4^{a}	1.54^{a}	37.9^{a}	0.110^{a}
-fert	5.47^{b}	549^{b}	13629^{b}	40.6^{b}		14.4^{b}	1.48^{b}	36.4^{a}	0.107^{b}
Year (Yr)									
1999	6.86^{ab}	524^{b}	14537^{b}	47.0^{b}		15.8^{b}	1.20^{f}	33.4^{d}	0.108^{d}
2000	5.56^{cde}	521^{b}	13982^{bc}	39.8^{d}		18.5^{a}	1.73^{c}	46.5^{b}	0.132^{b}
2001	5.71^{cd}	570^{ab}	13979^{bc}	41.1^{d}		14.0^{bc}	1.40^{e}	34.3^{cd}	0.101^{e}
2002	5.42^{de}	598^{a}	10824^{d}	50.2^{a}		17.5^{a}	1.93^{b}	34.9^{cd}	0.162^{a}
2003	4.74^{e}	595^{a}	15312^{b}	31.4^{f}		18.0^{a}	2.25^{a}	58.0^{a}	0.119^{c}
2004	6.28^{bc}	529^{ab}	13929^{bc}	44.4^{c}		13.9^{bc}	1.18^{f}	31.0^{d}	0.099^{e}
2005	5.14^{de}	599^{a}	13780^{bc}	37.1^{e}		12.9^{c}	1.51^{de}	34.6^{cd}	0.093^{f}
2006	7.18^{a}	580^{ab}	18149^{a}	39.6^{d}		13.8^{bc}	1.11^{f}	34.8^{cd}	0.076^{g}
2007	5.02^{de}	541^{ab}	13437^{bc}	37.4^{d}		14.5^{bc}	1.56^{d}	38.7^{c}	0.108^{d}
2008	4.93^{de}	558^{ab}	11887^{cd}	41.5^{d}		10.6^{d}	1.20^{f}	25.5^{e}	0.089^{f}
ANOVA GLM									
CS	***	***	***	***		***	***	***	***
F	**	*	*	**		**	*	*n.s.*	**
Yr	***	***	***	***		***	***	***	***
CS×F	*n.s.*	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	*n.s.*
CS×Yr	**	*n.s.*	**	***		**	*	*	***
F×Yr	*n.s.*	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	*n.s.*
CS×F×Yr	*	*n.s.*	*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	*n.s.*

The RUE of the grain yield was higher in the cropping system INT compared to ECO in all years but 2007 (*Table 3*). The RUE of INT was higher for the parameters n ears m^{-2}

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(except: 2003 and 2008), n kernels m^{-2} (except: 2007 and 2008) and TKW (except: 2001 and 2007). The RUE of these parameters was significantly higher with fertilization (except for n kernel m^{-2}). Bai et al. (2008) already have shown that at a given amount of rainfall the maximum rainfall use efficiency can be increased by increasing resource availability.

The RUE of the analyzed parameters was in the five years with <400 mm rainfall (dry years) in the growing season generally higher than in the five years with >400 mm rainfall. Huxman et al. (2004) and Bai et al. (2008) already have shown that the RUE is decreasing within an ecosystem with increasing annual precipitation. Aboveground biomass production is dependent on factors including precipitation and nutrient availability. The interactions are causing changes of the relative importance of limiting resources; e.g with greater than average precipitation, factors like soil nitrogen might become the limiting resource and thereby limiting biomass productions more strongly than precipitation (Huxman et al., 2004; Bai et al., 2008).

Conclusions

Higher grain yield and more favorable yield structure components of wheat were achieved in the integrated cropping system and by fertilization. Also rainfall use efficiency was higher in the INT system and with fertilization presumably due to increased resource availability. In the drier growing seasons the rainfall use efficiency was generally higher than in those with average rainfall as with increasing rainfall the relative importance as limiting factor might change from rainfall to nutrient availability.

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HOW WATER USE EFFICIENCY IS IMPORTANT IN HABITAT ADAPTATION OF *GALANTHUS NIVALIS* L. ?

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Abstract: Water use characteristics as the function of green water were examined on ecologically different populations of *Galanthus nivalis* L in order to get a better estimation for the survival in the habitats under abiotic stress. The generally exposed photosynthetic WUE turned to be the most beneficial under normal abiotic conditions, the biologically more responsive intrinsic WUE turned to be the most favourable under the circumstances of climate change. Lowland and mountain populations are variously adapted through their assimilation and stomatal conductance patterns, contributed to water use efficiency.

Keywords: common snowdrop, ecophysiology, stomatal conductance, transpiration, water use efficiency

Introduction

Galanthus nivalis L. (common snowdrop) is a herbaceous perennial plant, the most widely distributed species of the genus in *Amaryllidaceae* family. Furthermore it can be naturalized and introduced to cultivation elsewhere in the world. Plant grows from a bulb, normally produces two linear leaves with applanate vernation. Blossom emerges between January and April in the Northern temperate zone. It has six tepals, they have odorous substances by emitting essential oils in terms of pollination. The species is native all around in Europe, except the Southwest Mediterranean region, from lowlands to subalpine habitats. In Central Europe it is naturally abundant in the deciduous, mesophilous forest types (*Fagetalia sylvaticae*) including *Carpinion*, *Tilio-Acerion* or *Fagion* woodlands, characteristically on calcareous soil. In Hungary it is a specialist (S), environmental indicator of thermophilous woodlands (TB7) with fresh soils (WB6), basic habitats (RB7), soils that rich in mineral nitrogen (NB7), suboceanic belts on temperature extremities (KB4), halfshadow position (LB5) and absent in salty or alkalic locations (SB0) (Horváth et al., 1995).

In the case of early spring geophytes, abiotic environmental parameters are hardly effective for development, phenological stages or the growth correlated with leaf longevity by various carbon fixation or transpiration, according to adaptation type. In a low-temperature adapted species reduced biomass production, preceded flowering time but increased transpiration is expected at high temperature. It presumes significant changes in viability, life cycle and distribution as so as the elevated carbon-dioxide regime (Maak and Storch, 1997). Among variables temperature mediately regulates on source-sink imbalance between starch accumulation in storage organs and leaf senescence through variability of gas exchange pattern (Badri et al., 2007; Gardin et al., 2011).

According to earlier ecophysiological measurements of common snowdrop, net assimilation rate did not appreciabily reduced at high temperature, but optimum level of carbon fixation is reached at different radiation intensity: the higher the temperature the smaller the radiation (Kartusch, 1979). The inner tepals also include photosynthetically active green marks producing assimilates for seed development with one-fourth rate of fully developed leaves by significantly lower chlorophyll content by amoeboid type of

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chloroplasts (Ščepánková and Hudák, 2004; Aschan and Pfanz, 2006). In this study effect of elevated temperature and carbon-dioxide regime as the main components of a climate change event to green water use characteristics of common snowdrop is revealed. Our question is which one of two ecologically different habitats could be more suitable for common snowdrop's survival under Central-European climatic conditions.

Materials and methods

Ex situ gas exchange measuring was executed on snowdrop (*Galanthus nivalis* L.) populations collected from lowland (Szigetköz, 2000) and mountain (Mecsek, 2010) locations of Hungary. They were acclimated in the Botanical Garden, University of Pécs under identical abiotic conditions to eliminate environmental variability.

Data had been recorded by a portable, microclimate modulated IRGA equipment (LCPro+). Steady state leaf gas exchange measurements were carried out by standard-dized scale of light intensity (0-1800 $\mu molm^{-2}s^{-1}$) under constant relative air humidity (10 mBar), two levels of carbon-dioxide (370, 750 vpm) and temperatures (15, 25 ^{o}C).

Light responses were constructed on PPFD to selected gas exchange variables in each on populations (L = lowland, M = mountain) by carbon-dioxide and temperature treatments (370-15, 370-25, 750-25). Rate of gas exchange parameters at maximum light intensity were used to display results of treatments, e.g. L (370-15) is the lowland population at 370 vpm carbon-dioxide and 15 ^{o}C temperature, for further see *Table 1*. Similarity or difference in response characteristics was tested by one-way analysis of variance (ANOVA) at $p<0.05$ statistical probability level, marked by small letters (see *Figure 1.*). Photosynthetic gas and water exchange variables and responses to photon flux density were compared according to the populations and environmental factors as the treatments. Analyses are focused on variables of water utilization as photosynthetic (pWUE) and intrinsic (iWUE) water use efficiency and their background variables like assimilation (A), transpiration (E) and stomatal conductance for water vapour (g_s).

Abbreviations: PPFD, photosynthetic photon flux density ($\mu mol\ m^{-2}\ s^{-1}$); pWUE, photosynthetic water use efficiency as the ratio of A/E (μmol/mmol); iWUE, intrinsic water use efficiency as the ratio of A/g_s (μmol /mmol); A, net assimilation rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$); E, transpiration rate ($mmol\ H_2O\ m^{-2}\ s^{-1}$); g_s, stomatal conductance for water vapor ($mmol\ H_2O\ m^{-2}\ s^{-1}$).

Results and discussion

Photosynthetic water use efficiency (pWUE) as a general measure of water utilization according to the ratio of assimilation to transpiration (*Table 1*, *Fig 1 A,C,D*). Highest values developed under normal carbon-dioxide level at low temperature with a little bit higher value in the mountain population, due to lower transpiration rate. High tempera-ture at normal level of carbon-dioxide resulted significant decrease in populations declining by a higher extent in lowland (32.3%) than mountain (45.4%) one. It is caused by poorly increased assimilation versus highly increased transpiration. Elevated carbon-dioxide treatment at high temperature generated significantly higher values, rising by a little bit larger extent in mountain (191.3%) than lowland (186.8%) population. It is due to significantly increased assimilation in mountain population, likewise to transpiration rate in lowland one. Multiple treatment resulted a moderate decrease in pWUE, a bit differently in populations of lowland (84.8%) and mountain (61.9%).

Table 1. Maximum values of analysed gas exchange parameters (mean ± SD). Meaning of habitats, treatments and variables see in Materials and Methods.

	PWUE	IWUE	A	E	G_S
L (370-15)	12.85 ± 0.29	62.41 ± 2.66	13.40 ± 0.27	1.24 ± 0.03	0.21 ± 0.01
L (370-25)	5.83 ± 0.33	43.24 ± 2.98	16.59 ± 0.32	3.79 ± 0.04	0.39 ± 0.01
L (750-25)	10.89 ± 0.34	145.08 ± 3.10	19.06 ± 0.20	2.03 ± 0.04	0.13 ± 0.00
M (370-15)	15.31 ± 0.27	76.90 ± 2.42	12.11 ± 0.32	0.79 ± 0.02	0.16 ± 0.00
M (370-25)	4.95 ± 0.13	53.10 ± 1.95	12.75 ± 0.24	2.55 ± 0.04	0.24 ± 0.00
M (750-25)	9.47 ± 0.11	94.19 ± 1.68	25.81 ± 0.39	2.67 ± 0.04	0.27 ± 0.01

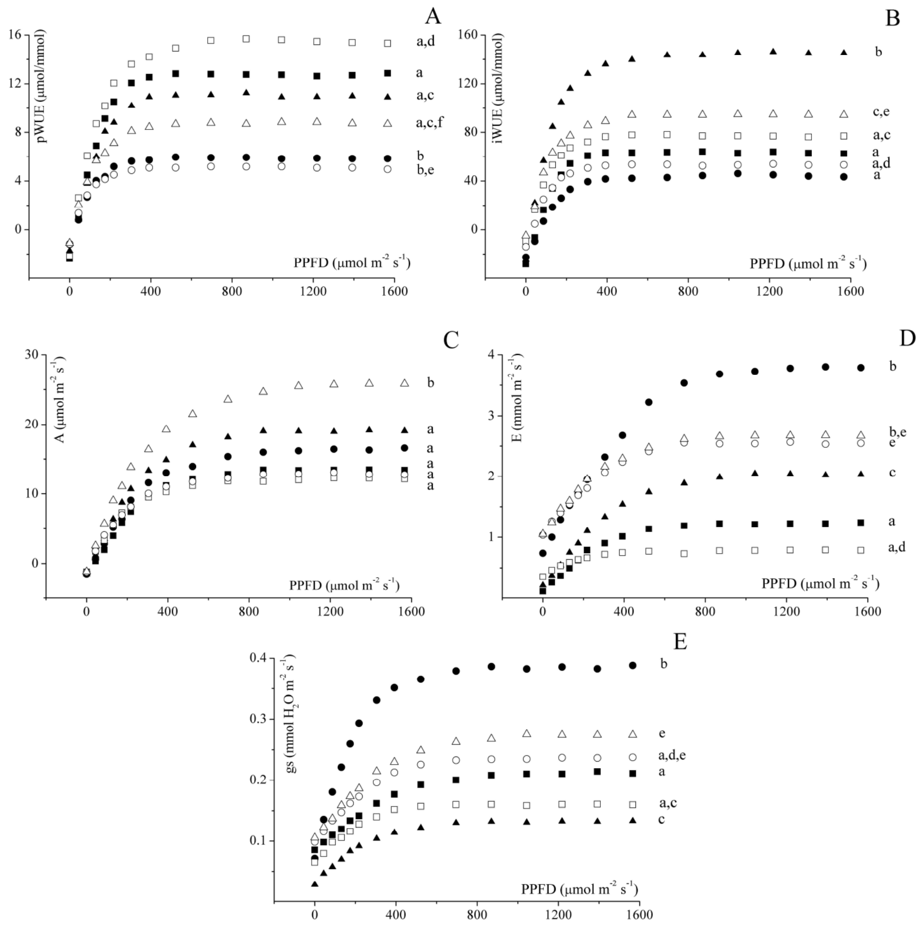

Figure 1. Light responses of gas exchange parameters. A) net assimilation rate, B) transpiration rate, C) stomatal conductance for water vapour, D) photosynthetic water use efficiency, E) intrinsic water use efficiency. Lowland habitat = full symbols (e.g. ■), mountain habitat = open symbols (e.g. □), 370-15 treatment = square (e.g. ■), 370-25 treatment = circle (e.g. ●), 750-25 treatment = triangle (e.g. ▲).

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Intrinsic water use efficiency (iWUE) is a more sensible parameter of water utilization in the plants because of higher relative changes in stomatal conductance (g_s) under environmental stress (*Table 1.*, *Figure 1.* B,C,E). Highest values developed under elevated carbon-dioxide level at high temperature in the populations, with higher values and significantly different variance in the lowland one, due to significantly lower value of g_s. High temperature at normal carbon-dioxide resulted any decrease of iWUE in populations, declining by equal extent in lowland and mountain (69.2%) ones. Elevated carbon-dioxide treatment at high temperature generated significantly higher values and variance, rising by much larger extent in mountain (335.5%) than lowland (186.8%) population. Multiple treatment resulted a moderate intrinsic water use efficiency increase in mountain population (122.5%) but a significant increase in the lowland (232.5%) one.

Conclusions

Lowland and mountain populations of common snowdrop were characterized by water use efficiency variables in different way. The generally interpreted photosynthetic WUE turned out to be the most beneficial at normal level of carbon dioxide and low temperature (370-15). Its background variables as assimilation and transpiration rate had no significant differences between the populations. Through the environmentally more responsive intrinsic WUE turned to be the most favourable at elevated carbon-dioxide and high temperature (750-25). Both of background variables as assimilation and stomatal conductance for water vapour had significant differences between the populations. It is concluded that lowland and mountain populations of common snowdrop are variously adapted to environment through assimilation and stomatal conductance patterns that would be essential for surviving in case of an abiotic stress.

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IMPACT OF DAILY WATER INTAKE ON THE ANGIOLOGICAL STATE

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Abstract: Impacts of daily water intake on the angiological state of series of random patients of an ambulance case study have been studied. Daily Water Intake (DWI) and age (Year) has been correlated with the General Angiological State (GAS) of the patients. The results obtained support a conclusion, that water availability to humans represents a peculiar stress factor in relation with vascular diseases. Within the study the patients gender impacts have also been evaluated. High correlations were found between water drinking patterns and the severity of vascular diseases in case of male patients. Age of patients was in accordance with the general angiological state, however vascular problems due to age were increased significantly.

Keywords: daily water intake, vascular diseases, angiological state

Introduction

Water intake, healthy food, their quantity and quality is a major source of most human health problems (Szentpétery et al., 2002; Greenspan et al., 2008). Several authors have reported, that vascular diseases are often related to daily water intake as well as to the age of patients (Romeo et al., 2008; Yuemang et al., 2006). Microvascular dysfunction in human hypertension has been reported by Farkas (2008). Angiological state of the population is being observed by various methods (USP, 2004; Michel, 2008; Ross et al., 2009). In most countries objective measurement methods are combined with empirical observations.

The present study is dealing with the occurence of vascular diseases in relation with nutritional patterns and age of patients.

Materials and methods

Daily water intake impacts have been studied in a random population within a case study run at the Railway Health Care Company Budapest in 2011. 31 patients, 14 female and 17 male have been studied within an age range of 28 to 83 years. Age, Daily Water Intake (DWI) and General Angiological State (GAS) were evaluated in general and in relation with the gender of patients. Statistical analyses have been applied in accordance with statistical evaluation package of Microsoft 2003.

General angiological state (GAS) has been determined by a 1-7 ranking as follows:

Three angiological diseases + diabetes	7
Three angiological diseases	6
Two angiological diseases + diabetes	5
Two angiological diseases	4
One angiological disease + diabetes	3
One angiological disease	2
Normal state	1

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The three vessels' diseases observed were as follows: carotic artheric stenosis, coronaria stenosis, peripherial arterial disease PAD. DWI and GAS, as well as age and GAS relations have been evaluated by regression analysis.

Results and discussion

The baseline data of patients, gender, age, DWI and GAS are presented in *Table 1*. The performance of patients in relation with these characteristics were of a broad spectra.

Table 1. GAS ratings of studied cases in relation with daily water intake, gender and age

No	Gender (male/female)	age	Body weight kg	DWI (Daily water intake) $lDay^{-1}$	GAS rating (general angiological state) 1-7
1	Male	62	82	3,5	2
2	Female	61	49	3,1	2
3	Female	38	72	1,5	3
4	Male	72	85	2,0	4
5	Female	65	58	3,0	6
6	Female	28	57	3,0	2
7	Male	67	73	1,0	6
8	Male	49	99,5	2,5	1
9	Female	34	82	3,0	4
10	Male	55	75	2,5	4
11	Female	54	58	3,0	2
12	Male	38	75	2,0	2
13	Female	43	82	2,0	1
14	Male	81	83	1,5	4
15	Male	79	80	2,5	4
16	Female	77	73	1,5	7
17	Male	68	90	2,5	5
18	Male	54	86	1,0	2
19	Female	63	78	1,5	2
20	Female	35	84	2,0	3
21	Male	41	57	2,0	2
22	Male	52	90	2,0	3
23	Female	57	80	1,5	3
24	Female	68	42	1,5	4
25	Female	55	77	2,0	1
26	Female	53	74	2,0	2
27	Male	83	59	1,0	2
28	Male	78	74	2,0	1
29	Male	75	59	1,0	4
30	Male	48	72	1,5	6
31	Male	54	75	1,5	6

The 31 patients studied were within 28 to 83 years age. DWI values were considerably diverse (1 to 3,5 l day^{-1}). In general most patients were in overweight state, and 12,9% of them were definitely obese. General Angiological State (GAS) of patients was gradual regarding the number and severity of vascular diseases and their combination with diabetes. DWI, GAS and age were evaluated both in general, and in relation with the gender of patients.

A statistical regression analysis is presented in *Figure 1.* and *Figure 2.* evaluating the performance of GAS in relation with daily water intake and age regarding both genders.

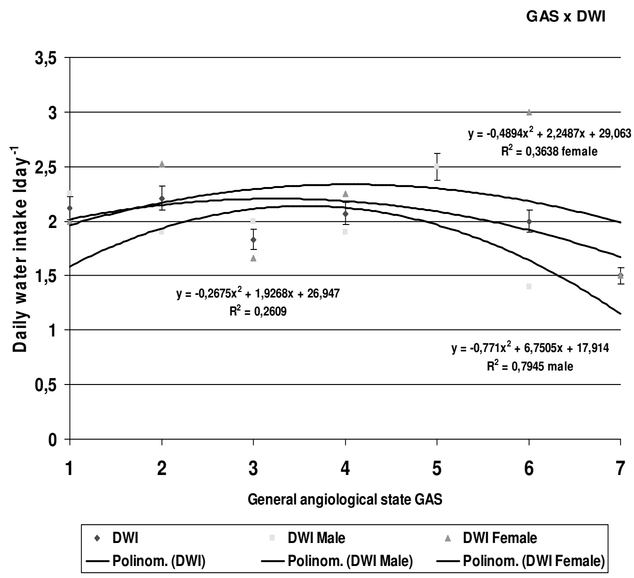

Figure 1. DWI, age and gender impacts on Generel Angiological State GAS performance

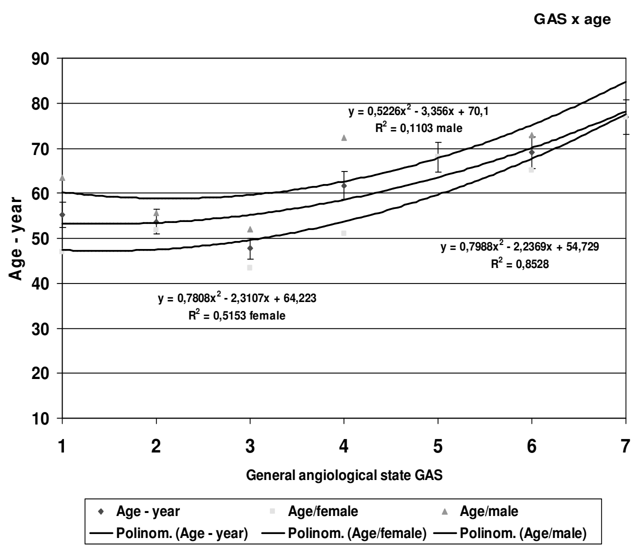

Figure 2. Age and gender impacts on Generel Angiological State GAS performance

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The results obtained support an evidence, that human daily water intake DWI represents a peculiar stress factor in relation with vascular diseases. High correlations were found between the drinking patterns and the severity of vascular diseases in case of male patients. Age of patients was in accordance with the general angiological state, however vascular problems were increased significantly in the female lot only.

Conclusions

Daily water intake patterns of the human population may have an impact on health conditions. In the present study the General Angiological State (GAS) was evaluated within a random population regarding gender, age and daily water intake (DWI). Three vascular diseases - carotic artheric stenosis, coronaria stenosis, peripherial arterial disease PAD - and their combination with diabetes have been studied in correlation with DWI. It can be stated, that low water drinking patterns, especially in male population are a major stressor that may have an influence on vascular diseases. Age proved to be a strong factor in vascular disease performance and could be related to the female lot mainly. Further studies are needed to explore daily water intake interactions in relation with other health parametres. Also, broader sampling of future case studies is needed to precise the results obtained.

Acknowledgements

This study was supported by AASW. The authors are indebted to the Hungarian Railway Health Care Company, Budapest for their kind assistance.

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GREEN DEVELOPMENT: WASTE WATER OR GREEN WATER?

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Abstract: Pollution of surface and groundwater is mostly land based and caused by agricultural overspill and waste materials carried by wind. Agricultural activities are affected very adversely if the resources are not managed properly. Moreover, reduction in biodiversity of flora and fauna, production capabilities of polluted waterways and aquatic ecosystems are the problems created by poor resource management. In modern science there is tremendous development in the concern to study the effective use of different categories of lands and availability of improved land practices for a successful future.
The aim of this work is to give a brief overview about of the effect of sewage sludge on some physiological parameters of plant seedlings. Sewage sludge is an unwanted and inevitable by-product of wastewater treatment management in several industrial processes. Sedimentation – both before and after wastewater bio-treatment – produces sewage sludge. An increasing volume of wastewater is produced by the development of the industry and agriculture, and as a concomitant of the improvement of human life.
The examined sewage sludge originated from Alkaloida Chemicals Co. Ltd (Eastern Hungary). The sewage sludge contains plenty of essential elements (e.g. Ca, K, and P). But, its aluminum and chrome contents also are considerable. The dry matter accumulation and relative chlorophyll content were measured. The flexibility of plant responses depends on composition, origin of examined wastes.

Keywords: crop nutrition, industrial side – products, sewage sludge

Introduction

The improvement of sewage sludge management is a key objective for the development of an integrated strategy for wastewater management. Sewage sludge has been already utilized in agricultural and horticultural applications for several years as it represents an alternative source of nutrients for plant growth (Logan and Harrison, 1995). In domestic wastewater, microorganisms originate from human excrete in household, commercial and hospital sewage. Combined sewage contains street and storm runoff, and these carry microorganisms from soils and animal dropping. Each of these sources contains a vast number and variety of microorganisms (Hansen et al., 2003).
So, the question is: microorganisms or element content of sewage sludge has or has not advantageous effect on plant growth? The aim of this study was to examine the effect of sterilized and non-sterilized sewages sludge on the some basic plant physiological parameters.

Materials and methods

Sunflower seeds *(Helianthus annus L. cvs. Arena)* were used in the experiments. The seeds were sterilized with 18% hydrogen peroxide, and then washed in distilled water. After that, they were germinated on moistened filter paper at 25°C.

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The seedlings were transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1 mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 10 µM $ZnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. Iron was added to the nutrient solution as Fe(III)-EDTA at a concentration of 10 µM. Effect of sterilized and non-sterilized sewage sludge was examined in 2g dm^{-3} and 4g dm^{-3} quantities. The sewage sludge was sterilized on 121 ^{o}C for 20 minutes.

The seedlings, 12 for each treatment, were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20 ^{o}C, relative humidity of 65–70% and a photosynthetic photon flux of 300 µmol m^{-2} s^{-1}) in controlled environmental room.

The element contents of materials were determined using an OPTIMA 3300DV ICP-OA Spectrophotometer. The relative chlorophyll contents of the 1st leaves of the sunflower were measured by Chlorophyll Meter, SPAD - 502 (Minolta). The number of repetitions was 60 on the 10th, 13th and 15th days of treatments.

The dry weight of shoots and roots were measured at the end of experiments with the use of thermal gravimetric analysis, after drying at 85 C° for 48 h.

The sewage sludge originated from ALKALOIDA Chemicals Co. Ltd., Eastern-Hungary.

Results and discussion

The examined sewage sludge contains plenty of essential elements (e.g. Ca, Fe, K and P) but its toxic elements concentration (e.g. Al, Cr, Ni and Pb) are also considerable (*Table 1*).

Table 1. Contents of some measured elements in the sewage sludge (mg kg^{-1})

Toxic elements				Essential elements			
Al	Cr	Ni	Pb	Ca	Fe	K	P
17,349	41.3	24.5	70.1	123,988	21,098	2,878	21,289

The elements can influence the growth of root and shoot depending on the accumulation efficiency. The dry matter content of shoots and roots of sunflower were also measured during the experiments. *Table 2* shows the results of dry matter accumulation.

Table 2. Effects of sewage sludge on the dry matter accumulation of shoots, roots (g $plant^{-1}$) and shoots/ roots ratio of sunflower seedling

Treatments	Shoots (g $plant^{-1}$)		Roots (g $plant^{-1}$)		Shoot/root	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Control	0.400	0.02	0.088	0.00	4.54	0.070
Non-ster.(2)	0.421	0.05	0.098	0.02	4.29	0.060
Ster.(2)	0.402	0.03	0.101	0.01	3.98	0.050
Non-ster.(4)	0.381	0.03	0.081	0.00	4.70	0.070
Ster.(4)	0.405	0.03	0.098	0.01	4.13	0.060

In crop production, optimal nutrient supply is usually achieved by the application of fertilizers. In our experiment the dry matter accumulation of shoots increased by 5% and dry matter of roots by 11% in the 2g sewage sludge treatments. When 2g sterilized sewage sludge was examined, the dry matter of roots increased by 14% and the dry matter accumulation of shoots was higher then the control value. The 4g treatment with non-ster. sewage sludge decreased the dry matter accumulation of shoots and roots but when 4g sterilized sewage sludge was applied these values were increased. Differences could be observed between the different amount of sterilized and non-sterilized sewage sludge. The dry matter of shoot was higher when non-sterilized sewage sludge was added to the nutrient solution in the 2g dm^{-3} treatment. The sterilized 2g dm^{-3} treatments increased the dry matter of shoots. The dry matter of shoot and roots also increased in the 4g dm^{-3} sterilized treatment

The ratio of shoot to root growth varies widely between plant species, during ontogenesis of plants, and it strongly modified by external factors. When parts of the shoots are removed, plants tend to compensate this by lower root growth and returning to a ratio characteristic for the species. However, there is some controversy as to whether this reflects functional equilibrium between roots and shoots (Klepper, 1991). The shoot/root ratio was the highest at the 4g dm^{-3} non-sterilized treatment. This value decreased at all other treatments comparison to the control.

The dry matter accumulation is very complicated process. One of the most influencing factor is a photosynthetic activity. So, the relative chlorophyll contents of 1st leaves of sunflower was measured the results are shown in *Table 3*.

Table 3. Effect of sterilized (ster.) and non-sterilized (non-ster.) sewage sludge on the relative chlorophyll contents of 1st leaves of sunflower (Spad Units)

Treatments	10th day		13th day		15th day	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Control	36.15	3.22	39.32	3.02	41.76	2.22
Non-ster.(2)	39.22	2.17	51.91	2.78	50.55	3.06
Ster. (2)	41.18	1.81	44.14	2.44	45.62	1.94
Non-ster. (4)	39.45	2.33	43.03	1.69	43.60	2.25
Ster. (4)	41.86	2.59	44.47	2.93	45.45	2.08

The sewage sludge treatments had favorable effect on relative chlorophyll content in all treatments and measuring time. The relative chlorophyll of 1st leaves of sunflower significantly increased on 10th day when sewage sludge was not and was sterilized with small differences. The increasing level was higher at the non-ster. treatment. On the 13th and 15th days the relative chlorophyll content increased significantly, except in the 4g non-ster. treatment. The relative chlorophyll contents also increased at the non-ster. treatment but by lower increase.

The relative chlorophyll content was higher when sterilized sewage sludge was applied than non-sterilized.

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Conclusions

Sewage sludge has an advantageous effect on dry matter accumulation of roots and shoots. It is a very important result, because the main product of agriculture is shoots at the fodder crop. The application of non-sterilized and sterilized sewage sludge influences relative chlorophyll contents. Sewage sludge increased the relative chlorophyll contents in the 1st leaves of sunflower on the 10th, 13th and 15th days of examination. The relative chlorophyll content was higher when sterilized sewage sludge was applied than non-sterilized.

Differences could be observed between the different amount of sterilized and non-sterilized sewage sludge. The dry matter of shoot was higher when non-sterilized sewage sludge was added to the nutrient solution in a smaller amount treatment. The sterilized 2g dm^{-3} treatments increased the dry matter of shoots. The dry matter of shoot and roots also increased in the 4g dm^{-3} sterilized treatment. The shoot/root ratio was the highest at the 4g dm^{-3} non-sterilized treatment. This value decreased at all other treatments comparison to the control.

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SITE-SPECIFIC NITROGEN FERTILIZATION DEVELOPED FOR WHEAT (*TRITICUM AESTIVUM* L.) WITH THE HELP OF OPTRXTM SENSOR

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Abstract: The intensification of agricultural production increased environmental pollution in a significant way. The widespread adaptation of precision farming technologies could be the solution to decrease groundwater and soil contamination by efficient and rational usage of input materials (fertilizers and herbicides). In this study examination of the site-specific nitrogen (N) management was carried out in the aspect of efficiency, in an experimental field (33.51 ha) near Győr, Hungary. On 26 February 2011, N fertilizer (ammonium nitrate, 34% N) was distributed using one rate (250 kg ha^{-1}) and on 9 May different rates were applied. The Normalized Difference Vegetation Index (NDVI) value of the wheat field was mapped by two OptRx^{TM} sensors during spraying before the second fertilizer distribution. Three NDVI categories were generated from the recorded values. Based on these categories the field was divided into irregular shape management zones and a fertilization map was prepared with three different rates (75, 120, 150 kg ha^{-1}). Two control plots (1.88 ha and 1.84 ha) were developed inside the field and fertilized using one rate (130 kg ha^{-1}). Except these areas the whole field was fertilized according to the fertilization map. For comparison four plots were selected in the field with similar size to the control plots. Yield data was recorded by Ag Leader monitoring system. In the control plots 5.91 t ha^{-1} average yield was measured and in the site-specific plots the mean yield value was 6.34 t ha^{-1} thus 0.43 t ha^{-1} extra yield was achieved by applying different rates compared to the conventional method. In addition, 7.78 kg fertilizer per hectare was saved by site-specific nitrogen management.

Keywords: site-specific N fertilization, NDVI, OptRx^{TM} active sensor

Introduction

Site-specific nitrogen (N) management has been suggested as a management tool to increase N fertilizer efficiency and reduce environmental impact. Environmental laws are being implemented throughout Europe to limit N fertilization on arable land, especially to protect drinking water areas (Link et al., 2006). The geographic information system (GIS) created by computing background makes possible to generate complex view about our fields and to make valid agrotechnological decisions (Neményi et al., 2003). Implementation of precision agriculture to date has utilized existing field machinery and added controllers and GPS to enable spatially variable application. Thus, conventional spray booms have been used for patch spraying and spinning disc applicators for variable fertilizer application (Stafford, 2000). There are two solutions for controlled distribution, the map based and the sensor based method (Németh et al., 2007). Spectral vegetation indices, such as normalized difference vegetation index (NDVI), have been shown to be useful for indirectly obtaining crop information such as crop biomass, productivity potential and potential yield (Penuelas et al., 1994). Raun et al., (2001) showed that predicted grain yield, as determined from NDVI had a strong relationship with actual grain yield in winter wheat (*Triticum aestivum* L). Ma et al.

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(2001) reported that NDVI could be used to reliably predict yield in soybeans (*Glycine max* L.). GreenSeeker^{TM} active sensor was used by Longchamps et al., (2011) to measure (NDVI) at several wheat growth stages in 24 winter wheat genotypes to improve nitrogen use efficiency. Mogyorósi et al., (2010) has found a strong correlation between N content of the winter wheat leaf samples and NDVI values that were measured by OptRx^{TM} sensor.

Materials and methods

In this study examination of the site-specific nitrogen (N) management was carried out in the aspect of efficiency, in an experimental field (33.51 ha) near Győr, Hungary. On 26 February 2011, N fertilizer (ammonium nitrate, 34% N) was distributed using one rate (250 kg ha^{-1}) and on 9 May different rates were applied. The Normalized Difference Vegetation Index (NDVI) value of the wheat field was recorded by two OptRx^{TM} sensors during spraying before the second fertilizer distribution. Three NDVI categories were generated from the recorded values. Based on these categories the field was divided into irregular shape management zones (*Figure 1*). After the three NDVI categories of the field were determined, leaf samples were collected from the wheat plants to validate the factory calibration of the sensors. Two areas were selected from each NDVI categories and leaf samples were collected by using grid sampling method. Leaf samples were analysed in an accredited laboratory to measure total nitrogen content.

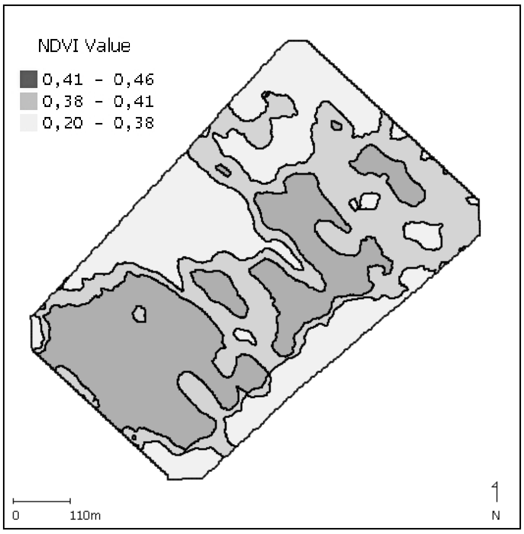

Figure 1. The generated categories from the recorded NDVI values

A fertilization map was prepared with three different rates (75, 120, 150 kg ha^{-1}) based on the NDVI categories. Areas with lower NDVI value were distributed using higher N fertilizer rate. Two control plots (1.88 ha and 1.84 ha) were developed inside the field and fertilized using one rate (130 kg ha^{-1}). Except these areas the whole field was distributed according to the fertilization map. For comparison four plots were selected in the field with similar size to the control plots. A Sulky X36 spinner disk applicator fitted with weighing frame, with a working width of 20 m was used connected to a Fendt 413 Vario tractor during the fertilizer distribution process. The map was exported to an Ag Leader EDGE monitor. During the distribution the amount of the fertilizer was controlled by the Sulky Vision terminal, based on the map that was shown on the EDGE monitor. The actual amount of the distributed fertilizer was recorded by the field monitor together with GPS coordinates. The accurate work was provided by Trimble Auto-Pilot steering system mounted with a real time kinematic (RTK) GPS receiver. Yield data was recorded by Ag Leader monitoring system. Evaluation of N fertilization and yield data was done with the help of Ag Leader SMS, Quantum GIS and Microsoft Excel software.

Results and discussion

Results in connection with analysis of leaf samples that were collected after the NDVI categories of the wheat field were determined are summarized in *Table 1*. The total nitrogen content of the leaf samples that were collected from the management zones shows a strong correlation ($r^2 = 0.87$) to the mean NDVI value of the investigated area. In this way, the factory calibration of the crop sensor is capable for analysing crop vigor.

Table 1. Total N content of leaf samples and mean NDVI values of selected management zones

code	N fert. rate (kg ha^{-1})	total N cont. (m/m %)	NDVI
1/1	75	5.50	0.422
1/2	75	5.30	0.415
2/1	120	5.09	0.410
2/2	120	4.90	0.395
3/1	150	4.99	0.359
3/2	150	4.24	0.275

Table 2. Yield data of the examined plots and amounts of distributed N fertilizer

code	area (ha)	avg.moist (%).	yield mass dry (t ha^{-1})
C1	1.88	11.62	5.90
C2	1.84	13.53	5.93
P1	1.62	11.93	6.54
P2	1.74	12.01	6.14
P3	1.68	11.94	6.60
P4	1.41	11.49	6.14

Based on *Table 2*. it could be calculated that in the control plots (C1, C2) 5.91 t ha^{-1} average yield was measured and in the site-specific plots the mean yield value was 6.34 t ha^{-1} thus 0.43 t ha^{-1} extra yield was achieved by applying different rates compared to the conventional method. Another goal of the experiment that extra yield was achieved by reducing fertilizer utilization. In this way 7.78 kg fertilizer per hectare was saved by

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site-specific nitrogen management. Results of this study provide useful information for researchers dealing with active crop sensors and for farmers interested in precision farming. However it couldn't be stated that the extra yield compared to conventional plots was achieved by using different rates only, because in February conventional fertilization was done. Furthermore soil properties and environmental impact must be taken into account. In further experiments these factors will be investigated, too.

Conclusions

It is suggested to collect and analyse soil samples from the areas of different NDVI categories to examine connection between soil properties of experimental field and plant total nitrogen content. Another important task is to analyse chemical composition and nutritional quality of wheat grain samples collected from conventional and site-specific areas. The OptRx™ sensor system is capable to control the actual amount of distributed fertilizer automatically based on measured NDVI value after preliminary field calibration. This real-time method and the above detailed map base method are required to be compared in the aspect of efficiency.

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SOIL MOISTURE MEASUREMENT IN PRECISION FARMING

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Abstract: In our research we looked for an instrument which provides enough data for precise mapping of soil characteristics and helps to decide the boundaries of various management zones within field. In the investigated field we have found that soil electrical conductivity measurement provides enough data for soil characteristics measurements, furthermore correlation between soil electrical conductivity (EC) and soil moisture content was R^2=0.79 in the best case (R^2=0.74 in the worst), therefore in the investigated area soil moisture mapping can be carried out by means of indirect, semi-online data collection.

Keywords: precision farming, soil moisture, electrical conductivity

Introduction

Site-specific crop management aims to manage soils, pests, and crops based upon spatial variations within a field (Larson and Robert, 1991). Improper cropping pattern and agrotechnics as parts of the irrational land use practices seriously affects the soil formation and processes (Várallyay, 2010). Soil characteristics are the main determining factors for conventional and precision plant production therefore site specific measurements are necessary for the spatial decision making. Data on soil parameters can be collected by various instruments and means, furthermore these data can be mapped by GIS methods to ensure visualization of within field differences (Milics et al., 2006; Morschhauser – Milics, 2009). Crop production is directly related to the temporal and spatial changes of soil moisture. Water and nutrients are the two major resources for the production. The use of available soil moisture by a crop is necessary and this can best be obtained from the accurate description of the distribution of soil moisture in the root zone. Assessment of such a distribution of soil moisture through field measurements is expensive, time consuming and laborious (Sharma et al., 1997). The water management of the soil means the amount, state, form and movement of water in the soil, and the temporal and spatial change of these factors. It includes the water infiltration, water permeability, water holding and water storage capacities of the soil and the conditions of drying (Birkás, 2010). According to Stefanovits (1975), the water management of the soil is the essential precondition of its fertility, as it influences the air, heat and nutrient management, the biological activities and the cultivability of the soil.

Materials and methods

The experimental site, where the research was carried out belongs to the Institute of University of West Hungary near Mosonmagyaróvár. The experimental site is situated in a 23.52 hectares large agricultural field on which precision agriculture has been applied since 2001. The measurements have been carried out directly after harvest on the wheat stubble of the above mentioned experimental site on 28th July 2009. We used a Spectrum TDR-300 type soil moisture probe for making the soil moisture map in 20 cm depth. This appliance defines the volumetric soil moisture content based on the TDR (Time Domain Reflectometry) measuring principle. Besides registering the moisture

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content of the soil, the appliance also stores the coordinates of the places of measurements. During the measurement of soil moisture content we walked through the analysed field, we stuck the TDR-300 probe into the ground every 5-10 meter, and then we stored the data. Parallel to the soil moisture measurements we also measured the electrical conductivity of the soil with a tractor-pulled Veris 3100 specific electrical conductivity meter in the field. The most important part of the Veris 3100 meter is 6 pieces of measuring disks (with diameters of ∅430 mm). The appliance measures the specific electrical conductivity of the soil between the depths of 0-30 cm and 0-90 cm at the same time. For the measurement a GPS receiver is needed, which operates in DGPS mode. The Veris 3100 meter stores the measured data and coordinate every second. The adjusted row distance was 5 m, consequently measured data were registered having approximately 5 m x 5 m distances between. After finishing the measurements we uploaded the data from both measuring appliances on a computer. Their further processing was carried out with Excel, EHT^2 and ArcGIS programs. Since the GPS we used WGS84 (World Geodetic System) geographic coordinate link to the soil moisture and electrical conductivity data, they had to be converted into the EOV (Unified National Projection System) coordinate system which is used in Hungary with the help of the EHT^2 program. We opened the saved data with the ArcGIS ArcMap 9.2 program, and we made the soil moisture and electrical conductivity map of the area by using the IDW (Inverse Distance Weighting) interpolation method.

Results and discussion

The Veris 3100 on-line measuring appliance collected 12 times more sampling places, compared to the number of soil moisture samples we collected during walking and the sampling places of electrical conductivity measurements are more evenly distributed than the sampling places of soil moisture measurements.

Maps made by ArcGIS ArcMap 9.2 based on the measured data and the EOV coordinates belonging to them can be seen on *Figure 1*.

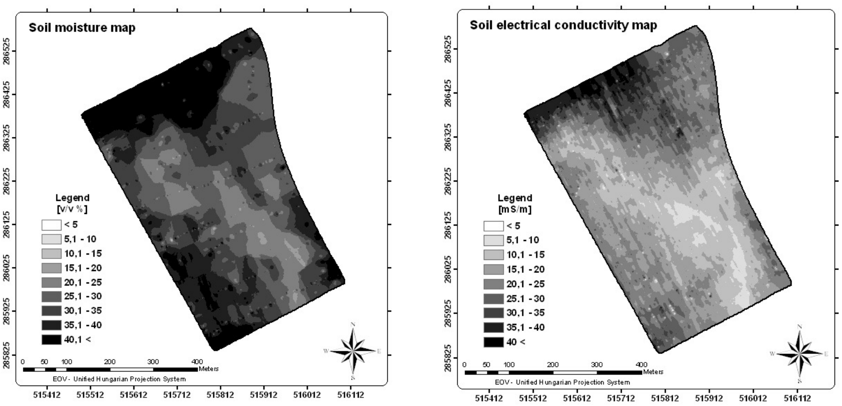

Figure 1. Soil moisture and electric conductivity maps (ArcGIS ArcMap 9.2)

If we look the figure carefully, we will find that the maps made according to the results of the two appliances are very similar, as they show the same pattern. According to the similarities, we think that electrical conductivity measurements made by the Veris 3100 meter are suitable for the measuring of soil moisture content. As a result, the time-consuming manual sampling during walking can be replaced with the much simpler and faster measuring method, which produces higher sample number, consequently is more representative. Based on this, we wanted to underpin our statement scientifically, and we wanted to prove it statistically that there is a correlation between the two measuring methods. One of the basic prerequisites for the statistical comparison of different measurements is that the values of the different measuring methods should belong to the same sampling places. Since during the measurements there were only a few values which exactly had the same coordinates from the two result series, we appointed 50 sampling sites within the agricultural field, which we further researched. This means that we took 50 pieces of rings with 1 m diameter as basic points (F. This is such a small area that in many places there were no soil moisture data within the ring that belonged to the close measurement results of the Veris 3100 meter. Therefore we placed different sized (having an additional 5 m, 10 m, 20 m radius) buffer zones (called as computational rings = CRs) around the basic area, and we analysed the values measured within their borders. Data recorded within their borders were averaged, and results collected this way were compared in regression analysis.

The value pairs of measurements were compared in regression analysis. The results of the analysis can be seen in *Figure 2*. We made separate analyses in the case of the different sized computational rings.

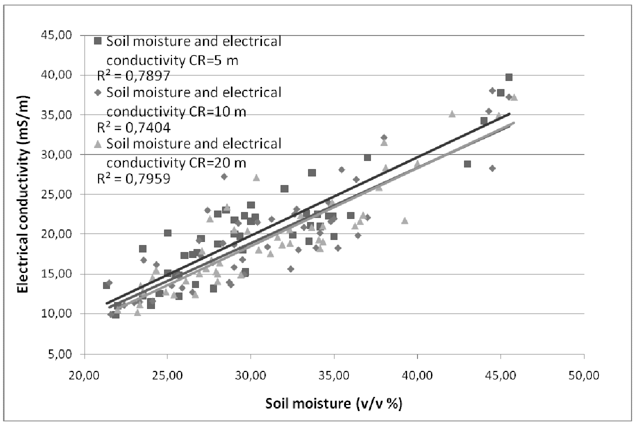

Figure 2. Data comparison of different buffer zones

It is clearly visible on the figure that the correlation between the soil moisture content and electrical conductivity is fairly strong within the 5 m computational rings, as it reaches R^2=0.7897. This area is still quite small, therefore the different measured results are situated close to each other within the ring, they hardly change, they have a small standard deviation, and they are situated close to the average. The correlation between the two measuring methods is slightly worse in the case of the 10 m computational rings, where R^2=0.7404. In this case, the area of the buffer zone is larger, it contains more measuring points, and the distances between the measurements are increased as well. Due to the increased distances, the standard deviation of measurements is larger.

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We got the best result in the third case, when we analysed the 20 m computational rings. In this case, the correlation was the following: R^2=0.7959. This zone has the largest area, this includes the highest number of measuring points, and measurement distances are the largest here. Although we got the largest standard deviation result here, the correlation between soil moisture content and electrical conductivity is the strongest in this case. Presumably, the reason for this is the higher number of measured data and the average value calculated from them, which is more representative from the point of consequences. In such a large area spatial changes can be more significant both in the positive and in the negative direction. Although the value of standard deviation was larger in this case, probably the average improved the result.

Conclusions

In our experiment we investigated one of the development possibilities of soil moisture measuring, which is one of the most important factors influencing the yield. According to our results, it can be stated that manual soil moisture measuring during walking can be safely replaced with the accurate mapping of the electrical conductivity of the soil. The Veris 3100 specific electrical conductivity meter that we used during our experiment proved that under proper conditions it can be used for defining the moisture content of the soil. It was proven that besides using maps made with geographical information systems, traditional statistical analyses also have to be carried out for the verification of correlations during making comparisons. The problem which encountered during statistical comparison – namely that the TDR-300 probe and the Veris 3100 meter use different coordinate systems for storing their data – was solved by using computational rings having different diameters. Further research is needed to define how the connection between soil moisture and electrical conductivity changes in the case of the different soil types, physical characters and salinity of the soils.

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LOSS OF NITROGEN WITH DRAINAGE WATER IN A LONG TERM FIELD EXPERIMENT

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Abstract: In a long term field experiment with different nitrogen rates the effect of nitrogen fertilization upon the concentration of nitrate and ammonia nitrogen in subsurface drainage water was studied in a period from 1997 to 2007. Increased rates of applied nitrogen led to higher average values of NO_3^--N concentration in drainage water. In treatments of up to 150 kg ha^{-1} N, average nitrate nitrogen subsurface runoff concentration was lower than 15 mg/L for the investigation period (1997 - 2007). Maximum average concentration increased to 25.8 mg/L NO_3^--N treated with 300 kg ha^{-1} N. Average ammonia nitrogen concentration ranged from 0.27 mg/L to 0.37 mg/L during the investigation period and were not in correlation with applied fertilization doses. Average losses of nitrate and ammonia nitrogen through drainage water varied from 6.3 kg/ha to 28.4 kg/ha, and from 0.24 kg/ha up to 0.52 kg/ha, respectively, depending on nitrogen rate applied. Results substantiate the importance of investigating the influence of different nitrogen rates applied for fertilization of arable crops upon nitrogen leaching in the agroecological conditions of Croatia, especially in regions where intensive agricultural production is practiced.

Keywords: Subsurface drainage, Nitrogen, Leaching

Introduction

Leaching of nitrogen is influenced by the crop, duration of the period between two crops (highest leaching occurs on areas without crops), weather conditions, soil tillage, and above all by the quantity and type of fertilizers applied. The highest nitrogen leaching occurs during the autumn and winter period when precipitation exceeds evaporation and the plant intake is reduced to the minimum. In Croatia, Simunic et al. (2002) studied the NO_3^- and NH_4^+ concentration in drainage water. The lowest values of leached NO_3^- were recorded just before the seeding and fertilization and they varied from 11.7 to 27.0 mgL^{-1} of nitrates in drainage water. The highest values were recorded in September primarily owing to extremely high precipitation in that month. Concentrations of leached NO_3^- were much above the tolerated 50 mgL^{-1} and ranged from 57 up to 107.8 mgL^{-1} NO_3^-. Klacic et al. (1999) studied the effect of different pipe drainage distances upon the concentration and quantity of nitrogen leached in winter wheat production on hydromorphic soils of Sava River valley. Depending on the pipe drainage distance, leached nitrogen ranged from 11.0 to 21.7 $kgha^{-1}$. Investigation goal of our research was to determine the influence of different mineral nitrogen rates on NO_3^- N and NH_4^+ N concentration in drainpipe water and on quantities of nitrogen leached.

Materials and methods

The trail was set up so that the area of each fertilizing treatment embedded two drainpipes in their full length of 130 m. Trial treatments were: 1.Check–unfertilized; 2. N_0 PK; 3. N_{100} PK; 4. N_{150} PK; 5. N_{200} PK; 6. N_{250} PK; 7. N_{250} PK + Phosphogypsum; 8. N_{250} PK + Zeolite tuff + $CaCO_3$ + Fertdolomite; 9. N_{300} PK and 10. Black fallow. NO_3^--N concentration in drainage water varied in dependence on the quantity of mineral

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nitrogen applied, on the quantity and intensity of precipitation, and on the drainage volume. In treatments without mineral nitrogen application, i.e. in the check treatment and in the treatment fertilized with just phosphorus and potassium (treatment No. 2), the average NO_3^- N concentration was relatively low. In the treatment involving black fallow, all tillage practices were the same as in other trial treatments, including also supplementary tillage practices. On experimental plots, crops were grown in the following crop sequence: 95/96, 98/99, 03/04 and 06/07 - maize (*Zea mays*), 96/97, 99/00, 02/03 and 05/06 - winter wheat (*Triticum aestivum*), 97/98 and 00/01 oilseed rape (*Brassica napus var. oleifera*), 01/02 and 04/05 soybean (*Glycine hispida max.*). The trial plot size was 30x130 m (3900 m^2) for each treatment, as conditioned by the drainpipe spacing and their length (130 m). Water samples were taken on a daily basis, and average sample was prepared every 5-7 days to be used for chemical analysis of water.

Results and discussion

The experimental station soil type is defined as Stagnosols, with A_h/E_{cg} – E_{cg} – B_{tg} sequence of soil horizons. Due to its physical (high content of fine sand, silt and clay) and chemical properties (calcium deficiency, low content of organic matter), this soil type has limited fertility. Intensive mineral fertilization is very important for arable farming at given conditions. Because of water stagnation in soil profile drainpipes were installed at the average distance of 20 m. NO_3^- N concentration in drainage water varied in dependence on the quantity of mineral nitrogen applied, on the quantity and intensity of precipitation, and on the drainage volume. In treatments without mineral nitrogen application, in the check treatment and in the treatment fertilized with phosphorus and potassium, the average NO_3^- N concentration is relatively low (Fig. 1). Increased rates of applied mineral nitrogen led to higher average values of NO_3^- N concentration in drainage water. At the treatments with 100 and 150 kg ha^{-1} N, average nitrate nitrogen concentration was lower than 15 mgL^{-1} for all years. At the treatments with higher doses of nitrogen, concentrations of NO_3^- N in drainage water were also higher, and they were in relation with quantities of applied nitrogen. Maximum average concentrations went up to 25,8 mgL^{-1} NO_3^- N at treatment with 300 kg ha^{-1} N. Similar results were attained by Klacic et al. (1999) and Simunic et al. (2002). During months when discharge volume was bigger, average nitrate nitrogen concentration decreased, but differences between trial treatments remain similar. Average NH_3 N concentration in drainpipe water was relatively low (Fig. 2) and it was not influenced by the quantity of mineral nitrogen applied. Values of the NO_3^-N and NH_3 N concentration in drainpipe water and the drainage volume were used for the calculation of the total nitrogen loss (*Table 1*). Average nitrogen leaching of 7.8 $kgha^{-1}$ NO_3^- N was recorded in the check treatment, and 6.3 $kgha^{-1}$ in treatment No. 2 with phosphorus and potassium. This was followed by treatment No. 3, in which 8.0 $kgha^{-1}$ N was leached by drainpipes. In the treatment No. 4 with 150 kg N ha^{-1}, 15.2 $kgha^{-1}$ was leached through drainpipes. Out of 200 kg nitrogen added in treatment No. 5, 19.9 kg was leached, while the leaching in treatments 6, 7 and 8 amounted to 20.1, 28.4 (max.) and 20.9 kg, respectively.

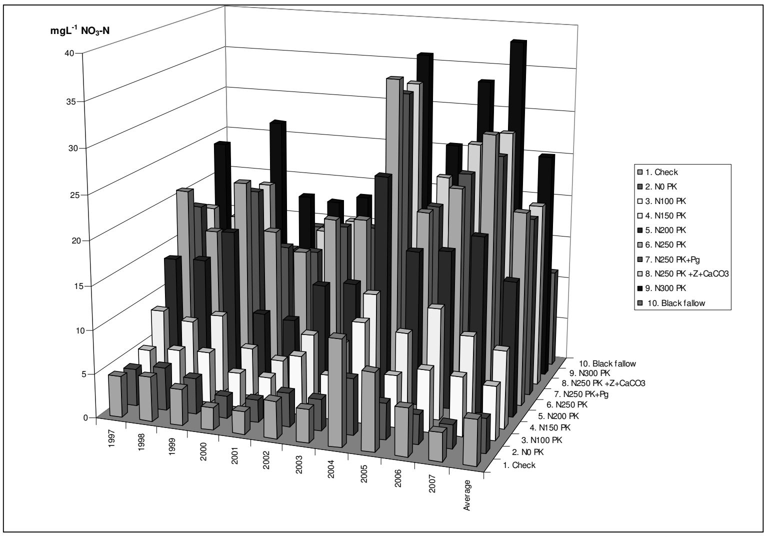

Figure 1. Average NO_3^- N concentration in drainpipe water, mgL^{-1}

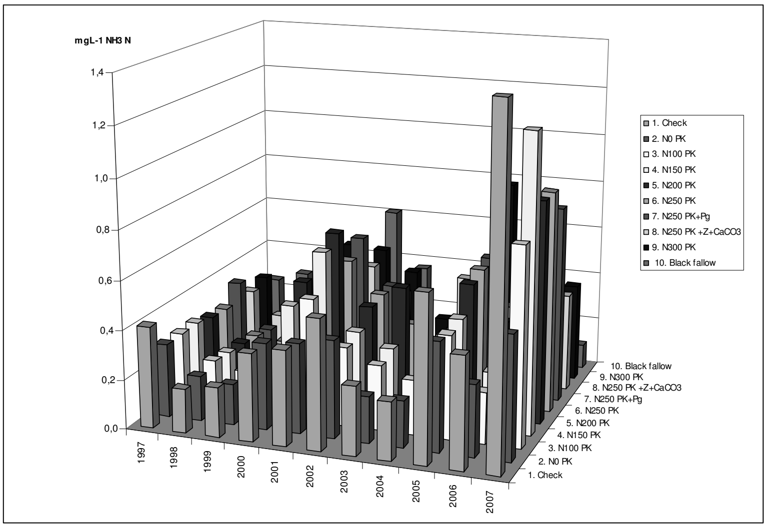

Figure 2. Average NH3 N concentration in drainpipe water, mgL^{-1}

Out of the maximum 300 kg nitrogen applied for grown crops in treatment No. 9, an average amount of 27.7 kg nitrogen was leached through drainpipes. With its 8.5 $kgha^{-1}$ of leached nitrogen, the last treatment – black fallow – ranks rather high, between treatment 3, in which 100 kg nitrogen was applied, and treatment 4, with 150 kg nitrogen. Losses of NH_3 nitrogen in drainpipe water in average were lower that 1 $kgha^{-1}$ N for all years and treatments and they were not influenced by the quantities of applied nitrogen.

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Table 1. Leaching of NO_3^-N and NH_3 N with drainpipe water, average 1997-2007

	I	II	III	IV	V	VI	VII	VIII	IX	X
Average N applied [kg/ha]	0	0	100	150	200	250	250	250	300	0
Average N-NO_3 losses [kg/ha]	7.8	6.3	8.0	15.2	19.9	28.1	28.4	20.9	27.7	8.5
Average N-NH_3 losses [kg/ha]	0.51	0.47	0.36	0.52	0.46	0.41	0.48	0.40	0.45	0.24
Average mineral N loss [kg/ha]	8.31	6.77	8.36	15.72	20.36	28.51	28.88	21.30	28.15	8.74
N leached/ N applied [%]	-	-	8.4	10.5	10.2	11.4	11.6	8.5	9.4	-

Conclusions

Trial results point to the following conclusions:

1. Nitrate nitrogen leaching in drainpipe water from different fertilization treatments varied from 6.3 $kgha^{-1}$ at the treatment No. 2 (N_0PK) without nitrogen up to the 28.4 $kgha^{-1}$ at the treatment No. 7 with 250 $kgha^{-1}$ N and Phosphogypsum.
2. Average nitrate nitrogen leaching in drainpipe water from treatments 1, 2 and 3 where crops were grown without mineral nitrogen fertilization or with 100 kg of N/ha varied from 6.3 to 8.0 kg per hectare. Compared to that, average nitrate nitrogen leaching at black fallow treatment was higher 8.5 $kgha^{-1}$.
3. Average N-NH_3 nitrogen losses were lower that 1 $kgha^{-1}$ N and they were not influenced by the quantities of applied nitrogen.
4. Compared to the average quantity of nitrogen applied, average quantity of total mineral nitrogen leached in drainpipe water from different trial treatments varied from 8.4% to 11.6% of applied mineral nitrogen.

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