WATER

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WATER-DEPENDENT LAND USE AND SOIL MANAGEMENT IN THE CARPATHIAN BASIN

György VÁRALLYAY

Research Institute for Soil Science and Agricultural Chemistry (RISSAC) of the Hungarian Academy of Sciences, H-1022 Budapest, Herman O. 15. Hungary. E-mail: g.varallyay@rissac.hu

Abstract: The agro-ecological conditions are generally and relatively favourable for rainfed multipurpose biomass production in the Carpathian Basin, especially on the Pannonian Plains (Láng et al., 1983). These favourable conditions, however, show high spatial (horizontal and vertical) and temporal variability; irregular (consequently hardly predictable), sometimes extreme; and react sensitively to natural and human-induced stresses. These factors make rational land use and sustainable soil management greatly „water-dependent". The type and rate of weathering, soil formation and soil degradation processes; the moisture and substance regimes in the „geological formation–soil–water–biota–plants–near surface atmosphere" continuum are all greatly water-dependent and determine soil fertility/productivity; the yields and yield fluctuation of crops. Consequently, the control of the hydrological cycle and soil moisture regime has priority significance both in economical development (production) and environment protection.

Keywords: agro-ecological conditions, extreme moisture regime, soil degradation processes, soil moisture control.

Introduction

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 crop site (geological strata–soil–water–biota–plants–near surface atmosphere continuum); in the physical and chemical weathering, soil formation and soil degradation processes, in soil resilience, fertility, productivity and environmental sensitivity (Várallyay, 2006, 2010a,b).

The shortage and/or surplus of water in the Carpathian Basin will be a strategic key issue of multipurpose biomass production, social (especially rural) development and environment protection. Mainly because of the following reasons (Láng et al., 1983; Somlyódy, 2000; Pálfai, 2000; Szabolcs, 1961; Várallyay, 2006, 2010a,b):

- the (hydro)geologically closed character of the Basin;
- the irregular and highly variable atmospheric precipitation;
- heavy-textured, low permeable soils in the lowlands;
- the increasing hazard of extreme hydrological situations: floods, water-logging, over-moistening vs. droughts;
- (at least periodically) negative water balance in the lowlands → predominance of accumulation in soil processes;
- the increasing risk of water-dependent soil degradation processes;
- the limited possibilities for direct soil moisture control (irrigation and drainage), consequently great "water dependence" of "rainfed" biomass production.

It is the reason that water control has always been in the focus of development in the region (Somlyódy, 2000; Pálfai, 2000; Szabolcs, 1961; Antal et al., 2000).

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Limited water resources

In the lowlands the average 450–600 mm annual precipitation shows extremely high, irregular and hardly predictable territorial and temporal (*Figure 1.*) variability – even at micro-scale – and this character will become more expressed in the future. Under such conditions a considerable part of the precipitation is lost by surface runoff, downward filtration and evaporation (Várallyay, 2010c). The available quantity of surface waters (rivers) will not increase, particularly in the critical low-water periods. A considerable part of the subsurface waters cannot be used because of their poor quality (Várallyay, 2006, 2010b) or environmental regulations.

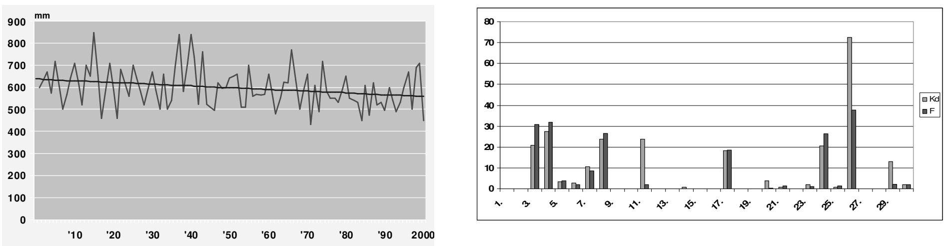

Figure 1. Irregularly fluctuating atmospheric precipitation in Hungary. Left: Annual distribution from 1990 to 2000. Right: Daily precipitation in June 2008 at two nearby meteorological stations.

Relief and soil conditions

The Carpathian Basin is a hydrogeologically closed "evaporative" basin with one outflow: the Danube at the "Iron Gate". The negative water balance of the lowland areas is equilibrated by surface runoff, seepage and groundwater flow from the surrounding more humid mountain regions. The water transports a huge amount of suspended and dissolved materials. As a consequence of these processes:

- Most of the low-lying areas are covered by heavy-textured fluviatile (alluvial) and colluvial deposits, and the heterogeneous, sometimes mosaic-like, relatively "young" soil cover is dominated by heavy soils with high clay and expanded clay mineral content.
- The soluble weathering products (including Na salts) originating from a large water catchment area accumulate in a (relatively) small area (*Figure 2.*) (Szabolcs, 1961; Várallyay, 2006, 2010a).
- The heavy-textured, sometimes Na^{+}-saturated, cracking Vertisols have unfavourable hydrophysical properties: low infiltration rate and hydraulic conductivity, high water retention and wilting percentage, low available moisture range, resulting high water-logging hazard and drought sensitivity (Várallyay, 2010c).
- Most of the limiting factors of soil fertility, the soil degradation processes (soil erosion by water or wind; acidification; salinisation/sodification; structure destruction and compaction; biological degradation; shallow depth, etc.) and soil pollution are related (are reasons and/or consequences of) the water regime (Várallyay, 2006, 2010a).

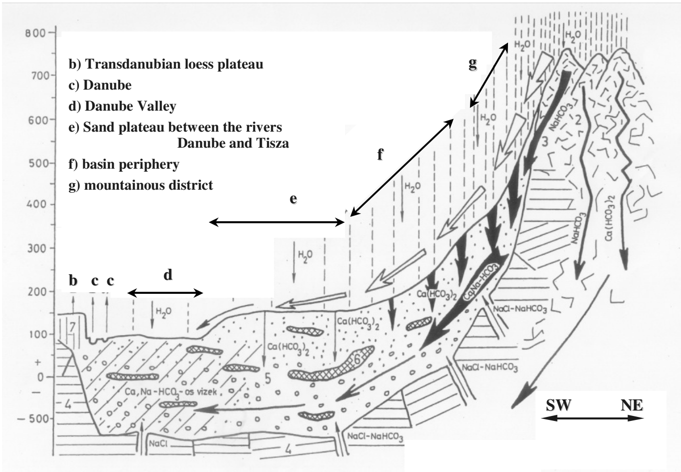

Figure 2. Salt accumulation processes in the Carpathian Basin

– The moisture conditions strongly influence the bio-geo-chemical cycles (abiotic and biotic transport and transformation processes) of natural and human-applied materials (manure, fertilizers, pesticides, herbicides, ameliorants, wastes, etc.) in the soil, determining their solubility, mobility, availability and toxicity (Várallyay, 2010b).

Soil as potential water reservoir – extreme soil moisture regime conflict

Under the given environmental conditions it is an important fact that soil is the largest potential natural water reservoir (water storage capacity). The 0–100 cm soil layer may store about 300–350 mm water, which is more than half of the average annual precipitation. About 50% of it is "available moisture content". This favourable fact is quite contrary with the high and increasing frequency of extreme hydrological situations. The reason of this fact is that in many cases this huge water storage capacity is not used because of the following reasons (Várallyay, 2006, 2010b,c):

– the pore space is not "empty", but filled by a previous source of water (rain, melted snow, capillary transport from groundwater, irrigation, etc.): "filled bottle effect";
– the infiltration of water into the soil is prevented by the frozen topsoil: "frozen bottle effect";
– the infiltration is prevented or reduced by a nearly impermeable soil layer on, or near to the soil surface: "closed bottle effect";
– the water retention of soil is poor and the infiltrated water is not stored within the soil, but is lost by deep filtration: "leaking bottle effect".

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Conclusions

According to long-term experiences, experimental results and detailed yield analyses the most important factor of crop yields is the crop site characteristics in the Carpathian Basin: climate (temperature, precipitation, etc.), soil (texture, reaction, carbonate and nutrient status, biological activity, etc.) and water supply. Water determines or strongly influences the biogeochemical cycles of the soils (including the regime of organic matter, plant nutrients and potential pollutants) and their resilience, fertility, productivity and environmental sensitivity. Consequently, rational land use and sustainable soil management are greatly water dependent (Birkás, 2008; Várallyay and Farkas, 2010; Farkas et al., 2009).

As the direct moisture control actions, irrigation and drainage are faced with serious limitations (limited quantity of good quality irrigation water, relief; poor horizontal and vertical drainage conditions) all efforts have to be taken for the improvement of "rainwater efficiency" by a "two-way" (double face) moisture control, to:

– help water infiltration into the soil and water storage within the soil in plant available form (at the same time reduce the evaporation, surface runoff and deep filtration losses);
– drain the surplus amount of water from the soil profile and from the area (improve the vertical and horizontal drainage conditions).

Most of these "moisture management actions" are – at the same time – efficient environmental control measures and reduce the risk and unfavourable consequences of other stresses (soil degradation processes, nutrient stress, pollution hazard, etc.).

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THE POSSIBILITY OF GROWING ORNAMENTAL PLANTS IN HYDROPONICS, WITH REGARDS TO YIELD, FLOWER QUALITY

Péter LÉVAI [1] – Zsuzsa TURI FARKAS [2]

[1] Kecskemet College, Faculty of Horticultural, H 6000 Kecskemét, Erdei F. tér 1-3., levai.peter@kfk.kefo.hu
[2] Kecskemet College, Faculty of Horticultural, H 6000 Kecskemét, Erdei F. tér 1-3., turine.zsuzsa@kfk.kefo.hu

Abstract: We started our chain of research with cut flower in hydroponics, and then we expanded this thematic research to pot flowers. As for the cut flowers we found that stem yield in hydroponics is about the same than that is in traditional soil mix and chemo culture. Flower quality is however better due to the more balanced nutriment supply. This is especially true for the vase-endurance. Quality attributes are also better in pot plants. In both crops timing is more effective than in traditional technologies.

Keywords: hydroponics, rose, Phytomonitor, potted plants.

Introduction

Closed, circulation system hydroponics satisfies the strictest environmental protection regulations, environmentally friendly, nutriments do not contaminate soil water and there is no need for soil sterilization, no chemicals are polluting the environment. It is well mechanised and controlled and optimal conditions for the plants are provided. Thus, yield increases. It is saving nutriment and water. By considering these facts we can say that there is a better timing, better programmed then chemo culture.

The advantages of hydroponics are:

- soil is not needed (Tarjányiné, 1980),
- independent from soil characteristics (no soil cultivation, no soil exchange and sterilisation) (Imre, 1995),
- it is easier to sterilise substrates than the soils (Tarjányiné, 1980),
- less labour consuming as there is no soil cultivation needed (Tarjányiné, 1980),
- no pests in the root substrate (Imre, 1995),
- substrate is inorganic and there is no need to protect plants against soil pests (Tarjányiné, 1980),
- the crop is standard especially in the root surrounding (Benoit and Ceustermans, 1995),
- we exclude soil infection and the accumulation of pesticide residues (Benoit and Ceustermans, 1995; Fischer, 1991),
- energy input can be lowered in the root zone (Benoit and Ceustermans, 1995; Morgan and Moustafa 1986; Imre, 1995),
- water uptake is reduced (Benoit and Ceustermans, 1995; Fischer, 1991; Imre, 1995),
- more efficient nutriment uptake (Benoit and Ceustermans, 1995; Fischer, 1991; Imre, 1995),
- more efficient control of plant vegetative and generative development (Benoit and Ceustermans, 1995; Fischer, 1991),
- earlier and higher yield (Benoit and Ceustermans, 1995; Morgan and Moustafa 1986; Ferencz, 1998 a),

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- longer growing season (plants are more healthy), changes of crops are faster than on soil (Imre, 1995),
- plant productivity is better utilized (Imre, 1995),
- higher income is achieved (Ferencz, 1998 b),
- better quality crop (Benoit and Ceustermans, 1995),
- more rational logistic (Benoit and Ceustermans, 1995; Ferencz, 1996),
- better automation and mechanization of crop (Benoit and Ceustermans, 1995; Morgan and Moustafa, 1986; Imre, 1995),
- 90% more utilization of space (Morgan and Moustafa, 1986),
- better stem, leaf and flower quality and more sprout is developed (Morgan and Moustafa, 1986),
- environmentally friendly (Benoit and Ceustermans, 1995; Imre, 1995; Lévai and Turiné, 2000).

Materials and methods

The plant species, used since 1998, are greenhouse carnation, Zantedeschia, rose, Poinsettia and Kalanchoe.
The experiments were done in Filclair and Primőr-1 greenhouses. The plants were planted in 4 repetitions. During research work we continuously measured the electric conductivity (EC) of nutrient solution and we tried to maintain a 5,5-6,5 pH and 2,5-3,5 mS EC.
The main aspects of hydroponic research are: effects of cultivation substrates, effects of cultivation methods, comparison of varieties, stem yield, flower quality attributes (length of stem, thickness of stem, flower size, plant height, size of ornamental upper leaves, number of stems), vase life.

Results and discussion

Rose

By using the hydroponic system, 80% of the shoots reached - at most of the varieties- the 1st class flower quality. Among several varieties, the Circus', 'Corvette', 'Dream' and 'Sioux' varieties produced for the best quality. Vase life is shown in *Table 1.*

Table 1. Vase life of rose varieties

Varieties	Vase life (day)	Vase life according to catalogue (day)
'Aloha'	10	12
'Circus'	15	14
'Corvette'	13	14
'Dream'	16	16
'Fantasia'	15	14
'Frisco'	18	16
'Metaliana'	14	12
'Red Corvette'	14	14
'Sioux'	17	18

Because of a well balanced nutriment supply the vase life of studied varieties exceeded the ones in the catalogue.
Based on the fluctuation of temperature (*Figure 1.*) the change of the day periods can be separated. Stem The expansion of stem also follows this cycle. We found that the higher are the daily maximums the more intensive is the set of stem thickness and the less is the fluctuation of temperature the set of stem thickness will be more even. The rise of temperature induces a more significant set of stem thickness. The temperature of leaf follows the temperature of air.

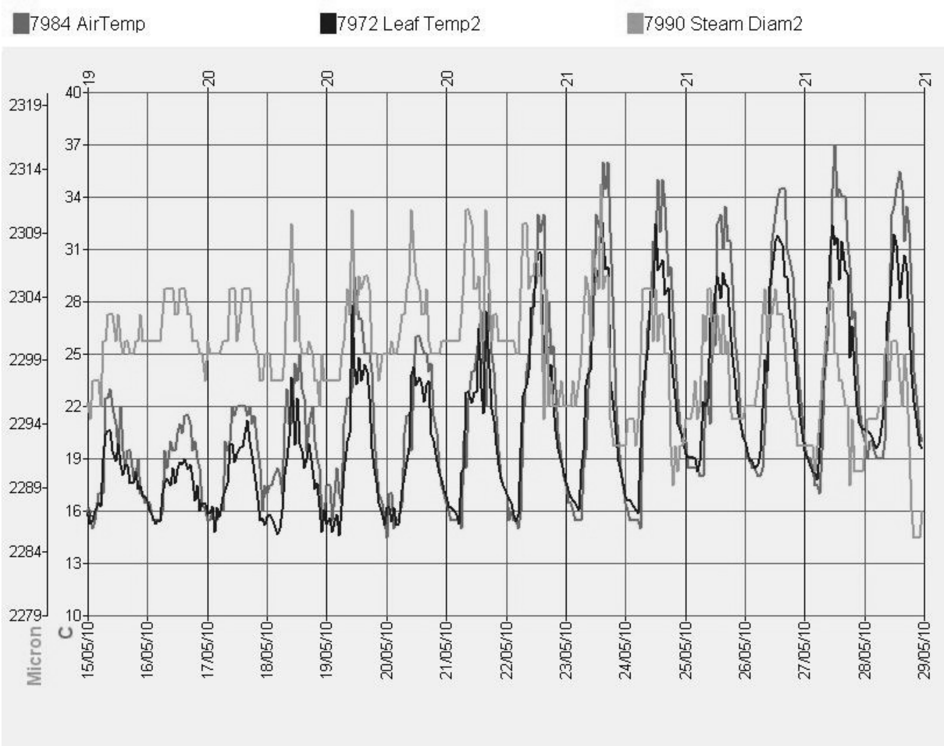

Figure 1. The effect of air temperature on rose leaf temperature and set of stem thickness (Kecskemét, 2010.)

Kalanchoe

By comparison of substrates in 'Beta' (*Table 2.*) variety we found that control plants were the highest at the end of research period (also in the beginning of research). The set of shoot however was the least in the control plants. The most intensive set of shoots was experienced in PUR population which was very important as far as the quantity of harvested cuttings is concerned.

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Table 2. Average hight and number of stems of Kalanchoe 'Beta' variety in different planting substrates (Kecskemét, 2004.)

Date of measurement	Plant height (cm)			Number of stems (piece)		
	grodan	foam	control	grodan	foam	control
10. 05.	24,7	26,0	28,3	12,0	9,0	8,0
10. 12.	25,3	26,2	29,5	12,3	11,3	11,3
10. 19.	25,5	26,3	30,0	16,0	18,3	14,3
10. 26.	26,2	26,2	30,8	21,0	24,0	20,0
11. 02.	27,0	26,5	31,0	26,7	24,3	18,0
11. 09.	27,0	26,7	31,0	26,7	24,3	18,0
11. 16.	28,5	27,8	31,0	26,7	24,3	18,0
11. 23.	28,7	28,7	32,0	26,7	24,3	18,0
11. 30.	28,7	28,7	32,8	26,7	24,3	18,0

Conclusions

The phytomonitor developed by Israeli Phytech Ltd. can measure plant height and development. Growers can follow the daily tendency of sprout growth, set of stem thickness. If the set of these factors differs from the optimal prompt intervention can be done. Ensuring optimal growing conditions results cost effectiveness.

Phytomonitor is one of the devices that can provide quick information about the development of plants. It is such an information technology that provides growers with invaluable information about the plant's physiologic condition.

Processing phytomonitor data makes it possible to work out optimal nutrient supply and thus we can develop a cost efficient, environmentally friendly technology in order that this method could spread in the domestic floriculture.

Hydroponics enables to maintain populations of potted ornamental plant and parent plants. Furthermore it enables to reuse the foam that derives from cut flowers.

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SECONDARY SALINIZATION BY IRRIGATION FROM DRILLED WELLS IN KARCAG AREA

József ZSEMBELI – Lilla SZŰCS – Lajos BLASKÓ

Karcag Research Institute, RISF, CAAES, University of Debrecen, 5300 Karcag, Kisújszállási út 166. Hungary, zsembeli@agr.unideb.hu

Abstract: In our study started in 2009 water samples were taken from 46 drilled wells located in the hobby gardens around the town of Karcag with aim of testing quality of the irrigation water (pH, electric conductivity, dry matter content, cation (Ca, Mg, Na, K) contents, anion (HCO_3, Cl, SO_4, NO_3). The total salt content of the investigated well waters varied in quite a wide range, but most of them were in the range of 550-600 mEq l^{-1}, the mean value was 689.1 mEq l^{-1}. Only 1 of the 47 samples had a value below the threshold, while 7 of them exceeded even the value of 1,000 mEq l^{-1}. The highest value was 1356.8 mEq l^{-1}.The average Na% of the investigated well waters was 75.3%, even the lowest value (53.7%) exceeded the threshold. Most of the waters we analysed contain 5-9 mEq l^{-1} hydrocarbonate anions, which is several times higher than the threshold. The sodium adsorption ratio (SAR) is also an index that indicates well the salinization effect of an irrigation water. If its value is lower than 4, the risk of secondary salinization is not high, the water is suitable for irrigation. The SAR value was mainly in the range of 4-10 with the average of 8.69. Only 2 samples had SAR value below the threshold.

Keywords: secondary salinization, irrigation, drilled wells

Introduction

Horticultural activities have been characteristic in the hobby gardens located in the northern and western areas around the town of Karcag for more than 300 years. Traditionally some citizens living in the town regularly go to their gardens where they grow mainly vegetables and fruits for their own consumption or even to sell these products in the local market. This way of life is still characteristic at the beginning of the 21st century. The narrow and relatively long plots of the gardens look totally different from the large plots of the large-scale farming that also characteristic for the region. Most of the hobby gardens lay on meadow chernozem soil, while a smaller rate on meadow solonetz turning into steppe formation (with the deepest A-horizon among salt affected soils). Both soil types are characteristic only the areas with higher elevation and can be considered the best soils of the region. Nevertheless both soil types are endangered by secondary salinization due to their susceptibility.

The increase of the level of salty groundwater or the application of poor quality (salty) irrigation water can cause secondary salinization. Salt affected soils are low fertility soils with unfavourable water regime. Alkaline salts, mainly sodium, are accumulated in these soils either naturally or this process can be human induced. The latter case is called secondary salinization and mainly related to improper irrigation. Intensively irrigated areas are endangered by secondary salinization worldwide (Letey, 1984; Mantel et al., 1985; Rhoades and Loveday, 1990). In the Great Hungarian Plain approximately 400,000 ha is the area where secondary salinization has occurred, mainly due to the rise of the level of salty groundwater. This was studied and proved by several scientists (Arany, 1956; Szabolcs, 1961, 1965; Várallyay, 1967a,b, 1968; Bacsó and Fekete, 1969; Fekete, 1969a,b; Rónai, 1985; Kuti et al., 1999). Blaskó (2005) monitored the salt- and water balance of irrigated areas and found the increase of salt content f the soil in several cases. During the 1980ies and 1990ies on 30% of the studied area (Jász-Nagykun-Szolnok County) increasing soil salt content could be detected, especially on

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the susceptible areas where the soil can be only potentially irrigated due to the high salt content in their deeper layers.

Irrigation from drilled wells is very characteristic in the small hobby gardens located around Karcag during the frequently droughty summers. Mainly vegetables and fruits with high water demand are grown in these gardens, hence quite a large amount of subsurface waters are used for irrigation. The quality of these waters is not checked by the owners of the gardens, the chemical composition, hence the suitability of the water for irrigation is not known. Furthermore most of these wells are illegal, not registered, therefore the central monitoring or control of irrigation cannot be solved in the gardens. Our hypothesis was that these waters are salty and irrigation with them involves the risk of secondary salinization.

Materials and methods

In our study started in 2009 water samples were taken from 46 drilled wells located in the hobby gardens around the town of Karcag (*Table 1.*). In order to get information on the quality of the irrigation water the samples were analysed according to the relevant Hungarian standards (MSZ 448:1986; MSZ EN 27888:1998; MSZ 1484:2006) in the laboratory of the Karcag Research Institute of RISF CAES, University of Debrecen and the following parameters were determined: pH, electric conductivity, dry matter content, cation (Ca, Mg, Na, K) contents, anion (HCO_3, Cl, SO_4, NO_3) contents. For the assessment of the salinization effect of the irrigation waters, the following indexes were calculated from the parameters determined in the laboratory as follows: *total salt content (c)*; *relative Na percentage (Na%)*; *calculated sodium-carbonate equivalent* (*S_{eq}*); *sodium adsorption ratio (SAR)*

Table 1. Designations of drilled wells of the tested area (1-46: Fig. 1-4) and tap water from the network

Garden	Drilled wells	Garden	Drilled wells	Karcag town	Drilled wells
Kisvén	1-9	*Völgyes*	27-34	*wells in the town*	43-46
Zug	10-19	*Koldus*	35-37	*tap water from the network*	47
Rokkant	20-24	*Nagyvén*	42		
Partos	25-26	*Agyagos*	43-46		

Results and discussion

The salinization effect of the investigated well waters was assessed according to the four indexes described in the Material and Methods chapter. In the case of soils sensitive for salinization, the upper threshold of the total salt content (*Figure 1.*) of the water is 500 mg l^{-1}, above this value the water is not suitable for irrigation. The total salt content of the investigated well waters varied in quite a wide range, but most of them were in the range of 550-600 mEq l^{-1}, the mean value was 689.1 mEq l^{-1}. Only 1 of the 47 samples had a value below the threshold, while 7 of them exceeded even the value of 1,000 mEq l^{-1}. The highest value was 1356.8 mEq l^{-1}. We tried to find correlation between the total salt content value of the water and the depth of the wells, but significant correlation could not be figured out. Nevertheless the waters with the highest values originated from shallow wells, mainly from the first aquifers (18 m).

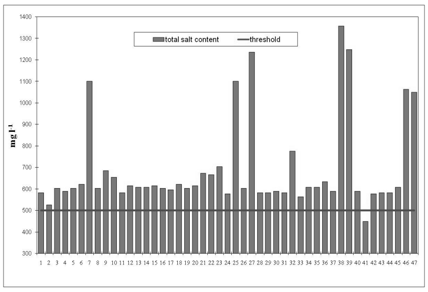

Figure 1. The total salt content values of the drilled well waters (Table 1.)

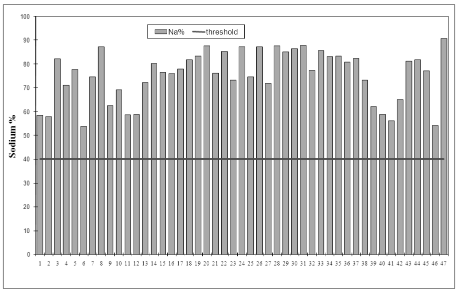

Figure 2. The Na% of the drilled well waters (Table 1.)

Taking the ratio of sodium among the cations into consideration, it can be concluded that sodium is the dominant cation (*Figure 2*.). The higher is the ratio of sodium, the higher is the risk of secondary salinization. A water is considered to be suitable for irrigation if the ratio of sodium among the cations is lower than 40%. The average Na% of the investigated well waters was 75.3%, even the lowest value (53.7%) exceeded the threshold. It can be concluded that irrigation with any of the waters we investigated involves the high risk of secondary salinization due to the dominancy of Na ions.

The calculated sodium-carbonate equivalent *(Figure 3.)* is a good index to express the salinization effect caused by carbonates and hydro-carbonates. The threshold from the point f view of irrigation is 1.25 mEq l^{-1}, below this value the water is suitable for irrigation. Most of the waters we analysed contain 5-9 mEq l^{-1} hydrocarbonate anions, which is several times higher than the threshold.

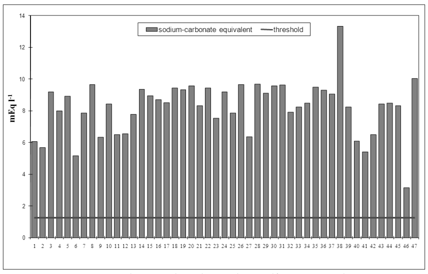

Figure 3. The calculated sodium-carbonate equivalent of the drilled well waters (Table 1.)

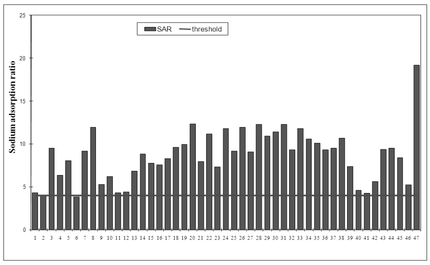

Figure 4. The SAR value of the drilled well waters (Table 1.)

The sodium adsorption ratio (SAR) is also an index that indicates well the salinization effect of an irrigation water. If its value is lower than 4, the risk of secondary salinization is not high, the water is suitable for irrigation. The SAR value of the waters we investigated (*Figure 4.*) was mainly in the range of 4-10 with the average of 8.69. Only 2 samples had SAR value below the threshold.

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Conclusions

On the base of the results we gained it can be concluded that the waters used for irrigation in the hobby gardens around Karcag are involves high risk of secondary salinization. All the indexes indicating the salinization effect of irrigation waters were above the thresholds in most of the cases, so it can be established that none of the investigated wells supply water that is suitable for irrigation without improvement.

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THE IMPACT OF PRECIPITATION ON CROP YIELD IN A SMALL-PLOT WINTER WHEAT (*TRITICUM AESTIVUM* L.) TRIAL SERIES

István BALLA [1] – Zsolt SZENTPÉTERY [2] – Márton JOLÁNKAI [1]

[1] Institute of Crop Production, Faculty of Agricultural and Environmental Sciences, Szent István University, Páter Károly str. 1., Gödöllő, H-2100, Hungary, e-mail: Balla.Istvan@mkk.szie.hu
[2] Faculty of Mechanical Engineering, Szent István University, Páter Károly utca. 1., Gödöllő, H-2100, Hungary

Abstract: The climatic elements have determinative importance in the formation of yield of winter wheat. The fluctuation of yield is also affected by climate elements, mainly the lack or surplus of precipitation. In the past few years reduction of the yield of winter wheat in our country was due to drought, that can be moderated only by modern agro-technological methods. While talking about lack of water it has to be mentioned that usually not the amount of precipitation induces the problem, but the unfavourable distribution of that. In the present year (2010) the exaggerated amount of moisture caused high degree deterioration in yields, through water logging and the overloading of the fields. To moderate the water abundance, the up-to-date agricultural technology would also be the perfect solution. It can be stated that the amount and distribution of precipitation has determinative role on the quality and quantity of the yield. In our experiment it has been examined in small-plot variety-comparing experiments the yield of winter wheat cultivars in relation with the precipitation amount of the year and the nutrition levels applied.

Keywords: precipitation, winter wheat, yield, different nutrient levels, nitrogen

Introduction

The aim of our research was to find connection between winter wheat yield and amount of precipitation in different years.
Biological agents such as variety and it's nutrient reactions in winter wheat fertilization are commanding affects. High differences appear in variety's nitrogen demand and usage which are affected by agro-ecological (vintage soil) and agro technical (forecrop plant protection etc.) factors (Harmati, 1975; Pepó, 1995). Adverse weather effects can be moderated by well nutrient replenishment (Fowler, 2003).
Precipitation is one of the most important factors affecting agricultural production and can be considered as a major stressor in relation with yield quality and quantity performance (Szalay et al., 2010).
Crop performance in rainfed cropping systems is generally depending on amount and distribution of rainfall (Yamoah et al., 2000). Agricultural success in non-irrigated cropping systems depends on efficient use of precipitation. Farmer decisions on which crops to plant and cultural practices such as mulching or reduced tillage that conserve soil moisture are determined in part by rainfall up to planting time. Crop rotations and multiple cropping systems that include two or more crops grown on a parcel of land may exploit moisture at different soil depths (Francis, 1989). As for soil moisture and other soil characteristic measurements it has to be taken into consideration that only the top soil surface information interdependent with different factors and can also be an indicator about the soil characteristics (Milics et al., 2010).
Farm characteristics, such as intensity of cropping, farm size and land use, contribute to the capacity to resist climate-induced yield variability (Reidsma et al., 2010).
Changes in weather conditions do not, however, solely determine the extent of yield variability. Crops respond variously to the timing of weather events, such as drought,

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heavy rains, low and high temperatures, depending on crop and phenotypic stability of the cultivar grown and management practices (Peltonen Sainio et al., 2010). With spatially more precise (or online) soil moisture monitoring, soil drought can be avoided in agricultural land system (Morschhauser and Milics, 2009).

Materials and methods

The experimental research field is located in Nagygombos (Hatvan), Heves County, Hungary. The experimental field is around 5 ha bordered by the M3 motorway and Hatvan-Salgótarján railway (*Figure 1.*). The experimental field is owned by a private farmer.

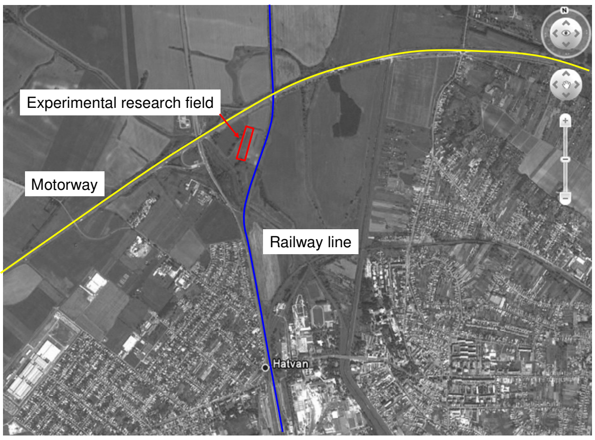

Figure 1. The location of Nagygombos (Hatvan), Hungary (Background picture: GoogleEarth)

Four different dozes of nitrogen fertilizer (0, 40, 80, 120 kg/ha) were applied in 5 different types (Mv Csárdás, Mv Magdaléna, Mv Suba, Mv Toborzó, Alföld 90) of winter wheat (*Triticum aestivum* L.). The size of each field was 1×10 m. It is well known in wheat production that there is very strong correlation between the applied amount of nitrogen fertilizer and quality parameters of grain. In our small plot research four different doses of nitrogen fertilizer on five different cultivars was investigated according to the precipitation. The different doses of nitrogen were applied as head fertilizing at the beginning of tillering. The data of precipitation in growing season was taken from meteorological measurements on site.

Results and discussion

In *Table 1.* yield of winter wheat cultivars in relation to the yearly amount of precipitation and the applied nutrition levels can be seen. The results of regression analysis can be seen in the last column of the table. The yield data of year 2010 is not indicated in this table. The yield of this year was not harvested for the sake of the water logging fields around our small-plots. We couldn't reach the experimental field with the harvester, however our yield samples were taken from 2 running meter in each small-

plot. In case we calculate with this data to the one hectare amount the data will be misleading.
In case of Mv Csárdás variety the correlation between the precipitation and yield is very strong by 0 and 40 kg/ha N application. This relationship by 80 and 120 kg/ha nutrient levels is flimsier, but we occurred the highest yield by 80 kg/ha N level in year 2006.
By Mv Magdaléna variety we experienced strong relationship in 40 and 120 kg N application. The top yield of this variety was in year 2008 with 80 kg/ha nutrient.

Table 1. Relationship between yield of winter wheat and precipitation of growing season

Wheat variaties and amount of applied N (kg/ha)		Years and amount of precipitation (mm)				Correlation (r^2)
		2006	2007	2008	2009	
		635	383	636	499	
Mv Csárdás	0	6.85	4.20	6.45	5.05	0.969540034
	40	7.15	5.00	7.00	5.43	0.941492673
	80	8.01	5.90	7.68	5.68	0.780441906
	120	7.95	6.03	8.00	5.68	0.757030977
Mv Magdaléna	0	5.38	4.03	6.48	4.73	0.810005173
	40	7.53	4.90	7.53	6.45	0.981988576
	80	7.35	5.63	8.28	6.18	0.864974986
	120	7.78	5.83	7.73	7.05	0.966767076
Mv Suba	0	7.55	4.13	5.60	5.60	0.66040505
	40	7.83	5.45	6.93	6.03	0.853063307
	80	8.00	6.10	7.55	6.65	0.937258647
	120	7.45	6.03	7.50	6.30	0.936175455
Mv Toborzó	0	7.03	4.18	6.33	4.80	0.91360214
	40	7.60	4.65	6.95	5.13	0.900991556
	80	8.35	5.20	7.90	5.90	0.942196954
	120	8.03	5.58	8.13	5.35	0.801522448
Alföld 90	0	6.75	4.20	5.88	5.78	0.807799518
	40	7.58	5.48	6.98	7.20	0.703308369
	80	7.01	5.58	7.45	7.10	0.750686186
	120	8.38	5.83	7.73	7.50	0.85389697

The worst data correlation can be seen in case of Mv Suba at 0 kg/ha nutrient level. At 80 and 120 kg/ha nitrogen amount the data has showed very strong correlation and the top yield of the cultivar was in year 2006 at 80 kg/ha nutrient dosis.
Best correlation occurred in case of Mv Toborzó. This variety shows correlation over r^2=0.9 in three cases. The top yield occurred again in level 80 kg/ha nutrient amount by this cultivar.

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We had the worst relationship with variety Alföld 90. The explanation of this is that this variety is the oldest one in the investigated group.

Conclusions

The results of our experiment showed that the relationship between yield of different winter wheat varieties and growing season's precipitation according to nutrient levels is very strong. It can be seen that in the worst case (Mv Suba, 0 kg/ha N) the correlation was r^2=0.66. In the best case (Mv Magdaléna, 40 kg/ha N)) the relationship was very strong. By Mv Toborzó variety correlation over 0.9 occurred three times. This cultivar has the best reaction for nutrient fertilizer and amount of precipitation. The top yield of four Mv varieties can be seen on 80 kg/ha nitrogen level and high amount of precipitation. In case of Alföld 90 can be seen that this cultivar hasn't got so good nutrient-reaction according to the precipitation. It is not so intensive variety. However the best yield of the experiment was produced with this cultivar in 2006 on 120 kg/ha N level.

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IMPROVING THE WATER MANAGEMENT IN MENA REGION

Yahia Ali MUGHRAM – László GUTH – Karim KHALED

Institute of Regional Economics and Rural Development, Faculty of Economic and Socials Sciences, Szent István University, 2100 Gödöllő, Páter Károly u. 1, Hungary, e-mail: zsarnoczai.sandor@gtk.szie.hu

Abstract: In Middle East and North Africa (MENA) region the average per capita water availability is very low with international comparising. The scarcity of water was resulted by two main reasons: population has sharply increased for the last decade, and influences of global warming resulting in longer period drought, which decreased the surface water amount. The case study aims at analysing and comparing the allocation of different water resources in MENA region, for example surface water, ground water, soil water and desalinization capacity.

Naturally the other difficulties are namely inadequate drinage 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.

Mainly the solutions for these difficulties, which are as follows: decrease the soil erosion, sedimentation, groundwater depletion, increasing water quality, urban wastewater treatment, increasing the desalinization.

The water scarcity is general in region, so the desalinization is very important, in spite that this is the most expensive method for available water. In MENA region this was almost 60 % of the world desalinization capacity, of which about half was in Saudi Arabia alone, where the desalinized water increased to 3.6 times the renewable water sources to the level of 52 million m^3 (MCM), in Qatar 163 MCM annually per capita. Also the urban wastewater treatment became very important for renewable water, in which for example Syria treated wastewater 1 MCM per a day.

Keywords: Global warming, surface water, sedimentation, water quality, wastewater treatment

Introduction

In Middle East and North Africa (MENA) region the average per capita water availability is very low with international comparising.

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 (Ligetvári et al., 2006). The increasing global warming and sharply increasing number of population have main role in decreasing average per capita water.

It is important to find how more water resources can be available in MENA regions. In this case the desalinization and wastewater treatment can be emphasized to realise these aims. Naturally the adequate water policy and water managemet are either to prevent the land degradation or increase the water quality.

The land degradation concerns the waterlogging and the salinity difficulties. The salinity means, that the soil content increases, which is resulted by increasing water use per hectare in order that the farmers can realise more intenzive crop production to obtain more yield. The intensive crop production results in more water use, which is with using non-adequate drainage system leads to waterlogging. Consequantly this last one leads to decrease the yield finally. This case-study analyses the solution for this complex problem.

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Materials and methods

The case study aims at analysing and comparing the allocation of different water resources in MENA region, for example surface water, groundwater, soil water and desalinization capacity. All of these water resources are important but each one has so different share of all used water ammount. 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.
These difficulties resulted in the development of new technologies to obtain other water resources like desalinization, wastewater treatment. In Saudi Arabia they had implemented desalinization about 700-800 MCM, in Kuwait the desalinated water was about 170 MCM water yearly for 1990's, but the other non petrol exporting countries do not have enough income to improve this most expensive technology. Naturally the wastewater treatment should be used to ensure water for human consumption and avoid of more environmental pollutions either for soil or for other water resources.

Results and discussion

The scarcity of water was resulted by two main reasons: population has sharply increased for the last decade, and influences of global warming resulting in longer period drought, which decreased the surface water amount.
The water scarcity is general in this region, so the desalinization is very important, in spite that this is the most expensive method for available water. In MENA region there was almost 60 % of the world desalinization capacity, of which about half was alone in Saudi Arabia, where the desalinized water increased to 3.6 times the renewable water sources. Also the urban wastewater treatment became very important for renewable water resource. This technology use has extended in MENA region since the beginning of the 1990's, even in those countries, which are not oil petrol exporting countries, in which for example, Syria treated wastewater 1 MCM (million m^3) per a day. The technological equipment for cleaning wastewater is considerably cheaper, because these are more extended in the world wide side.
This technology could extent easily, because the cost of treated wastewater unit was about 18-20 % of cost for desalinization of sea-water. This lower cost level stimulated the extent of this technology. Also the population of urban areas need clean water, in those urban areas, which are very far from the sea areas. This low cost of wastewater technology has been used since the beginning of the 1990's (World Bank, 1993).

The urban wastewater treatment can contribute to remain the quality of the water. This treatment can realise avoiding of pollution for natural environment, which pollution can result lare demages for the nature and for the human health. Also the treated water can be used by more times for human using, which can compensate the difficulties resulted by scarcity of water.
The water quality difficulties emerge, which connect with point source pollutions according to industrialized cetnres or towns in highly and none highly developed countries. Even also this problem can be experienced in industrial centres of developing

countries, including MENA countries. Even this water quality problem can appear in oil petrol mining areas, where the petrol, as chemical pollution can go into the soil and soil water resouces, which occures demages for water used by population. Also there are non-point sources, which were resulted by mainly chemical materials of agricultural production, for example fertilizers and pesticides in cultivated wide side areas in any country.

The water can transit the pollution from country to the other one, when one country in upper areas of a river can become as water supply country, like Etiophia and Sudan for Egypt. Naturally Sudan and Egypt can be transit countries because the river Nile brings any water pollution from municipial areas, large urban areas and wide side agricultural areas. Cairo, capital of Egypt needs wastewater treatment in order that no any pollution can go into the river Nile and Delta ares, which are the most favourable areas for agricultural production. The water pollution transition can appear within MENA region between countries, or between regions of a country, or within a region between different economic sectors, for example from urban areas to its neighbour agricultural cultivated lands. Even the water pollutions were resulted in a farmer to the other one by through the irrigation channel.

In this case countries of the MENA region can also use some important advantages of ground water for their interests. Countries can improve the irrigation capacity in order to create the wholly unified irrigation system to supply water for small and medium scale farmers and their agricultural production. Also countries can stimulate the water market creation in order to use water more efficiently by less cost of each water unit. Also the governments would like to make equil possibility for small, medium and large scale famres to access water.

International cooperation is needed for neighbour countries of MENA region in order that any water deficit country can get more water from water-plus country. For example Turkey, Syria and Iraq can make cooperation in this field. Also Sudan and Egypt can create such kind of these cooperations. There is an importan international cooperation possibility between Gulf countries in field of fossile water transit and desalinization process in order to decrease cost of these economic activities. This cooperation is very considerable, because of scarcity water.

In Saudi Arabia according to Eighth Development Plan the Saline Water Conversion Corpn (SWCC) is the largest producer of desalinated water of the world, which accounts for 25 % of global production. This project provides bout 3.4 MCM water per a day, which is equivalent to three – fifths of the country's daily water needs. Also Saudi Arabia had some water transmission networks under construction in 2006, and based on the plan the total length of water pipelines was planned more than four thousand km during the Eighth Development Plan. The Plan estimated the SWCC project about 50 billion Dollar US by the end of 2020.

Also Saudi Arabia made construction of dams in all of the country, in order to presereve the rainwater, which they requested to expand this planned project. By the end of 2000, the total number of dams in Saudi Arabia was 197, which had about total storage capacity of 809 MCM. The Saudian Government would like to construct more 11 dams in the early 21st century. Water – renewable underground and surface water, rainwater and recycled sewage water – consumed by the agricultural sector totalled as about

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18000 MCM in 2000, of which the renewable underground water was about 40% of the total water amount.
These projects can provide good example for new production technology, environment-friendly construction and investments in MENA region, how the countries would like to solve their water demands.

Conclusions

Mainly the solutions for these water difficulties analysed above, which are as follows: decrease the soil erosion, sedimentation, groundwater depletion, increasing water quality, urban wastewater treatment, increasing the desalinization.
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.

Some authors declared that the water supply and available amount of water are determined by the global warming process (Dobó et al., 2006).

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 regions. So the wastewater treatment should be developed in this region in order to remain the water quality for population and agricultural production.

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THE EFFECT OF ABA AND BAP ON GASES EXCHANGE AND WATER USE EFFICIENCY IN MAIZE *(ZEA MAYS* L.) DURING WATER STRESS

Václav HEJNÁK

Department of Botany and Plant Physiology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague 6 - Suchdol, Czech Republic, e-mail: hejnak@af.czu.cz

Abstract: The effect of abscisic acid (ABA) and synthetic cytokinin benzylaminopurine (BAP) on photosynthesis rate (P_N), transpiration rate (E) and water use efficiency (WUE) was studied during water stress of maize. Young plants of the cv. Anjou 245 were grown under managed conditions in a greenhouse. The growth regulators were applied by a spray device on the leaves of the plants. The concentration levels BAP 1 µM and 10 µM and ABA 100 µM were used in the application dose, corresponding to 100 cm^3 m^{-2} when converted. The results confirmed that growth regulators supplied to C_4 maize plants growing on a drying-up soil during a water stress can effectively influence its photosynthetic performance and water management capability. Reducing the gas exchange parameters by applying ABA can generally improve the ability of plants to survive an unfavourable drought because reduction of the amount of water evaporated through transpiration enables the plant to economise water, to adapt gradually as concerns osmosis and to redistribute water in its organs. Another aspect that apparently also matters are the interactions of exogenously supplied substances and the natural levels of hormones in plants, as shown by the findings obtained after application of BAP. A lower dose ultimately supported the ability of maize plants to economise water and improved water use efficiency (WUE). A higher dose supported improvement of WUE by increasing the photosynthesis rate.

Keywords: maize, water stress, abscisic acid, benzylaminopurine, rates of photosynthesis and transpiration, water use efficiency

Introduction

Sustainable development of the cultivation eco-systems for maize is only possible if the stability of the circulation of water, nutrients and energy in the whole system consisting of soil, plant and atmosphere is ensured. Physiological responses at the level of stomata, which regulate the output of water as well as intake of CO_2, are very important to ensure good balance between water intake through roots and water output through leaves. Much attention is paid to the effect of growth regulators on the regulation of water management of plants. In a number of agricultural crops, including maize, the effect of abscisic acid (ABA) on the closing of stomata and the effect of cytokinins on their opening was proved (Stuchlikova et al., 2007; Hejnak, 2010). The objective of this work was to identify how ABA and cytokinin benzylaminopurine (BAP) in C_4 maize plants influence the gas exchange parameters if they are applied as late as during a deepening soil drought.

Materials and methods

Young maize plants (*Zea mays* L., cv. Anjou 245) were used for the experiment. The experiments were taking place in a physiological greenhouse under controlled conditions: 14-hour photoperiod, the temperature 20–25 °C during the day and 16–20 °C at night and the relative air humidity 50–60%. In containers filled with soil, 5 plants were cultivated on an area of 0.05 m^2. The soil moisture was maintained at the level of

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60–70% of the maximum capillary water capacity. Plants 8 weeks old were divided into 6 groups with 4 repetitions: 1. control group – plants irrigated throughout the experiment; 2. plants stressed by drought – complete interruption of irrigation; 3. plants stressed by drought + 3 days after interruption of irrigation, 100 μM ABA was applied; 4. plants stressed by drought + 3 days after interruption of irrigation, 1 μM BAP was applied; 5. plants stressed by drought + 3 days after interruption of irrigation, 10 μM BAP was applied; 6. plants stressed by drought + 3 days after interruption of irrigation, 10 μM BAP + 100 μM ABA was applied.

The growth regulators (BAP and ABA) were applied by a spray device on the leaves of the plants. The concentration levels BAP 1 μM and 10 μM and ABA 100 μM were used in the application dose, corresponding to 100 cm^3 m^{-2} when converted. The Citovett wetting agent was used.

The responses of the plants to changes of the moisture content in soil and the applications of the growth regulators on the leaves of the plants were identified by measuring the relative water content (RWC) in leaves, the photosynthesis rate (Pn), the transpiration rate (E) and the water use efficiency (WUE) as a Pn/E. Pn and E were identified in intact leaves by means of a gasometrical infrared analyser *LCA-4* (*ADC Bio Scientific Ltd.*, Hoddesdon, UK). 3 leaves were measured in each experimental container. The immediate reactions on the applications of the growth regulators were detected by measurement of Pn, E and WUE in the period 24 hours after applications. The longer-range trends were detected in the period 3–9 days after applications of the growth regulators. In the assimilation chamber, the temperature during the measuring process was 25 °C, the level of irradiance was 750 μmol m^{-2} s^{-1}, air humidity was 50 % and the concentration of CO_2 was 350 μmol mol^{-1}.

The statistical evaluation was carried out by means of a variance analysis at $\alpha = 0.05$ in the Statistica computer software, version 6.1 CZ, the ANOVA module. The mean values measured in three series of experiments have been published.

Results and discussion

Young plants of maize, cv. Anjou 245, exposed in variants 2 to 6 to gradual drying-up of soil substrate retained a high RWC > 80 % (84 through 89 %), throughout the experiment, which was not statistically different from the levels observed in the control variant 1.

However, in spite of the high RWC, stomatal limitation of the gas exchange parameters (Pn and E) occurred on the drying-up soil (*Figure 1-2.*). There were observed a statistically significant decrease of the photosynthesis and transpiration rates in the plants stressed by drought in variant 2 in comparison with the non-stressed variant 1. WUE was approximately the same or lower in comparison with the non-stressed plants (*Table 1.*).

Growth regulators applied on the plants stressed by drought at the point of time after 3 days significantly influenced the parameters of the exchange of gases between the maize leaves and the surrounding environment. When 100 μM abscisic acid (ABA) was sprayed on a leaf (variant 3), this resulted, throughout the experiment, by tighter closing of stomata and by lower levels of Pn and E in comparison with the stressed plants, not treated by growth regulators. The decrease of the gas exchange parameters was greatest shortly (in the period 24 hours) after the application when the differences were highly provably in comparison with the untreated plants. The statistically non-significant improvement of WUE was occurred after the application of ABA.

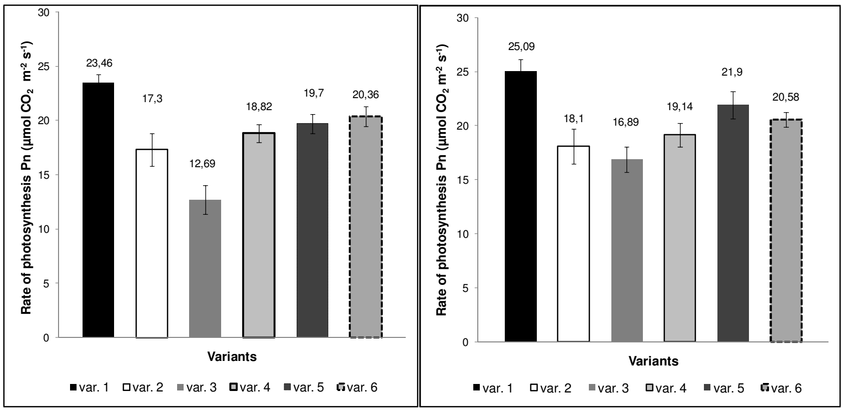

Figure 1. The photosynthesis rate (Pn) of young maize plants, cv. Anjou 245, during water stress in the period 24 hours (left) and 3–9 days (right) after applications of the growth regulators. Mean ± SD (n=9).

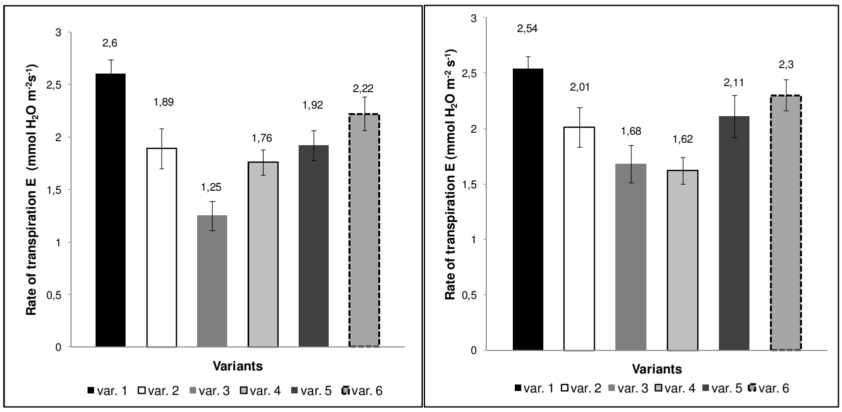

Figure 2. The transpiration rate (E) of young maize plants, cv. Anjou 245, during water stress in the period 24 hours (left) and 3–9 days (right) after applications of the growth regulators. Mean ± SD (n=9).

When benzylaminopurine (BAP) in the concentration of 1 µM (variant 4) was sprayed on the maize plants, this resulted in steady, but statistically improvably higher levels of Pn. On the contrary, E was lower than in the stressed plants, not treated by growth regulators, and it was lower to a statistically provable extent during the period 3–9 days after applications of BAP. When a stronger concentration of BAP amounting to 10 µM (variant 5) was used, Pn increased to a statistically highly provable extent in comparison with the untreated plants but it did not reach the level of Pn in the control plants that were irrigated throughout the experiment. The levels of E identified by measuring were

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hovering around the levels identified in the stressed untreated plants. The application of both concentration of BAP on plants stressed by drought resulted, throughout the monitored period, in improve level of WUE in comparison with the stressed plants not treated by BAP.

When the stronger concentration of BAP and 100 µM ABA were applied common (variant 6), Pn and E increased in comparison with stressed plants, not treated by growth regulators, but WUE didn´t improve.

Table 1. The water use efficiency (WUE) of young maize plants, cv. Anjou 245, during water stress in the period 24 hours and 3–9 days after applications of the growth regulators. Mean ± SD (n=9).

Variants	WUE (mmol CO_2 mol^{-1} H_2O) during water stress in the period 24 hours after application of the growth regulators		WUE (mmol CO_2 mol^{-1} H_2O) during water stress in the period 3–9 days after application of the growth regulators	
	Mean	SD	Mean	SD
1	9,02	0,46	9,88	0,59
2	9,15	0,84	9,01	0,91
3	10,15	0,75	10,05	0,67
4	10,69	0,47	11,81	0,6
5	10,26	0,52	10,38	0,72
6	9,17	0,55	8,95	0,41

Conclusions

Reducing the gas exchange parameters by applying ABA can generally improve the ability of plants to survive an unfavourable drought because reduction of the amount of water evaporated through transpiration enables the plant to economise water, to adapt gradually as concerns osmosis and to redistribute water in its organs. Another aspect that apparently also matters are the interactions of exogenously supplied substances and the natural levels of hormones in plants, as shown by the findings obtained after application of BAP. A lower dose ultimately supported the ability of maize plants to economise water and improved water use efficiency (WUE). A higher dose supported improvement of WUE by increasing the photosynthesis rate.

Acknowledgements

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THE ADOPTION OF THE RAIN-STRESS MITIGATING METHODS IN A DAMAGED ARABLE SOIL

Tibor KALMÁR – Szilveszter CSORBA – András SZEMŐK – Márta BIRKÁS

Institute of Crop Production, Faculty of Agricultural and Environmental Sciences, Szent István University, Gödöllő, Páter K. 1. H-2103; e-mail: tibor.kalmar@vaderstad.com

Abstract: Impacts of surface cover and soil preserving tillage were studied in a *Chernic Calcic Chernozem* soil of a degraded structure in the summer 2009 and 2010. The objectives of remedying the soil included to avoid deterioration of the existing compaction, to reduce dust formation and to help crumb formation, to manage the water transport and to alleviate climate-induced stress. These goals were achieved by wisely chosen continuous moisture managing, structure and OM conserving stubble tillage and by keeping the soil covered throughout the critical summer season. Steps towards improving the condition of the soil of a degraded structure were combined with stubble tillage techniques that are suitable for alleviating rain-stress. In this study the possibilities of remedying soil defects caused by tillage before the so-called stubble-climate experiment is reported.

Keywords: soil degradation, conservation, crumb, rain-stress, surface cover

Introduction

Soil is an environmental element labelled by a variable state and quality: renewed or degraded (Várallyay, 2010). This renewal capability of the soil can be maintained by continuous treatment carefully aligned to the prevailing circumstances. Therefore the primary task of tillage is to maintain favourable soil quality and fertility and to prevent climate sensitiveness. Concerning authors (Birkás et al., 2009; Huisz et al., 2010; Macák et al., 2010) confirm that unreasonably disturbed soils steadily lose organic matter, as a consequence of which their bearing capacity and workability deteriorates and the soils grow more exposed to the risk of degradation. As has been reported by Kalmár et al. (2007) and Bottlik and Stingli (2009) in conventional tillage field residues are removed, i.e. they are not used for protecting the soil. Perception of the tillage-induced soil deterioration needs to be taken care of particularly because of its obstruction of water absorption and transport, thereby aggravating climate damage (Birkás and Kisić et al., 2009; Sajko et al., 2020). Good opportunities arise for the remedy of the soil during the 'resting', stubble phase.

Materials and methods

The experimental period started in summer 2004 in a soil with a top layer of a degraded structure – *Chernic Calcic Chernozem* by WRB, with clay loam texture – in the vicinity of the town of Hatvan (47°41'N, 19°36'E). This trial has been repeated every summer in stubbles of the winter wheat tilled by disking in the previous autumn. In this study concerning results from the last two extreme periods are discussed. This periodical trial was carried out in three repetitions of random arrangement in patches. Two of the applied six treatments are widely used in practice – that is conventional disking (CD) and ploughing (P) without surface pressing – and others are the methods to be recommended that is tillage by flat plate disk (FD), mulch-cultivator (K) and plough and press (PP). The control variant of the trial has been always undisturbed stubble (S). Depth of the tillage has been applied by commercial patterns, that is 6-12 cm at the

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shallow tillage, and 30-32 cm at the ploughing variants. Some additional data can be seen below:

Table 1. Data of the experiment

Period	Soil moisture level at exp. setup	Precipitation (mm)			Mass of wheat stalk in the surface before tillage (t ha^{-1})
		from 1 April till trial setup	in the period	difference from multiyear average (±)	
10.07–18.10, 2009 (100 days)	moist	168	154	-10	4
20.07– 24.10, 2010 (96 days)	wet	441	273	+112	2

Soil moisture measurement in terms of $m^3 m^{-3}$ was taken with PT-I stick sound and the soil mechanical resistance measured with a Szarvas-type penetrometer (in terms of MPa) to the prescribed depth. The depth of the loosened layer was checked by measuring the penetration resistance. Sampling and separating of the soil fractions (clod, crumb and dust) were taken with Dvoracsek's instruction (1957). The percentage rate of crop residues remaining on the soil surface in a given area is established with the aid of a 0.25 m^2 measuring frame (with 4 repetitions per treatment). Both soil and residue sampling and measuring were established in accordance with the relevant standards and regulations (Tóth et al., 2009, Macák et al. 2010). Biometric evaluation was carried out pursuant to the scheme described by Sváb (1981).

Results and discussion

In view of the climate induced damages, summer tillage practices – including stubble tillage – have to be judged somewhat more critically. The two seasons selected for the trials were special from the aspect of the soil and of soil moisture. In 2009 the experiments were set up on a soil that was dry in the top layer and wet below 10 cm (27 m^3m^{-3}). In 2010 the surface, as well as the layers below were wet (29-30 m^3m^{-3}). The great challenge stemmed from the extent of damage caused by the tillage tools and the possibility of alleviation that was expected to be observed by the end of the season. The following is a discussion of certain important changes in the condition of the soil.

Role of the cover in the protection of the soil surface

Our earlier experiments and findings confirmed that the soil is particularly in need of protection outside the growing season (Birkás, 2009). A minimum of a 55-65 % surface cover is required between the time of harvest and stubble tillage, while after shallow stubble tillage a 35-45 % is required. Optimum cover is increasingly important in the case of the strong rains, since it contributes to the regeneration of the damaged soil (Macák et al. 2010). This is why the straw:soil ratio is regarded to be highly important. The straw to soil ratio on the surface was 85:15 in 2009 before it had been changed by tillage (*Figure 1.*, Straw), in which the smallest decrease was observed where no stubble tillage (S) was carried out. In the wake of stubble tillage the ratio dropped to 48:52 (FD) and 30:70 (CD). As time passed the straw cover dropped to 13 % and 9 % while the ratio of volunteer crop and weed cover (Plant) increased in the case of each treatment. From late August on, after the chemical treatment of the green vegetation the role of soil protection taken over from the decreased amount of straw by the so-called dead mulch. The straw:soil ratio can be expressed more simply in terms of the coverage rate. In the case of little cover this rate is small (<0.4), while in the case of substantial cover it is high (>2). The measurements showed that the ratio of bare soil surface should not be higher than 35-65 %, within which range the straw:soil ratio varies as follows: 35:65, 40:60, 45:55, 46:54, 50:50, 55:45, 60:40, or 65:35 %. In this case the cover rate per unit of area varies between 0.5 and 1.8. In a longer dry period (as in 2009) higher cover rates, i.e. 55-60 % on tilled soils and 65-85 % on untilled soils should be more favourable. This criterion was fully met by the FD and the K, and it was still acceptably met by CD, S and PP while it was not met by P at all. In the summer of 2010 we found that the ratio of the soil surface without mulch cover must not exceed 65-70% even in a rainy season because of the risk of structure damage.

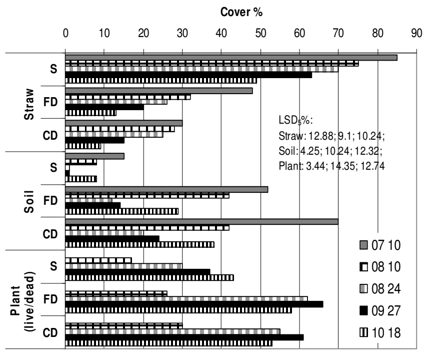

Figure 1. Ratio of covered soil surface (by straw, plants) to the bare soil surface (Hatvan, 2009). Note: S: stubble, FD: tillage by flat disk, CD: tillage by conventional disk

The loosening of the soil in the 'stubble/stripped stubble phase'

We confirmed that the depth of the loosened layer resulting from stubble tillage increases the retention of water and of the moistening of the stripped soil layer, and the disk pan becomes easier to crumble. The elimination of surface protection (removal of the covering layer as we did on the 65th day) however, cuts the process of loosening (*Figure 2*,. CDt and FDt variants). This phenomenon was observed in both dry and wet season. Moreover, inadequate surface protection (CD) impedes the loosening of the disk pan. This was also referred to by Birkás et al. in their study (2009).

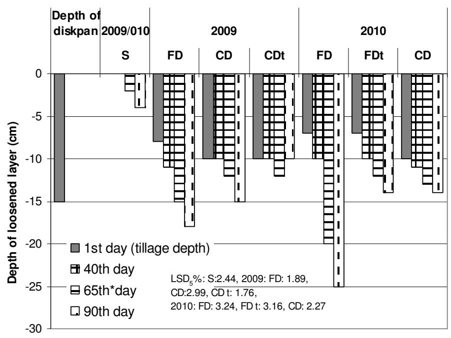

Figure 2. Increase in the depth of the loosened layer under various treatments (Hatvan, 2009-2010). Note: S: stubble, tillage by FD: flat disk, CD: conventional disk, t: straw removal

Degraded structure vs. crumb formation

In 2009 the ratio of clod-crumb-dust fractions within the agronomical structure that is characteristic of the soil was 18:75:7 and in 2010 accounted for 36:63:1. In 2009 the shortage of rain, while in 2010 too much rain impeded crumb formation. In the dry year the little rains and in the wet season the beginning of a dryer period was favourable for crumb forming (*Figure 3*). The soil behaved in a particular way where the stubble stripping tool caused less damage to the soil (FD, K). Crumb forming was similar in the ploughed soil in both years, and structure regeneration was extremely slow.

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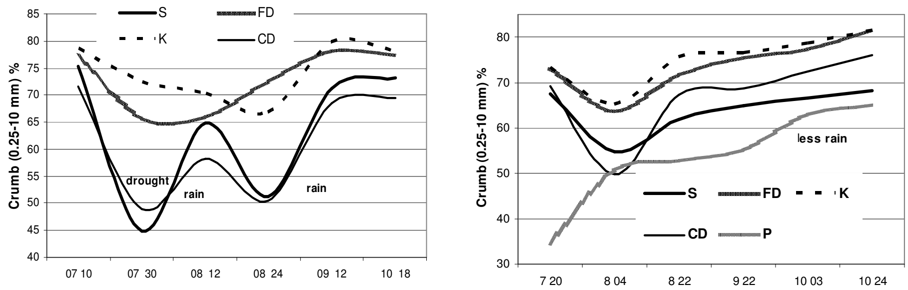

Figure 3. Crumb forming trend (2009, left, 2010, right) Note: $LSD_{5\%}$, 2009: S: 5.09, FD: 4.12, K: 4.57, CD: 6.21, 2010: S: 5.42, FD: 2.99, K: 3.54, CD: 3.98, P: 5.21

Conclusions

Work aimed at improving a soil of a degraded structure should be started out of the growing season, during the 'stubble phase'. A cover layer should be formed by stubble tillage, providing a coverage ratio of 35-65% in an average season, 55-60% in a persistently dry season or at least 30-50% in a wet season. The effects of stubble tillage resulting in improved workability were proven. The damage was found to be alleviated only in the case of less severe defects, if the damage had occurred in the so-called biologically active zone, and if the minimised heat and rain stress, crop residues as food for earthworms and microbes, moisture and aeration were met.

Acknowledgements

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DYNAMICS OF THE WATER SUPPLY IN THE SOIL PROFILE STRUCTURAL BORDER

Július ŠÚTOR – Marek RODNÝ

Institute of Hydrology, Slovak Academy of Sciences, Račianska 75, Bratislava, Slovakia,
e-mail: sutor@uh.savba.sk, rodny@uh.savba.sk

Abstract: Dynamics of water supply in the soil aeration zone in upper part of Žitný Ostrov.The water regime in the soil aeration zone is determined by the position of the soil profile in relief, climatic conditions, hydrological properties of soil, participation of ground water in water balance of the aeration zone, and vegetation cover. In the upper part of Zitny Ostrov, the position of soil profile in the subsurface layer of lithosphere plays a dominant role in creation of the water supply in the aeration zone. The soil cover layer is laid on gravel basement thus forming structural interface. This interface plays a significant role in creation and dynamics of water supplies in the aeration zone of soil in selected localities of Zitny Ostrov, respectively in hydrology of subsurface water of the above-mentioned region. Presented study is oriented to problem of water regime of the soil aeration zone in two selected localities of upper Zitny Ostrov, where water regime is influenced gravel interface in the depth of ca. 80-100 cm. For those conditions there is presented characteristic distribution of moisture on the height of soil profile and course of water supply in the aeration zone for years of organized monitoring.

Keywords: structural interface, monitoring of soil water, soil water regime

Introduction

Natural environment of the Žitný ostrov territory has its origin in the alluvial deposits of Danube delta. Topsoil substrate horizon known as "cover layer" has thickness varying from 50 to 500 cm. It overlies the coarser sandy-gravel subsoil (Šútor, 2008).Soil water retention and dynamics of these texturally distinct materials strongly differs under conditions of three-phase system in the soil aeration zone. The boundary between texturally distinct materials (a capillary barrier) plays important role in the soil water regime, respectively in the hydrology of ground water at Žitný ostrov. If the ground water table is permanently situated in the sub layer, it is assumed as a reference level equilibrated at the atmospheric pressure, with the water potential=0 and the continuous fine–coarse interface acts as a retarder for water and land-applied chemicals percolating from the cover layer (Šútor,1999; Štekauerová and Nagy, 2006). Retardation of unsaturated water flow is also influencing the cover layer plant water availability in a positive manner. Furthermore it significantly affects soil water content distribution along the depth of the soil profile during the year, respectively the vegetation period. From the eko-hydrological framework the subsoil water content plays only a minor role and therefore can be considered as “negligible”. Volume fraction of water which can be drained from the gravel subsoil under prescribed conditions (ground water table unit decrease) can be determined by the Coefficient of drainable porosity (P_d, [% vol.])

Study presented here describes the soil water regime of a layered soil profile with a capillary structure interface. It contributes to works dealing with the soil aeration zone non-homogeneity of different kind and origin (Koltai et al., 2008; Várallyay, 2008; Lehoczky et al., 2009).

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Materials and methods

Soil water content direct monitoring was done simultaneously at 10 distinct sites to evaluate the impact of the Gabčíkovo - Nagymaros Waterwork on Žitný ostrov soil water regime (Šútor, 1999, Rehák and Šútor, 1998). The volumetric soil water content was measured biweekly by a neutron probe method. Measurements were simultaneously validated each 3 months using a gravimetric method (Nagy and Igaz, 2009). For purpose of this work the soil profile structural boundary interactions were examined at two specific locations in the upper part of Žitný ostrov near the township Lehnice (sites 4 and 8) in the period 1991 – 1997 (*Figure 1.*). The cover layer thickness, i.e. the depth of the capillary barrier below the soil surface was 80 cm on the site 4 and 100 cm on the site 8.

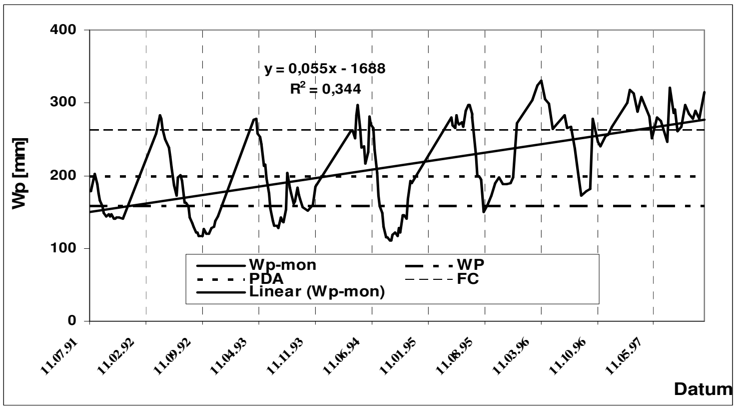

Figure 1. Monitored water supply in the aeration zone of soil (Wp-mon) in the locality Lehnice (N8) 1991-1997, the thickness of the cover layer =100 cm

Results and discussion

The above mentioned topsoil–subsoil boundary acts as a retardation barrier if the soil water potential of the cover layer is at or above the water entry value derived from the wetting branch of the coarse subsoil moisture retention curve. The boundary is under the atmospheric pressure and acts as a reference level for accumulated water above it. When this structural interface is relatively near the soil surface, the accumulation process in the aeration zone tends to reach a balance, and the soil water content distribution follows the moisture retention curve. In this situation, a capillary fringe is formed above the border line. Its thickness will rise under further water inflow until reaching the „bubbling pressure“. If this threshold potential is reached the hydraulic conductivity is high enough and the cover layer water will penetrate into the underlying coarse layer.
A similar situation occurs when in case of balanced distribution of moisture above the boundary where fluctuation of ground water table formed suction pressure corresponding to „bubbling pressure“.

Due to the mentioned phenomena interactions, the distributions of the moisture content above the relevant border line are different from distributions that are known for active horizon of the soil aeration zone (Štekauerová and Nagy, 2006; Stehlová and Štekauerová, 2008). Especially the variation space of moisture content from the soil surface to the structural boundary is not getting narrow but belongs to wide interval of value (*Figure 2.*). Analyzed soil moisture profiles were monitored during the year 1996 on site 8.

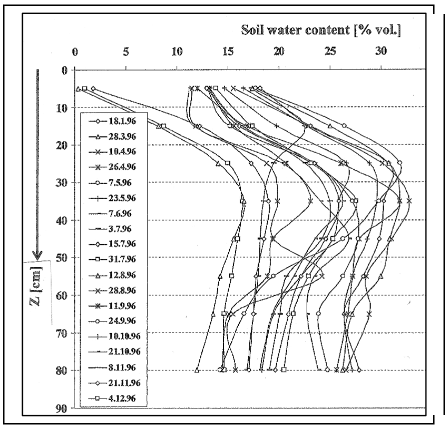

Figure 2. Soil water content vertical distribution at the location Lehnice (N4) in the period 18.2. - 4.12.1996, the thickness of the cover layer=80cm

Conclusions

Soil and soil substrate horizon under condition of Žitny ostrov is situated on coarse gravel basement. This horizon is named as cover layer of the environment of Žitny ostrov. The thickness of the cover layer fluctuates from 50 cm to ca 555 cm. Here the water regime in the aeration zone receives its characteristic properties. They are determined by the occurrence of the ground water table and its position with respect to interface cover layer – gravel horizon.The zone of the natural environment above the boundary cover layer – gravel horizon significantly differs with its water retention and water dynamics from the zone below this border line. In the period when the ground water table occurs below this boundary, the boundary acts as a retarder with respect to discharge of water from the zone above this boundary. Retardation of discharge optimizes in some way the use of water supply in the aeration zone by vegetation cover and thus significantly influences the course of moisture distribution along the depth of the soil profile during the year, respectively vegetation period (*Figure 1.* and *Figure 2.*) In this study there are presented results of monitoring from upper Žitny ostrov (localities (N4) and (N8) near Lehnice) and processed sets of data on moisture from situation, when during vegetation period, respectively hydrological year is the ground water table below mentioned interface. The study presents influence of this interface on
•Course of soil moisture according to depth of the aeration zone in the locality Lehnice (N4) in the period 18.2. - 4.12.1996, the thickness of the aeration zone is 80cm

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•Monitored water supply in the aeration zone of soil Wp-mon in the locality Lehnice (N8) in the period 1991 - 1997, the thickness of the aeration zone 100 cm.
The ground water table does not participate in water balance of the aeration zone under these conditions. Creation and dynamics of the water supply is determined by mutual interactions of the aeration zone of soil, vegetation cover and meteorological conditions.

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THE EFFECT OF CHANGING CLIMATE ON AGRICULTURAL PRODUCTION

Péter KÖLES [1] – János PUSKÁS [1] – Ákos BODNÁR [2]

[1] Technical Institute of Water and Environmental Faculty, SZIE, Szarvas, Szabadság út 1-3.
E-mail: koles.peter@mkk.szie.hu
[2] Environmental Science of Agricultural and Environmental Faculty SZIE Gödöllő, Páter K út 1.

Abstract: The climate change impacts every field in the Carpathian basin as well. Agriculture is the most influenced one, but the other economic sectors are also suffering from its effects. Dealing with this issue is a major challenge for this sector in the Carpathian Basin since agricultural production is becoming riskier and there has been a significant increase in the product prices.

Keywords: climate changing, evapotranspiration, agriculture, crop production

Introduction

Worldwide measurements prove that the green house effect has been strengthening, which causes the warming up of the atmosphere of the Earth leading to climate change. As a result meteorological phenomena are experienced being significantly different from the characteristics of the given climate belt. They can be monitored under local and regional conditions as well as under global ones in the forms of climatic anomalies. Their impact is to be felt in every branch of the economy and in the response of the society. This unusual behaviour is directly embodied in the occurring changes of the meteorological elements such as extreme levels of air temperature, quantity and intensity of the precipitation, wind conditions, evaporization constants and the intensity of the dangerous radiation, respectively.

Materials and methods

The climate change involves a great challenge for the agriculture of the Carpathian Basin because of its characteristic geographical endowments and special climatic connections. According to the data of the OMSZ (OMSZ, 2001), during the last more than 100 years the climate has changed considerably on the plain territories of the Carpathian Basin.

Results and discussion

In the Carpathian Basin the temperature raised by the amount of 1.6 degrees Celsius between the end of the 1870s and the end of the 1940s (Horváth, 1997) and it continues to grow as shown in *Figure 1*. The annual average precipitation amount has shown a decreasing tendency since the 1870s (Molnár, 1996).

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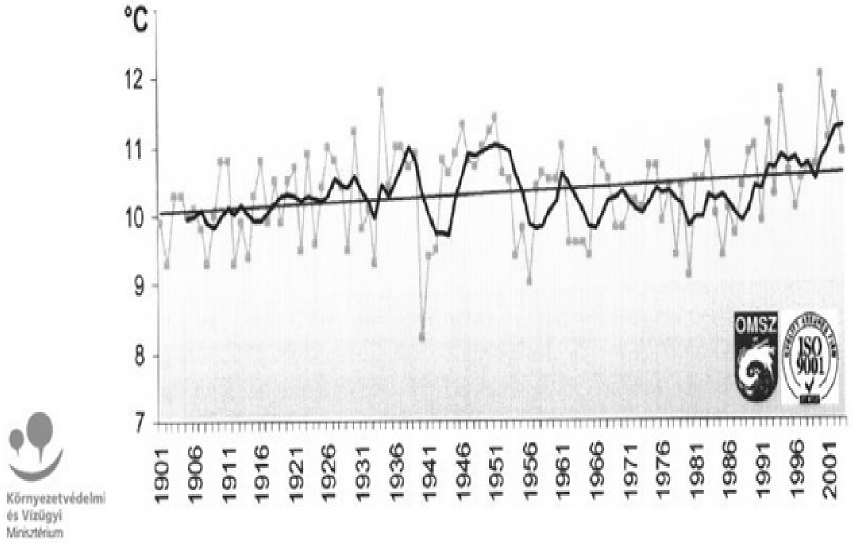

Figure 1. The annual average temperature in Hungary (1900-2001) OMSZ (National Meteorological Service) Climatic Map of Hungary

The previously mentioned single climatic elements affect the everyday human activities both one by one and in a complex way. The environmental changes can not only have synergic effects but antagonistic ones too. The geographical position and the exposition contribute seriously to the results of climate change within the Carpathian Basin indicating drought mainly on the flat areas with greater frequency. Therefore, in Hungary, the Great Hungarian Plain (mainly its southern and south-eastern part) is exposed to great extremities as shown in *Figure 2*. (Makra, et al. 1986).

There has been an increase observed in the evaporization of the open water surface during the past 30 years. The long term amount of average evaporization of the Lake Balaton, the biggest lake of the Carpathian Basin, was 860mm (Antal et al., 1977). However, Anda and Varga (2001) concluded that the evaporization average was 914.2mm on the entire surface of the Lake between 1992 and 2002, thus the increase in evaporization of the lake surface surplused 50mm. Considering the total size of the lake surface, which is 594 square kms, almost an additional amount of 30 million cubic metres of water is evaporating annually.

Climate change also remarkably affects the growing, producing, touristic etc. opportunities. It necessarily leaves its marks on the social and economic sectors with either positive or negative results (Köles et al., 2003). The climate change indirectly imposes an inevitable challenge for the stake holders as well, e.g. Tokio or Rio de Janeiro Conferences, etc.

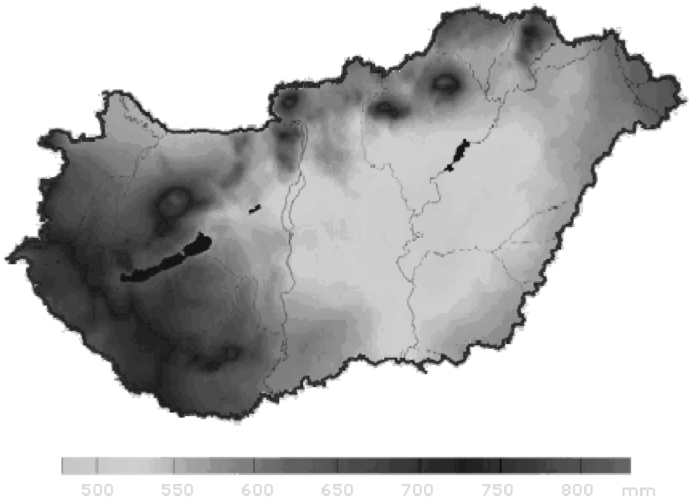

Figure 2. The average precipitation quantity in Hungary OMSZ: The Climatic Map of Hungary (2006)

The effects of scarcity of water and precipitation quantity on the plant products

In the territory of the Carpathian Basin those dealing with agricultural activities primarily have to face the unfavourable effects of climate change. The most and biggest problems occur because of the unpredictable meteorological incidents and the increase of their intensity. The agricultural producers are exposed to all elements contributing to climate crisis (Köles et al., 2003). In the middle region of the River Tisza the precipitation evaporating is 60mm higher on the average than the falling amount (Horváth et al., 2001). It means water famine of 600 cubic metres per hectare. Examining the period between 1951 and 1993 it can be stated that climate change had a measurable effect on the agricultural production. The amount of evapotranspiration has increased by a linear trend of 0.18mm/year resulting an 8-mm average increase considering the total examination period. The examined factors show close connection: the correlation coefficient is: R=0.81.

Consequently, in the Carpathian Basin, especially on the flat areas droughts are even more likely to occur. In Hungary it is the territory of the Great Hungarian Plain – primarily its southern and south eastern part – that is extremely exposed to drought (Makra et al., 1986).

Both the grown plants and the natural ones are considerably affected by this. The growth, development and crops of plants are in close connection with the directly surrounding atmosphere through the processes of metabolism and energy exchange. The connection between the plants and their environment is an interrelation to be detected in the quantity and quality of crops (Horváth et al., 2001).

The clear effects of the climate change are to be observed in keeping animals, animal husbandry, feedstuff production, animal health care and in making animal products. The frequent weather extremes, the succeeding natural catastrophes (unusual temperatures for the given season, flooding, inland waters/saturated lands, storm damages) make the

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quantity and quality of forage and litter/bed of staw to be produced uncertain. In the extremely unfavourable years or growing periods the quantity of forage to be produced is not enough for satisfying the needs in forage for the animal stock. For the last 25-30 years the quantity and quality of the forage have significantly changed under the unpredictable weather conditions. It is partly due to these unpredictable natural factors that the national animal stock has been decreasing from year to year. The extreme activities of the climate elements – the weather anomalies characterizing the given territory- to go along with the improper keeping of animals in response to these extreme conditions, choosing the improper technology and not utilizing the pasture grounds and grasslands make the situation of animal keepers (and animals) more difficult.

The reports of VAHAVA Program 2005-2006 highlight the fact that the risk due to the weather is lower in animal farming based on crop feedstuff than in case of that based on fibrous or liquid forage.

However, it must be noted that the conditions are favourable in most parts of our country for keeping ruminant animals in the fields. The territory of more than 1.1 million hectares of grassland is a considerable potential in national animal farming. For instance, grazing in the flood areas has been a tradition for several hundreds of years and tends to return in the present day practices. By improving the technological standards of grazing grounds and grasslands a considerable basis of feedstuff can be produced for farmers keeping beef cattle, sheep, horses produced for meat and goats.

Conclusions

The climate change impacts every field and everybody in the Carpathian basin as well. In agriculture crop production, horticulture and animal husbandry are all effected. Its favourable effect is also observable but producers mainly meet its harmful consequences. Due to the climatic risks producing safe products is possible only by increasing capital expenditures resulting in more expensive base material. The prices of production increase and the knowledge necessary for producing base materials becomes more crucial. The climate change has resulted in a process with many factors and it is yet to be determined what kind of difficulties farmers and other participants in agriculture may face in the future.

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EFFECTS OF WATER DEFICIT ON CHLOROPHYLL CONTENT, RELATIVE WATER CONTENT AND GRAIN YIELD OF SIX CROATIAN WINTER WHEAT GENOTYPES

Ivanka HABUS JERCIC [1] – *Marijana BARIC* [1] – *Snjezana KERESA* [1] – *Anita MIHOVILOVIC* [1] – *Milan POLJAK* [2]

[1] Department of Plant Breeding, Genetics and Biometrics, Faculty of Agriculture, University of Zagreb, Svetosimunska 25, 10000 Zagreb, Croatia, e-mail: ihabus@agr.hr
[2] Department of Plant Nutrition, Faculty of Agriculture, University of Zagreb, Svetosimunska 25, 10000 Zagreb, Croatia

Abstract: Drought is one of the major environmental factors that inhibits many metabolic processes and constrains plant growth and crop productivity. Croatia is part of Mediterranean Drought Group with late season drought stress during the grain filling in wheat. In order to evaluate water deficit on relative water content (RWC), chlorophyll content (Chl) and grain yield of six Croatian winter wheat genotypes, a factorial experiment based on randomized complete block design with three replications was conducted in 2009-2010. Factors were six winter wheat genotypes (Kaja, Divana, Karla, Kuna, Banica and ZGM 13) and two water regimes (control and water deficit occurred from anthesis to maturity). Physiological responses (RWC and Chl) were measured in late milk maturity (LMM) and in early waxy maturity (EWM). Grain yield, yield per spike and 1000 grain weight were measured after harvesting the plots at maturity.
Results showed that genotypes Kuna and Banica had the highest Chl in LMM, and the genotype Karla had the highest Chl in EWM in both environments. The highest RWC was observed in the genotype Karla in LMM, and in the genotype Kuna in EWM in both environments. Genotypes Karla, Kuna and Banica are all high yielding genotypes, but Kuna and Banica had the biggest loss in yield in stress condition (17%, 15.9%). For this reason Karla, that is high yielding genotype, with high RWC, and high Chl, could be recommended for planting in regions with Mediterranean type of drought.

Keywords: Wheat (*T. aestivum* L.**),** yield, water deficit, chlorophyll content, relative water content

Introduction

Approximately 32% of the wheat-growing regions experience some type of drought stress during the growing season (Morris et al., 1991). Croatia is a part of Mediterranean Drought Group which experience late season drought stress during grain filling of wheat. Drought had a negative effect on physiological processes and within on the agronomic traits of wheat (Balla et al., 2008). Plant physiologists found that chlorophyll content could be a valuable tool to monitor plant stress response. Fotovat et al. (2007) found that chlorophyll content of wheat leaf significantly decreased in presence of drought stress. Relative water content (RWC) is also very responsive to drought stress and has been shown to correlate well with drought tolerance (Schonfeld et al., 1988).
The objective of this study was (1) to investigate effects of water deficit on physiological traits and their influence to yield under water deficit and (2) to find out which of the six investigated genotypes could be recommended for planting in regions with water deficit conditions during grain filling.

Materials and methods

In order to evaluate water deficit on chlorophyll content (Chl), relative water content (RWC), grain yield and yield components (yield/spike and 1000 grain weight) of six winter wheat genotypes, a factorial experiment was conducted during the growing season of 2009-2010. Genotypes were grown in the experimental field (Zagreb, Croatia)

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under two treatments: (1) near optimum-field conditions (control) and (2) water deficit (stress) from the beginning of anthesis to maturity. Water deficit was induced by installing mobile plastic roof above the crops. Chl and RWC were measured first time in late milk maturity (LMM, 26 to 35 days after anthesis according to genotypes) and second time in early wax maturity (EWM, 40 to 49 days after anthesis according to genotypes). Chl of flag leaf was measured with the CCM - 200 (ADC, Bio Scientific Ltd. UK). For the measurement of leaf relative water content samples were collected from control and stressed plants between 9.30 am to 10.30 am. Experiment was conducted as described by Tas (2007). RWC were calculated according to Beadle et al. (1993) using the equation:

RWC= ((fresh weight - dry weight)/(turgid weight - dry weight)) x 100.

At maturity, plants were harvested and their yield and yield components were determined for each treatment separately. Statistical analysis was done using SAS 9.01.

Results and discussion

Chlorophyll content

The mean Chl at LMM in flag leaves for all genotypes in stress environment did not differ significantly ($p<0.05$) from mean Chl in control environment.

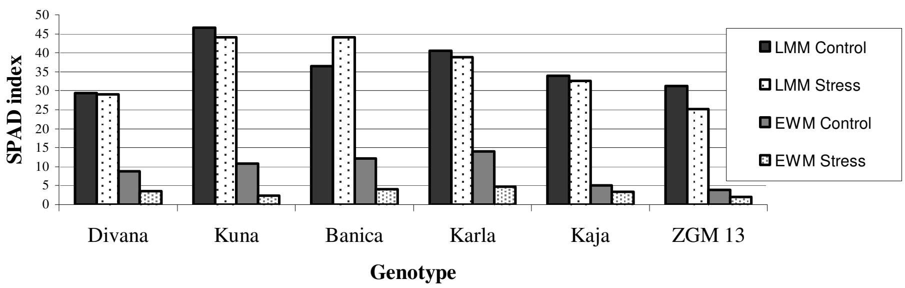

Figure 1. Effect of water stress on chlorophyll content (SPAD index)

Genotype Banica slightly increased Chl in flag leaves in stressed plants at LMM, but after longer period of drought, it decreased (*Figure 1.*) that is in agreement with findings of Nikolaeva et al. (2010). Considerable difference between control and stressed plants at LMM had genotype ZGM 13 which belongs in early maturing group of genotypes. Genotype Karla exhibited the highest Chl both under control and stress conditions at EWM.

Relative water content

When exposed to drought decline in RWC was recorded in all genotypes (*Figure 2.*). Our results are in agreement with the finding of Liu et al. (2002) who observed decrease in RWC in many different plant species under drought stress. The highest RWC at LMM in control and stress conditions was found for genotype Karla (60.11%, 53.8%). Other genotypes showed lower RWC in control and stress conditions and mutually did not differ significantly. At EWM genotype Kuna had the highest RWC in both environments (47.92%, 46.36%). Genotype ZGM 13 in stress conditions at EWM had RWC of only 11.57%. According to Rampino et al. (2006) genotypes exhibiting RWC below 25% in stress condition are dehydration-sensitive; therefore genotype ZGM 13 belongs to dehydration-sensitive genotypes.

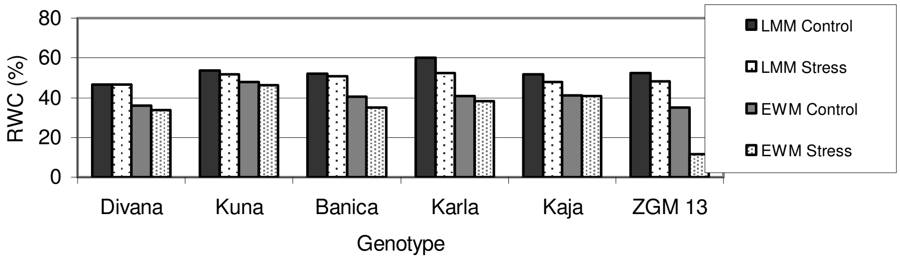

Figure 2. Effect of water stress on relative water content (RWC)

Yield and yield components

The highest grain yield in control and stress condition was determined for genotype Kaja, but it had also the biggest loss of yield (16.5%) together with genotype Kuna (17%) (*Table 1.*).

Table 1. Yield and yields components in control (C) and stress (S) environment

genotype	yield (t ha^{-1})			1000 grain weight (g)			yield per spike (g)		
	C	S	C-S (%)	C	S	C-S (%)	C	S	C-S (%)
Divana	5.7	5.5	3.5	45.7	45.7	0.0	0.88	0.85	3.41
Kuna	9.25	7.68	17	52.7	48.0	8.9	1.52	1.26	17.11
Banica	9.79	8.23	15.9	45.7	40.7	10.9	1.99	1.61	19.10
Karla	9.06	7.86	13.2	48.3	43.7	9.5	1.6	1.49	6.88
Kaja	11.19	9.34	16.5	49.7	45.0	9.4	1.48	1.24	16.22
ZGM 13	10.31	8.95	13.2	53.3	39.7	25.5	1.35	1.15	14.81

The genotype Divana was genotype with the lowest yield production that also had the lowest yield reduction in stress environment (3.5%). That is consistent with the results of Barić et al. (2008) who found that high yielding genotypes have higher losses in stress conditions, while low yielding cultivars have more stable yield under drought stress condition. Results showed that the genotypes with the lowest differences between Chl measured in LMM and EWM had the lowest reduction in yield in stress condition and vice versa. This is in agreement with Hassanzadeh et al. (2009).

Genotype with the highest 1000 grain weight in control was ZGM 13 (53.3 g), but it also had the biggest loss of this yield component in stress conditions (25.5%). Our results indicate that bigger reduction of RWC between control and stress at LMM and EWM caused the bigger reduction in 1000 grain weight (*Figure 1.* and *Table 1.*).

Genotype Banica had the highest kernel weight per spike in both conditions (1.99 g, 1.61 g) and again the biggest losses in kernel weight per spike in stress condition (19.1 %) that is consistent with the previously showed results (Barić et al., 2008).

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Conclusions

Chl and RWC decreased in all genotypes after a longer drought period. High yielding genotype Karla that had low difference between Chl measured in LMM and EWM and the highest RWC in flag leaf at LMM had the lowest reduction in yield and yield components in water deficit condition (along with low yielding genotype Divana). Genotype ZGM 13 which had the biggest loss in Chl in LMM and the highest loss of RWC in EWM, both in drought environment had also the highest loss in 1000 grain weight in stress condition. We can conclude that Chl and RWC could be valuable, but not the only indicators of the genotype tolerance to water deficit. High yielding genotype Karla that showed good performance also under water deficit condition could be recommended for planting in regions where the water availability is low in the grain filling period.

Acknowledgements

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IMPROVEMENT OF WATER REGIME OF SOIL AGROECOSYSTEM OF A LANDSCAPE UNDER CONDITION OF DROUGHT

Stefan REHAK [1] – Peter STRADIOT [2]

[1] Department of Soil Hydrology and Landscape Interaction, Water Research Institute, Nábr. arm. gen. L. Svobodu 5, 812 49 Bratislava, e-mail: rehak@vuvh.sk
[2] Department of Soil Hydrology and Landscape Interaction, Water Research Institute, Nábr. arm. gen. L. Svobodu 5, 812 49 Bratislava, e-mail: stradiot@vuvh.sk

Abstract: In order to keep the biodiversity of the agro-ecosystem in a landscape it is necessary to have optimal volume of water in the aeration zone. The drought is spread in the hydro-ecological cycle of a landscape and its display is climatic, hydrological, hydrogeological and soil. Besides that it affects following damages according to its intensity and duration. In order to decrease drought impact in agricultural landscape it is necessary to adopt a combinatory approach based on identification of drought, evaluation of its spatial occurrence, intensity and duration, an d thus landscape structure optimisation with help of use proper biological and water management processes.

Keywords: agroecosystem, biodiversity, drought adaptation measures

Introduction

The biodiversity in natural ecosystems and agroecosystems of the region of Záhorská Lowland consisting mainly of sandy, loam-sandy and sandy-loam soils is significantly affected by microrelief where its spatial-differentiation function is expressed through the content of water in soil (Project JICA, 2002). Depending on the types of geo-ecological factors, the communities of xerophilous, mesophilous and psammophilous vegetation represented by pine forests are present in the natural ecosystems of this region. Grain crops (winter wheat, spring barley and corn) are grown on agricultural soils and various kinds of vegetable and potatoes are grown on extremely light soils (sandy soils). In these agroecosystems managed by human activities, the water content in the zone of soil aeration has a significant effect. The content of water in soil has a significant effect on the stability of agroecosystem and agrobiodiversity. This stability is disrupted during drought periods. Adaptation measures against droughts shall be implemented comprehensively.

Materials and methods

Agricultural land is a spatial and an organized system S_{PH} that is expressed according to the theory of systems as a system in formalised form of ordered pair $S_{PH} = \{G_{PH}, R_{PH}\}$. This pair represents the system, in which G_{PH} is a set of elements representing individual components of agricultural land where Ga_1 is the atmosphere and its circulation system, Ga_2 is the hydrosphere and its hydrological cycle, Ga_3 represents upper layers of lithosphere and their structure with quaternary unit as a soil-forming substrate, Ga_4 is the pedosphere including the spectrum of its soils and soil regimes and Ga_5 is the biosphere as a whole together with phytosphere and zoosphere. R_{PH} is a set of relationships and links among the G_{PH} elements that form the structure of the S_{PH} system. Vertical and horizontal relationships are two basic components of the substance and energy cycle in a landscape (Krcho and Rehák, 1999). Ecosystems are formed by organisms which are in interactions with other organisms and with physical

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environment: recognized as physical and biological components and resulting interactions (Cox and Wood, 1999). Agrobiodiversity is significantly affected by human activity. Differentiation of crops in agroecosystems is crucial regarding the existence of biodiversity. Agroecosystems, similarly to other types of ecosystems, differ from each other by their biodiversity and the organization of this biodiversity among species, types or cultivars (Cox and Wood, 1999). Agrobiodiversity has real or potential impact on agricultural production (Wood and Lenné, 1999). Agroecosystems can be described as the systems with hierarchical structure (Edwards et al., 1999). Hierarchical level of agrobiodiversity can be determined with respect to spatial level as regional, choric (local) and topical (point). Fundamental interactions in the landscape agroecosystem exist among soil, hydrosphere, atmosphere and biosphere. Basic feature of water regime in soil is its moisture $\theta = \theta\ (x,y,z,t)$ – soil moisture potential $h_w = h_w\ [\theta\ (x,y,z,t)]$. Moisture is characterized by the volume of water in a soil, i.e. it describes water retention in soil in time and space. For the assessment of available water resources in soil for vegetation, the following specific points of the moisture retention curve (characteristic conditions of retention – water content in soil) are selected based on the convention.

a) wilting point (BV) corresponding with the value pF = 4.18 (soil moisture – vegetation is permanently without sufficient water supplies from soil and plants wilt),
b) Point of decreased availability point (BZD) corresponding with the value pF = 3.3 (soil moisture, where physiological processes of vegetation are limited by water shortage),
c) Field water capacity (PVK) corresponding with the value pF = 2.0 to 2.7 (soil moisture retained in a soil profile for relatively longer time and the soil aeration is sufficient for development of vegetation.

Water content in unsaturated zone of soil between the points PVK and BV (PVK - BV) is an interval of water content that is vital for vegetation cover (Šútor and Rehák, 1999).

Results and discussion

Identification of water supply in soil in time and spatial occurrence is a basic assumption for proposal of drought adaptation measures. Hydrophysical characters of agricultural land in Zahorska Lowland are processed in the form of representative values for particular soil types on a regional level (Šútor et al., 2008). Moisture retention curves are characteristic for particular soil types. There were formed groups of soils from moisture retention curves allotted them there were derived corresponding hydrolimits, i.e. Field Water Capacity (PVK), Point of Decreased Water Availability for crops (BZD) and Wilting Point (BV) (*Table 1.*).

Table 1. Characteristic points of moisture retention curves of the agroecosystem of the Zahorska Lowland

Soil type	Hydrolimit – soil moisture in % vol.		
	BV	BZD	PVK
Light soils	8,90	14,87	27,30
Medium heavy soils	14,77	21,21	32,03
Heavy soils	18,24	25,24	34,74
Very heavy soils	24,41	34,02	42,77

Calculation of the water content in the soil aeration zone for particular area and soil type is in the *Table 2.*

Table 2. Water supply in the soil aeration zone in the Zahorska Lowland for the soil horizon 100 cm

River basin	Soil type	Area of agricultural land [ha]	Water supply [m^3]		
			PVK	BZD	BV
Dolná Morava	Light soils	33907	92 600 017	50 419 709	30 177 230
	Medium soils	70912	227 131 136	150 404 352	104 737 024
	Heavy soils	13603	47 256 822	34 333 972	24 811 872
	Very heavy soils	1220	5 217 940	41 504 440	2 978 020
Total		119642	372 205 915	276 662 473	162 704 146

According to hydrological balances in the river basin Morava it is not possible to secure required water amount for agroecosystems by irrigation systems due to lack of irrigation water resources. In evaluation of drought impact on a choric level, we calculated index of expected yield of winter wheat (dominant crop in the area) for 5 year period (1997 – 2001). We used climatic and hydropedological data from the Final Report – Case Study JICA and from experimental station Malacky.

(1 – Ya/Ym) = Ky (1 – Etcadj/ETc), where

Ya/Ym: index of expected yield,
Ya: expected yield under condition of water deficit,
Ym: maximal expected yield taken from actual average maximal yields,
Ky: Yield response factor,
ETcadj: actual evapotranspiration during growing period
ETc: reference evapotranspiration of crop for common conditions during growing period.

Calculation of reference evapotranspiration to actual evapotranspiration of given vegetation cover is described in the FAO paper (Allen et. al., 1998) on the level of seasonal courses through crop coefficients.

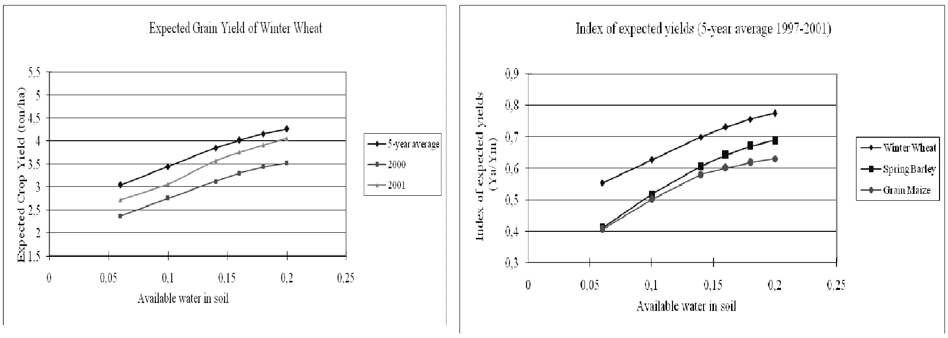

Figure 2. Expected yield of winter wheat and index of expected yields

It was proved, that in case of 15% of available water capacity in soil the yield of winter wheat significantly decreases. Drought impact is supported also by other factors, which

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is proved by different influences in evaluated periods – 5 year average, year 2000, year 2001 (drying winds, soil tillage system, crop growing systems, protection against pests and diseases).

Conclusions

Drought impacts in agroecosystems show themselves on production and economic level. We evaluated drought impacts on the choric (local) spatial level (parcel, plot) as relatively homogenous spatial unit with the help to production index on winter wheat. In case of 15-% decrease of available water capacity yields go went down which indicates the drought start. In evaluation of drought impacts on winter wheat, spring barley and maize there was shown different drought impact on particular crops (winter wheat exploits accumulated winter precipitations). It is necessary to implement adaptation measures on drought in a wide complex and systematically on regional level (e.g. Zahorska Lowland), taking into account structural relations in a landscape and interactions among agroecosystems and natural ecosystems. Since the drought is spread in a hydrological cycle, flows in streams and ground water tables tend to decrease. This limits irrigation water resources significantly. It is necessary to prefer low-energy and water saving irrigation systems (drip irrigation, micro irrigation) and use existing canal network for ground water table control. Since each crop responds to drought differently it is necessary to take into account hydrophysical soil properties in crop growing systems and to place crops on relatively homogenous units – choric level (parcel, plot). It is necessary to build wind breakers protecting soil against drying by wind.

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DIFFERENCES IN EVAPOTRANSPIRATION CHARACTERISTICS IN COMMON WEED SPECIES

Zoltán NÉMETH [1] – Krisztina PAP [3] – Orsolya SZIRMAI [2] – Szilárd CZÓBEL [1]

[1] Department of Nature Conservation and Landscape Ecology, Institute of Environmental and Landscape Management, Faculty of Agricultural and Environmental Sciences, Szent István University, Hungary Gödöllő, Páter Károly str. 1., e-mail: nemeth.zoltan@mkk.szie.hu
[2] Botanical Garden, Szent István University
[3] Szent István University, Faculty of Agriculture and Environmental Sciences

Abstract: The main goal of the research was to measure the evapotranspiration characteristics and potential of different weed species, namely *Ambrosia artemisiifolia, Artemisia vulgaris, Chenopodium album, Amaranthus retroflexus, Sorghum halepense*, which are common in the Carpathian Basin. It is allowing us to estimate the soil water loss on untreated stubble-fields, covered with plant biomass compared with bare soil surface. The investigation was carried out in monodominant plots (1m x 1m, in 3 repetitions) of the Botanical Garden of Szent István University, using a portable infrared gas-analyzer. The sampling frequency was weekly or fortnightly. All investigated plots had a remarkable evapotranspiration level, and interspecific differences were also found. The water loss was always remarkable higher in the uncovered plots, than plant covered ones.

Keywords: evapotranspiration, biomass

Introduction

As a result of global climate change, the condition, moisture content and moisture cycle of soils calls for a higher level and more detailed attention (Birkás, 2009). Evapotranspiration is higher at warmer air temperature (Tasi et al., 2009), thus it is getting more important by the global warming. The main goal of the research was to measure the evapotranspiration (ET) characteristics and potential of different weed species (*Ambrosia artemisiifolia, Artemisia vulgaris, Chenopodium album, Amaranthus retroflexus, Sorghum halepense*) which are common in the Carpathian Basin, in order to provide details about the potential water loss on untreated stubble-fields.

ET is the sum of evaporation from soil and transpiration of plants (Lawrence et al., 2007). Both factors can be influenced by treatment in order to reduce the soil water content loss. Manipulative experiments (cutting the above ground biomass after reaching the maximum development) were also carried out to reduce the transpiration element of ET. It made us possible to estimate the potential water loss caused by growing weeds on stubble-fields.

Soil water loss due to evapotranspiration was traditionally measured with lysimeters (Trambouze et al., 1998). It is capable for indirect measurements, by weighting the sample area. The evapotranspiration can be measured directly with infrared gas analyzators both with eddy covariance (Schwärzer et al., 2009) and chamber technique (Pickering et al., 1993). We have used an open chamber method in order to detect the differences between the investigated taxa. The chosen weed taxa were representing different functional groups and photosynthesis types (C_3, C_4).

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Materials and methods

Study site:
The experiment was carried out in the Botanical Garden of Szent István University, Gödöllő, Hungary, Central Europe (19°14'E, 47°25'N, 250m altitude). Mean annual rainfall is 500. Mean temperature is 10,5°C.

Evapotranspiration measurements at stand level:
The aggregated evaporation and transpiration values were measured by a portable infrared gas analyzer (CIRAS-2, PP Systems, Hitchin, UK). The measurements were performed at weekly resolution. Different sized (60 up to 200cm high, diameter was constantly 60cm) water clean plexi chambers were used in accordance with the actual shoot height of the investigated stands (Czóbel et al., 2005).
Data were collected at least for 35 minutes in each species and manipulation type. The sampling sequence was 10 records per minute constantly.

Biomass measurements:
The samples were taken from plants outside the examined plots and the individual plants were consistent with the development status (phenological phase) of the environment. During sampling we ensured to collect the full underground biomass (plants, storing and propagating structures) and to remove all possible soil dirts. From the above ground biomass (including shoot and reproductive structures) of the studied species 3 samples were taken for each species and treatment collecting the entire plants. The collected samples were immediately separated to above and below ground biomass and packed to paper bags, then the samples were oven-dried at 80°C for at least 48 hours until constant weight. For calculation of above (AGB) and below ground biomass (BGB) the actual shoot numbers and plot size were considered, in order to upscale the results to a square meter.

Meteorological measurements:
Meteorological measurements can be divided into continuous and periodic measurements. The continuous measurements were performed by the sensors and automated data logger of a HOBO micrometeorological station (MicroStation, Onset, Massachusetts, USA). The instrument was installed next to the investigated plots and collected data continuously (sampling frequency was 5 minutes) thus providing a complete meteorological data set for the entire vegetation period of the weed species. The HOBO micromet station collected the following parameters: actual photosynthetically active radiation (at 40 cm height), soil temperature and soil moisture (at 5 cm soil depth) both in the control and manipulated plots.

Statistics:
The Kolmogorov-Smirnov test was performed to test for normal distribution of the data. For normally distributed data the t-test was applied to identify significant differences between datasets, for non-normally distributed data the nonparametric Mann-Whitney test was performed instead. Statistical analyses were calculated using SigmaPlot2000

(SPSS Inc., Chicago, USA). Regressions and correlations were fitted and computed using SigmaPlot2000. Data were evaluated by two-way ANOVA**.** Error bars represent the standard errors of seasonal mean values.

Results and discussion

The correlation neither between evapotranspiration intensity and photosynthesis type nor with the biomass was significant. Although *Chenopodium album* had the highest biomass (*Figure 1.*), it was characterized by the lowest mean ET level (*Table 1.*), despite the fact that this taxa is known as a C_3 plant. Surprisingly the highest evapotranspiration level was measured in *Amaranthus retroflexus* dominated plots. After cutting all stands, the formerly pigweed dominated plots were still characterized by the highest evaporation level. However, the transpiration intensity was the lowest at this species. *Amaranthus retroflexus* has a C_4 photosynthesis pathway, which allows higher water use efficiency (Ghannoum, 2009). *Sorghum halepense* (C_4 photosynthesis type) had also remarkable ET level, although it is featured the lowest biomass production. In contrast to pigweed, the transpiration level was noticable high at this species.
The cutting was the most effective at *Ambrosia artemisiifolia* dominated plots, because this species displayed the biggest relative proportion of transpiration (59,7%) in the ET. After cutting the common ragweed plots had the lowest ET level (*Table 1.*).

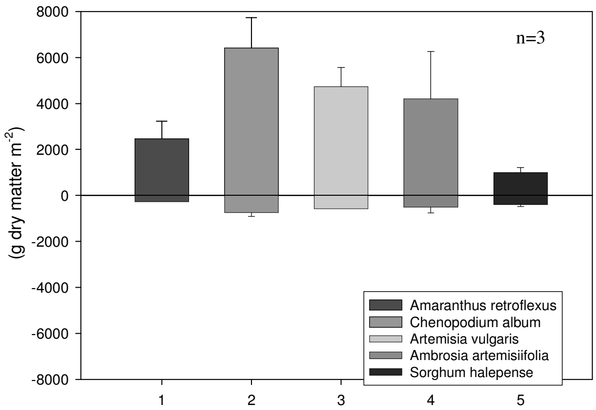

Figure 1. Above and below ground biomass values of the examined weed taxa

Above ground biomass cutting significantly (P<0,001) reduced the evapotranspiration rate in most weed stands, except *Amaranthus retroflexus*. The standard deviance (SD) values of ET were relatively high in all investigated plots. SD values were noticeable higher after removing the plant cover. In accordance with other studies (e.g. Young et al., 2009) vegetation can regulate the evapotranspiration if the surface has enough plant cover. Vegetation cover of the investigated weed taxa correlated stronger, but not significant with ET, than the between ET and above ground biomass.

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Table 1. Evapotranspiration values of the studied species before and after cutting

Chen. alb.		Ama. ret.		Art. vulg.		Amb. art.		Sor. hal.		
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
3,622	2,010	4,522	1,811	3,719	3,794	4,484	2,458	4,296	2,822	before cutting
2,602	2,557	4,387	4,274	2,808	3,705	2,229	1,824	2,563	2,057	after cutting

Conclusions

Each taxa had remarkable transpiration potential, and in all investigated plots significant evapotranspiration level were measured. The results of this study show, that simple cutting the weeds on stubble-fields (without any soil treatment) can reduce the loss of soil water content at reasonable level, but the efficiency of this treatment is strongly depending on the weed species. The results emphasize the importance of the adequate treatment of agricultural fields after harvesting the cultivated plants, to avoid unnecessary water loss, and to store as much water as possible for the next vegetation period.

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YIELD AND YIELD PARAMETERS OF MAIZE (*ZEA MAYS L.*) GENOTYPES IN IRRIGATED AND N FERTILIZED CONDITIONS

Monika MARKOVIĆ [1] *– Marko JOSIPOVIĆ* [2] *– Hrvoje PLAVŠIĆ* [2] *– Ivan BRKIĆ* [2] *– Jasna ŠOŠTARIĆ* [1]

[1] Department of Crop Production, Faculty of Agriculture, University J.J. Strossmayer, Trg Sv. Trojstva 3, 31 00 Osijek, Croatia, Monika.Markovic@pfos.hr

[2] Department of Agricultural Technics and Melioration, Agricultural Institute Osijek, J. predgrađe 17, 31 000 Osijek, Croatia

Abstract: Field experiments were set up at Agricultural Institute Osijek (Croatia) as split split-plot method with three replications thru two growing seasons (2008-2009). Soil type at trial field is classified as eutric cambisol, non calcareous. Soil retention water capacity was close to the value of field water capacity (FWC, 36.6% volume). Aim of this research was to determine the influence of irrigation, nitrogen rate, and maize genotype on yield and yield parameters of maize (cob length, cob weight, grain number per cob, grain weight per cob, and number of rows per cob). Irrigation (A) as main factor had treatments as follows: A1-control treatment, A2-soil water content was controled from 60% to 100% FWC, A3-80% to 100% FWC. Nitrogen fertilization was sub factor (B1-control treatment, B2-100 kg N ha^{-1}, B3-200 kg N ha^{-1}) while the sub sub-factor (C) was maize genotype (hybrids FAO group 500 and 600). Irrigation treatment resulted in statistically significant increase of grain yield from 8 159 kg ha^{-1} (A1) to 9 097 kg ha^{-1} (A3) in 2008 and from 9 788 kg ha^{-1} (A1) to 10 315 kg ha^{-1} (A3) in 2009. N fertilizers have significantly increased yield from 7 689 kg ha^{-1} (B1) to 9 336 kg ha^{-1} (B3) in 2008 and from 9 318 kg ha^{-1} (B1) to 11 119 kg ha^{-1} (B3) in 2009. Grain yield significantly varied thru tested genotypes from 8 336 kg ha^{-1} (C3) to 9 137 kg ha^{-1} (C4) and from 9 831 kg ha^{-1} (C1) to 10 704 kg ha^{-1} (C3) in 2008 and 2009, respectively. Treatments resulted in significant differences in yield parameters.

Keywords: irrigation, N fertilization, maize hybrids, yield, yield parameters

Introduction

Maize (*Zea mays L.*) is the most important cereal on arable lands in Croatia. According to central bureau of statistics (2010) harvested area of maize was 314 062 ha with average yield of 8 t ha^{-1} in 2008, while one year later (2009) the harvested area was reduced by 5.77% (296 910 ha) with lower yield by 8.1% (7.4 t ha^{-1}). Available amount of water and nitrogen (N) fertilizer are two main factors which have direct influence on maize yield (Mosera, 2006; Fülöp and Péter, 2007; Betrán et al., 2003). Pandey et al. (2000) reported that water stress reduced kernel number, kernel weight, and yield as well. According to Eck (1986) water deficit during the vegetative growth reduced kernel numbers but had small effect on kernel growth. The potential yield of maize is determined by kernel weight. Number of kernels per cob is closely associated with yield of maize and yield component that varies markedly with stress (Oktem et al., 2008). The aim of this study was to evaluate the effects of irrigation rate, rate of nitrogen fertilizer and tested genotype on maize yield parameters - cob weight (CW), row numbers (RN), kernel number (KN) and kernel weight (KW), while maize yield was presented by Josipović et al. (2010).

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Materials and methods

Two experiments were carried out during two vegetation (2008-2009) seasons at the trial fields of Agricultural Institute in Osijek. Four maize hybrids have been tested in order to determine the influence of irrigation management, N fertilizer rate and genotype on maize yield and yield parameters. The split-split plot design with three replications was used in both vegetation season, where irrigation treatments (A1 was control variant, A2 - 60%-100% field water capacity [FWC] and A3 - 80%-100% FWC) were in the main plots. Sub plot contained nitrogen fertilizer treatments (B1 - control, B2 - 100 kg N ha^{-1}, and B3 - 200 kg N ha^{-1}), and the genotype (C1 = OSSK 596; C2 = OSSK 617; C3 = OSSK 602; C4 = OSSK 552) was inclided in the sub-sub plots. Soil type is Eutric cambisol (Soil Survey Division Staff, 1993) with silt clay loam texture, shallow gley, pH in KCl from 6.5 to 6.9, P_2O_5 content is from 22.6 to 26.4 mg $100g^{-1}$ of soil, K_2O content is from 30.4 to 36.5 mg $100g^{-1}$ of soil. Planned crop density was 58309 plants ha^{-1}. Soil water content has been measured every second day with Watermark (US company) device. Maize crops were irrigated with sprinkler linear move system. Three rates of the nitrogen fertilizer were used. Two-thirds of nitrogen were added in autumn and before sowing (urea: 46% N) and the rest (one-third) by two top-dressings at early growth stages (calcium ammonium nitrate: 27% N). Four different genotypes with similar vegetation group (end of FAO 500 and beginning of FAO 600) were tested. At the harvest time, ten average cobs were taken from each plot in order to determine yield parameters. For the analysis of the weather conditions, dates from Osijek Weather Bureau have been used (2010). Analysis of variance, an ANOVA was carried out with the General Linear Model (GLM) Statistical Software Package (SAS, 2003) procedure. As it can be seen in *Table 1.* weather conditions were quite different during two vegetation seasons (2008-2009) with unfavourable conditions for maize production. In both years of research mean air temperatures were above 30-year mean, while year 2009 was also characterised with amount of precipitation (230.8 mm) below the long-term average (368.3 mm).

Table 1. Mean air temperatures (°C) and amount of precipitation (mm) for Osijek region in vegetation season 2008-2009, and 30-year averages (1961-1990)

	Mean air temperatures (°C)			Amount of precipitation (mm)		
Month	2008	2009	61-90	2008	2009	61-90
April	12.6	14.6	11.3	51.6	15.7	54.1
May	19.3	19.0	16.5	114.5	45.5	58.9
June	22.0	19.7	19.4	88.9	73.9	83.5
July	22.8	23.6	21.1	70.1	31.0	66.6
August	23.1	23.5	20.3	27.8	61.9	59.6
September	15.9	19.6	16.6	85.4	2.8	51.8
Mean/∑	19.3	20.0	17.5	437.3	230.8	368.3

Results and discussion

The average value for yield and yield parameters: cob weight (CW), kernel number (KN), kernel row (KR), kernel weight (KW) for vegetation seasons 2008-2009 are presented in *Table 2*. In both tested vegetation season irrigation treatment resulted in yield increasing as follows: in year 2008 yield was higher by 8.3% at A2 variant of irrigation compare to the control, and by 10.3% higher at A3 variant, while by 5.2% higher at A2, and 5.1% at A3 compare to the control in year 2009.

Table 2. Influence of irrigation water regime, N fertilizer rate and genotype on yield (Y) and yield parameters of maize (2008-2009) cob weight (CW), row number (RN), kernel number (KN), kernel weight (KW)

Year	2008	2009	2008	2009	2008	2009	2008	2009
	A1 - control		A2-60%-100% FWC		A3- 80%-100% FWC		Mean	
Y	8159	9788	8897	10320	9097	10315	8717	10141
CW	278	265	296	262	300	267	291	265
RN	15	15	16	15	16	15	15.6	15
KN	696	649	721	653	716	648	711	650
KW	234	229	251	225	254	230	246	228
Influence of N fertilization								
	B1 - control		B2 - 100 kg N a^{-1}		B3- 200 kg N ha^{-1}		Mean	
Y	7689	9318	9127	10927	9336	11119	8717	10455
CW	270	248	298	273	304	273	291	265
RN	16	15	15	15	15	15	15	15
KN	711	641	701	650	720	659	711	650
KW	229	213	253	235	258	236	247	228

Influence of genotype										
	C1 OSSK596		C2 OSSK617		C3 OSSK602		C4 OSSK552		Mean	
Y	8630	9831	8767	10629	8336	10704	9137	10410	8718	10394
CW	276	275	308	257	304	270	276	255	291	264
RN	15	14	16	14	16	15	16	15	16	15
KN	713	673	721	621	709	638	701	667	711	650
KW	236	239	260	221	254	230	236	223	247	228

LSD values 2008															
	CW			RN			KN			KW			Y		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
5	5.5	15	14	0.2	0.5	0.5	18	25	38	6	14	12	173	441	342
1	7.2	20	18	0.3	0.7	0.7	24	33	51	8	18	16	228	581	462
LSD values 2009															
5	14	12	14	0.3	0.3	0.4	22	25	30	14	11	12	230	258	311
1	18	16	19	0.4	0.4	0.5	29	33	41	18	15	16	303	339	420

Y=yield; KW=kernel weight; CW=cob weight; RN= row number; KN= kernel number; A=irrigation; B=N fertilization; C=genotype; 5=LSD 0.05; 1=LSD=0.01

The result is comparable to many authors who also reported yield increasing under the irrigation treatment (Yang et al., 1993; Khan et al., 2001; Josipović et al., 2010; Dagdelen et al., 2008; Pandey et al., 2000). Amount of applied water resulted with slightly increasing ($p<0.01$; $p<0.05$) of CW (A1= 278; A3=300) and KW (A1=234; A3=254) in year 2008, although in year 2009 irrigation treatment was not significant, which can be explained thru different distribution of precipitation during the two tested vegetation seasons (Table 1). Result is comparable to previous researches of many authors (Oktem et al., 2008; Dagdelen et al., 2008) who reported that water deficit reduced kernel numbers, that kernel number per cob is moisture dependent, and that the kernel number per cob is primary effect of water deficit to maize grain yield. Nitrogen fertilizer (B) increased Y (B1=7689; B3=9336 in 2008 and B1=9318; B3=11119 in 2009), KW (B1=229; KW=258 in 2008 and B1= 213; B3=236 in 2009) and CW (B1=270; B3=304 in 2008 and B1= 248; B3=273 in 2009) in both tested vegetation

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seasons ($p<0.01$; $p<0.05$). Namakka et al. (2008) in his results reported significant increase of CW under N fertilizer treatment. Siam et al. (2000), Yang et al. (1993) also reported that increasing N fertilizer doses leads to increasing CW and KW as well. Genotype (C) showed very significant (<0.01) and significant (<0.05) impact on all tested features in year 2009, although it was not significant in case of RN and KN in year 2008. The highest Y was measured at C4 = 9 137 in year 2008 and C3 = 10 704 in year 2009. The highest CW was measured at C2 = 308 in year 2008 and C1 = 275 in year 2009. The highest KN was measured at C1 = 239 in year 2009. The highest KW was measured at C2 = 260 in year 2008 and C1 = 239 in year 2009.

Conclusions

As result of 2-years experiment it can be concluded that maize yield and yield parameters where significantly affected by water stress. The highest yield, kernel weight and cob weight where obtained by applying the highest amount of irrigation water (80% - 100% FWC) and nitrogen fertilizer (200 kg N ha^{-1}), while kernel number mostly depended on genotype. Since grain yield was primarily associated with kernel number and secoundarily with kernel weight, selection for those yield parameters can be used to create genotype resistant to drought but with high yield potential as well.

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UTILISATION OF EXCESS WATER HAZARDED AREAS IN BÉKÉS COUNTY OF HUNGARY

Csaba BOZÁN [1] *– János KÖRÖSPARTI* [1] *– László PÁSZTOR* [2] *– Imre PÁLFAI* [3]

[1] Research Institute for Fisheries, Aquaculture and Irrigation, P.O.B. 47, H-5541 Szarvas, HU, e-mail: bozancs@haki.hu
[2] Research Institute for Soil Science and Agricultural Chemistry of the HAS, P.O.B. 35, 1525 Budapest, HU
[3] Directorate for Environmental Protection and Water Management of Lower Tisza District, P.O.B. 390, 6724 Szeged, HU

Abstract: According to the global and local climate change the frequency of excess water inundations related to land use risk may be higher in the near future. The investigated area was Békés County which is highly hazarded by excess water inundations. In this study the alternative utilisation of excess water hazarded areas was examined. First step to create an excess water hazard map which is suitable to classify the hazarded areas (not, moderately, meanly, highly and extremely hazarded). Next step is to determine those utilisations (forestation, pasture, wetland, field specific agricultural production etc.) which can suitable for unfavourable water management conditions. The highest land use risk values were found on those areas which used for extensive agricultural production. Accordingly there is a need for an adequate field specified agricultural production which can take into consideration the actual risk of excess water inundation. The results assisted and enabled the land use planning of the inundated and saturated areas by excess water, as well as it could be used for the calculation of different water management and land use scenarios.

Keywords: excess water hazard, land use scenarios

Introduction

The Great Hungarian Plain (43,600 km^2) is the largest lowland of Central Europe. The average annual precipitation may show extremely high territorial and temporal variability. Under such conditions a considerable part of precipitation is lost by surface runoff, downward filtration and evaporation, but in the flat-land regions the excess waters cause several damages mainly in the agricultural areas (Tamás et al., 2007; Várallyay, 2008). Damage caused by excess waters can be occurred about 1.8 million hectares, from which 60 % is located in the arable-land. According to Pálfai (2000) the area affected by inundation in every 5 years is 150,000 hectares on average. Reasonable and preventive management of agricultural areas requires satisfactory information on the spatial and temporal distribution of excess water (Bozán and Tamás, 2008). This paper is concerned with the alternative utilisation of excess water hazarded areas. For this reason there was a need for an accurate excess water hazard map which was suitable for the risk-assessment in order to allocate the potential land use practices.

Materials and methods

For the whole investigated territory (558,178 ha) of Békés County GIS based quantification and large scale mapping of excess water hazard was carried out. Limited numbers of affecting environmental factors (soil, agro-geology, relief, groundwater, land use, hydrometeorology) were considered, and information on these factors was collected and each factor was represented and typified by one parameter. Multiple regression analysis was used for the determination of Complex Excess Water Hazard Index (CEWHI) to compile the excess water hazard map. For the method of risk-assessment was based on the principle of quantifying the factors triggering and

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modifying the phenomenon of excess water in a spatial division, then are ranked according to the weighted values assigned due to their significance. The indices obtained were classifies by the method of Jenks and were ranged, according to the level of vulnerability: 1. not; 2. moderately; 3. meanly; 4. highly; 5. extremely hazarded.

Results and discussion

Effect of soil (SOIL) was modelled and spatially represented by the water management characteristics of soil (infiltration capacity, mm/h) which based on Kreybig map series (1:25,000) and 1:100,000 scale map of the hydrophysical characteristics of soils (Várallyay et al., 1980). Geology (GEOL): a complex index taking into consideration the depth and thickness of the uppermost aquitard. Relief (RELI) intensity: variation in elevation per km^2 (1:10,000 digital terrain model). Groundwater (GW) depth: the average of its ten highest values within 50 years. Land use (LU): a numeric coefficient based on CORINE Land Cover (CLC-50) database and individually attributed to its categories. Hydrometeorology (HU): humidity index (10% possibility of occurrence of root square of sum of monthly weighted precipitation and sum of monthly weighted potential evapotranspiration ratio). According to the excess water hazard modelling method the higher the values of all the above mentioned influential factors are, the more significant the role in excess water development is. The map of relative frequency of excess water events was also compiled from 1951 to 2009. Since both its spatial resolution and confidence was weaker than those of the above listed factors, generalized versions of the quantified spatial layers (as independent variables) were jointly analyzed with the relative frequency map in a grid with cell size of 1x1 km^2. Multiple regression analysis was used for the determination of the role of influential factors thus providing weights for its linear estimation by the applied factors. For the sake of standardization the values coming from the regression equation were multiplied by and added to a constant value: CEWHI = (2.533–0.257*SOIL+0.014*GEOL–0.086*LU–0.025*RELI–0.291GW)*5HI. The CEWHI values were used to compile the excess water hazard map based on a more detailed original map layers. The excess water hazard map was classified by the method of Jenks (*Figure 1.*). Different alternative utilisations of excess water hazarded areas were collected (*Table 1.*).

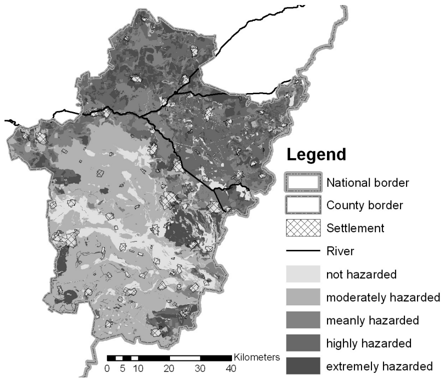

Figure 1. Excess water hazard map compiled for Békés County

Table 1. Alternative utilisation of excess water hazarded areas

Utilisation	Characteristics, requirements	Alternatives
Uncultivated land (fallow)	Neglected fallow is harmful; centre of infection: parasites, pests and weeds	Not recommended, not sustainable
Field specified agricultural production	Adaptation of early maturity groups; decreasing of plant population; increasing of amount of fertilisers and manures; considered plant protection and weed control	Corn hybrids (FAO 200-400); Silage maize (lower FAO number); Fodder-crops (millet, Hungarian grass, Sudan-grass, white mustard, green maize); Traditionally produced plants (rice, fibre hemp, sunflower, cabbage, herbs, alfalfa); Fodder sorghum (Sudan-grass, broomcorn); Protein rich fodder-crops (five-finger, hairy vetch, Hungarian vetch, white lupine, yellow lupine, white melilot, alsike clover, berseem clover, Persian clover, red clover, cat's-tail)
Forestation and grassland management	Removing of harmful shrubs (Amorpha fruticosa) from floodplains; Plantation of native species in autumn especially on the excess water hazarded areas; One of the main characteristics of grassland is the excess water toleration.	Forestation: white willow, ashen, black walnut, poplars, oak, leaved maple, limes, alders, elms, swamp cypress Planting of energy useful native trees. Grassland: meadow-foxtail, slough grass, reed canary grass, Yorkshire fog, creeping bentgrass, meadow fescue, purple moor grass, rough-stalked meadow-grass
Meadow and pasture management	The temporary excess water inundation can be useful for meadow and pasture, but the long-term inundation can not be tolerable.	Recommended seed mix: meadow fescue (25 %), narrow-leaved meadow grass (40 %), creeping bentgrass (20 %), white clover (10 %), birdsfoot trefoil (5 %).
Orchards	Native species; Bio-production	Plum, apple, walnut
Reed production	Reed production based on the water flowing; nutrient filtering function	Reed, sedge, bulrush
Rice production	High temperature and water demand; good water retention soil	Multi-functionality (rice and fish)
Medicinal herb production	It can be produced on temporarily inundated areas.	Anise, menthol mint, licorice, lovage, caraway, fennel
Water retention and storage	Application of constructed wetlands with filtrating fields (reeds, sedges, bulrushes).	Temporary water reservoir, excess water reservoir, other purposed reservoirs, fish ponds, oxbows, dead river beds
Fish ponds, multifunctional fish production	Multi-functionality; combined extensive-intensive aquaculture system; pond in pond system; native species	Multifunctional wetlands
Grazing husbandry	Direct manuring; extensive animal husbandry	Skudde sheep, mangalica pig, Hungarian grey cattle, native poultry species
Tourism and ecotourism	Development of infrastructure (parking places, restaurants, picnic areas, bird watching places, tourist paths, prospects, maps, information desks and signs, tourist guides, publicity etc.)	Oxbows, lakes, arboretums, parks, multifunctional ponds etc.
Hunting management	Supplemental feeding; artificial game protection places	Big- and small-games
Nature conservation area	Damage caused by suddenly raising water level; preventing from spreading of invasive species; buffer zones	National Parks; Protected Landscapes Areas; Nature Conservation Areas; Special Protected Area (SPA); Proposed Sites of Community Interest (pSCI)
Wetland restoration and construction	Biodiversity conversation; landscape management; good quality and quantity of water	Lakes, ponds, reservoirs, channels, dead river beds, lowland features areas, excess water hazarded areas etc.

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Conclusions

Frequent occurrence of extreme anomalies with regard to excess water hazard is a great problem for the agricultural production in Hungary. An important step towards an effective solution is the detailed and reasonably accurate mapping of the influential environmental factors of excess water inundation. According to the compiled excess water hazard map the spatial distribution of hazarded areas can be studied in details.
There is a need for rationalisation of land use management on the highly (119,635 ha; 21.5%) and extremely hazarded (78,915 ha; 14.2%) areas. In case of agricultural planning should be taken into consideration the high risk of any kind of production. For this reason it is strongly recommended to use other kind of land use activity, i.e. forestation; reed production; multifunctional fish ponds; rice production; meadow and pasture management; wetland restoration, enhancement, creation and construction. On the meanly hazarded areas (92,854 ha; 16.6%) an adequate field specific agricultural production should be adapted by considering the possibilities of agro-techniques (ameliorative deep ploughing, loosening, agricultural drainage, mole drainage etc.). These areas are used for extensive agricultural production where agricultural damages caused by excess water inundation can be significantly increased by the subsoil compaction (disk-pan, plough-pan), decreasing natural drainage condition of root zone and the neglected table drainage channels. The improvement of the efficiency of agricultural water management (vertical and horizontal drainage conditions of the soil profile, prevention of over-saturation and excess water inundation) are necessary. It is recommended protein rich fodder-crops, orchards and medicinal herb production. On the not (77,668 ha; 13.9%) and moderately (189,102 ha; 33.8%) hazarded areas can be used for conventional production.
This study has allowed drawing several conclusions and identifying limitations that would have wide applications in the use GIS methodology for decision-making process with regard to land use changing.

Acknowledgements

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ESTIMATION AND PLANAR PRESENTATION OF FORECASTED CHANGES OF SOIL WATER STORAGE CAUSED BY THE CLIMATE CHANGES

Milan GOMBOŠ [1] *– Dana PAVELKOVÁ* [2]

[1] Institute of Hydrology, Slovak Acagemy of Sciences SAV, 071 01 Michalovce, Hollého 42, gombos@uh.savba.sk
[2] Institute of Hydrology, Slovak Acagemy of Sciences SAV, 071 01 Michalovce, Hollého 42, pavelkova@uh.savba.sk

Abstract: Because of the climate changes the characteristics of hydrometeorologic factors have changed. Actual development of climate factors confirms that the potential impacts of the climate changes have become reality. Therefore, the objective of recent hydrological research has become the quantification of the expected climate change effects on hydrological cycle. From the systemic point of view, hydrological cycle is a multiple unit that consists of several interrelated entities. This system is structured as follows: atmosphere - plant cover - unsaturated zone - groundwater (saturated zone).
In the light of present research subject, the research works are based on the quantification of interaction processes between sub-systems of unsaturated zone and groundwater layer. The resultant of these processes influences the distribution of soil water storage (Nagy et al., 2007, Vilček, 2004) . Research works took place on the East-Slovakian lowland. Planar presentation of changes in soil water storage was elaborated for the part of the Medzibodrožie on the southern part of the East Slovakian lowland.
Information on the soil water storage changes during the reference years 2010, 2030 and 2075 represents the quantification of the expected climate change impacts on water storage of surface layer of Medzibodrožie area soils. On the basis of the results it is possible to quantify the rate of gradual Medzibodrožie area drying caused by climate changes.

Keywords: climatic changes, numerical simulation, soil-water storage, planar presentation

Introduction

For estimation and planar presentation of the expected changes in soil water storage was chosen a part of Medzibodrožie area. From the historical point of view Medzibodrožie area was the northern part of Ugrian Lowland (called Alföld) bounded by rivers Latorica, Bodrog and Tisa, of more than 700 km2 in extent. In the present article the term Medzibodrožie describes the south-eastern corner of East-Slovakian Lowland of 385 km2 in extent.
The investigated Medzibodrožie area is limited from the east by the state border with Ukraine, from the north by river Latorica, from the west by river Bodrog and from the south by the state border with the Republic of Hungary, which is partially formed by the river Tisa (in the length of 5.2 km) and by the river Karčava (in the length of 22 km).
From the hydrogeological point of view, Medzibodrožie is created mainly by quarternary river sediments. These sediments create homogeneous hydraulic aquifer. Hydraulic conductivity of the aquifer varies between 8.19E-05 and 2.42E-04 m.s-1.
Medzibodrožie area is covered mainly by very heavy soils, heavy soils and medium-heavy soils. Together they cover 63.5% of the area.

Materials and methods

It was necessary to create broad database for planar presentation of the changes in the soil water storage. Database included meteorological and climate characteristics,

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characteristics of the plant cover, hydrological characteristics of the area, topographical data and hydrophysical characteristics of the area of interest.

For estimation and presentation of the results it was used triangular calculation net shown at the *Figure 1*. The estimation was done in every node in the programme Visual Basic for Aplication. In every node both the depth of groundwater level under the surface and the soil type were evaluated. On the basis of the evaluation, particular analytical equations were chosen in order to estimate the soil water storage in the root zone of the soil profile into the depth of 1 m. Analytical equations express the dependency soil water storage into the depth of 1 m (Pavelková, 2010).

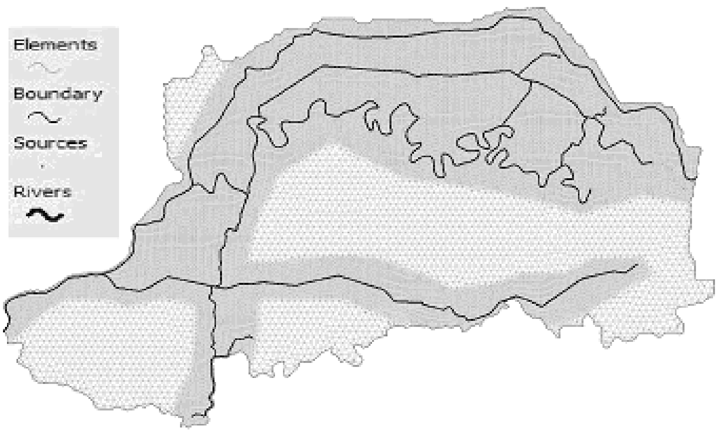

Figure 1. Presentation of the triangular net calculation nodes

Soil water storages were quantified for chosen, specific position of GWL (groundwater level) in the area of Medzibodrožie. Their spatial redistribution was displayed in the form of maps using GIS. As reference groundwater level was used long-term average groundwater level measured during years 1997-2005.

Spatial formulation of lower boundary conditions is based on the utilization of the triangular calculation net (Baroková, 2007). The net has 32 206 nodes (*Figure 1.*). Grid size is densed up to 100m next to the rivers and channels, at distant and plain areas the grid size equals 300m. Every node is clearly spatially defined by coordination „x“ and „y“ in the coordinate system S-JTSK. Every node indicates the elevation above the sea level, soil type and the average groundwater level during the period 1998-2005. GWL data in every node were gained by the calculation in numerical simulation model TRIWACO (Royal Haskoning, 2002). On the basis of this calculation, a digital elevation map and digital map of average groundwater level during the period 1997-2005, i.e. digital image of lower boundary condition of unsaturated zone of soil profile were gained. Thus it is possible to estimate soil water storage into the depth of 1m in every node and represent the results in the maps. Besides, levels estimated by scenario CCCM 2000 for reference years 2010, 2030 and 2075 were used in the calculations. Groundwater levels during the reference years were gained from the results (Tall, 2010).

Results and discussion

Digital representation of the lower (GWL) and upper (terrain) boundary condition is shown in the *Figure 2*. The representation has been elaborated using GIS method by means of the module TRIPLOT, which is a part of TRIWACO program. Water-management map was used as a basis for the digital representation elaboration.

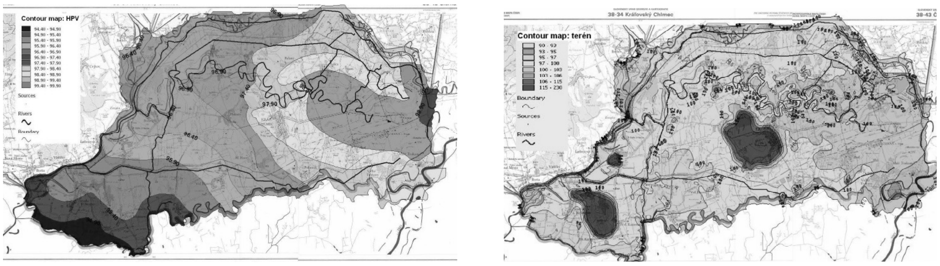

Figure 2. Digital map of upper (left) and lower (right) boundary condition

Figure 3. shows the average water storage in the surface soil layer to the depth of 1 m in Medzibodrožie area between the years 1997 – 2005 and the average water storage in the surface layer up to the depth of 1 m in Medzibodrožie area in the vegetation periods (VO) in the reference years 2010, 2030 and 2075.

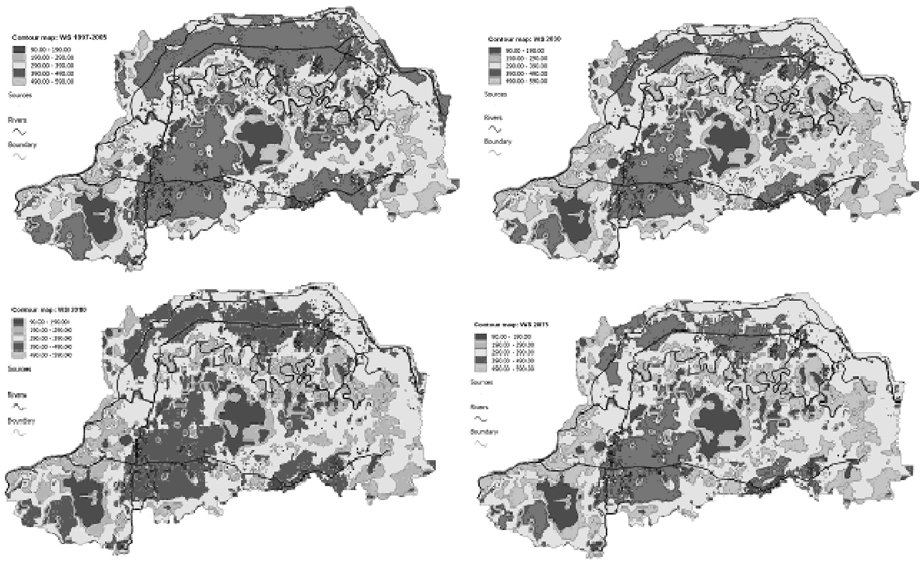

Figure 3. Average water storage in the soil surface layer to the depth of 1 m in Medzibodrožie area between 1997 – 2005 (up, on the left) and average water storage in the soil surface layer to the depth of 1 m in Medzibodrožie area in the vegetation period (VO) in the reference years 2010 (up, on the right), 2030 (down, on the left) and 2075 (down, on the right)

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The comparison between the figures, as well as the comparison of the figures with the *Figure 3*. indicates that the land is being gradually dried on account of gradual decrease in soil water storage volumes caused by climate changes.

It is particularly obvious if the data from the years 2010, 2030 and 2075 are compared with the average values from the period 1997-2005 and the differences are analysed. These figures imply the extent of soil water storage changes and their distribution. Soil water storage volumes obviously decrease in the surface layers of the soil up to 1m depth.

Conclusions

Information on the soil water storage changes during the reference years represents the quantification of the expected climate change impacts on water storage in the surface layers of Medzibodrožie area soils. On the basis of the results, it is possible to quantify the rate of gradual Medzibodrožie area drying caused by climate changes. Gained results show that climate changes, which cause groundwater level decrease, will influence mainly lowland areas where GWL is near the soil surface. In the areas of heavy soil occurence, climate changes will affect GWL as well, though the groundwater level is in deeper soil horizonts (in Medzibodrožie up to 4 metres). In the case of the light-textured soils the effects shall be more intense but they shall end after GWL decreases more than 2 m under the surface. In the areas where GWL is under the critical value the soil water changes can be induced only by rainfall and evapotranspiration variation.

Acknowledgements

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OBTAIN OF SOIL BULK DENSITY VALUES AND ITS INFLUENCE ON THE SOIL WATER RETENTION IN HURBANOVO (SOUTHERN SLOVAKIA) LOCALITY

Viliam NAGY

Institute of Hydrology, Slovak Academy of Sciences, Račianska 75, 83102 Bratislava, nagy@uh.savba.sk

Abstract: The bulk density is a physical characteristic expressing the mass of an undisturbed dry unit soil volume. It is a part of more mathematical - physical interrelationships, as e.g. used for calculations of porosity, of volumetric soil moisture, of the soil water storage, of the various substances in soils, of amount of accessible nutrients and mass amounts of various soil volumes. The bulk density, together with the granulometric soil composition, plays a dominant role in formation of the pedotransfer functions (PTF). With their help, it is possible to state the moisture retention curve, and the unsaturated hydraulic conductivity. Both these characteristics are part of the input data for mathematical models used in determination of the aeration zone soil water regime. In the this contribution, results are presented of the monitored changes in the upper surface topsoil profile, during the 2008 vegetation period on locality closely located to the Hurbanovo municipality in southwestern Slovakia.

Keywords: bulk density, monitoring of soil moisture, dynamics of soil water resource

Introduction

Soil is a rather complicated system. Therefore it is necessary to define carefully the procedure to be used for its interpretation. The basic subject in soil sciences is the soil physics, a branch of the mechanics, of the hydrodynamics, and of the hydropedology. Many physico- chemical soil properties belong and are studied by the soil physics. It refers to thermodynamics and to the colloidal acting in the soil structure. None treatment in the soil physics can be complete, if it does not refer to its conditions (soil physical) upon the vegetation growth and the soil degradation.

We concentrate here our attention to soil properties evaluation in relation to the soil hydrology, i.e. to its retention and to the soil water dynamics. In centre of attention are particular physical soil characteristics - the bulk density ρd, expressing the mass of an undisturbed unit dry soil volume. These characteristics are of a highly dynamic nature. It is expressing the instantaneous soil mass, which is changing often in relation to the soil moisture.

During the course of the year, however, ρd is changing mainly in the upper soil horizons, due to natural impacts, as the natural compacting, drying shrinking, swelling (expanding), freezing and defreezing, vegetation root systems development, and similar. Soil unsaturated zone water storage is influenced also through the water flow through its upper boundary - its surface, with or without the vegetation cover. It reacts directly upon meteorological and climatic conditions by evapotranspiration. It is the place enabling the precipitation input into the lower soil profile horizons (Stehlová and Mikulec, 2004a,b; Mikulec et al., 2003; Mikulec et al., 2001; Štekauerová and Nagy, 2001, 2002; Šútor et al., 2002a,b).

During severe drought periods, the surface soil horizons show very low water conductivity. Such soil layers are not able to transfer higher precipitation amounts into the lower layers. Even smaller precipitation amounts is percolating into the soil very slowly, it evaporates mostly. Drying of the soils is in favour of formation of the preferred percolation pathes through formation of the soil cracks (Várallyay, 1989).

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Even higher change of ρd can be noticed in case of the anthropgenic impacts, mainly by soil loosening (lightening) or compacting, by technological activities through the cultivating and harvesting machines (Birkás, 2004).

Materials and methods

In order to determine the areal and temporal variability of the bulk density ρd, there was organized on the Hurbanovo locality in 2008 a monitoring programme, in a monthly frequency, and on three observation sites. Its methodology was based on soil sampling into 100 cm^3 cylinders of the surface soil (topsoil) horizon up to the 40 cm soil depth. Samples were dried in a laboratory, and from the weight of the dry sample and from its volume, the bulk density ρd was determined, as well as its soil moisture. For this monitoring, the mentioned three sites were chozen, with various granulometric soil composition: 1- loamy- sandy soil, 2- loamy soil, 3- sandy- loamy soil.
Bulk density ρd is changing first of all, in the topsoil horizons, mainly due to natural effects, e.g. by natural compacting, shrinking, swelling, freezing, defreezing, root system development, etc. Bulk density also depends on amount of precipitation (*Figure 1.*)

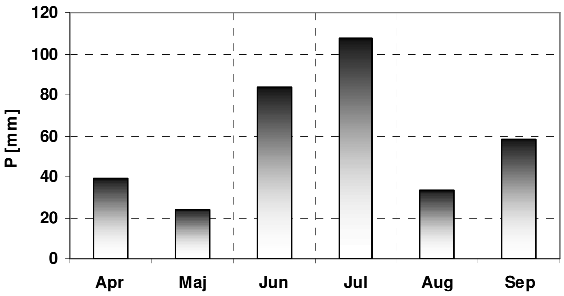

Figure 1. Monthly total precipitation P in Hurbanovo, year 2008

Results and discussion

Also anthropogenic impacts are important, like use of cultivation and harvesting heavy mechanisms. In consequence, the bulk density shows a distinct temporal and areal variability (Neményi et al., 2006; Neményi and Milics, 2007). It is mostly evident in the surface (topsoil) soil horizon, appr. up to the 40 cm soil depth. Also mostly evident it is in the months of the vegetation period (*Table 1.*).
Most relevant impact of the bulk density change is that on the soil retention properties, i.e. upon the critical retention curve points, and upon the saturated and unsaturated soil conductivities.

Table 1. Average monthly values of bulk density [g/cm^3] in four layers of the upper 0,40 m topsoil profile in Hurbanovo on monitored locality 1, 2 and 3 in year 2008

Month	Bulk density (Loc. 1)	Bulk density (Loc. 2)	Bulk density (Loc. 3)
Apr	1.78	1.79	1.79
May	1.76	1.73	1.56
Jun	1.62	1.58	1.59
July	1.64	1.66	1.67
Aug	1.87	1.88	1.85
Sept	1.60	1.66	1.65

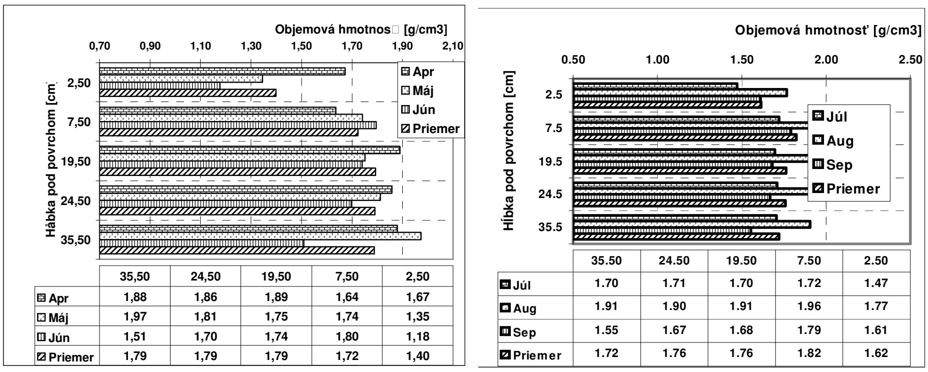

Figure 2. Course of granulometric soil composition in the upper 0,40 m topsoil profile in Hurbanovo on monitored locality 3 trough first and second part vegetation period in year 2008

Conclusions

Based upon reaults achieved from the bulk density monitoring on Hurbanovo localities, it can be stated :

- Determination of the equilibrium bulk density for description of the physical soil properties on a given site, can be considered sufficient, for characterizing soil from the pedological aspect. However, it is not sufficient for a daily water regime quantification by numerical simulation. This was confirmed by the bulk density monitoring.
- For numerical simulation by mathematical model of the soil water regime, it is not sufficient for the surface (topsoil) horizon, to take bulk density only from a single time horizon of the year. Having sufficient information on bulk density variability, it is necessary tot take this change into account in relation to the soil water storage, represented by moisture retention curve, and to the unsaturated hydraulic conductivity. For this, use of the pedotransfer functions (PTF) would be suitable.

Relationship between volumetric mass changes and the soil water storage, is not an explicit one. Agreement in case of saturation, or with a minor error at hydrolimit FC (field capacity), is valid only for rigid soils. Soils with the first fraction content (content

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of the physical clay), exhibit swelling or shrinking, and thus the bulk density is becomming dependent upon the moisture. To quantify volumetric changes for such soils, it is necessary to perform under laboratory conditions, on the undisturbed and geometrically defined soil volumes.

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ANALYSIS OF IMPACT OF MANAGEMENT ON GROUNDWATER LEVEL OF ABROD WETLAND

Mária PÁSZTOROVÁ – Jana SKALOVÁ – Justína VITKOVÁ

Department of Land and Water Resources Management, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Radlinského 11, 813 68 Bratislava, maria.pasztorova@stuba.sk

Abstract: The aim of this paper is to compare the impact of different managements on groundwater level of Abrod wetland. In this area during the past decade the groundwater level decreased significantly. Therefore, we decided to evaluate the groundwater level for three different managements - the current management consisting of mowing once a year, intensive management of mowing twice a year, which were made in the past, and also no management options, i.e. without mowing.

Keywords: groundwater level, management, mathematical simulation

Introduction

Abrod is one of the most valuable wetland ecosystems in Slovakia. It was declared as National Nature Reserve (NNR) in 1964. NNR Abrod with a total area of 923,723 m^2 is located in the western part of the geomorphological unit Borská lowland and in a natural depression at an altitude of 149-153 meters above sea level. It is also part of Protected Landscape Area (PLA) Záhorie. Its location is shown in *Figure 1*.

Territory of Abrod NNR is situated in the plain and in intensively used part of Slovakia; it was exposed to strong anthropogenic influences, which results in significant changes of groundwater level (GWL). Therefore monitoring network of GWL probes has been realized in the wetland, and the GWL is measured by workers of Záhorie PLA since 2001 in the period twice a month.

Significant changes in GWL may be also due to replacing of rare wetland vegetation with invasive species, as reed and shrubberies. Therefore, the management of Abrod NNR, which is done in this area, wants to preserve rare plant communities of wet meadows. On the present in NNR, the management by mowing is made once a year (in beginning of July). Therefore the aim of this contribution will be determination of the impact of different management practices on GWL changes in wetland. We decided to assess the impact of three from them, namely the current management consisting of mowing once a year, intensive management of mowing twice a year, which were made in the past, and also without management options, i.e. without mowing.

Impact of three mentioned management practices on course of GWL we decided to analyses with mathematical simulation models, because they are the most suitable methods for determining the GWL in the event when we have not available monitored data. The main advantage is the relatively fast realization (Nagy and Brezianska, 2010; Horváth et al., 2007). We used for simulation the HYDRUS-ET model (Šimunek et al., 1997), which allows simulation of GWL changes too (Pavelková, 2010).

Materials and methods

By reason of GWL changes, it has been in the wetland realized the monitoring network of GWL probes, in which the GWL is measured by workers of Záhorie PLA since 2001 in the period twice a month. From the monitoring network (*Figure 1.*) was chosen for

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simulation the GWL probe No. 21, because it is placed on area, where is ongoing management by mowing, and where were taken the samples of vegetation and soil.

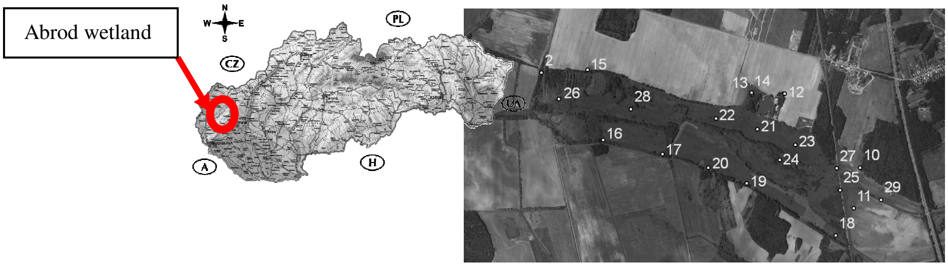

Figure 1. Location of Abrod wetland in Slovakia and monitoring network of GWL probes (GWL probes are marked with numbers)

The course of measured GWL in probe No. 21 is shown in *Figure 2.* which indicates a decreasing trend of GWL. The nearest object of GWL observation network of SHMÚ, which has a longer time series of measurements and it is therefore more appropriate to assess the course of GWL in the evaluated area is located near the village Malé Leváre. The course of weekly measured GWL in this probe for the period 1958-2003 documents also decreasing trend of GWL.

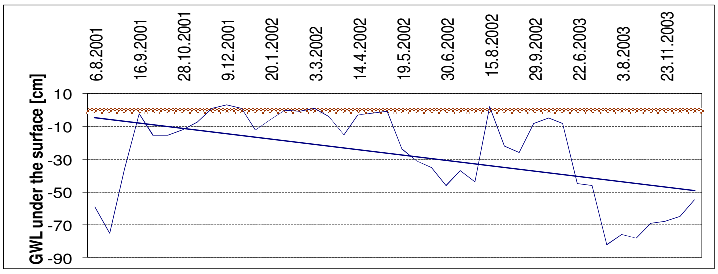

Figure 2. Course of GWL in probe No. 21 for period 2001-2004

For simulation we used the HYDRUS-ET model (Šimunek et al., 1997), which is based on the solving of Richard's formula.
Input data into the mathematical model are mainly canopy characteristics (Klupács, 2009), hydrophysical soil characteristics, meteorological data and initial condition, which was the GWL in a first day of simulation.
The value of leaf area index (LAI) was established directly in the wetland by measuring in three cycles - 5.6., 3.7. and 27.8. - The values of albedo, roughness of vegetation and depth of the root system were derived from already existing works. Hydrophysical soil characteristics were measured on soil samples taken near the GWL probe No. 21. It was determined the saturated hydraulic conductivity K=150 cm per d, Van Genuchten's parameters (Van Genuchten, 1980) of water retention curve α=0,00377 cm^{-1} and n=1,2738, water content at saturation θ_s =0,71 $cm^3.cm^{-3}$ and residual soil water content θ_r =0,02 $cm^3.cm^{-3}$.

Meteorological data entering in modeling include daily precipitation, daily air temperature, daily duration of sunshine, the average daily partial water vapor pressure and the average daily wind speed. Meteorological data were taken from the observation station Kuchyňa and Malacky.

At first model HYDRUS-ET was verified on the period 2001-2003. It was comparing the measured GWL in probe No. 21 with simulated GWL. From the visual comparison it can be seen that the calculated GWL approximately follows the course of measured GWL (*Figure 3.* - year 2003). For comparison of the measured and simulated GWL it was used also regression analysis (*Figure 4.*). The correlation coefficient R = 0.81 shows the close relationship between the assessment elements. On this basis, it can be concluded that HYDRUS-ET model is suitable for forecast the course of GWL in Abrod wetland.

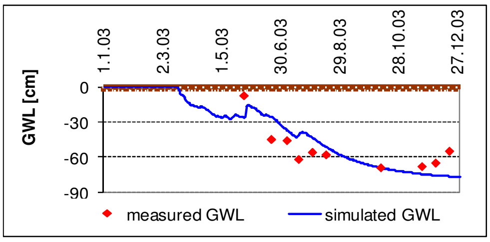

Figure 3. Course of measured and simulated GWL for period 2003

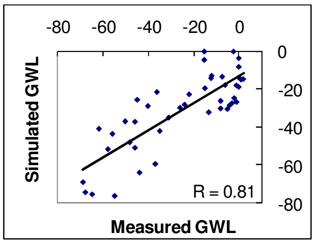

Figure 4. Dependence between the measured and simulated GWL

Results and discussion

Course of simulated GWL for different practices of management - without mowing of grass, mowing once a year and mowing twice a year for years 2002 and 2003 in Abrod wetland is shown in *Figure 5*.

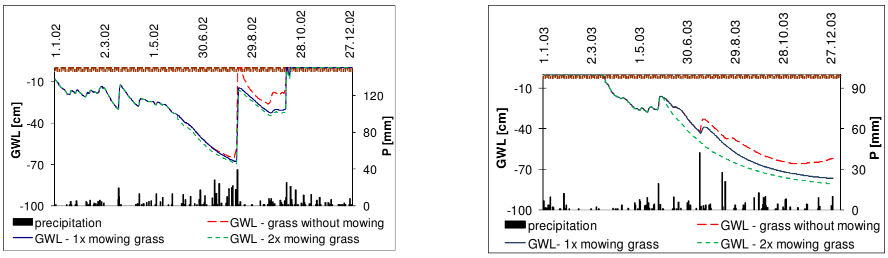

Figure 5. Course of simulated groundwater levels (GWL) for twice a year mowing grass, once a year mowing grass and without mowing grass and course of daily precipitation (P) measured in the station Kuchyňa during the years 2002 and 2003

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The daily precipitation from the observation station Kuchyňa are shown in the *Figure 5* too. As we can see precipitations increase the level of GWL and vice versa. From comparing of the simulated GWL for different management practices results that the level of GWL for twice a year mowing grass is deepest below the surface, and for the grass without mowing is highest. The biggest differences between the evaluated management practices is mostly in summer, when are the largest differences between the characteristics of the crop.

Conclusions

Wetlands are unique systems where significant plant species grows. Dynamics of groundwater levels is very important for wetland's plants, because its closeness to the soil surface during the growing season is great condition for the existence of wetlands. Therefore, the aim of this paper was to assess the impact of wetland management on the course of GWL on the example of Abrod wetland.

In Abrod wetland it was evaluated the impact of management (mowing of grass) on ground water level, whereas the current mowing of vegetation takes place only once a year. Compared was the actual management with intense mowing twice a year, which was made in the past and with the case without mowing.

For this purpose, mathematical model HYDRUS-ET has been used. Its suitability for Abrod wetland was verified by comparing simulated and measured GWL (R=0,81).

Form of management influences GWL during the year minimal, but the most during the growing season, when there are largest differences between the characteristics of the vegetation. Dynamics of GWL, which are fundamental assumption for the existence of wetlands, are not significantly influenced by evaluated managements. Rainfalls have critical influence on the GWL, rainfalls affect the level of water in surface streams and consequently below the surface.

In conclusion, we can say that evaluated different management practices in Abrod wetland significantly don't affect the water regime and therefore management is not important from the view of the conservation of specific wetland plant species.

Acknowledgements

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THREE DIMENSIONAL DYNAMIC WATER REGIME ASSESSMENTS IN ORCHARD MANAGEMENT TITLE

Attila NAGY – János TAMÁS

Deptartment of Water and Environmental Management, Faculty of Agricultural and Food Sciences and Environmental Management, Centre for Agricultural and Applied Economic Sciences, University of Debrecen, H-4032 Debrecen, Böszörményi 138. e-mail: tamas@agr.unideb.hu

Abstract: Most of the water regime assessments are one dimensional whether it is horizontal or vertical. This study aims to survey the dynamic change of soil heterogeneity and water regime in 3 dimensional scales in orchards. The main goal is to establish such a precision decision support system, with which the water management properties of soil can be improved, and the irrigation management can be rationalized.
The examinations were carried out at an intensive apple orchard in Debrecen-Pallag in 2010. 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. Upper limit of plasticity according to Arany, maximum and minimum waterholding capacity, pF, matrix potential of soils, soil density and soil penetration resistance were measured in two soil layers to obtain appropriate information on the physical and water management properties of the soil.
With 3 dimensional assessments the water regime of soils, physical characteristics were determined. Based on the results of soil penetration resistance and matrix potential measurements, the accurate spatial positions of compacted layers, physical barriers were characterized, where soil loosening should be implemented in 40-70 cm depth to eliminate the negative effect of periodic surplus water. The matrix potential measurements also contribute to the determination of the irrigation time.

Keywords: 3 dimensional water regime, apple orchard, penetration resistance, matrix potential

Introduction

The limited water resources and the increasing frequency of extreme hydrological events (floods, water-logging, over-moistening and drought) due to the high territorial and temporal variability of atmospheric precipitation; the heterogeneous (micro) relief; and the unfavourable physical/hydrophysical characteristics of soils are pressing to improve agricultural water use efficiency and necessitates an efficient control of soil moisture regime in the Carpathian Basin (Pálfai, 2000; Somlyódy, 2000; Várallyay, 2002; 2007). Hungary has favuorable agro ecological potential for pomaceous fruit production. Nowadays one of the novel and widespread achievement of pear production is the intensive pear plantations with high tree density (Takács, 2009; Soltész and Szabó, 1998; Hrotkó, 1999). Orchards are 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. It cannot imagine the fruit production without modern irrigation system. Nowadays, in Hungary there isn't any intensive apple and pear orchard, where they would question the importance of the irrigation and assessment of water regime.

Materials and methods

The aims of our study was to survey the spatial distribution of physical and water management properties of soils in order to assess the dynamic change of soil heterogeneity and water regime in 3 dimensional scales.

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Due to the heterogeneous terrain surface special attention has to be paid to places with different location in order to examine all of the different soil varieties. The coordinates of the sampling points were collected by GPS (*Figure 1.*). Systematic sampling strategy was carried out based on the number of the rows and apple trees to collect as much information as possible with possibly the least number of samples. The soil samples were collected from the surface and 40cm, 70 cm depth. The upper limit of soil plasticity (K_A) – according to Arany – was measured in order to determine the spatial distribution of the physical characteristics of the examined site. Using the samples with the original soil structure, maximal (pF=0) and minimal (pF=2) waterholding capacities were determined to evaluate water bearing properties of the examined soils. Soil density was also measured on field. 3T System penetrometer was used to measure the soil penetration resistance at each centimeter for 60 cm depth and expressed in kPa. It also measures the soil moisture content at each 1-cm-thick layer. Cone angle of the probe which penetrates to the soil and collects the soil density data was 60˚.
The matrix potentials of soil were measured by analogous tensiometers, from 1. June 2010. to 31. August 2010. The measured pressure value was converted to water height in cm so as the water content of soils can easily be determined if the pF curves of soils are known. The tensiometers can successfully be used on light sandy soils to automate the monitoring of the water regime of soils. Gauges were set at 6 sampling points in 40 and 70 cm depth. The soil moisture tension values were always measured in the morning at the same time. The pF curves of the soil were measured in 40 and 70 cm depth in accordance with the MSZ-08-0205:1978 13 Hungarian patent.

Results and discussion

Based on soil plasticity, according to Arany, sites with different characteristics could be distinguished in every layer (surface, 40 cm and 70 cm). The spatial variability of soil plasticity, thus the physical features of the soil appeared differently in each layer (*Figure 1.*). Since the maximal saturation percentage (K_A=30) measured at the sampling point with the lowest altitude, it was caused by the micro and mezo relief. Significant differences among physical characteristic of the three soil layers can not be found.
Soil density of the soil varies between 1.51 – 1.57 t m^{-3}. The measured pF curves are typical for sandy soils. The water management properties of soils can be determined by this pF curves. The available water capacity was 8.61 V/V% at 40 cm depth and 9.24 V/V% at 70 cm depth. The amount of water, that a soil doesn't hold against gravitational forces and could be drained, was 23 V/V% at 40 cm layer and 18 V/V% at 70 cm layer. Concerning these data, the examined sandy soil with low capillarity loses the great amount of its water content even in the case at low tensions. So the water retention of this soil is slight, and have small amount of available water regime, which means that this soil can only satisfy the water content of the apple orchard for a short term dry period.
Despite the fact, that there is a sandy soil at the examined site, surplus water occurred at the whole vegetation period in 2010, due to the frequent, intensive and large amount of precipitation. The presence of surplus water was even supported by the compacted layer at 40-60 cm depth. Even in the 20-30 cm soil layer the soil density reached and exceeded the 3MPa soil penetration resistance value, which is the threshold for the high

soil density, according to Birkás (2002) measurements. The mean penetration resistance values of deeper soil layers were clearly exceeded this threshold. The high soil density changed dramatically the waterholding capacity, infiltration intensity and water saturation properties of the sandy soil. At the Eastern part of the examined site, sandstone layer with extreme high soil density was found at 30-40 cm depth. At this layer penetration resistance values exceeded the upper limit of the measurement range (10000 kPa) of the penetrometer, therefore it was not possible to measure further soil layers (*Figure 1.*).

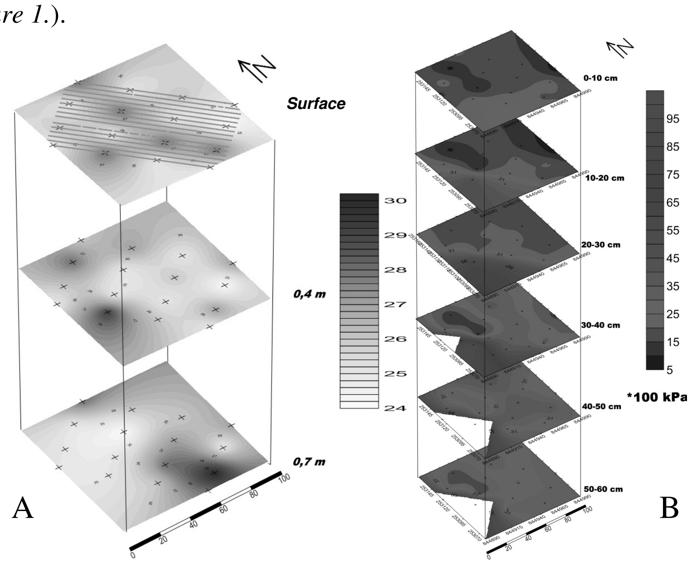

Figure 1. A: Spatial distribution of soil plasticity, K_A (apple trees illustrated as points on the surface layer); B: spatial distribution of soil density (soil penetration resistance *100kPa; blanked sites means above detection level of the penetrometer).

The soil water tensions measured by tensiometers were varied between pF 0 and 2.5 due to the extreme precipitation circumstances in 2010. Based on both of the soil moisture tension values and pF curves the rate of easily drainable gravitation pore volume was considerable. Tensiometers at 40 cm depth resulted fast and significant respond to precipitation; the tension was dropped markedly. While in 70 cm depth, rainfall had slight effect on soil moisture tension, total water content was only measured at concerned dates, after long lasting heavy rainfalls, e.g. at the end of July (*Figure 2.*).
This phenomenon also suspects the presence of compacted layer at 40-70 cm depth. To determine the accurate amount of the drainable gravitation water regime total and field water capacity was also measured and described in 3 dimensions. In accordance with the results the amount of drainable water regime was about 20.6 V/V% at 40 cm depth and 18.6 V/V% at 70 cm mainly.

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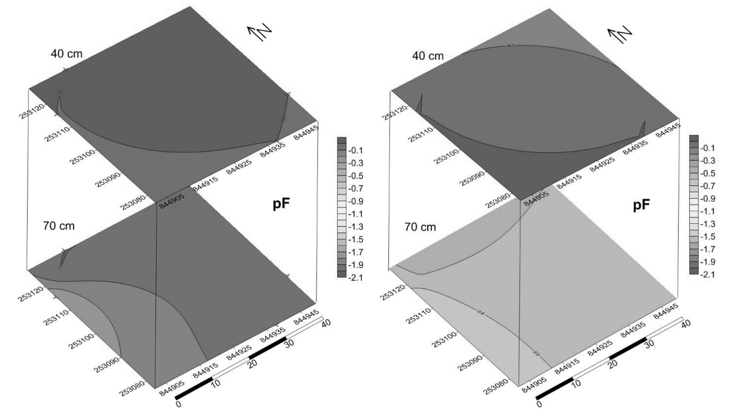

Figure 2. The soil moisture tensions at 3 June and 28 July 2010.

Conclusions

The total drainable water regime is 920 m^3 ha^{-1} from the upper 40cm soil layer and 1460 m^3 ha^{-1} from the upper 70 cm soil layer. The harmful surplus water can be infiltrated by the loosening of the compacted soil layer in the 50-70 cm depth or led off by vertical drainage. Therefore one, solo knife coulter is suggested to use at 80-90cm depth. The narrow loosening width does not injure considerably the pomaceous tree root zone, but the surplus water can be infiltrated to deeper soil layers. Thus the harmful effects (fruit crack, falls, tree necrosis) can be prevented.

Acknowledgements

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THE CROP CONDITION AND PRODUCTIVITY OF GREEN PEA AND GREEN BEAN UNDER EXTREME WATER SUPPLY

Krisztina MOLNÁR [1] – Róbert VIG [2] – Attila DOBOS [3] – Eszter NEMESKÉRI [4]

[1] Institute for Land Utilisation, Technology and Regional Development, Center of Agricultural Sciences and Engineering, University of Debrecen, 138 Böszörményi street, Debrecen 4032, Hungary, e-mail: molnark@agr.unideb.hu
[2] Hungarian Academy of Sciences - University of Debrecen, Research Group of Cultivation and Regional Development
[3] Hungarian Academy of Sciences - University of Debrecen, Research Group of Cultivation and Regional Development
[4] Institute of Horticulture, Center of Agricultural Sciences and Engineering, University of Debrecen

Abstract: Crop production, especially olericulture is characterised by high weather-sensitivity. Rainfall deficiency and excess rainfall cause significant yield-fluctuation in the case of different species and varieties, which contributes to the marketing processes and affects the establishment of the following year's sowing structure.
Considering all these, we must strive to develop a sowing structure that adopts to the environmental conditions, to use varieties and hybrids that are tolerant to environmental stress factors and to choose a crop site that is suitable for the crop's needs.
The aim of our experiment was to examine the changes of the physiological parameters and water utilization in the different development phases of field vegetables that have different breeding seasons and to reveal the correlation between the physiological reactions and yield. All these are based on the measurement of LAI (Leaf Area Index) and SPAD (Soil Plant Analyses Development) values and stomatal resistance, and then we evaluated the measured data with using the adequate statistical method. The results make it possible to choose the varieties and hybrids that have good adaptation to extreme rainfall, which can significantly increase the efficiency of field vegetable production.

Keywords: vegetable species, yield safety, crop condition, leaf area index (LAI), Soil Plant Analysis Development (SPAD)

Introduction

One of the fundamental conditions of economical production is the development of a sowing and variety structure that serves yield safety, that is field crops, hybrids and varieties whose agroecological needs are aligned with the production site and environmental conditions need to be grown. In order for yield safety to increase, it is practical to include into the sowing structure varieties and hybrids that are tolerant to various environmental, biological and technological stress factors (Lecoeur and Guilioni, 1998; Nagy, 2000; Csontos, 2004; Nagy, 2008; Sezen et al., 2008).
One of the most frequently examined issue about environmental stress factors is crops' tolerance to drought and the judgement of the efficiency of irrigation. Several authors showed in field and small plot experiments that by producing drought-tolerant varieties and applying irrigation adjusted to the field crop's needs, yield and its quality can be significantly increased (Silim et al., 1992; Kuchinda and Lawal, 2003; Gencoglan et al., 2006; Huzsvai and Ványiné, 2009; Megyes, 2010).
If the amount of precipitation and soil moisture is higher than the needs of the field crop, it could lead to yield depression, whose extent depends on the applied production technology and the genetic endowments of the produced species and variety (Rosenzweig et al., 2002), therefore, in this study, we evaluated the genetically different green bean and green pea varieties' tolerance to excess precipitation.

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Materials and methods

The examinations were carried out in the demonstration garden of the Institute for Horticultural Sciences of the University of Debrecen on chernozem soil on 4.2 m^2-sized (green pea) and 5.1 m^2-sized (green bean) plots, involving four green bean varieties (Poweron, Magadi, Konza, Serengeti) and three green pea varieties (Avola, Milor, Twin) with 9 replications per variety. The green pea was sown on 05/05/2010 using a manual sowing gun with 38.0 cm row width, 5.0 cm stem width and 5.0 cm sowing depth.

The leaf area index (LAI) was measured in the vegetation using a *LI-COR LAI-2000* analyser (Welles and Norman, 1991) on 15/07/2010 (green bean) and on 07/06/2010 (green pea), SPAD (Soil Plant Analysis Development) values were also obtained using a *Minolta SPAD 502* meter (Güler and Özcelik, 2007) on 09/07/2010 (green bean) and 07/06/2010 (green pea), whereas the plant height (cm) was recorded right before harvesting.

Yield samples were collected between 16/07/2010 - 19/07/2010 (green bean) and 09/06/2010 - 16/06/2010 (green pea) 10 times per replication and from 90 crops per hybrid.

The examinations were performed in Debrecen, in the northeastern part of the 9/a district as defined by Ángyán (1985), therefore, the precipitation conditions of 2010 were compared to the values characterising the climate district. 2010 was an extremely wet year, as the amount of yearly precipitation (01/10/2009 - 30/09/2010) was 70 % higher (377 mm), that of the autumn-winter term (01/10/2009 - 31/03/2010) was higher by 44% (100 mm), the precipitation in the spring-summer term (01/04/2010 - 30/09/2010) is higher by 88% (277 mm) and that of July is higher by 43% (29 mm) than the average typical values in the climate district.

The statistical evaluation was performed by using *SPSS for Windows 14.0*. A one-sample variance analysis (ANOVA) to compare the varieties and Duncan's or Games-Howell simultaneous mean value comparison tests were done as a supplement of the variance analysis, depending on whether the variance of the variables to be compared was identical or different.

Results and discussion

During the statistical evaluation of the examination results, it was established that there were significant differences on $p<0.001$ and $p<0.05$ levels among the examined green bean varieties in terms of their parameters characterising the plant conditions (plant height, SPAD, LAI), whereas there were also significant differences in terms of the productivity parameters (pod number, pod weight).

The plant height (cm) was significantly different ($p<0.001$) in the case of all four green bean varieties. The highest significant value was obtained in Serengeti, whereas the lowest was recorded in the case of Magadi. The average difference in the plant height values of the examined species was 21.9%. The lowest difference (5.4%) was observed between Serengiti and Poweron, whereas the highest (39.8%) was measured between Serengeti and Magadi. The highest SPAD value was obtained in the case of Magadi, that has the lowest plant height. Similarly to the plant height data, the differences between the SPAD values of the green bean varieties were significant ($p<0.001$), but there were smaller differences than in the case of plant height. The smallest difference (0.6%) was observed between Konza and Poweron, whereas the highest (7.6%) was recorded between Magadi and Poweron. The average difference between the varieties was 4.3%. Based on the F value, the least expressed differences were obtained in the case of LAI. While the significance value of plant height and SPAD values was lower than 0.001, the significance value of LAI was between 0.1 and 0.5 and a clearly significant difference was observed only between Poweron and Konza. Based on the pod number (number per plant) and the pod weight (g per plant), Serengiti had the best and Magadi had the worst productivity (*Table 1.*).

Table 1. Statistical evaluation of the differences between green bean varieties

Variety	Plant height (cm)		SPAD		LAI		Pod number (no. per plant)		Pod weight (g per plant)	
Konza	36.5 ± 6.6	C	33.3 ± 3.6	BC	1.2 ± 0.4	B	12 ± 7	B	34.2 ± 28.1	BC
Magadi	32.2 ± 7.5	D	35.6 ± 4.0	A	1.7 ± 0.4	AB	8 ± 4	C	30.3 ± 17.9	C
Poweron	42.7 ± 8.4	B	33.1 ± 3.8	C	2.2 ± 0.6	A	11 ± 6	B	41.0 ± 27.4	B
Serengeti	45.0 ± 6.3	A	34.4 ± 3.8	B	1.8 ± 0.8	AB	14 ± 8	A	51.9 ± 32.6	A
F value	52.1***		7.3***		3.7*		14.7***		9.8***	

***p<0.001, *p<0.5, SPAD (Soil Plant Analysis Development), LAI (Leaf Area Index)

There were significant differences in the plant height and LAI of the green pea varieties (p<0.001), their pod numbers (no, per plant) (p<0.01) and pod weights (g per plant) (p<0.05), but there were no significant differences in the case of the SPAD values of the greenpea varieties (*Table 2.*).

Table 2. Statistical evaluation of the differences between the green pea varieties

Variety	Plant height (cm)		SPAD		LAI		Pod number (no. per plant)		Pod weight (g per plant)	
Avola	68.8 ± 7.1	C	39.7±5.2	A	3.7±0.6	C	4 ± 1	B	19.3 ± 5.9	A
Milor	74.8 ± 10.7	B	39.7±5.1	A	4.6±0.5	B	5 ± 3	A	16.5 ± 9.9	B
Twin	78.5 ± 7.7	A	38.6±5.9	A	5.4±0.7	A	5 ± 2	A	18.7± 9.7	AB
F value	21.1***		1.1n		17.3***		6.4**		2.6*	

***p<0.001, **p<0,01, *p<0.5, SPAD (Soil Plant Analysis Development), LAI (Leaf Area Index)

The highest plant height was measured in the case of Twin, compared to which Milor was shorter by 4.9% and Avola was shorter by 8.7%. Similarly to plant height, the highest LAI value was observed in the case of Twin, compared to which Milor and Avola has significantly lower LAI values. There were no significant differences in the pod number and pod weight (*Table 2.*).

As a result of the abundant precipitation, there were notable differences between the productivity of the green bean varieties, like in the case of green pea. The differences between the pod number and the pod weight were observed between the green bean varieties on a p<0.001 level with 14.7 and 9.8 F values, wheres the respective data were p<0.01, p<0.05, 6.4 and 2.6 F value in the case of green pea (*Table 1. and Table 2.*).

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Conclusions

The knowledge of the tolerance characteristics of hybrids and varieties is of economic importance, as the deviation from the optimal circumstances results in yield depression, therefore, it is necessary to include into the sowing structure varieties and hybrids that are tolerant to various environmental, technological and biological stress factors. The resistance and tolerance examinations mainly cover the tolerance to pathogens, pests, drought and weather anomalies. Similarly to drought, the precipitation supply exceeding the needs of field crops results in yield depression, therefore, it is an important aspect during the development of the sowing structure to get to know the crop's tolerance to abundant precipitation, too.

Acknowledgements

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DETERMINING THE INTENSITY AND DURATION OF SOIL DROUGHT BY THE METHOD OF EFFECTIVE PRECIPITATION

Branislav KANDRA [1] – Andrej TALL [2]

[1] Institute of Hydrology, Slovak Acagemy of Sciences SAV, 071 01 Michalovce, Hollého 42, kandra@uh.savba.sk
[2] Institute of Hydrology, Slovak Acagemy of Sciences SAV, 071 01 Michalovce, Hollého 42, tall@uh.savba.sk

Abstract: For assessing of the severity of drought are usually used many indicators in the form of various indexes. Their calculation is expressed by mutual relationship of key components of water balance, therefore particular state of moisture conditions in particular place, at particular time. Their calculation is the expression of the relations between the key components of water balance for particular moisture conditions in a particular place at a particular time. Nowadays is expression of drought usually limited to monthly or yearly characteristics of the evaluated area and thus provides only a rough view of the situation. For the purposes of more accurate assessment of the beginning and end of meteorological drought and its impacts on the formation and intensity of soil dryness it is more appropriate to use the methods that can express moisture conditions in daily increments. H. R. Byun and D. A. Wilhite suggested a solution to the shortcomings of the previous methods by calculating the indices of effective precipitation. In this contribution daily index values have been calculated by using the effective rainfall of the Milhostov area in 47-year period of time. From these data other indices for determination of the driest years were obtained. From the selected years were further separated the longest consecutive days with significant under-normal values that persisted during the growing period. Similarly, water supplies to the depth of 1 m were simulated in these intervals in the selected Milhostov profile. Obtained results were compared.

Keywords: soil drought, effective precipitation, soil water storage

Introduction

Drought means extreme in nature, in terms of weather it is usually defined as a negative deviation from the long-normal precipitation, which may be subsequently reflected in the soil. This extreme situation is cumulative, that means that it increases depending up to length of duration of the dry or moisture deficit period. There are used many indicators in the form of various indexes for assessment of the severity of drought. Their calculation is expressed by mutual relationship of key components of water balance, and thus particular state of moisture conditions in particular place, at particular time. Usually is that time limited to monthly or yearly characteristics of evaluated area and therefore provides only rough view of the situation. For the purposes of more accurate assessment of the beginning and end of meteorological drought and its impacts on the formation and intensity of soil dryness it is more appropriate to use the methods that can express moisture conditions in daily increments. Byun and Wilhite (1999) proposed a solution that avoids the limitations of these indices by the method of calculation of effective precipitation. The advantage of the index is that it is not demanding on large quantities of input data and is based only on daily precipitation in particular locality that lies in particular altitude with typical distribution and amount of precipitation. Total water loss is there expressed by reduction functions and therefore does not require a hardly obtainable evapotranspiration data (Rodný and Šurda, 2010).

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Materials and methods

Daily exhaustion of water resources for locality Milhostov in 47 year period (1962-2008) was calculated the by the method of effective precipitation EP_i (effective precipitation) in inscribed paper. The area of interest is located on the Eastern Slovakian lowland at the altitude of 101 m. The climate in the area is warm, very dry, lowland and continental. Soil is pedologicaly classified as a heavy clay-loam soil of fluvial-glue soil type. The calculation is based on the equation: $EP_i = \left[\left(\sum_{m=1}^{n} P_m \right) / n \right]$ where i is time of summation (DS, usually DS=365; 15), P_m is precipitation m days ago. P1 means the latest precipitation. As i was used the value of 15, which represents data gained during 15 days. The selected value is suitable for assessing of soil moisture deficiency. Equation is based on assumption that rainfall m days ago is added to total water storage in type of average rainfall during m days (for instance EP2 = P1 + (P1 + P2)/ 2). This concept EP_i is based on fact that change of runoff ratio is the most significant just after the rain. This agrees with many hydrological runoff models. In next step were calculated from EP_{15} following indexes: DEP (Deviation of EP from MEP), from equation DEP = EP – MEP where MEP is the average EP for each day during the period. Standardizing DEP obtained the index SEP (Standardized value of DEP), which allows comparisons of drought intensities between different places. SEP = DEP / σ(EP) where σ(EP) is the standard deviation for each daily series EP_{15}. Negative values of DEP and SEP means the period of water deficiency, because EP_{15} is below-normal. Quantification of the drought intensity can be done by the sum of consecutive days with a negative value of SEP (DEP). Firstly, each month was evaluated in terms of time repetition below-normal and dry days in the long run period. As below-normal days were considered days with SEP<0 as dry days with SEP<-1. In next step the growing seasons (GS) were ranked according to the sum of SEP<-1. There were separated periods with the largest number of consecutive days with SEP<0 in 8 driest periods of GS. In those days was also calculated the water storage into the depth of 1 m by the method of numerical simulation using the model GLOBAL. The dry periods were classified according to the various criteria such as duration, sum of SEP and SEP average per day. To obtained values of soil water storage during the selected dry periods the dependency with the values of EP_{15} with the course of groundwater level (GWL) was gained by linear correlation. There were watched possibilities of utilization of EP_{15} for determining length and intensity of drought as well as mutual comparison of index with soil water storage during dry periods by inscribed methodology. In these methods were studied options of use EP_{15} for define the duration and intensity of drought and mutual comparison of development between index and soil water storage during dry periods.

Results and discussion

The assessment of droughts in years via SEP<0 shows that each day of the year belongs to some dry period in the time series. The time period is balanced, on average 1.5 year on each day. On the whole, more frequent are days in spring and autumn, and less frequent are summer and winter days (*Figure 1.*). The droughts defined by SEP<-1 in the individual months were more differentiated. There was a higher frequency of dry days in the summer and winter, and there were fewer dry spring and autumn days. The average frequency of summer dry days is every 9 years, of winter days every 10 years, of spring days every 13 years and of autumn days every 12 years (*Figure 1.*).

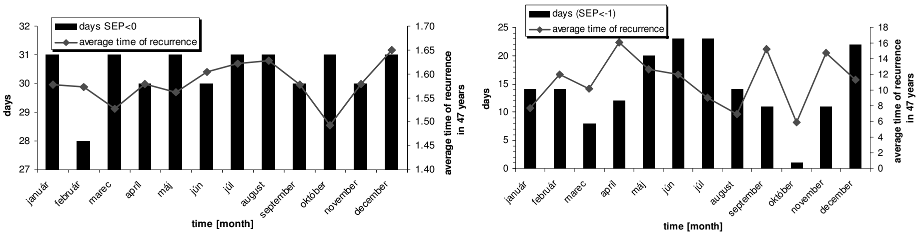

Figure 1. Number of dry days in months, according to the SEP and average time of recurrence

The longest periods of draughts during the selected growing seasons in the time series are shown in *Table 1.* It is clear from the table that prolonged dry period does not necessarily mean higher intensity of droughts although the intensity increases with the draught duration. For example, in 2006, the draught lasted for only 26 days but the average intensity of drought is higher (-0.88) than the intensity in 1992 (-0.86) when the draught lasted for 47 days.

Table 1. Sort of dry periods by indicators during GS

o.n.	by length	length	by SEP	SEP	by SEP/day	SEP/day
1	19.7.92-3.9.92	47	19.7.92-3.9.92	-40,50	3.7.06-28.7.06	-0,88
2	25.7.76-2.9.76	40	25.7.76-2.9.76	-28,31	19.7.92-3.9.92	-0,86
3	26.8.99-27.9.99	33	14.6.91-13.7.91	-25,07	14.6.91-13.7.91	-0,84
4	14.6.91-13.7.91	30	26.8.99-27.9.99	-24,13	4.9.86-30.9.86	-0,75
5	4.9.86-30.9.86	27	3.7.06-28.7.06	-22,90	26.8.99-27.9.99	-0,73
6	3.7.06-28.7.06	26	4.9.86-30.9.86	-20,22	11.8.07-3.9.07	-0,73
7	11.8.07-3.9.07	24	11.8.07-3.9.07	-17,45	25.7.76-2.9.76	-0,71
8	7.8.89-27.8.89	24	7.8.89-27.8.89	-15,25	7.8.89-27.8.89	-0,64

Table 2. Indicator values in selected dry periods during GS

o.n.	period	WS min-max	EP_{15} min-max	GWL min-max	R^2
1	19.7.92-3.9.92	226,06-232,86	0,29-34,13	185,72-166,55	0,8744
2	25.7.76-2.9.76	179,74-223,55	0,00-43,34	167,50-148,00	0,7935
3	14.6.91-13.7.91	196,28-246,60	0,69-37,13	124,49-146,64	0,8994
4	26.8.99-27.9.99	253,18-278,32	1,32-27,96	181,30-163,29	0,7395
5	3.7.06-28.7.06	226,10-298,12	0,00-31,65	151,67-108,50	0,8025
6	4.9.86-30.9.86	220,80-229,72	0,36-30,67	187,75-174,50	0,7171
7	11.8.07-3.9.07	195,60-197,30	2,38-26,26	189,00-182,00	0,5995

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Table 2. shows the maximum and minimum values of WS in 1m depth, EP_{15} index and GWL. High dependency ratio was established between the EP_{15} and WS in the form of R^2. Figure 2 illustrates high linear relationship between the EP_{15} and WS in one of the selected dry periods. The picture also shows the daily course of these parameters and GWL position. It is obvious that for determining the soil drought severity other important variables should be taken into account apart from the index, such as GWL location, evapotranspiration, etc.

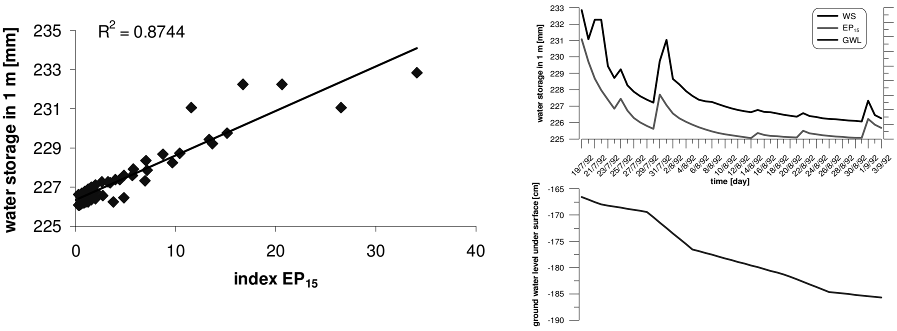

Figure 2. Addiction and running water storage, EP_{15} and GWL in the selected period

Conclusions

For the calculation of Milhostov area water source daily depletion was used effective precipitation method EP_{15} . The index provided other indices, such as MEP, DEP and SEP. The method enables to determine dry periods and draughts. Draught intensity was determined by SEP. The individual days of the months were evaluated from the long-term point of view, according to the frequency and abundance. At the next stage, the longest subsequent dry days in GS period were selected. Then, they were ordered by the length and intensity of the draught. There were analysed the relations between the EP_{15} and WS. The analysis has shown a high dependency of the values, however, it is necessary that other important indices be taken into account, such as GWL and evapotranspiration. The development of the method has not come to its end yet and the types of reduction function and summation period length used are still unresolved.

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CLIMATOLOGICAL ESTABLISHMENT OF SITE STUDIES AND LAND USE: THE CARPATHIAN REGION

Sándor SZALAI

Department of Soil Sciences and Agrochemistry, Institute of , Faculty of Agricultural and Environmental Sciences, Szent István University, Pátar K. street 1., Gödöllő, H-2103, Hungary, szalai.sandor@mkk.szie.hu

Abstract: Atmosphere is the most variable part of the climate system, both temporally and spatially. Therefore, the meteorological/climatological parameters are one of the basic input information for any kind of site studies. It is common, that land use studies have scaling problems with the country sizes in the Alps-Adria region, i.e. many small countries make difficult the overview of the regional situation, the migration of species, distribution of different harmful processes, etc. Situation is worse because of the meteorological data policy of the countries and different measuring techniques and data management practices at the (hydro)meteorological services. Data management processes, co-operations are not supported internationally. Therefore, a large development was the publication of a tender with the title Climate of the Carpathian region for maximum 10 countries. The final outcome of the service will be meteorological and climatological gridded fields. Meteorologically, up to daily temporal scaled fields have to be presented, climatologically, the climate atlas of the region will be produced in decadal step. The presentation will give an overview about the tender call, requirements to the participants, expected results of the services and the freely available final products, the gridded databases. The work is supported by the European Union via Joint Research Centre in Ispra.

Keywords: Carpathian region, climatology, climate change, gridded database

Introduction

One of the largest problems is the availability of good quality long-term time series in the climate and connected sciences. This problem is based on the relative small countries in Europe, the difference in the measuring systems and data managements, and the general problem of data availability. Furthermore, the climatological data management was taken politically as a national task of the individual countries both on expert and financial point of view. This approach made not possible a powerful international co-operation.

Finally, the European Parliament accepted a Hungarian initiative (Olajos, 2009) to support an international co-operation on the climate of Carpathian Basin in 2008 (the final title became Climate of the Carpathian Region, CCR). The final tender call was published in June 2010 with a deadline of mid-August.

Establishments of gridded databases are widely distributed recently. Global gridded databases have been created earlier, but their spatial resolution is not appropriate for regional and even less for subregional level. EUMETGRID is the biggest attempt to create a European gridded database (Tveito, 2010) under the umbrella of EUMETNET, the co-operation of the European Meteorological Services.

The main aim of the service is to improve the basis of climate data in the Carpathian Region for applied regional climatological studies such as a Climate Atlas and/or drought monitoring. The service will investigate the fine temporal and spatial structure of the climate in the Carpathian Mountains and the Carpathian basin with unified or at least directly comparable methods. Currently, there is no valid description of the climate of the Carpathian Region.

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The service will improve the digital data basis at national meteorological services in the Carpathian region, and will facilitate access to derived climatological datasets by the wider scientific community (JRC, 2010).
The spatial area of interest includes the Carpathian Mountain Chain (including the Transylvanian Depression), the Carpathian Basin (i.e. the Pannonian Depression), and adjacent areas, necessary to study the climate of the area. This includes part of the territory of the following countries: Bulgaria, Czech Republic, Croatia, Hungary, Moldova, Poland, Romania, Serbia, Slovakia, and Ukraine. The winner consortium has 9 participants, the (hydro) meteorological institutes and services of Czech Republic, Slovakia, Austria, Poland, Ukraine, Serbia, Hungary, and the National Research and Development Institute of Environmental Protection of Romania and the Szent Istvan University from Hungary. The Croatian Hydrometeorological Service takes part in the project as well. The Slovenia supports the initiative.
For the production of the digital climate atlas, the resulting climatological grids should cover the area between latitudes 50°N and 44°N, and longitudes 17°E and 27°E, approximately. An overview of the area is provided in *Figure 1*.

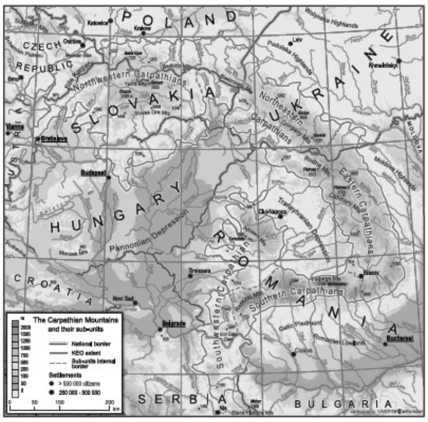

Figure 1. The Carpathian Mountains and their sub-units

Materials and methods

The work is divided into three modules:
Module 1: Improve the availability and accessibility of a homogeneous and spatially representative time series of climatological data for the Carpathian Region through data rescue, quality control, and data homogenisation.
Module 2: Ensure Carpathian countries data harmonisation with special emphasis on across-country harmonisation and production of gridded climatologies per country.
Module 3: Develop a Climate Atlas as a basis for climate assessment and further applied climatological studies, create publicly accessible dedicated web site of the Climate Atlas, including a web map server and data download/access infrastructure, freely available gridded climatological datasets and searchable metadata catalogue for the Climate Atlas.

The planned timeframe of the action is 1961-2000, but the consortium tries to enlarge this period according to the possibilities.
The tender specification (JRC, 2010) contains the more detailed list of parameters (*Table 1., Table 2.*).

Table 1. Minimum set of meteorological variables in daily temporal resolution to be provided

Variable	Description	Units
Ta	2 m mean daily air temperature	°K
Tmin	Minimum air temperature from 18:00 to 06:00	°K
Tmax	Maximum air temperature from 06:00 to 18:00	°K
p	Accumulated total precipitation from 06:00 to 06:00	mm
DD	10 m wind direction	0°-360°
VV	10 m horizontal wind speed	m/s
Sunshine	Sunshine duration	hours
cc	Cloud cover	octas

Table 2. Minimum set of variables and indicators to be provided for the Digital ClimateAtlas of the Carpathian Region

No	Variable/Indicator	Description	Units	Frequency
1	T	Average air temperature (2 m)	°K	Daily
2	T	Average mean air temperature (2 m)	°K	Monthly, yearly
3	Tmin	Minimum air temperature from 18:00 to 06:00	°K	Daily
4	Tmin	Average minimum air temperature	°K	Monthly, yearly
5	Tmax	Maximum air temperature from 06:00 to 18:00	°K	Daily
6	Tmax	Average maximum air temperature	°K	Monthly, yearly
7	Precipitation	Accumulated total precipitation from 06:00 to 06:00	mm	Daily
8	Precipitation	Accumulated total precipitation	mm	Monthly, yearly
9	u_10m_max	Maximum 10 m horizontal wind speed	m/s	Daily
10	u_10m	Average 10 m horizontal wind speed	m/s	Daily, monthly
11	u_2m	Average 2 m horizontal wind speed	m/s	Daily, monthly
12	Sunshine	Sunshine duration	hours	Daily, monthly, yearly
13	Cloud cover	Average cloud cover	octas	Daily, monthly
14	Radiation	Measured global radiation	$MJ\ m^{-2}\ day^{-1}$	Daily, monthly
15	R.H.	Average relative humidity	%	Daily, monthly
16	p_vap	Mean vapour pressure	hPa	Daily, monthly
17	p_air	Mean surface air pressure	hPa	Daily, monthly
18	Snow depth	Snow depth	mm	Daily, monthly
19	Snow water	Snow water equivalent	mm	Daily, monthly
20	Frost days	Number of frost days	-	Monthly, yearly
21	Summer days	Number of days with Tmax above 25 °C	-	Monthly, yearly
22	Hot days	Number of days with Tmax above 30 °C	-	Monthly, yearly
23	PAI	Palfai Drought Index	-	Yearly
24	SPI -3	Standardized Precipitation Index averaged over a three-months period	-	Monthly

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Results and discussion

The project as a tender service has a strict timetable and will finish by the end of 2012. This strong timing makes possible for any users to be prepared for the use of the outcomes of the project and set up own application projects. The time step is three months, i. e. deliverables will be presented and reported on the project meetings in each third month. The service has a very dense project agenda, and therefore, continuously new results will be provided. Furthermore, not only data fields will be available, but metadata as well. Advisory board will be invited to support the work of the consortium from different applied fields like climate modelers, similar projects, international organizations, etc.

Conclusions

The Joint Research Centre (Ispra, Italy) announced a tender call for the Climate of the Carpathian Region. The project begins in 2011 and its duration is 2 years. This is the first effectively financed work for creation of regional high-resolution, high-quality gridded database in the European region. The development of such a database is not only a large step in the climatology, but gives a strong support for any kind of applied researches and plans in the applied fields by common and comparable regional data availability.

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