SOIL

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EFFECT OF FERTILIZERS AND MELIORATIV LIMING ON SOIL ORGANIC MATTER FRACTIONS

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Abstract: The effect of fertilization and meliorativ liming on the quality and quantity of the soil organic matter was examined in the NULTFE experiment at Karcag. We determined the organic C-content of the fractions with different solubility and stability, and also their extinction. in the UV-VIS range. In case of limed soils the amount of hot water soluble organic C-content increased significantly with the increasing fertilizer doses. On the contrary fertilization decreased the humus stability number. Examining the non-limed soils we did not find such tendencies due to fertilization. The hot water soluble organic C-content was one order of magnitude lower than in case of limed soils. The humus stability number also was significantly lower in non-limed soils. Examining the organic C-content of the fractions we found that the amount of NaOH-soluble humic matters increased while that of the NaF-soluble humic matter content decreased in the absence of liming. Our results proved that liming has a favourable effect on the constitution of soil organic matter, increasing the ratio of humic matters with greater molecular weight adsorbed to the clay particles.

Keywords: fertilization, meliorativ liming, organic C, humic substances

Introduction

Soil fertility is characterized by several factors depending on the constitution of clay minerals and organic materials. Organic materials play a significant role in the global carbon cycle as well. The organic carbon content of the soil is significantly affected by the soil usage and the type of cultivation. The carbon pool of the soil can be divided to fractions with different stability commonly classified according to their solubility in different extractants. The solubility of these fractions is determined by their absorption on the surface of clay minerals and their interaction with polyvalent cations. (Kaiser and Ellerbrock, 2005). The easily mineralizable fraction refers directly to the fertility of the soil and predicts the changes in the organic material content of the soil. (Bankó et al., 2007). Recent examinations verified that fertilization affects not only the total amount of organic carbon but also the constitution of the organic materials (Debreczeni and Győri, 1997; Michéli et al., 1995; Zsigrai et al., 2007).

In our country the extraction and spectrophotometric analysis of humic susbstances is carried out according to the Hargitai method. The method suggests that NaOH solution extracts primarily the raw, acidic humus fractions with unfavourable characteristics while NaF solution dissolves humic materials of good quality adsorbed to Ca and clay minerals of the soil (Hargitai, 1957). The ratio of extinctions of these two fractions measured at a certain wavelength is the Q humus stability number which refers to the quality of the soluble humic substances of the soil. (Németh, 1996).

The simplest method for the determination of mineralizable organic matter fraction is measuring the hot water extractable organic carbon (HWC) content of the soil. (Hot Water Carbon – HWC) (Debreczeni and Győri, 1997).

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Materials and methods

Soil samples were collected from the upper layer of the parcelles of the NULTFE experiment at Karcag treated with different fertilizer doses and lime (CaCO3: 0, 11.5 t ha^{-1}). Examinations were carried out on selected samples listed in *Table 1.*

The soil of the experimental site is deep solonetzic meadow chernozem with deep humus layer. The region is one of the most arid areas in Hungary with extreme distribution of temperature and precipitation and with strong continental characteristics.

Table 1. Label of the selected samples and the treatments applied

Label		L+1	L+2	L+3	L+4	L+5.	L - 1	L - 2	L - 3	L - 4	L - 5
N	(kg t ha^{-1})	0	200	200	200	250	0	200	200	200	250
P_2O_5	(kg t ha^{-1})	0	0	120	120	180	0	0	120	120	180
K_2O	(kg t ha^{-1})	0	0	0	100/200	100/200	0	0	0	100/200	100/200
Liming ($CaCO_3$: 11.5 t ha^{-1})		+	+	+	+	+	-	-	-	-	-

Determination of the hot water extractable organic C-content (HWC): extraction was carried out with Hot Water Percolator equipment at SZIU (Füleky and Czinkota, 1993). The extinction of the extracts was measured in the 190-900 nm wavelength range. Determination of humus quality according to Hargitai: extinction of the 0.5 (m/m)% NaOH oldattal and 1 (m/m)% NaF extractable humic fractions oldattal was measured in the 360-800 nm wavelength range. The organic-C content of the extracts was determined with Turin-method (Búzás, 1988).

Results and discussion

The chemical examination of the selected samples showed clearly the acidifying effect of fertilization that was moderated by liming. The humus content increased with the increasing fertilizer doses both in limed and non-limed experiments.

Analysis of the hot water extractable organic substances indicated that in soils treated with lime the organic C-content was approximately one order of magnitude greater than in untreated soils and increased slightly with the increasing fertilization doses (*Figure 1.*). This increase revealed clearly in the spectra recorded in the UV – range (*Figure 1.*). In non-limed soils those organic substances were represented in a very small amount and the effect of fertilization was not detectable.

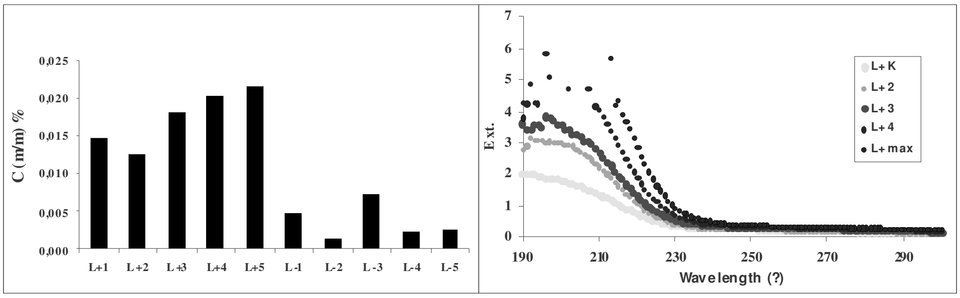

Figure 1. Effect of fertilization and liming on the organic C-content and the extinction of HWC of the selected soil samples.

Extinction of the extracts prepared according to Hargitai was measured and the ratio of the extinctions was figured (*Figure 2.*) in the 360-620 nm wavelength range and also at 465 nm (Q). From the results of limed experiments we deduced that increasing fertilizer doses enhanced the ratio of humic substances with smaller molecular weight bonded weakly to the clay particles.

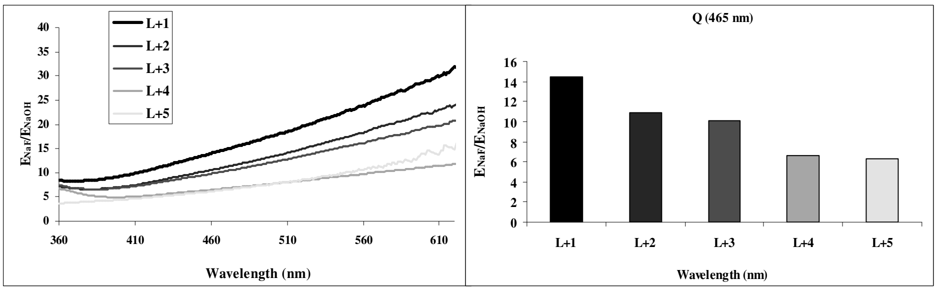

Figure 2. Effect of fertilization on the ratio of extinctions of NaOH- and NaF-soluble humic substances of samples from limed experiments.

The Q of unlimed samples was approximately one order of magnitude lower than that of the limed samples (*Figure 3.*). That result suggests that without lime amelioration the ratio of humic substances adsorbed to clay minerals (NaF-soluble) decreased. In contrast to limed experiments unlimed samples did not show an unambiguous tendency as a result of fertilization (only the control site had an outstanding Q number).

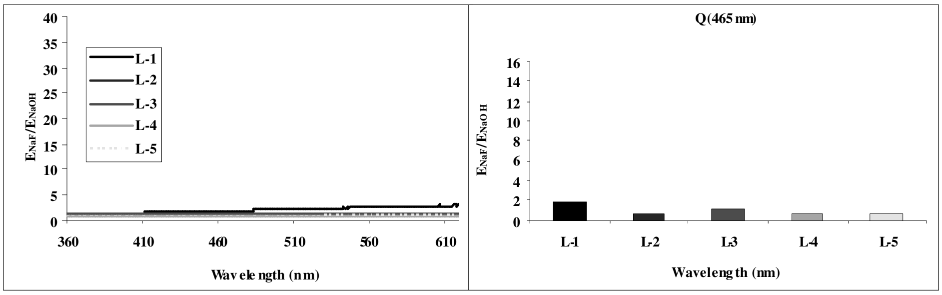

Figure 3. Effect of fertilization on the ratio of extinctions of NaOH- and NaF-soluble humic substances of samples from non-limed experiments.

Determining the organic C-content of the extracts we found that liming modified remarkably the ratio of organic matter fractions soluble in different solutions and attached in different degree to the clay particles of the soil. In limed experiments the amount of humic substances with greater molecular weight increased compared to the non-limed samples while there was a decrease in the amount of raw humic substances with smaller molecular weight. The effect of fertilization revealed in the increasing amount of NaOH-soluble fraction. The distribution of the organic C-content between the different fractions is summarized in *Table 2.*

 DOI: 10.1556/Novenyterm.60.2011.Suppl.2

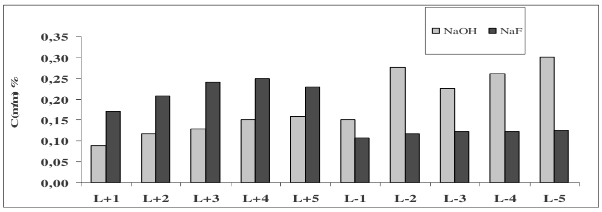

Figure 4. Effect of fertilization and liming on the NaOH- and NaF-soluble organic C-content of the soil.

Table 2. Distribution of the organic C-content between the different fractions.

Label		L+1	L+2	L+3	L+4	L+5	L-1	L-2	L-3	L-4	L-5
Organic C-content $(m\ m^{-1})$%	Total	1.44	1.53	1.56	0.56	1.55	1.38	1.53	1.51	1.51	1.58
	HWE	0.015	0.013	0.018	0.020	0.022	0.005	0.001	0.007	0.002	0.003
	NaOH	0.09	0.12	0.13	0.15	0.16	0.15	0.28	0.23	0.26	0.30
	NaF	0.17	0.21	0.24	0.25	0.23	0.11	0.12	0.12	0.12	0.13

Conclusions

The examination of extinction and C-content of humic matter fractions showed that fertilization and ameliorative liming affected significantly the ratio of these materials in the soil. In case of liming the humus stability number (Q) decreased, the ratio of organic matter with smaller molecular weight increased as a result of fertilization. In case of unlimed experiments the organic C-content of NaOH-soluble fraction increased while the amount of NaF-soluble C and HWC did not show any changing as a result of fertilization, but the Q decreased significantly compared to the control site. Meliorativ liming increased significantly the humus stability number. The hot water extractable organic C-content increased with one order of magnitude as a result of liming.

Acknowledgements

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THE INFLUENCE OF DIFFERENT SOIL TILLAGE AND TOP-DRESSING MANAGEMENT ON POST-HARVEST SOWN MILLET

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Abstract: Post-harvest cropping is one of the solutions to the growing demands both in food and bio-energy. The millet crop (*Panicum miliaceum*) trials were set up at three sites in northeastern Croatia during the summers of 2009 and 2010. After the harvests of main crops (winter barley, winter wheat or oilseed rape), three soil tillage treatments were applied: CT) mouldboard ploughing (25-30 cm deep), followed by disk harrowing and seedbed preparation; HDH) two passes by disk harrow (15-20 cm deep), followed by seedbed preparation, and; LDH) single pass of disk harrow only. Beside the no-side-dressing control (NO), four side-dressing were applied twice: KAN) 100 kg ha^{-1} KAN (27 % N) in granular form; UF) 60 kg ha^{-1} urea (46 % N), applied as 5 % foliar fertilizer; PM1) 8 l ha^{-1} of foliar fertilizer "Profert Mara", which contains both macro (N, P, K, Ca) and micro (B, Cu, Fe, Mn, Mo and Zn) nutrients, and PM2) double rate of PM1. There were no significant differences among soil tillage treatments (1895, 1932 and 1902 kg ha^{-1} for CT, HDH and LDH, respectively). In both years, all side-dressing treatments had higher yield than control (1541 kg ha^{-1}). Treatments KAN and UF were not different (1744 and 1848 kg ha^{-1}), but they had lower yield than PM1 (2009 kg ha^{-1}). The highest yield was on PM2 (2408 kg ha^{-1}). Results are suggesting better effects of foliar than granular fertilizers for post-harvest sown millet, either in drought (year 2009) or over wet (year 2010) conditions.

Keywords: millet, post-harvest crop, soil tillage, side-dressing, foliar fertilization

Introduction

Modern agriculture of high yields is based not only on genetic potential of crops, but also on agrotechniques, where fertilization is accounted for up to 50 % of crop yield. However, the dangers of excessive and careless fertilization for the environment and human health have been recognized long time ago as one of the major problems of modern agriculture (Bohlool et al., 1992). Among the nutrients that are used for fertilization, the strongest reaction is caused by nitrogen, but the losses of added nitrogen fertilizers can be very significant. For a variety of crops, from 5 to even 60% (Ayoub et al., 1995) is not being utilized by the crop, because nitrogen in the soil is either fixed by microorganisms (60%), or lost through the processes of denitrification (30%) or leaching (20%), mostly in the nitrate form (Parker, 1972). These processes, especially the leaching of nutrients from the soil, may in the near future become even more pronounced, due to the impact of extreme weather events (droughts, torrential rains), where some regions can be severely affected (Várallyay, 2010). Application of the needed nutrients through incorporation by primary soil tillage and a few top dressings reduces losses, but this method can also lose up to 50% of nutrients (Lopez-Bellido et al., 2006). Application of foliar fertilizers is one of the potential solutions to environmental pollution reduction by excess nitrogen, since the total amount of applied nutrients is significantly lower, with higher utilization ratio (Gooding and Davies, 1992). Combined NPK foliar fertilizer, with the addition of other macro-and micro-elements are also increasingly used for various crops and other plant species (Galić et al., 2006), but not always with very positive results (Haq and Mallarino, 2000), so there

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is a need for further research to establish their effectiveness. Further reduction of nitrogen pollution could be achieved by selecting crops with low nitrogen requirement, such as millet (*Panicum miliaceum* L.). Furthermore, grown as a post-harvest crop, it can utilize nitrogen, which remained after the main crop was harvested (Anderson et al., 1986), and thus reduce leaching and prolong the cycle of circulation of nitrogen in the soil. The main objective of this research was to determine effects of different soil tillage and foliar fertilization cropping systems on millet in post-harvest cultivation.

Materials and methods

The trial fields for this research have been established at the Family Agricultural Enterprise (FAE) "Matricaria", near Široko Polje, FAE "Kolar Darko" near Valpovo, and FAE "Stipešević Ivica" near Poljanci, Croatia, during the summers of 2009 and 2010. The soil type was the eutric brown soil, with favorable crop production properties. The millet (*Panicum miliaceum* L.) cultivar "Kornberg" was used in both years, obtained from the seed producer RWA, with the seeding norm of 15 kg ha^{-1} and aimed crop density of 180-200 plants m^{-2}. The preceding crops were winter barley (*Hordeum sativum* L.) in year 2009 and oilseed rape (*Brassica napus* L.) or winter wheat (*Triticum aestivum* L.; site Valpovo only) in year 2010. In both years, the agrotechniques for preceding crops included soil preparation by conventional tillage, based on autumn moldboard ploughing before fine seedbed preparation by disk harrowing and seedbed cultivator and usually recommended fertilization for both crops (120 kg N, 100 kg P and 120 kg K per ha). The experiments were set up as the split-plot design in four repetitions, with three levels of soil tillage and five sub-levels of side-dressing, with basic plot size for side-dressing of 2 m x 5 m. Treatments of soil tillage were as follows: CT) conventional soil tillage, executed by moldboard ploughing up to 25-30 cm depth, followed by two light disk harrow passages at 10-15 cm and with seedbed preparation cultivator, with the finest seedbed preparation and no previous crop residues on the soil surface; MD) one passage with heavy disk harrow up to 15-20 cm, followed by two passages of light disk harrow and seedbed preparation cultivator, with around 30% of soil surface covered by previous crop's straw; and SD) single passage by heavy disk harrow up to 15-20 cm, followed by seedbed preparation cultivator, with coarse seedbed preparation and over 50% of soil surface covered by previous crop's residues. Pre-seeding fertilization was omitted for post-harvest sown millet. The seeding was performed with available cereal seeders at the depth of 2-3 cm. In year 2009 seeding had been performed in the first week of July, and in year 2010 in the third week of July. Sub-treatments of side-dressing were as follows: NO) no-side-dressing control; KAN) two applications of 100 kg ha^{-1} KAN (27% N) in granular form; UF) two applications of 60 kg ha^{-1} urea (46% N), applied as 5% foliar fertilizer; PM1) two applications of 8 l ha^{-1} of foliar fertilizer "Profert Mara", which contains both macro (N, P, K, Ca) and micro (B, Cu, Fe, Mn, Mo and Zn) nutrients, and PM2) double rate of PM1, applied also twice. Side-dressings were performed 4 and 6 weeks after the seeding in each year. Harvests were performed manually in the last week of September 2009, and the second week of October 2010, and grains were separated later on by laboratory thresher. Harvested millet grain yields were weighted and sub-sampled for grain moisture and yield component calculations (hectoliter mass and 1000 grains mass), and recalculated at the 14% moisture content. The statistical analysis of the variance

(ANOVA) of experiment was performed by SAS statistic package (V 9.1, SAS Institute, Cary, NC, USA, 1999). The Fisher protected LSD means comparisons were performed for P=0.05 significance levels for year, soil tillage, side-dressing and their interactions.

Results and discussion

The weather during both seasons is presented by *Table 1*. The summer 2009 was hot and dry, with severe drought (only 13 mm from July through September) and practically all necessary moisture for post-harvest crop was supplied from the soil retention capacity only. On the other hand, the summer 2010 was extremely wet, with 500 mm from June to October, which caused numerous floods not only in Croatia but also in other European countries.

Table 1. Weather patterns in summer 2009 and 2010, CDA weather station Đakovo, Croatia

		June	July	August	September	October		
T (°C)	2009	18.9	22.8	22.5	19.2	18.3	means	20.3
	2010	19.9	22.7	21.2	15.9	15.1		19.0
P (mm)	2009	109	1	1	1	10	sums	122
	2010	249	109	95	2	45		500

Table 2. Average grain yield (kg ha^{-1}) of millet, years 2009 and 2010

	NO	KAN	UF	PM1	PM2	x_{till}
	Year 2009					
CT	2120 a†	2205 a	2254 a	2284 a	2406 a	2254 A
HDH	2191 a	2379 b	2578 b	2785 b	3107 b	2608 B
LDH	2369 b	2678 c	2695 c	3222 c	3215 c	2836 B
$x_{side\text{-}dressing}$	2227 A	2421 B	2509 B	2764 C	2909 D	
	Year 2010					
CT	1281 c	1483 b	1601 b	1600 c	1719 b	1537 B
HDH	798 b	841 a	959 a	1004 a	2681 c	1257 AB
LDH	485 a	880 a	1002 a	1159 b	1319 a	969 A
$x_{side\text{-}dressing}$	855 A	1068 B	1187 BC	1253 C	1906 D	
	Means					
CT	1701 b	1844 b	1928 b	1942 a	2063 a	1895 A
HDH	1495 a	1610 a	1769 a	1895 a	2894 b	1932 A
LDH	1427 a	1779 ab	1849 ab	2191 a	2267 a	1902 A
$x_{side\text{-}dressing}$	1541 A	1744 B	1848 B	2009 C	2408 D	

†means labeled with the same lowercase or uppercase letter for same Till, Side-dressing or Till x Side-dressing average in each Year or Means group are not statistically different at P>0.05 significance level.

The results of millet grain yields are presented in the *Table 2*. Although there were no significant differences among average soil tillage treatments (1895, 1932 and 1902 kg ha^{-1} for CT, HDH and LDH, respectively), it is visible that in a dry year, such as 2009, when the soil moisture conservation is the primary task of soil tillage, lesser soil disturbance by shallower soil tillage and better soil surface mulch by harvest residues are superior to ploughing. On the contrary, excessive water had been managed better with deeper soil tillage, where rhizosphere had better drainage and soil dried faster than in shallow soil tillage. Nelson and Fenster (1983) also found that soil tillage for millet

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didn't make impact on grain yield. In both years, all side-dressing treatments had higher yield than control, with mean of 1541 kg ha^{-1}. KAN and UF treatments were not different (means of 1744 and 1848 kg ha^{-1}), but they had lower yield than PM1 (2009 kg ha^{-1}) and PM2 (2408 kg ha^{-1}). Higher yields can be explained by better utilization of N with addition of P, as observed by Fofana et al. (2008).

Conclusions

Results of the research of the effects of soil tillage and side-dressing systems for post-harvest sown millet in Northeastern Croatia indicate better effects of foliar than granular fertilizers for post-harvest sown millet, either in drought or excessive wet conditions. To cope with both weather extremes, the results suggest that the soil tillage used for post-harvest sown millet establishment should have both good soil moisture retention capability for drought and reasonable percolation of excess water below millet rhyzosphere for avoidance of water logging problems.

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SYNERGISM OF CLAY-LOAMY SOIL TILLAGE, PHYSICAL PROPERTIES AND YIELD OF WINTER RAPE SEED

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Abstract: Optimal development of crops is very much effected by suitable land use. Synergism of different soil tillage, physical soil properties and yields of winter rape is shown and quantified here. Experiments were carried out between 2007 and 2009 on clay-loamy soil. Three soil tillage technologies were examined (CT-conventional tillage, MT-minimum tillage, NT-no-tillage). Bulk density, total porosity, maximum capillary capacity and available water capacity were tested. Yields of winter rape seeds were evaluated. Direct sowing without ploughing (no-tillage) on clay-loamy soil increased bulk density and decreased porosity in comparison with conventional tillage and minimum tillage as well. Maximum capillary capacity and available water capacity were relatively equal and ascertained values were typical for given soil texture. Decreasing of intensity of soil cultivation caused also decreasing yields of winter rape seed. The best yields were obtained in conventional tillage (in average 3.47 t ha^{-1}). Minimum tillage (average yield 3.27 t ha^{-1}) appears to be more efficient in comparison with direct sowing into no-tilled soil (average yield 2.25 t ha^{-1}).

Keywords: clay-loamy soil, physical properties, soil tillage, yield of winter rape

Introduction

The East Slovak Lowland is a very important agricultural area of Slovak Republic, with very specific soil and climatic conditions. High presence of heavy soil with high content of clay elements is characteristic for this area. Soil tillage is basic element of the technological systems of agricultural plant cultivation on arable land. Tillage has impact not only on soil properties, but also on the efficiency of crop production (Birkás, 2004). Winter rape has a permanent place in crop rotations. During the past years in winter rape production conservation soil tillage is used frequently along with conventional tillage. Environment conditions and soil tillage technologies effect the yield rape formation (Kátai, 2010; Muchová and Fazekašová, 2010).
The aim of this work was to determine synergism of physical properties of clay-loamy soil, different tillage and yield of winter rape seed.

Materials and methods

Between 2007 and 2009 at the experiment site of the Slovak Agricultural Research Center Piešťany – Research Institute of Agroecology Michalovce, a field experiment took place on heavy clay-loamy soil. The experimental site is located in Milhostov, on the East Slovak Lowland near the city of Trebišov with 48° 40' N latitude, 21° 44' E longitude and 101 m altitude. Gleyic Fluvisol (FM_G) in Milhostov is characterized as heavy, clay-loamy soils with average content of clay particles higher than 53%. Gleyic Fluvisol was formed on heavy alluvial sediments during the long-time contact with groundwater and surface water. The topsoil has lump aggregate structure with high binding ability and it has a weak perviousness in its whole profile. At the depth of 0.7–0.8 m of soil profile, a layer of dark grey clay is found. The level of underground water is high. Experimental area is characterized as warm and very dry lowland continental climate region T 03. The weather conditions at the site during the experimental years are shown in *Figure 1.*

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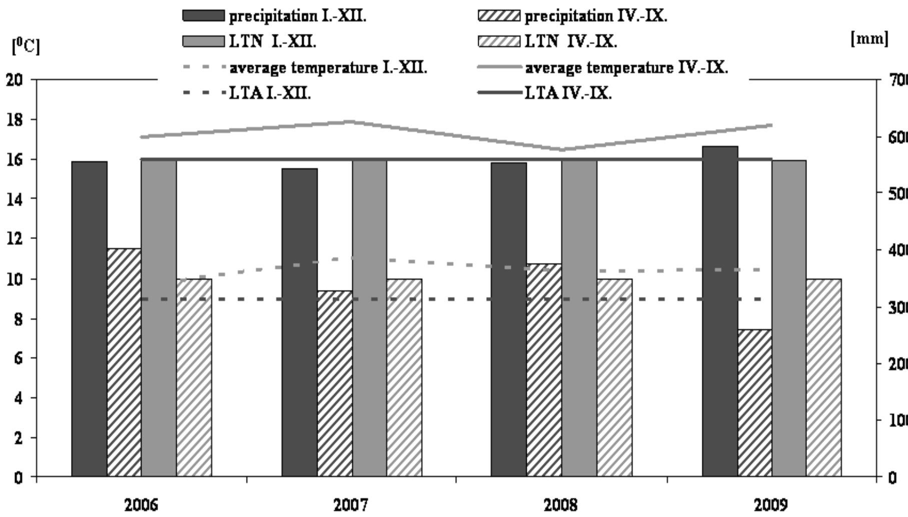
Physical and hydro-physical properties of clay-loamy soil were determined based on undisturbed soil samples taken once a year in spring (in spring crops 14 days after sowing, in winter crops in April). Sampling was carried out by Kopecký method sampling cylinders with 100 cm^3 volume from topsoil, depth 0.0 – 0.3 m, each 0.1 m (with four replications). Soil bulk density (BD, $kg.m^{-3}$), total porosity (Po, %), maximum capillary capacity (MCC, %) and available water capacity (AWC, %) were determined as described by Fiala et al. (1999).
In field experiment three tillage technologies of clay-loamy soil were examined: conventional tillage (CT) – traditional method with ploughing by requirements of winter rape, minimum tillage (MT) – for the soil preparation a skive plough-harrow was used, no-tillage (NT) – direct sowing without ploughing by sowing machine Great Plains.



LTA – long-time average, LTN – long-time normal

Figure 1. The course of weather conditions

Two variants of fertilization with different nitrogen dose (F1 – higher dose of N, F2 – lower dose of N) were observed. Doses of mineral fertilization for winter rape were the following: F1 – 200 kg N ha^{-1} + 50 kg P ha^{-1} + 150 kg K ha^{-1}; F2 – 150 kg N ha^{-1} + 50 kg P ha^{-1} + 150 kg K ha^{-1}.
Winter rape was harvested by a small plot harvester from the area of 34.5 m^2. The results presented here are the average from four repetitions.
Synergism of observed parameters and factors was quantified by analysing the variance (Chajdiak, 2005).

Results and discussion

Bulk density and total porosity are highly effected by soil tillage. Details of values of selected physical and hydro-physical characteristics of clay-loamy Gleyic Fluvisol in various tillage systems are presented in *Table 1*. In observed experimental period years

2007 – 2009 values of bulk density ranged from 1399 kg m^{-3} to 1484 kg m^{-3}. In average the lowest bulk density was determined at minimum tillage and bulk density increased in the following order MT < CT < NT. Total porosity corresponds with bulk density values. In our experiment, the values of porosity were within 46.32 – 42.92 % range. Average porosity decreased in the following order MT > CT > NT.

Table 1. The average values of physical properties of clay-loamy soil

Year	Soil tillage	BD [kg m^{-3}]	Po [%]	MCC [%]	AWC [%]
2007	CT	1464	42.92	35.30	7.90
	MT	1460	43.43	35.53	11.18
	NT	1484	43.23	35.77	10.67
2008	CT	1428	45.73	37.38	10.61
	MT	1399	46.32	39.96	13.77
	NT	1465	44.30	36.95	10.19
2009	CT	1440	43.84	39.20	17.09
	MT	1452	43.08	38.05	15.95
	NT	1470	43.31	37.34	15.64
average	CT	1444	44.16	37.29	11.87
	MT	1437	44.28	37.84	13.63
	NT	1470	43.61	36.69	12.17

Values of maximum capillary capacity were balanced in all three tillage variants (35.30 – 39.96%), but the lowest were recorded in year 2007. It was also related to the course of weather conditions. The influence of soil tillage system on this soil parameter was not discovered. Similar results were also published by Dam et al. (2006) and Kotorová – Mati (2008). In average, the values of maximum capillary were increasing in the following order NT < CT < MT.

The available water capacity is connected with content of clay particles in soil profile and in heavy soils the values are very low. It was evaluated in our experiment, when its values were in the range between 7.90 and 17.09%.

The productive year has significant effect on final yield of winter rape seed. In all observed years, the course of meteorological conditions was important at the beginning of stands, in autumn time and during the winter period. The cause of lower rape seed yields in year 2007 was extremely dry and cold weather in April, which slowed down tillering of winter rape plants. Flowering stands were damaged by late spring frosts and the amount of winter rape siliques decreased by 25%.

Table 2. The average yields of winter rape seed [t ha^{-1}]

Year	CT	MT	TT	xY
2007	3.11	3.02	2.69	2.94
2008	3.51	3.40	1.62	2.84
2009	3.79	3.39	2.45	3.21
xT	3.47	3.27	2.25	2.99

In years 2008 and 2009, the course of meteorological conditions was more favorable and yields of rape seeds were higher (*Table 2.*). On the average, the lowest yields were obtained from no-till variant and yields were increasing in the following order NT < MT

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< CT. From the comparison of rape seed yields in years 2007 and 2008, the differences between conventional and minimum variant weren't significant. A more pronounced difference was determined in year 2009 (0.4 t ha^{-1}). Higher yields of winter rape seed were obtained from variant F1 with higher dose of nitrogen fertilizer.

Table 3. Regression analysis of observed parameters

Source of variability	D. f.	BD MS	Po MS	MCC MS	AWC MS	Yield MS
Year (A)	2	9120.890++	37.033++	54.766++	258.181++	0.871++
Fertilization (B)	1	8.000++	0.016++	0.051++	0.051++	0.961++
Soil tillage (C)	2	8801.560++	3.021++	8.010++	21.347++	10.167++
Interactions						
AB	2	10.667++	0.016++	0.361++	0.361++	0.037++
AC	4	1574.560++	3.677++	10.311++	19.414++	1.488++
BC	2	312.667++	0.461++	0.271++	0.271++	0.027++
ABC	4	10.333++	0.013++	0.266++	0.266++	0.032++
Residual	12	0.00011	1.4E-7	2.8E-6	2.8E-6	3.3E-7
Total	71					

As the result of statistical testing data (*Table 3.*), we can see statistically significant effect of all observed factors (year, fertilization, soil tillage) on evaluated soil parameters and winter rape seed yields. The Interactions (*Table 3.*) indicate synergisms of productive year, fertilization and also soil tillage system on yield of winter rape seed.

Conclusions

Higher bulk density and lower total porosity were ascertained at direct sowing without ploughing (no-tillage) in comparison with conventional tillage and minimum tillage by producing winter rape on clay-loamy soil of the East Slovak Lowland. Maximum capillary capacity and available water capacity were relatively equal and ascertained values were typical for the given soil type.

The final yield of winter rape seed was significantly influenced by meteorological conditions and the productive year. Based on obtained data for clay-loamy soils on the East Slovak Lowland, minimum tillage for found of winter rape stands are better than no-till system with direct sowing.

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EFFECT OF SOIL TILLAGE AND CROP MANAGEMENT ON SOIL PHYSICAL CHARACTERISTICS AND YIELD RESPONSE OF SUGAR BEET, SPRING BARLEY AND SUNFLOWER CROP ROTATION PATTERN

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Abstract: The aim of research was to evaluate the effect of conventional and reduced tillage, farm yard manure and residue management practices on crop yield, soil bulk density (SBD) and total porosity on silt loam Haplic Cherozems. During 2004-2006, the sugar beet-spring barley-sunflower crop sequence was evaluated at the experimental farm in south-western Slovakia. The main plot with four replicates was 10 m by 550 m. The soil tillage treatments were as follows: T1 conventional mould board ploughing with farm yard manure application to sugar beet and incorporation of aboveground biomass of forecrops; T2 conventional mould board ploughing without organic fertilization; T3 reduced till. During June the soil samples were taken from 0.05-0.10 m, 0.1-0.2 m, 0.2-0.3 m. The SBD and total porosity was influenced by growing practices, tillage system and weather conditions of evaluated years. The positive effect of farm yard manure on total porosity was noted in 2004 during sugar beet phase which is in relationship with SBD 1.266 $t.m^{-3}$-1.279 $t.m^{-3}$ in topsoil layers 0.05-0.20 m. In subsequent evaluated years 2005-2006 the topsoil layers 0.05-0.20 m were more compacted with comparison to 2004. The conventional mould board ploughing with farm yard manure and incorporation of aboveground biomass form the most suitable soil environment (SBD 1.395 $t.m^{-3}$, total porosity 43.65%). Reduced till system decreased the yield of sugar beet up to 19.5%, but we recommended reduced till for spring barley and sunflower without significant decrease of yield in this specific crop site.

Keywords: manure, porosity, soil bulk density, tillage, yield

Introduction

Environmentally sound tillage techniques as one of the most important prevention method of soil degradation process, indicate a positive impact on soil environmental components, as reduced energy needs, reduced erosion along with reduced run-off of nutrients and pesticides subsequently affecting water quality and farm management (Fazekašová et al., 2007; Týr, 2008; Birkás et al., 2009; Molnárová, 2010; Smutny, 2010). The importance and influence of tillage systems on physical and environmental characteristics is broadly recognized (Lacko-Bartošová, 2006; Birkás et al., 2008b; Muchová et al., 2010). The aim of this work was to evaluate the influence of conventional and reduced tillage, farm yard manure and residue management on the soil bulk density, total porosity and yield of sugar beet, spring barley and sunflower.

Materials and methods

The field trial was conducted at the experimental farm Kalná nad Hronom (south-west Slovakia) in 2004-2006. Experimental farm is situated in warm and moderate arid climatic region. The average annual rainfall is 539,0 mm and temperature 10,2˚C. Sum of precipitation for period of April-June was 178 mm in 2004 and 163 mm in 2005. Figure for 2006 are 218 mm which is 41 mm above long-term average of 177 mm. Soil is silt loam Haplic Chernozems. The particle-size distribution is 280,3 g kg^{-1} of sand,

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533,7 g kg^{-1} of silt and 186,0 g kg^{-1} of clay. In 2004 before the start of the present study average soil bulk density of the soil profile (0-0,3 m) was 1,49 t m^{-3}, porosity 40,1%, total nitrogen 1400 mg kg^{-1}, organic carbon 15,1 g kg^{-1} and maximum water capacity 34,7%. Soil bulk density (SBD) and total porosity were determined for 0,05-0,10 m, 0,1-0,20 m, 0,2-0,3 m soil layers. Bulk samples were taken by cylinders with the cubic content 0,001m^3 in four replicates in the beginning of July. The yield was determined by conventional harvest machines. The sugar beet-spring barley-sunflower crop sequence was evaluated. The main plot with four replicates was 10 m by 550 m. The soil tillage treatments were as follows: T1 conventional mould board ploughing with 40 t ha^{-1} farm yard manure (FYM) application to sugar beet and incorporation of aboveground biomass of sugar beet, spring barley and sunflower; T2 conventional mould board ploughing without organic manure; T3 reduced till by Horsch disc coulters tools.

Results and discussion

Figures of total porosity and SBD under different soil tillage and crop management are documented in *Table 1.* and *2*. The positive effect of FYM was noted in 2004 during sugar beat phase of rotation in first and second soil layers 0,05-0,10 m (T1 47,47%) and 0,10-0,20 m (46,93%) which is in relationship with SBD 1,266 t m^{-3} and 1,279 t m^{-3} in topsoil layers 0,5-0,20 m. In subsequent evaluated years 2005-2006 the topsoil layers 0,5-0,20 m were more compacted with comparison to 2004 after first year of FYM application. The most compacted soil layers were noted in 2006 under canopy of sunflower in conventional treatment without organic manure application. In evaluated soil layers SBD ranged from 1,556 to 1,672 t m^{-3}. The knowledge of the soil porosity and SBD is of the highest importance because the whole dynamics of soil depends on it (Kováč et al., 2005; Boja et al., 2008). We evaluated temporal and spatial dynamics of porosity and SBD. The incorporation of FYM and aboveground biomass significantly influenced the increase of total porosity with comparison to lack of organic matter incorporation (*Table 1.*).

Table 1. Total soil porosity under different soil tillage systems at Kalná nad Hronom, 2004–2006

Soil layer	T1			T2			T3		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
0.05 - 0.10	47.47	43.39	41.54	40.20	42.52	34.17	44.65	44.88	41.61
0.10 - 0.20	46.93	44.40	42.82	40.32	41.38	37.66	47.17	41.91	42.93
0.20 - 0.30	39.42	46.92	40.00	39.61	41.31	38.50	44.10	47.83	40.00

*Table 2. S*oil bulk density (t m^{-3}) under different soil tillage systems at Kalná nad Hronom, 2004–2006

Soil layer	T1			T2			T3		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
0.05 - 0.10	1.266	1.438	1.485	1.513	1.460	1.672	1.406	1.400	1.483
0.10 - 0.20	1.279	1.340	1.427	1.510	1.485	1.579	1.342	1.400	1.448
0.20 - 0.30	1.460	1.343	1.518	1.528	1.485	1.556	1.420	1.320	1.518

The effect of tillage and crops grown on total porosity and soil bulk density is documented in the *Table 3.* and *4*. In average, no statistical differences between soil layers were noted. Application of FYM and incorporation of aboveground biomass (T1) significantly improved the porosity state.

Table 3. Effect of tillage systems and crops grown on total porosity (%) in evaluated soil layers at Kalná nad Hronom, 2004–2006 (P<0,05)

Tillage		Depth		Crops	
T1	43.65b	0.05-0.10 m	42.27a	sugar beet	43.31b
T2	41.09a	0.10-0.20 m	42.83a	barley	43.83b
T3	42.31ab	0.20-0.30 m	41.96a	sunflower	39.91a

Weather conditions with tillage treatments create specific physical conditions. This is in accordance with the information about differences of soil physical properties caused by different tillage, published by Skukla et al. (2003) and Lacko-Bartošová et al. (2010). Soil compaction is the rearrangement of soil aggregates and/or particles by reducing or even eliminating voids and pores between aggregates and particles, causing the soil to become denser. The porosity of the internal aggregates is also influenced (Birkás et al., 2008a).

Table 4. Effect of tillage systems and crops grown on soil bulk density (t m^{-3}) in evaluated soil layers at Kalná nad Hronom, 2004–2006 (P<0,05)

Tillage		Depth		Crops	
T1	1.3951a	0.05-0.10 m	1.4581a	sugar beet	1.4137a
T2	1.4922b	0.10-0.20 m	1.4233a	barley	1.4078a
T3	1.455ab	0.20-0.30 m	1.4608a	sunflower	1.5206b

Conventional mouldboard ploughing with appropriate residue management (T1) created significantly better soil condition but no significant differences between soils layers were noted. Significantly higher soil compaction was noted under canopy of sunflower in wet year 2006. Soil tillage creates also predisposition for yield formation (Molnárová, 2008). We investigated the influence of tillage systems on two row crops and one cereal.

Table 5. Yield of sugar beet, sunflower and spring barley (t ha^{-1}) under different soil tillage systems in the years 2004–2006 (P<0,05)

Tillage	Sugar beet yield	Sunflower yield	Spring barley yield
T1	73.0 c	3.46 a	6.63 a
T2	68.2 b	3.37 a	6.53 a
T3	56.8 a	3.25 a	6.11 a

Yield of sunflower and spring barley did not depend on tillage system. But tillage significantly influenced sugar beet yield (*Table 5*). The highest yield 73 t ha^{-1} was in conventional mould board ploughing with FYM application and incorporation of aboveground biomass (T1), the significantly lowest yield of sugar beet was in reduced tillage system (T3). Similar results were detected also by Marinkovic et al. (2007).

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Conclusions

According to three years study the conventional mould board ploughing with FYM and incorporation of aboveground biomass of forecrops, significantly form the better soil environment expressed by SBD and total porosity with comparison to mould board ploughing with absence of organic manure. We observed no significant differences of total porosity and soil compaction in reduced tillage treatment with comparison to conventional ones. Reduced tillage significantly decreased the yield of sugar beet only. We recommended the reduced tillage for prevention and reduction of soil degradation processes and sustainable production of sunflower and spring barley in this specific area of Slovak region. The further investigation for adoption of appropriate tillage technique is needed.

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EFFECT OF SOIL TILLAGE ON MOISTURE CONTENT AND TEMPERATURE OF THE SOIL IN OILSEED RAPE

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Abstract: The effect of three different soil tillage systems (1. ploughing, 2. loosening and 3. tillage+sowing in one pass) on soil moisture content and temperature was studied in winter oilseed rape in three different sites of Hungary. The effect of the experimental treatments were significant mainly in the first half of the growing period. Due to the extremely rainy weather condition during the Spring and Summer period the differences between the effects of the experimental treatments had been reduced.

Keywords: soil tillage, penetration resistance, moisture, temperature, oilseed rape

Introduction

The physical condition of soil through its basic role in porosity determines the water and air characteristics of soil. Since the structure of soil can be deteriorated as a result of environmental effect and human activity, beside aggregate size distribution water resistance of soil aggregates is also a very important property (Dexter, 1998).

Soil tillage has a direct effect on the physical condition of soil. This effect can be favourable or not and its duration is also different. For this reason the application of soil tillage should be always proper and careful, otherwise one has to take account with the deterioration of soil structure, which through the functional transformation of the porosity has disadvantageous effect on the water and air management of the soil (Várallyay, 1993). Birkás (2008 and 2009) and Birkás et al. (2009) warn against regular, schematic and monotonous soil tillage even with plough, disc and cultivators equipped with horizontal blades since tillage pan can be created easily.

Soil tillage generally hase a basic role in crop production. Some of the crops more, some of them less demanding. Torabi et al. (2008) found that rape had high standards. In our study the effect of different soil tillage systems on soil physical properties was tested in winter oilseed rape.

Materials and methods

The aim of the study was to compare three different soil tillage systems in winter oilseed rape production (1. ploughing, 2. loosening and 3. tillage+sowing in one pass) in different sites of Hungary (Site 1: Újudvar – nearby Mosonmagyaróvár , Site 2: Szekszárd, Site 3: Hódmezővásárhely). The experimental treatments had three replications within the farm-scale fields. The previous crop was winter wheat. The variants of soil tillage systems were carried out in the following passes:

1. stubble tillage, deep ploughing+secoundary tillage, seedbed preparation+sowing,
2. stubble tillage, middeep loosening+secoundary tillage, seedbed preparation+sowing
3. tillage (with disc, heavy cultivator and roller combination)+sowing in one pass.

The date of sowing was 24-28 August 2009.

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Soil moisture content and temperature were registered four times during the growing period in October 2009 as well as March, June and July 2010 by an Aquaterr T300 device as well as gravimetric method in a depth of 0-20 cm and 20-40 cm, respectively. Ten measurements were taken per plot.
Analysis of variance was used to test the statistical significance of the treatments.

Results and discussion

The effect of the different soil tillage systems was significant mainly at the beginning of the growing season. The significant effect of soil tillage on the moisture content and temperature of the soil decreased gradually during the growing period. In the Autumn significant differences were found between the effect of soil tillage systems in case of all the measured values in the 20-40 cm deep soil layer and in most of the cases in the 0-20 cm deep layer (*Table 1.*).

Table 1. Soil moisture content and temperature in the Autumn (9-10th October 2009)

Site 1 (Újudvar)		Site 2 (Szekszárd)		Site 3 (Hódmezővásárhely)		Tillage systems	Depth (cm)
Mean	$LSD_{5\%}$	Mean	$LSD_{5\%}$	Mean	$LSD_{5\%}$		
Moisture content (v/v %)							
35.67	NS	39.60	3.05	38.13	3.77	Ploughing	0-20
36.77		29.73		28.93		Loosening	
33.70		28.30		29.10		Tillage+sowing	
44.53	2.53	37.00	3.35	51.20	4.02	Ploughing	20-40
38.50		32.87		39.37		Loosening	
43.50		39.77		46.67		Tillage+sowing	
Temperature (°C)							
21.70	0.31	24.20	NS	24.47	0.21	Ploughing	0-20
21.93		24.03		24.67		Loosening	
22.37		24.07		24.90		Tillage+sowing	
21.77	0,27	24.23	0.11	24.43	0.19	Ploughing	20-40
21.87		24.00		24.53		Loosening	
22.33		24.03		24.83		Tillage+sowing	

In Site 2 and 3 (where the weather was dryer than in case of Site 1) soil moisture content was significantly higher in the 0-20 cm layer when ploughing was the primary tillage compared to the other variants. Between the effect of loosening and tillage+sowing in one pass no significant differences were observed.
In the 20-40 cm deep layer loosening resulted in significantly lower soil moisture content compared to the other tillage variants in case of all the three sites. In Site 3 (where the weather was the dryest) ploughing resulted in significantly higher moisture content even than tillage+sowing in one pass.
The effect of soil tillage on soil temperature was also significant in case of all the measured values in the 20-40 cm soil layer and in most of the cases in the 0-20 cm layer (*Table 1.*).

In Site 1 and 3 soil temperature was significantly higher in the 0-20 cm layer when tillage+sowing was applied in one pass compared to the other variants of tillage. Between the effect of ploughing and loosening no significant differences were observed. In the 20-40 cm deep layer tillage+sowing in one pass also resulted in significantly higher temperature values in Site 1 and 3, while in case of Site 2 ploughing resulted in slightly, but significantly higher temperature values than the other variants.
Due to the effect of the weather condition during the Winter by the beginning of the Spring the differences between the effect of soil tillage systems on the measured soil parameters reduced dramatically. Significant differences were measured only in case of Site 2 and 3 in the 0-20 cm layer between soil moisture values (*Table 2.*). In case of Site 2 ploughing, while in case of Site 3 tillage+sowing in one pass resulted in significantly higher soil moisture content compared to the other variants.

Table 2. Soil moisture content in the early Spring (12-23rd March 2010)

Site 1 (Újudvar)		Site 2 (Szekszárd)		Site 3 (Hódmezővásárhely)		Depth (cm)	Tillage systems
Mean	$LSD_{5\%}$	Mean	$LSD_{5\%}$	Mean	$LSD_{5\%}$		
Moisture content (v/v %)							
38.13	NS	32.33	1.77	24.20	1.72	Ploughing	0-20
38.03		28.23		23.60		Loosening	
37.70		29.63		28.97		Tillage+sowing	
41.97	NS	35.00	NS	31.53	NS	Ploughing	20-40
42.00		34.03		31.27		Loosening	
41.90		35.17		31.23		Tillage+sowing	

By the time of the later sampling occassions no significant differences were measured between the variants of soil tillage systems regarding either soil moisture content or temperature values.

Conclusions

The effects of the different soil tillage systems were significant mainly in the first half of the growing periode of the winter oilseed rape. Soil tillage resulted in significant differences in case of all the measured values in the 20-40 cm deep soil layer and in most of the cases in the 0-20 cm deep layer. By the beginning of Spring the number of significant results regarding the tested parameters reduced dramatically. At the later sampling occassions no significant differences were measured at all between the variants of soil tillage systems regarding either soil moisture content or temperature values.
It can be concluded that beside moisture content soil tillage had significant effect on soil temperature values at the beginning of the growing periode, which is also a very important factor of germination. From the six moisture and temperature test that were carried out in the two soil layers of the three sites in the Autumn the highest moisture content were combined with the lowest temperature values in three cases (Site 1 – 20-40 cm, Site 3 – 0-20 cm, Site 3 – 20-40 cm).

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MODELLING OF SOIL COMPACTION AND SATURATION DISTRIBUTION OF LOOSE AGRICULTURAL SOILS BY PENETROMETER

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Abstract: The compaction and the ideal moisture content is an important factor of sustainable land use and agriculture. The traffic and the tillage operations on loose agricultural soils cause significant soil compaction, what effects to the porosity, the volumetric moisture content distribution and therefore the development of the crop production.
To investigate the soil resistance and the saturation we performed penetrometer tests under different compaction levels. Three different kind of Hungarian, loose, agricultural soils (sand, sandy loam and clay) at different moisture contents were investigated in field and in a 80x100x80 cm soil bin in the laboratory using 3T type electronic soil layer indicator, to determine the distribution of soil's moisture content and of the penetration resistance until 40 cm depth with 1 cm depth-increment. In the laboratory experiments different loads was applied to simulate the natural process of compaction and the effect of cultivation. Effective normal stresses, deformations and the changes of penetrologs were evaluated to determine the depths of influence.

Keywords: penetrometer, porosity, saturation, agricultural soils

Introduction

The soil compaction is the main soil degradation process during land cultivation. Soil compaction reduces the pore space and effects to the soil functions related to the productivity. In the literature the soil is harmful compacted if the density is more than 1.5 g cm^{-3} and the soil resistance is higher than 3 MPa in the upper arable layer (Birkás, 1995). To maintain the sustainable land use the best cultivation management practices has to develop to minimize the further injurious effects of running tire. Due to the soil compaction is the change in the rate of soil matrix and pore volume, it can be well-characterized by physical soil assessment methods, like parallel measurements of soil resistance and humidity.
For the investigation of the vertical distribution of compacted layers and the determination of the magnitude of compaction the most frequently applied method is the soil resistance measurement with penetrometer (Szőllősi, 2003). The device can measure parallel the volumetric moisture content of the soil also. Due to the soil resistance is more sensitive for the load than the density, the penetrologs describes the compaction by more realistic way. In our investigations 3T type electronic soil layer indicator device was used in laboratory conditions.

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Materials and methods

Three different kinds of soils were chosen to cover the properties of typical Hungarian agricultural soils. The sand, sandy loam and clay have well separable properties in the system of physical soil types. The measurements were done in laboratory conditions. The description of the investigated soil samples can be found in the *Table 1*. We applied the same measurement conditions in each tests.

Table 1. The description of the investigated soil types

	Sand	Sandy loam	Clay
Genetic class	Sandy soil with humus	Meadow chernozem	Clayey meadow soil
Moisture content [%]	72	92	72
pH value	6.9	7.5	5.9
Organic matter content [%]	1.59	4.1	3.95
$CaCO_3$ content [%]	0	2.4	0
Preconsolidation pressure [bar]	0.5	0.5	0.5

In the sample preparation phase the soil was grinded and sieved with mesh sieve size 2.5 mm. We used the fraction under 2.5 mm. During the measurements we were applied three compaction levels of the soil samples in a soil bin (with dimensions 80 cm x 100 cm x 80 cm) by a plain pushing tool. To reach the different compaction levels we applied 1 bar, 2.2 bar and 7 bar vertical load. With the 1 bar load we got the “natural-like” compaction level of sedimentation, the 2.2 bar and 7 bar is related with the effect of vehicles during cultivation. For the determination of saturation level and penetration resistance penetrometer tests performed with 3T type electronic soil layer indicator device. This simple equipment measures the soil humidity in % of the field water capacity (pF 2,5) by 1 cm layers until 40 cm depth of the soil. The equipment calculates an average value for the applied range and displays individual values measured at each cm, and average values as well. The equipment detects - parallel to the soil humidity - the penetration resistance (soil compaction) of the soil to the penetration of a measuring cone taken in each 1 cm layers of the examined soil. The rate of the penetration resistance displayed in kPa.

Results and discussion

The humidity and the soil resistance were plotted in function of the depth of the investigated soil. The results can be found on the *Figure 1*. Both the distribution of soil resistance and humidity show logical trends in function the magnitude of different vertical loads.

In the 0-20 cm depth range the soil resistance and moisture content shows high deviation and has relatively high values due to the strongly compacted upper zone, while in the deeper region the vertical load had less effect to the porosity, that is why the graphs of the moisture content-resistance distributions has similar trends for all of the three soil types. Under 7 bar load the soil resistance reached the critical 3MPa value in case of the sandy loam and clay soils.

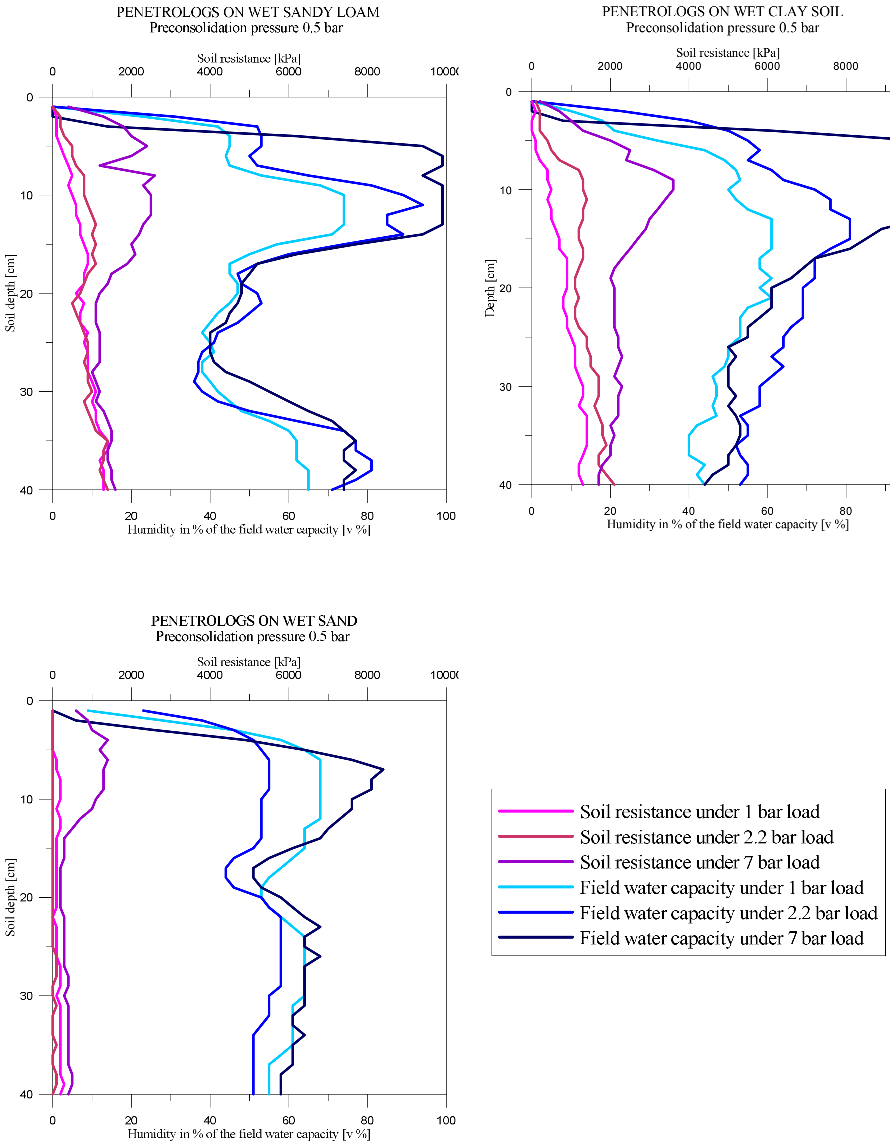

Figure 1. The measured penetrologs of the investigated soil types (sand, sandy loam and clay)

The soil resistance depends on the moisture content: the magnitude of the soil resistance-growth is related to the moisture content decreasing, only the sandy loam soil behaves quite different. At wet soils it can be seen that as consequence of the compaction of the soil due to the applied load the upper 13-15 cm can became fully saturated. Since the penetrations were performed in a given distance of the loaded surface the measurement results of the shallow 5 cm is irrevelant. In case of the

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investigated wet soils the significantly changed volumetric moisture content can lead to the change of soil mechanical behavior, what makes a harmful difference both in compaction, in rolling resistance and in pulling force of the cultivating machines.
With the comparison of the obtained results for the three soil types it can be concluded, that due to the higher clay content the slope of the lines is steeper: The magnitude of the resistance change is increasing with the clay content of the soil types.

Conclusions

In the agricultural practice the parallel measurements of soil resistance and humidity is a frequently used method for the characterization of the soil compaction. The 0-20 cm depth range was the most sensitive for the vertical stress. Both the distribution of soil resistance and humidity shows logical trends in function the magnitude of different vertical loads. The decrease of the moisture content is increasing the soil resistance, and the clay content also effects to the measured resistance values. The penetrologs describes the compaction realistic way.

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INVESTIGATION OF THE EFFECTS OF VARIOUS ACID TREATMENTS ON THE OPTICAL REFLECTION SPECTRA OF A SOIL SAMPLE

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Abstract: The assessment of soil state forms an important part of precision farming. Instead of applying the traditional examination technologies, the Hyperspectral Working Group of the Hungarian Institute of Agricultural Engineering (HIAE) uses airborne hyperspectral technology for carrying out quick and cost-effective soil surveys of large areas. Various experiments were carried out in the spectral laboratory of HIAE for the investigation of the effects of soil acidity on the features of reflectance spectra of soil samples. Moderately acidic soil was measured by ASD FieldSpec®3 MAX spectroradiometer, in the wavelength range of 350 nm to 2400 nm. Soil samples were collected from the region of Szeged. We applied acid treatments with three different acids (including Hydrocloric acid, Sulphuric acid and Acetic acid) with three different concentration. As a control, a sample treated with distilled water was measured, too. All samples were dehydrated before being analyzed. The measured reflectance spectra showed variations in the absorption features of the –OH group. The statistical relationship between pH values of the various samples and the absorption depths proved to be linear with different slope values being characteristic to the type of the acid. These results are valid only in laboratory circumstances, in which temperature and water vapour concentration were held constant during the measuring process. Further experiments are proposed in order to study the effects of other environmental parameters on the absorption patterns of the –OH group. The establishment of a spectral library for the comparative analysis of soil samples has started.

Keywords: hyperspectral, soil parameters, reflectance spectra, soil pH

Introduction

To remediate acid soils, one important thing is to know the degree of the acidity, and the spatial distribution of these soils. The accuracy of determining the quantity of the lime used for repairing the soil (Tolner L. et al., 2008, Vágó et al., 2008) can be improved by working out new evaluation methods in laboratory (Czinkota et al., 2002, Simon et al., 2006) and by developing the remote sensing technologies (Farouk et al., 2010). The hyperspectral airborne and field equipment used in the Hungarian Institute of Agriculture Engineering (AISA DUAL airborne imaging system, ASD FieldSpec®3 Max spectroradiometer) are capable of data acquisition in the wavelength range of 350 nm to 2500 nm (Szalay et al., 2010). The spectral absorption features referred to soils can be examined optimally with the inclusion of the upper part of this interval (Kardeván et al., 2000; Kardeván, 2007). Those changes in molecules, molecule portions, ions that arise from different chemical reactions taking place during soil acidification cause changes in the light reflection characteristic of the soil composition, which can be detected by hyperspectral imaging systems. As recent experiments have proved (Seiler et al., 2007), the structural change involving the –OH group can be characterized by spectroradiometry.

Csorba and Jordán (2010) studied the harmful effects of mine wastes in Recsk by using optical detection of acidic soil pollution. Tolner I. et al. (2010) examined the differences of the spectral reflectance of soil samples treated with various doses of Hydrochloric acid. Experience showed that the humidity greatly disturbs the obtained results. Hence knowing the precise humidity parameter of the soil (Milics et al., 2004; Neményi et al., 2008), or using dried soil samples among laboratorial conditions are necessary.

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Materials and methods

The soil samples were collected from the experimental area (Kiszombor) of the Cereal Research Non-Profit Ltd, Szeged. Samples were grinded, dried and sifted to 2 mm granule size. Different pH value templates were prepared by various acid treatments (Hidrocloric acid, Sulfuric acid, Acetic acid) and carried out in four repetitions. 100 g soil samples were combined smoothly with 100 cm^3 acid. The acid concentrations were the followings: 0.05, 0.1, 0.2 mol dm^{-3}. Consequently the 100 g samples received 5, 10, and 20 mmol acid treatments. Control samples were prepared with 100 cm^3 distilled water. At 105 °C dried samples were cooled down and stored in desiccator until the optical assay.

The spectra were recorded in a light isolated cabinet of the laboratory room. The reflectance value of the specially covered cabinet interior in the spectral range of the ASD FieldSpec®3 Max (from 350 up to 2500 nm) does not exceed the value of 0.02. Proper experimental arrangement makes possible minimization of the undesired environmental effects. Although dust formation by grinded soil samples, the heating effect of the illumination source on soil samples and the wetting of the soil samples are present, but they can be reduced with adequate methodology and sample preparation and considered as a constant, negligible factors. Every sample was measured four times by rotating them with 90 degrees. For each soil sample ten spectra were recorded (in the whole wavelength range) each consisting of 50 scans.

Megj. Igen elnagyolt volt a fordítás.

Results and discussion

Studying the effect of the rotation of sample holder, it was found that it has no relevant impact on the individual shape of spectra, but the variations in shadow conditions caused by the micro-geography of the obliquely illuminated surface resulted in shifts of the whole reflectance curves.

Therefore the average spectra of the four direction were evaluated (*Figure 1.*).

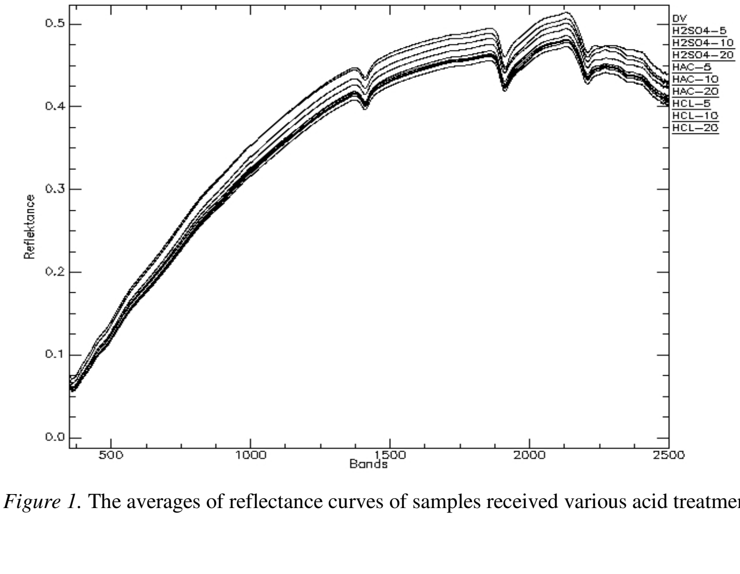
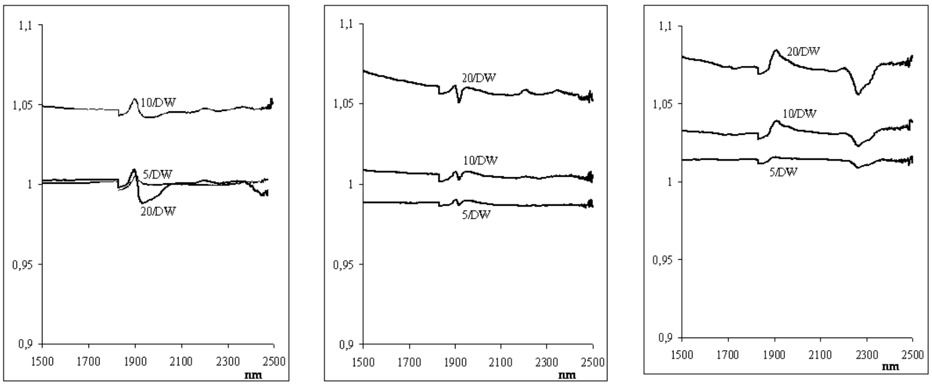


Figure 1. The averages of reflectance curves of samples received various acid treatments

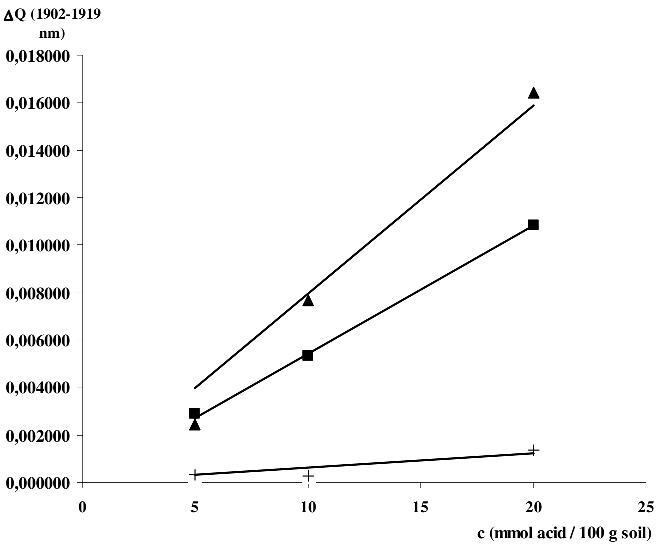
The correlation between the reflectance values of the spectrum average at certain wavelengths and the pH values is not obvious at first sight. By examining, however, the variations of relative spectra compared to the control treated with distilled water (DW), a sequence of spectrum ratios presents systematic differences according to the variation of pH parameters (*Figure 2.*).



A B C

Figure 2. The characteristic sequence of the spectrum ratios (“A” Hidrocloric acid, „B” Sulfuric acid, „C” Acetic acid)

At the wavelength range of 1900 nm to 1941 nm the differences of spectrum ratios show very strong correlation with the various acid treatments (*Figure 3.*).



Acid	a	R^2
HCl	0,000795	0,972
H_2SO_4	0,000541	0,999
HAc	0,000061	0,830

Figure 3. The correlation between the acid treatments and the differences received of reflectance ratio at a wavelength of 1900 nm to 1941 nm (“▲” Hidrocloric acid, „■” Sulfuric acid, „+” Acetic acid).

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Conclusions

As a conclusion it can be stated, that there are clearly two different effects that can be seen on the relative curves, as a result of the acid treatments of soil samples: the physical effect caused an overall shift of the relative curves (see *Figure 2.*), were as a chemical effect in forming absorption dents is also present on these curves. The separation of these effects is curtail to quantify the pH changes on the basis of spectral reflectance measurements.

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MYCORRHIZA INOCULATION FOR IMPROVED GRAPEVINE PRODUCTION AT VINEYARD CONDITIONS

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Abstract: The use of arbuscular mycorrhiza fungi (AMF), as potential introduced treatments of the sustainable agricultural practice was studied on the groth of grapevine (*Vitis sp.*) among arable field conditions. Beside the organic fertilizer application the compatibility between a commercial AMF inoculum and two grapevine varieties (Jázmin and 52/4) were investigated on the macronutrient (P, K, Mg) uptake and the moisture levels of plants, measured after 2 years of AMF applications. Among the used *Vitis* sp. varieties, a better response of the inoculation was found at 52/4 with only 1 commercial inoculum, showing the necessity of appropriate compatibility between the macro- and microsymbiont partners. Improved nutrition and water content of inoculated plants highlight the key-importance of artificial inoculation in soils with low activity of indigenous mycorrhiza populations and also among sever environmental stress conditions.

Keywords: mycorrhiza, *Vitis* spp., micorrhiza inoculation, moisture content, plant nutrition,

Introduction

Association between arbuscular mycorrhiza fungi (AMF) and grapevine roots are well-known phenomenon in the agriculture. AM fungi might have a symbiosis not only with the *Vitis* spp., but with 80 % of higher vascular plants, resulting the inevitable mutual benefits of both partners (Biró et al., 2005; Czakó-Vér and Biró, 2008). These AM fungi are ubiquitous both in natural and in man-made artificial environments, including vineyards. Abundance of the fungi however is not frequent in some cases at those arable field conditions, due to the soil-disturbance and the intensive use of agricultural chemicals, including the fungicides. Among such conditions it is the mycorrhiza inoculation, which can be used in a most sustainable way (Kovárová et al., 2010). The fungus hyphal network can colonize the roots of the host plant, and extend the absorptive area. According to this increased root surface, the AM fungi enhance the nutrient (especially phosphorus) and water uptake by the host plant as an indirect effect of the symbiosis (Schreiner, 2003). In return, the host plants provide organic carbon (Archer et al., 2004) and some of the growth factors for the fungus. Grapevines with mycorrhizal association are known to gain higher plant growth and increased tolerance against salinity, drought, pathogen infections and heavy metals like in case of other hosts (Leyval et al., 1997; Biró et al., 2010). In addition the association between host plant roots and fungal mycelium can improve soil structure and fertility.
The objective of this study was to determine the efficiency of mycorrhizal inoculation on some grapevine growth parameters under field conditions in two years of periods. The effect of AMF inoculation was assessed on the nutrient and water uptake of host plants, as compared to the non-inoculated controls in red-clay rendzina soils, near Pécs, Hungary.

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Materials and methods

The red-clay rendzina soil used in the experiment was located in a traditional vineyard area in the hill of Mecsek, Pécs city, South-Transdanubian region, Hungary (46,07^{o}N; 18,17^{o}E). The samples were collected from the subsurface root-zone layer (30-40 cm). Main characteristic of soil is the phosphorus richness, on a rather non-available form. Shallow surface soil has an indifferent water management.

The experimental plants were *Vitis vinifera* L. (Berlandieri x Riparia Teleki 5C) variety Jázmin and a variety of 54/2. Three treatments were used in the experiment: 1.: untreated control, 2.: organic fertilizer,(11.5 t ha^{-1}) and 3.: SYMBIVIT commercial mycorrhizal product (contains *Glomus* sp.) as 300 g m^{-2} inoculums. The inoculated grapes were planted in a random-way in 6 repetitions at each treatment in 2008 december and evaluate for growth characteristics 16 months later in 2010 april. The collected roots were cleared using hot 10% KOH (invam.caf.wvu.edu) before staining them with aniline-blue as it described by Trouvelot et al. (1986). Mycorrhizal colonization was evaluated by using the 5-class system on 30 root segments, where the infection intensity (M%) and the arbusculum richness (A%) was evaluated by dissecting microscope and later calculated by Mycocalc program. Beside the AMF parameters, shoot nutrient (P, K, Mg) and moisture content of grapes were analysed by Perkin Elmer Atomic Absorption Spectrophotometer (Model 3110).

Results and discussion

The microscopical analysis confirmed our hypothesis, that the grape roots can be strongly colonized by the arbuscular mycorrhizal fungi. In case of the Jázmin variety the highest mycorrhizal infection (M%) values were found at the inoculated plants (*Figure 1.*). Differences among control and the SYMBIVIT-inoculated treatments were found to be significant and those "SYMBIVIT plants" could show more than 250 % higher activity compared to the uninoculated control. Organic fertilizer as additional extra-nutrients has decreased the infection rates of the mycorrhiza fungi, showing the symbiosis benefits mainly among the nutrient-poor conditions.

When considering the arbusculum richness (A%) the same tendency of results was found. Inoculated plants could show the highest values, however differences among the inoculated and non-inoculated plants could be significant in case of the SYMBIVIT inoculums. Those plants showed approximately 250 % higher growth in comparison with the non-inoculated controls (*Figure 2.*). The lowest values of mycorrhiza colonization were found at the organic fertilizer treatment again.

At the early developmental phases of host-plants, no real significant differences were observed in shoot element analysis regarding the three treatments, used (*Table 1.*). Results of the grapes production and of the wine-products will be analyzed in a later stage of the research.

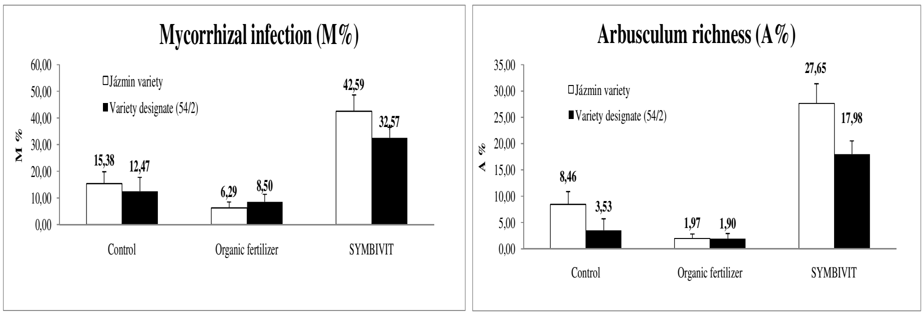

Figure 1. Mycorrhizal infection intensity, M% (left) and arbusculum richness, A% (right) of two grapewine varieties (Jázmin and 54/2) influenced by organic fertilizer treatments and SYMBIVIT mycorrhiza fungi inoculums among natural conditions (Pécs, 2008).

As the root measurements showed there were significant differences found between the inoculated and the non-inoculated hostplants both in case of mycorrhizal infection frequency (M%) and arbusculum richness (A%) parameters (*Figure 1.*). Compared to the control plants, SYMBIVIT treatments showed always the highest values. Mycorrhizal infection resulted approximately 250% higher growth at the SYMBIVIT inoculation. Considering the arbusculum richness (A%) nearly 500% of better values could be found at the two-year-old plants. In each situation the organic fertilizer gave the lowest values of AMF colonization. We also found mycorrhiza hyphae in the non-inoculated control plants, showing, that the experimental soil already has contained indigenous AM fungal species. The taxonomical identification of the native AM fungi is being in progress, but it is also clear, that much less arbusculum richness could be developed in comparison with the highly diverse inoculums of the SYMBIVIT.

Table 1. Some nutrients (P, K, Mg) and the moisture content of two grapevine varieties (Jázmin and 54/2) as treated with organic fertilizer and SYMBIVIT mycorrhiza inoculums.

Treatment	Phosphorus (%)		Potassium (%)		Magnesium (%)		Moisture (%)	
	Jázmin	54/2	Jázmin	54/2	Jázmin	54/2	Jázmin	54/2
Control	0.137	0.143	0.457	0.463	0.067	0.053	49.75	44.310
Organic Fertiliser	0.140	0.137	0.463	0.467	0.067	0.050	48.64	45.420
SYMBIVIT	0.137	0.147	0.453	0.487	0.070	0.057	49.71	45.823

The shoot analysis showed at the 54/2 variety that, there were no significant alterations found between the three measured mineral elements at the two-year- old plants, except the magnesium content at the mycorrhiza inoculated treatments. The phosphour and the potassium content were improved also slightly by the SYMBIVIT inoculation. The two varieties behaved differently for the used treatments. Generally the SYMBIVIT inoculation has resulted the highest values at almost all measured parameters (*Table 1.*). The mycorrhizal inoculation significantly enhanced the moisture content of the plants at the 54/2 variety. Just like the mineral nutrient-contents, the SYMBIVIT inoculations showed the better values of the moisture levels of grapevines. Beside it the organic-

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fertilizer plants differed significantly from the control uninoculated plants, resulted by the better water-absorbing capability of organics (*Table 1.*) only at 54/2 variety.

Conclusions

Successful colonization of mycorrhizal fungi could result a benefit on grapevine plant's, through the direct and indirect nutrient and water management. Among environmental stress-conditions inoculated plants might have better survival capacities, and better products for nutritive values of grapevines. Response for mycorrhiza inoculation however is strongly dependent on the used varieties, with better values on 54/2, than the Jázmin, under the field conditions in this study. Selection of appropriate macro- and microsymbiont partners therefore is a key to the successful mycorrhiza inoculations. Beside this the used inoculum can be efficient only in case of a less productive native, indigenous mycorrhiza population.

Acknowledgements

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THE IMPORTANCE OF PRECISION PLANT NUTRITION IN REDUCING SOIL POLLUTION FROM A MACROECONOMIC POINT OF VIEW

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Abstract: From a crop site – land use synergism point of view nutrition is an important factor, as well as the artificial chemicals burden on both the crop sites and the environment.. Regarding agricultural technical development, wide range use of up-to-date technologies and precision plant production match all the three requirements of sustainability. Harmonizing the relations it reduces the harmful material we put into the land and the non-adsorbed amount by the plants.
We examined the macroeconomic relations of potential savings by modeling. After turning to precision plant production the fertilizer ingredient use can be reduced by 340 thousand tons at the same expected yield level in an optimistic scenario in the EU-25, while the savings in pesticide use can be 30 thousand tons (calculating the nowadays dose). This will diminish environmental burden up to 10-35 %.The wide spread of all new technologies that effects positively on preserving natural resources, on "their reproduction" in agriculture on farmers' level, and by which the farmers can achieve at least such income that covers the return of invested capital (reaching the economic effectiveness) leads to the direction of sustainability. The diffusion of precision plant production as a manifestation of innovation in agriculture encourages social sustainability by producing food, inputs for industry and for energetic purpose and by reducing environmental burden.

Keywords: potential savings, EU, modeling

Introduction

From the middle of the 20th century agriculture has been greatly accelerated, the natural and human (labour) resources being replaced by the industrial tools, and industrial inputs, also called technical development. At the same time, some trends appear to have reduced the environmental impact, by reducing the amount of artificial chemicals released into the environment, in order to ensure its sustainability. The definition of sustainability of agriculture and environment according to Pearce and Atkinson's (1995) understanding, is that the natural resources and man-made capital are complementary to each other in the production process, so that natural resources are creating the limiting factors to increase production, and at the same time, they should be used rationally during the production. By the turn of the millennium, sustainability has a broader interpretation. The new paradigm of agricultural research and development was based as an interaction on three factors; ecological sustainability, economic efficiency combined with equal opportunities, as well as mutual help from government and non-governmental sectors to improve the enterprise system's performance and profitability. This become the basic paradigm of the 1990s and the following decades sustainable agro-economics'. (Caffey et al., 2001; Bongiovanni and Lowenberg-Deboer, 2004; Lang, 2003; Várallyay, 2007).
Precision farming is a technology which will essentially neither show up as a yield effect nor as unnecessary expenditure, but this targeted chemical application will reduce the environmental impact, thereby helping promote environmental sustainability. It can be considered as one factor of agricultural innovation that has affect not only on the technology, but on the management also. (Lencsés and Takácsné, 2010) According to Jørgensen (2000), sustainability must be taken into consideration not only at sectoral

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level; but also at national level, , meaning supplies needed for the production – at least – allow simple reproduction, irrespective of wherever the source of the capital's origin is. The research aims to examine how the conversion to precision plant production can decrease artificial chemical usage on national level.

Materials and methods

As a result of our research there have been multiple scenarios built regarding the proportion of crop and mixed field crop producing farms within the EU that can take upon to transfer technology, furthermore regarding the decrease in fertilizer usage that can be achieved. Data on farm structure have been derived from EUROSTAT and HCSO (Hungarian Central Statistical Office) databases, data regarding chemical usage on the other hand have been made available by the OECD.
The following assumptions were used during the modeling:

- We assumed in case of over the 100 ESU farm-size, that they are plant crop farms (cereals, other crops and animal feed crops), and based on their size and quality they are able to switch to precision farming with their own investments. In case of farm sizes 16-40 and 40-100 ESU I presumed that a common form of cooperation is required amongst the farms to be able to transfer to precision crop management. (Takács-György, 2008, Takácsné György, 2010)
- The ratio amongst the farms that choos transition is 15-25-40%, at pessimistic, ignorant and optimistic scenarios of the event.
- The savings in case of fertilizer is 5-10-20%, assuming the previous yield. The basis of input – output functions was the results of several years crop production researches. (Szentpétery, 2004; Csathó et al., 2008; Debreczeniné and Németh, 2009, Berzsenyi, 2009; Kismányoki, 2009) In order to quantify the applied quantity of fertilizer and pesticides, we used the 2007 OECD data, and presumed that the EU-15-s value as the base.

Results and discussion

The test farm database of the European Union (FADN) in 2006 represented 1897900 farms, and these used up to 82787 thousand ha of agricultural land. From this area 51.4% was used for cereal, 16.7% was occupied with other crops, and on 20.5% fodder plants were grown. After examining the economic size categories, the observation was that the share of cereals did not change significantly, they stayed between 48% and 53%, although along the increasing growth rate of the economy size of the farm, ratio of the field crops was increased, on the expense of fodder crops. This suggests that in case of larger farms proportionally larger area (can) be used of high-precision plant growing, due to changes in production structures.
According to the initial assumptions we determined the potential savings in fertilizer use for the represented area by the EU-25, where the high-precision technology would be established. Although (5-10-20%) of the fertility savings counted in the models should be conditionally used, because if the purpose of the precision fertility treatment

implementation is to compensate the yield in case of heterogenic nutrient levels, in this case the 20% saving per unit is not achievable. In that case if we waive this fact, and if 15% of the farms will switch to precision farming, we can expect savings between 32 and 127 thousand ton of active fertilizer use with the help of precision fertility treatment, keeping the yield at the former level. If we are assuming 25% switch to precision farming, the volume of saving can be between 53 and 211 thousand tons, in case of 40% switch, the saving can be between 85 and 338 thousand ton of active fertility per year. (*Table 1.*) From an economic point of view such kind of decline in the fertility level usage at unchanged yield level can result in significant cost savings. At production level, amongst the costs, the cost of nutrient materials is between 8-15% in cereal production. Within the cost of materials this saving can be in 0.6-6.2%, that can improve the income situation of the cereal production. Another, considerable benefit is the reduction of the environmental impact from the unused, artificial chemical decline.

Table 1. The expected savings in the fertility usage by the farms which switched to precision farming

Name			Farms choosing conversion		
			15%	25%	40%
16-100 ESU	Conversion area (ha)		5086330	8477217	13563547
	Savings in fertility use (t)	5%	16276	27127	43403
		10%	32553	54254	86807
		20%	65105	108508	173613
>= 100	Conversion area (ha)		4818598	8030997	12849595
	Savings in fertility use (t)	5%	15420	25699	41119
		10%	30839	51398	82237
		20%	61678	102797	164475
total	Conversion area (ha)		9904928	16508214	26413142

Source: own calculations

Spread of precision crop farming EU-25-wide can result in 327.1 – 1308.3 M EUR savings in fertilizer costs.

Regarding fertilizer usage in order to supply soil nutrition, it has been determined– assuming constant production intensity (yield level) – that savings in chemical agents can be up to 32-338 thousand tons per year in the EU-25 countries depending on the number of farms transitioning and the size of field they cover. This may result in 0.6-6.2% savings in cereal production costs, increasing this way the sectorial competitiveness. In conclusion transition has an effect not only on cost reduction but on competitiveness as well, furthermore it has an important impact on decreasing environmental burden.

Conclusions

The base principle for sustainable agriculture is to continue farming in the natural environment in a way that helps reduce the emission of unnecessary and harmful chemicals with the applied farming method, but in the same breath will ensure the farms long term viability and achieve income, beside this the environment should be kept and maintained as part of the social function of living.

Farms above 100 ESU can apply the entire technology of precision crop farming based on their own technology, while farms between 16-100 ESU may as well do so by

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forming common machinery operations or using such services. Considering the optimistic scenario we assume the transition of 40% of above described farms within the EU-25, where there can be 338 thousand tons of fertilizer saved at a constant yield level, while there can be cost savings achieved on operational level resulting in the increase of individual income. Besides achieving material cost savings, another crucial factor is achieving reduction in polluting the environment with non-utilized artificial chemicals. In every single case when the farmer's aim with precision farming is to optimize the farming, the fertilizer used for treating parts of the field is to improve the utilization of that 'parcel's' potential, this way increasing the farmer's income at the same time, however in this case the agent reduction is not guaranteed at the field level.

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SALINIZATION AND ALKALIZATION AS DEGRADATION SOIL PROBLEM AT SOUTH-EASTERN PART OF DANUBE LOWLAND (SLOVAKIA)

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Abstract: The contribution deals with analysis of salinisation and alkalization processes of soil profile and with judgement of hazard coming out by these processes. The area, which has been investigated, is the south-eastern part of the Danube Lowland in Slovakia. It is a part of Rye Island – the most productive agricultural area of Slovakia. Groundwater is putting down as one of the most important aspect of soil salinisation and alkalization. It is known that these facts impact adversely on vegetation and crops, so there is a reason why it is important to solve this problem. The contribution used the monitoring data from the period of years 1989 – 2006. We collected soil samples and samples of mineralized groundwater at the area mentioned above. It was subsequently carried out their analysis to determine total dissolved solids (TDS), electrical conductivity (EC), pH, cation exchange capacity (CEC), sodium adsorption ratio (SAR). In selected locations, salt content and sodium exchange has reached the limit and slightly above-limit values. The results show that in all monitoring localities it is in motion both the process of salinisation, by indicated above-limit residue values and EC values, both alkalization process indicated by above-limit values of ESP and pH. In areas where ESP stands at 5-20%, alkalization is the dominant process. From groundwater quality indicators, monitored in the period 1989 - 2006 in selected locations, come out that during this period the groundwater quality decline in terms of salinisation and alkalization. Concentrations of majority of those indicators have increasing trend, as well as SAR and EC values.

Keywords: salinization, alkalization, soil degradation, electrical conductivity EC, total dissolved solids TDS

Introduction

Danube Lowland, situated in southernmost part of Slovakia, is locality with the largest loess cover extension. In the evapotranspiration regime carbonates in loess have been preserved, even formed in alluvial soils of whole alluvial river plains of this lowland. These parent materials and soil forming processes impacted the occurence prevailingly calcareous soil character. There are occured Calcaric Fluvisols, in depressions Fluvi-Calcaric Phaeozems, Fluvi-mollic Calcaric Gleysols to Calcaric Gleysols in alluvial areas of lowland rivers (Danube, Váh, Nitra). In lower lying southernmost parts of lowland with mineralized groundwaters, also saline soils are occuring locally (*Figure 1.*).

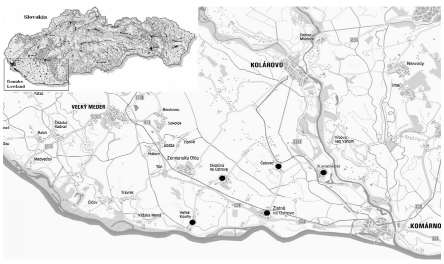

Figure 1. Specification of the interested area with marked sampling sites

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Danube lowland area is consistently covered by Quaternary cover, and that is why underlying Neogene sediments crop out locally, in tectonically elevated parts. Extensive alluvial plains originated in descending parts of lowland (Čurlík and Šefčík, 1999; Červenka 1970, Šútor and Štekauerová, 2000; Burger and Čelková 2007, 2009).
In the territory of Slovakia occur relatively large groundwater supplies. The best groundwater resources are present in sandy-gravels deposits of river alluvial plains in Rye Island. Groundwater are supplied by infiltrating Danube water at this location. Groundwater levels hydromorphically influenced the soil cover development and some chemical particularities connected with their mineral content and hydrothermic regime. Saline soils are widespread in some localities reflecting the predominance of sodium in groundwaters and soil solutions. Sodicity and alkality is shown to be a latent problem in saline soils where deleterious effects are evident. A classification of soils based on TDS, EC, SAR, ESP and pH is published in studies Barzegar et al., 1994; Burger-Čelková, 2004; Curtin et al. 1994; Kováčová, 2009; Rapant et al. 1999; Suarez, 1981). Except the groundwater composition causes soil salinity irrigation water quality, the water level and water quality in the whole channel network system (Dulovičová and Velísková, 2007; Burger and Čelková, 2004; Kaledhonkar et al., 2001). The salt-affected soils occur in the south-east part of Danubian Lowland. The dry and warm summer climate, evaporation soil water regime and mineralized groundwater create convenient conditions for development and spreading of the saline and alkaline soils here. Two processes in the development of the salt-affected soils occure:
1. Process of salinization – is conditioned by presence of neutral sodium salts, mainly $NaCl$ and Na_2SO_4. The indicators of salinization are dry evaporative rezidue > 0,2% and electrical conductivity of saturated soil extract EC > 400 $mS.m^{-1}$. Low value of salinization rate is running from EC = 200 - 400 $mS.m^{-1}$ or evaporative rezidue of salts 0,1-0,2 %. The result of salinization processes are middle saline soils and solonchaks.
2. Process of alkalization – is conditioned by presence of alkaline sodium salts, mainly Na_2CO_3, $NaHCO_3$, Na_2SiO_3. The indicators of alkalizaton are exchangeable sodium percentage ESP > 5 % and pH 8 or higher. The result of alkalization processes are middle alkaline soils and solonetz (Levy et al. 2003; Richter-Kreitler, 1993). In natural conditions both of this processes are represented by different rate and the result is the mixture of both of this processes, but one of them is dominant usually. The relationship between electrical conductivity and degree of salinity is presented e.g. in U.S Salinity Laborat. Staff, 1954; Recommended Chem. Soil Test Proc 1998; Burger-Čelková, 2009.

Materials and methods

Soil samples were taken from soil profiles from various depths (0-150 cm) for determination of the spatial variability of sodicity. The soils were air-dried and passed through a 2-mm sieve. Electrical conductivity (EC) and soluble ions (Na, Ca, Mg, K, SO_4 and Cl) were determined on saturated-paste extracts. The concentrations of Ca, Mg, Na and K were determined by atomic absorption spectroscopy (AAS); SO_4, Cl by ionselective electrode. The basis of the salinization impact model is the sodium adsorption ratio (SAR) – the relationship between Na^+, Ca^{2+} and Mg^{2+} concentrations that predicts the Na^+ status of the soil exchange complex (Recommended Chemical Soil

Test Procedures, 1998; US Salinity Laboratory Staff 1954). It is given by the following expression :

$$SAR = \frac{Na}{\sqrt{Ca + Mg}} \quad (1)$$

where ionic concentrations are expressed in mol.l^{-1}. Presence of sodium is a potential cause of structural instability when Na occupies more than l0-15% of the exchange sites (Curtin et al. 1994a). SAR is related to the exchangeable-Na ratio (ESP) of the soil by the following equation:

$ESP = k_g SAR$ (2)

where k_g, is the Gapon selectivity coefficient and ESP is estimated:

ESP = exchangeable Na/(CEC - exchangeable Na) (3)

where CEC is the effective cation-exchange capacity.

Results and discussion

Measured basic charakteristics of groundwater chemical composition indikate, that Na levels in interested area are higher then average values (*Table 1.*). The objective of this contribution is to judge state of salinization and alkalization of the soil profile in localities with high-mineralized groundwater and different phases of saline-soils developmen. Results are shown in (*Figure 2.*)

Table 1. Basic statistical characteristics of groundwater chemical composition (n=128)

	Mean	Median	Stand.Deviation	Min.	Max.
pH	7,32	7,30	0,40	5,76	9,89
TDS (mg.l^{-1})	643,0	641,5	265,1	49,2	1935,8
Ca+Mg (mmol.l^{-1})	3,561	3,536	1,721	0,120	13,021
Conductivity(µS.cm^{-1})	688,1	686,5	289,6	54,5	2200,0
Free CO_2 (mmol.l^{-1})	0,77	0,65	0,69	0,12	11,5
Na (mg.l^{-1})	21,06	15,20	23,11	1,10	260,00
K (mg.l^{-1})	5,53	2,10	11,31	0,05	114,00
Ca (mg.l^{-1})	91,93	89,78	44,49	2,40	352,70
Mg (mg.l^{-1})	30,81	28,58	18,82	0,50	114,55

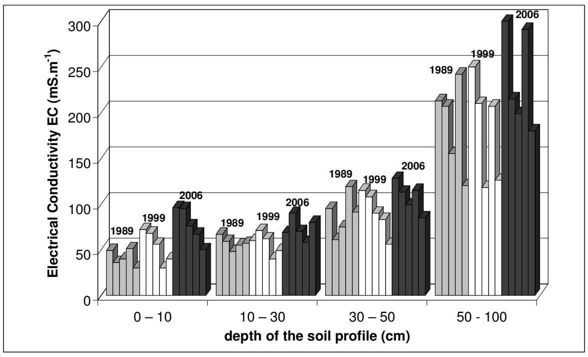

Figure 2. Electrical Conductivity of the soil profile in the most salt - affected localities : 1 – Veľké Kosihy (EC1), 2 – Okoličná (EC2), 3 – Čalovec (EC3), 4 – Zlatná na Ostrove (EC4), 5 – Kameničná (EC5) in the time period 1989 - 2006.

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Conclusions

Five localities with high-mineralized groundwater were monitored to judge salinity and alkality in the period 1989-2006. At the begginning of monitoring in localities 1 – 5 evaporative residues (salt content) reached the value 0,1 – 0,2 % in the bottom horizons, but in year 2006 this value has been spreading to whole soil profile and in the bottom horizons reached > 0,22 %. EC in localities 1,2,4 was > 200 $mS.m^{-1}$ – that is the salinization potential for development of saline soils. Values of ESP in 2006 was higher than 11 % and pH in loc. 4 were measured higher 8,5 - so the alkalization is more marked and dominant there. The mentioned data allow us to declare that salinization and alkalization of soils start from the bottom of soil horizons through middle part of the soil profile up to the top horizons.

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INVESTIGATION OF THE EFFECT OF ZINC AND COPPER ON *LEPIDIUM SATIVUM* IN POT EXPERIMENT

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Abstract: As the result of the anthropogenic activity, in general due to industrial emission, irrigation with contaminated water or usage of fertilizers and metal-based pesticides, there has been a significant increase in the concentration of heavy metals in soil. The contribution of edible plants to the daily intake of metals needs to be monitored. Hence the purpose of this study was to simulate the different level of zinc and copper contaminations that may be presented to plants over a growing season in a controlled laboratory setting. Primarily the bioaccumulation of these pollutants was investigated on garden cress (*Lepidium sativum*), which has been chosen as the key component of the pot experiments representing a simplified ecosystem.
After a 10 day long vegetation period the accumulated metal concentrations in root, stem and leaves were measured by FAAS and the effect of the different pollution levels on the plant's physical parameters was studied too. According to our results garden cress is a good accumulator therefore its role in phytoremediation in case of controlling moderate pollution is worth considering. Taking into consideration the starting pseudo total heavy metal concentrations (Zn: 415.29 $mgkg^{-1}$ d.m.; Cu: 136.94 $mgkg^{-1}$ d.m.) in soils and the pseudo total heavy metal concentrations in the soil after the removal of plants, it was found that after removing the plants, the least concentration (221.18 $mgkg^{-1}$ d.m) of the pseudo total Zn-ions remain in the soil in case of the highest pseudo total concentration of Zn-ions, and the same tendency was valid to the pseudo total Cu- ions concentration (39.27 $mgkg^{-1}$ d.m), too.

Keywords: heavy metals, Zn and Cu accumulation, garden cress

Introduction

Nowadays alarming amount of pollution enters into the environment due to anthropogenic activities. Human health is directly endangered when these pollutants get into the food chain. Because of the environmental pollution luckily there is an increased attention on the potentially toxic elements and on the dangers related to heavy metals (Vermes, 1994). Detailed and intensive examinations are imperative in order to avoid extended and extensive contaminations (Kádár, 1995). Wide range of technologies are available to remediate the contaminated soils however, most of these methods are costly and non aesthetic solutions (Yoon et al., 2006). Phytoremediation provides a cost-effective, long-lasting and aesthetic solution for remediation of contaminated sites, so the aim of our study was to examine the phytoremediation of Cu and Zn polluted soil.

Materials and methods

1.) Soil

Soil sampling and preparation of soil: The soil samples were collected from 0-20 cm depth (Nagyréde, Hungary), then they were left to dry. After that, the samples were sifted through a 2 mm sieve to remove the bigger stones and other pollutants.
Determination of initial condition: Determination of dry weight content was made according to standards no. MSz-08-0205-1978; and pH by MSz-08-0206/2-1987.
Humus content was measured by Jenway 6105 UV/VIS Spectrophotometer (Jenway Ltd, England) with method described by Győri et al. (1998). Samples were prepared for

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pseudo total heavy metal determination*:* at first samples were sifted through a 0.2 mm sieve. 0.5 g soil was taken into each teflon bomb. Then 5 cm^3 65 % HNO_3 and 2 cm^3 30 % H_2O_2 were added before starting the digestion program. Samples were digested by a MILESTONE 1200 Mega Microwave Digester (Gyarmati at al., 2010).

Table 1. Properties of used soil from Nagyréde (Hungary)

Properties	Value	±SD
Humus content (m/m%)	3.8	0.07
pH_{H_2O}	7.21	0.07
pH_{KCl}	6.89	0.08
Cu (mg kg^{-1})	24.44	1.54
Zn (mg kg^{-1})	115.29	1.72

In the digested samples the initial total Zn- and Cu-ions concent-ration were measured by ATI UNICAM 939 FAAS. *Table 1.* shows the initial condition of the used soil.

2.) Phytoextraction experiment

Experimental design: Phytoextraction processes were conducted with *Lepidium sativum*. Each pot contained 230 g soil. In case of control soils the remoistening was performed by 50 cm^3 distilled water, which was mixed with the soil thoroughly. Similarly, the artifically polluted soils were prepared with Cu-ions instead of distilled water: $CuSO_4$ solutions with different concentrations (172.5 $mgdm^{-3}$; 345.0 $mgdm^{-3}$; 517.5 $mgdm^{-3}$) were applied. The soils artificially polluted with Zn-ions, were prepared also similarly, and instead of $CuSO_4$ solutions, $ZnSO_4$ solutions with different concentrations (460 $mgdm^{-3}$; 920 $mgdm^{-3}$; 1380 $mgdm^{-3}$) were applied.Then the soil was artificially polluted up to the concentration detailed in *Table 2.*

Table 2. Cu and Zn concentration in different soils (mg kg^{-1})

Cu and Zn Treatments	Heavy metals concentration in soil at the beginning of the experiment (mg kg^{-1} dry matter)	
	Cu	Zn
Control	24.44	115.29
1:	61.94	215.29
2:	99.44	315.29
3:	136.94	415.29

2 g cress seeds (cv. "Rédei Kertimag" JSC) were used per pot. After a 2 day long germination period 50 ml distilled water per day was used to keep the seed moist optimal for germination. The temperature and the light intensity were equal for all pots.

Plant preparation and heavy metal determination: The plants were removed on the 10th day after sowing. Each removed plant was separated into root, stem, and leaf to measure the length of the root and stem and the surface of leaf. After a 72 hour long drying process at 70 °C the separated plant tissues were crushed and sifted through 0.2 mm sieve. 6 cm^3 65 % HNO_3, 1 cm^3 30 % H_2O_2 were used for extraction (Gyarmati et al., 2010). The pseudo total Zn and Cu concentration were measured in every sample of cresses by ATI UNICAM 939 FAAS.

3) Statistical analysis

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

Results and discussion

1) Effect of copper pollution on plants

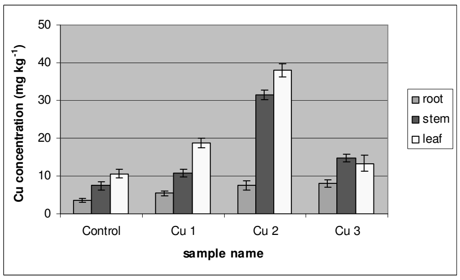
Analysis of physical parameters: results are displayed in *Table 3.* There is a significant decrease in root ($LSD_{5\%}$= 0.09) and stem ($LSD_{5\%}$= 0.43) length. There is also significant difference in leaf surface ($LSD_{5\%}$= 0.58). In general it can be stated, that the Cu contamination has an adverse effect on the plant physical parameters. Nevertheless,

the average root, stem length and the leaf area of Cu 2 are the highest among the Cu treated samples.
Cu concentration measured in plants:

Table 3. The physical parameters of plants

Treatments	Physical parameters of plants					
	Root [mm]	±SD	Stem [mm]	±SD	Leaf [mm^2]	±SD
Control	4.39	0.18	4.68	0.16	82.35	0.06
Cu 1	3.30	0.69	3.87	0.16	49.95	0.10
Cu 2	4.19	0.09	4.11	0.22	55.35	0.06
Cu 3	2.56	0.13	3.41	0.08	24.30	0.04
Zn 1	4.06	0.09	3.73	0.06	60.75	0.10
Zn 2	3.43	0.27	3.93	0.13	63.45	0.21
Zn 3	2.67	0.34	3.44	0.28	28.35	0.06

The two-way randomized block analysis shows that, there is significant difference in treatments with different Cu concentrations ($LSD_{5\%}$= 1.65) (*Figure 1.*). However there is no significant difference between the results of Cu 1 and Cu 3 treatments. The garden cress can tolerate copper pollution. Since Zn has already been present in our soil, the synergism is needed to mention, as the available zinc might modify the effect of Cu and its toxicity (Luo and Rimmer, 1995).
The Cu concentration in the different plant parts is significant in all case ($LSD_{5\%}$= 1.43). The Cu accumulation is in the root is the lowest and in the leaves is the highest.



Firuge 1. Measured Cu concentration in plant parts (mg kg^{-1}in d. m.)

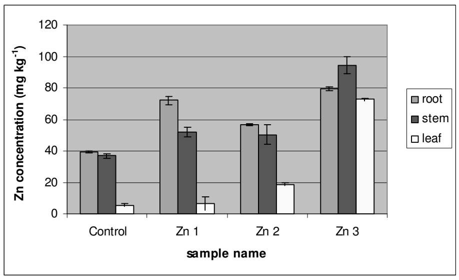


Figure 2. Measured Zn concentration in plant parts (mg kg^{-1}in d. m.)

The remaining copper content after the removal of plants: The Cu concentration is significantly lower compared to the initial Cu content measured at the beginning of the experiment ($LSD_{5\%}$= 3.65). According to the results the highest removal was achieved in the case of Cu 3 treatment, but there is no significant difference between Cu 2 and Cu 3 (*Figure 3.*)

2.) Effect of zinc pollution on plants

Analysis of physical parameters: The results are in *Table 2.* The result of the experiment is similar to the result of Cu pollution. The length of root ($LSD_{5\%}$= 0.11) and stem ($LSD_{5\%}$= 0.88) as well as the surface of leaves ($LSD_{5\%}$= 0.56) are significantly smaller when the Zn concentration increases.
Amount of Zn in the different parts of plant: The two-way randomized block analysis shows that, there is a significant difference in treatments with different Zn concentrations ($LSD_{5\%}$= 3.74) (*Figure 2.*). There is no significant difference between

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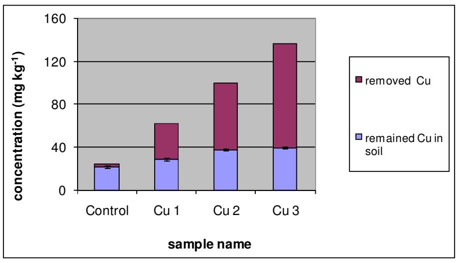
the results of Zn 1 and Zn 3 treatments. The direction of accumulation is reverse compared to the Cu ($LSD_{5\%}$= 3.24).

Amount of residual Zn in the soil after removing the plants: After removing the plants the amount of residual Zn concentration shows significantly smaller amount compared to the initial Zn content ($LSD_{5\%}$= 6.44). The highest removal was achieved in the case of Zn 3 treatment. Results are displayed in the *Figure 4.*



Firuge 3. The residual Cu concentration in soil (mg kg^{-1} d.m.)

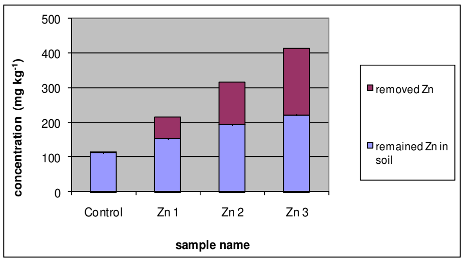


Figure 4. The residual Zn concentration in soil (mg kg^{-1}d.m.)

Conclusions

The results of the experiment showed that both the Cu and the Zn pollutions affected the physical parameters of the plants. The sizes of different plant parts were significantly smaller with the increase of the pseudo total concentration of heavy metal ions except of treatment Cu 3. Results showed that the plants with the treatment Cu 3 and Zn 3 made the most effective removal from soil in this experiment. It was also observable that the Cu was localized in the leaves while Zn was accumulated mostly in root.

Acknowledgements

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NITROGEN UPTAKE AND NITROGEN CONTENT OF WINTER WHEAT GROWN ON HEAVY METAL AMENDED SOIL

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Abstract: Nitrogen is generally the most limiting nutrient in crop production and most often establishes yield levels. Most of available microelements (micronutrients) are also adequate for crops, but some of them are harmful for plant growth in high concentration. The availability of elements is influenced by the presence of other ions in the soil solution. This work presents some data about nitrogen uptake and nitrogen content of winter wheat crops grown on soil that was treated with high dose of heavy metal salts. Nitrogen content of wheat plants wasn't significantly affected by the increased dose of applied elements (As, Cd, Cr, Hg, Pb, Cu, Zn). NO_3 – N content of wheat shoot was slightly decreased by the phytotoxic treatments (high doses of Cr, Zn, Cu and As elements) at shooting phenophase, moreover the extreme high dose of Cr (270 kg ha-1) somewhat increased the nitrogen concentration in plant tissues. At harvest the NO_3 – N concentration was equalized both in straw and grain.

Keywords: soil, heavy metal contamination, winter wheat, nitrogen uptake

Introduction

Nitrogen is generally the most limiting nutrient in crop production, except for well-nodulated legumes, and most often establishes yield levels. Along with water, N supply is a major factor in global production levels (Gardner et al., 1985; Futó, 2006). The available microelements, which are required in minute amounts, are generally adequate for crop production. However, high– and low–pH, organic, and sandy soils are frequently deficient in certain micronutrients, depending on the crop (Szabó and Fodor, 2006). On the other hand, rarely soils may be naturally high in micronutrients – including toxic elements – that originate natural weathering of rocks, or soils with high heavy metal content are found in industrial and urban areas, along motorways, and in arable land treated with heavy application of sewage sludge (Kádár, 1995). The availability of elements is influenced by the presence of other ions in solution. The presence of certain elements is antagonistic to absorption of others. Normally cations compete with others; for example some cations decrease NH_4^+ uptake (Fodor and Szabó, 2003). N-transformation are biological and therefore sensitive to soil pH, temperature, moisture and it is also greatly inhibited or simulated by presence of trace elements or natural inhibitors (Tucker, 1981). We have only poor scientific information about nitrogen uptake of crops on heavy metal contaminated soils. This present work provides data and discusses how increasing microelement treatment influences nitrogen uptake and nitrogen content of winter wheat.

Materials and methods

Data are originated from a long-term field experiment with heavy metals, which was established in 1994 at Tass-puszta Model Farm of Károly Róbert College. The soil type of the experiment field is a slightly acid chernozem brown-forest sol, which formed on a basic volcanic rock (andesite, andesite tuff). Its main characteristics are as follows: $pH_{(H2O)}$=6.4; $pH_{(KCl)}$=5.4; y_1=9.5; $CaCO_3$%=0; humus content=3%; upper limit of

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plasticity (K_A) = 45; L%=70; hy=4.8. This is a silty-clay soil; its bulk density is 1.21 g cm^{-3}.

The field trial was set up with 8 elements (Al, As, Cd, Cr, Cu, Hg, Pb, Zn) on 3 levels each (0/30, 90, 270 kg elements ha^{-1}), i.e. 24 treatments all in triplicate with 72 plots altogether arranged in split-plot design. Treatments were carried out once at initiation using soluble salts of elements (*Table 1.*).

Table 1. Treatments of the field trial

Element	Loading levels kg element ha^{-1}			Form of salt applied
	1	2	3	
Al	0	90	270	$Al(NO_3)_3{\cdot}9H_2O$
As	30	90	270	$NaAsO_2$
Cd	30	90	270	$3CdSO_4{\cdot}8H_2O$
Cr	30	90	270	K_2CrO_4
Cu	30	90	270	$CuSO_4$ $5H_2O$
Hg	30	90	270	$HgCl_2$
Pb	30	90	270	$Pb(NO_3)_2$
Zn	30	90	270	$ZnSO_4{\cdot}7H_2O$

Winter wheat was the experimental plant in 1995. Plots were cultivated with commonly used agrotechnics. Plant samples were taken at the end of shooting and at harvest (4x1 m above ground part per plot). After weighting, drying and grinding the element content was determined by cc.HNO_3+H_2O_2 digestion and ICP-MS technique.

Results and discussion

Winter wheat can be characterized with an intensive nutrient uptake at shooting. At this stage, Cr and Zn treatments were highly, As and Cu loads moderately phytotoxic. The data of visual assessment and shoot weight are presented in *Table 2*. With higher loads, the crop grew yellow and dry, the dry matter content increased, which reflected problems in life function.

Table 2. Effect of treatments resulting phytotoxicity of wheat at shooting

Element	Treatments, kg element ha^{-1}				$SD_{5\%}$	Mean
	0	30	90	270		
Visual assessment (1=very weak, 5=well developed stand)						
As	5.0	5.0	4.3	3.0	1.1	4.1
Cr		4.7	3.3	1.7		3.2
Cu		4.7	4.0	3.0		3.9
Zn		4.3	3.2	2.7		3.4
Green shoot kg per 4m (0.5 m^2)						
As	1.36	1.29	0.91	0.89	0.4	1.03
Cr		1.02	0.50	0.16		0.56
Cu		0.90	0.80	0.76		0.82
Zn		0.98	0.60	0.40		0.66

The phytotoxic As, Cu and Zn treatments didn't cause significant changes in the nitrogen content of wheat shoot, but the extreme high doses of Cr (90 kg ha^{-1}, 270 kg

ha^{-1}) increased the concentration of nitrogen (*Table 3.*). Compared to the normal composition of vegetative organs of wheat (3.5-5% N), the increased nitrogen concentration is not very high. There was only slight decrease in the NO_3-N content of shoot by treatments caused toxic effects.

Table 3. Effect of phytotoxic microelement treatments on the nitrogen uptake of winter wheat at shooting

Element	Treatments, kg element·ha^{-1}			$SD_{5\%}$	Mean
	30	90	270		
N%					
As	4,24	4.25	4.46	0.36	4.32
Cr	4.29	4.82	4.84		4.65
Cu	4.38	4.25	4.06		4.23
Zn	4.22	4.54	4.49		4.42
NO_3-N%					
As	0.26	0.28	0.32	0.12	0.32
Cr	0.34	0.28	0.27		0.30
Cu	0.27	0.23	0.22		0.24
Zn	0.26	0.25	0.24		0.25

Phytotoxic effect of As, Cr, Cu and Zn treatments were also observed at harvest. Grain yields decreased by more than 2 t ha^{-1} with high applications of Cr, Cu and Zn, while As application caused not statistically significant loss of grain (*Table 4.*). The total biomass reached 10-12 t ha^{-1} on the control plots, while it was only 6-9 t ha^{-1} on plots with 270 kg ha^{-1} Cr, Cu and Zn loads.

Table 4. Effect of treatments causing decrease in wheat yield at harvest

Element	Treatments, kg element ha^{-1}				$SD_{5\%}$	Mean
	0	30	90	270		
Grain, t ha^{-1}						
As	4.94	5.48	4.86	4.29	1.31	4.88
Cr		5.22	4.96	2.70		4.29
Cu		5.43	4.51	3.41		4.45
Zn		4.86	4.44	2.52		3,94
Air-dried total biomass, t ha^{-1}						
As	12.13	12.98	12.65	10.74	2.71	12.12
Cr		12.56	11.67	6.60		10.28
Cu		12.74	10.43	8.77		10.65
Zn		11.55	10.63	6.74		9.64

Nitrogen content varied between 2 and 3% in the grain at harvest. It was equalized in case of As, Cr and Cu treatments, but the highest Zn load resulted in increased N content. The NO_3-N content was less then one percent of N concentration in the grain and it wasn't affected by toxic element treatments (*Table 5.*). N concentration was about 0.8-1% in the wheat straw at harvest. Significant changes weren't experienced in this experiment (*Table 6.*).

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Table 5. Effect of phytotoxic microelement treatments on the nitrogen content of winter wheat grain at harvest

Element	Treatments, kg ha^{-1}			$SD_{5\%}$	Mean
	30	90	270		
N%, grain					
As	2.42	2.32	2.39	0.45	2.38
Cr	2.48	2.35	2.58		2.47
Cu	2.29	2.28	2.51		2.37
Zn	2.29	2.33	2.73		2.45
NO_3-N%, grain					
As	0.011	0.028	0.006	0.055	0.015
Cr	0.004	0.002	0.004		0.003
Cu	0.057	0.005	0.008		0.023
Zn	0.28	0.009	0.006		0.014

Table 6. Effect of phytotoxic microelement treatments on the nitrogen content of winter wheat straw at harvest

Element	Treatments, kg ha^{-1}			$SD_{5\%}$	Mean
	30	90	270		
N%, straw					
As	0.59	0.88	0.95	0.37	0.81
Cr	1.11	1.14	1.22		1.15
Cu	0.96	0.84	0.93		0.91
Zn	0.91	0.87	0.85		0.87
NO_3-N%, straw					
As	0.10	0.10	0.11	0.30	0.10
Cr	0.04	0.04	0.06		0.05
Cu	0.29	0.27	0.23		0.26
Zn	0.08	0.08	0.06		0.07

Conclusions

High doses (90 and 270 kg ha^{-1}) of As, Cr, Zn and Cu proved to be toxic for winter wheat, but increased doses of these elements didn't cause significant changes in the N content of wheat organs. Phytotoxic microelement treatments slightly decreased the NO_3-N content in wheat shoots at shooting phenophase. At harvest the NO_3-N concentration was equalized both in straw and grain. Therefore, toxic effects and symptoms caused by increasing As, Cr, Zn and Cu treatments weren't resulted in the N deficiency of winter wheat tissues.

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OPTIMAL NUTRITION OF WINTER WHEAT IN DIFFERENT AGRO-ECOLOGICAL CONDITIONS IN LONG-TERM FERTILIZATION EXPERIMENTS

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Abstract: Studies were made on the effect of unfertilized control and 19 different fertilization treatments on the grain yield of winter wheat at two out of the nine experimental sites of the Hungarian National Long-Term Experimental Network. On the chernozem brown forest soil of Bicsérd (BI) site and on the calcareous chernozem soil of Iregszemcse (IR) site, the optimal level of NPK nutrition of winter wheat regarding the grain yield was determined in a crop rotation of wheat-maize-maize-wheat in 1968-2000. An NPK dose was regarded as optimal fertilizer level, if in comparison to it, the yield increase effected by the maximal NPK dose was lower than the significance level. Of course, the optimal NPK doses have considerably changed from time to time during the 32 experimental years depending on the soil fertility of the sites, seasonal effects (precipitation), plant diseases and cumulative fertilizer effects. On the average of the 17 years of the biculture, 126 kg N, 89 kg P_2O_5 and 76 kg K_2O ha^{-1} $year^{-1}$ ensured the optimal wheat yields at BI, while 123 kg N, 78 kg P_2O_5 and 65 kg K_2O ha^{-1} $year^{-1}$ at IR. The yield responses of the unfertilized wheat and the optimal yields were 2.57 and 5.26 t ha^{-1} at BI, while 2.47 and 4.31 t ha^{-1} at IR, respectively.

Keywords: long-term fertilization, winter wheat yields, optimal NPK nutrition, precipitation

Introduction

The oldest long-term field experiments were established in Rothamsted in 1843. In Hungary Cserháti and Kosutány studied the fertilization of plants and the soil fertility of arable lands already at the end of the 19th century, and Sigmond (1904) was the first, who developed soil analytical methods related to soil fertility. Várallyay (1954) organized the establishment of classic experiments with nutrient deficient treatments on different soil types in our country. In 1963 the Hungarian Long-Term Field Fertilization Experimental Network was set up in order to study the effect of mineral fertilization (Debreczeni and Németh, 2009). These experiments, the results and findings drown from them are characteristic of the given site and make possible to study timely causal relations, which can not be found out from experiments of other types. The investigation of nutrient accumulation, leaching and transformation, as well as the modeling of soil organic matter formation within the frame of stable crop rotation systems applied in the long-term experiments largely help us in understanding of long-term processes in the soil. Studies on environmental and seasonal (precipitation and temperature) effects taken on the agriculture are summarized in the publications of Steiner and Herdt (1993), Debreczeni and Körschens (2003).

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Materials and methods

The Hungarian National Long-Term Experimental Network was established in 1967 in different agro-ecological regions of the country. Fertilizer treatments with increasing NPK doses and different rates were applied. In our days experiments are conducted at nine sites, with two crop rotations and at four sites with maize monoculture. These experiments can be powerful tools to recognize the effect of long-term fertilization on the soil, ground water, yield and quality of our cultivated plants.

Table 1. Main soil properties of the experimental sites

Site	Soil type (FAO)	Clay (%)	pH(KCl)	Humus (%)	AL-soluble P_2O_5 (mg kg^{-1})	AL-soluble K_2O (mg kg^{-1})	Precipi-tation (mm)
BI	Luvic Cambisol	27	6.40 (in 1979) 5.04 (in 1999)	2.30 2.00	58 51	263 268	634* 453**
IR	Calcaric Phaeosem	18	7.25 (in 1979) 7.35 (in 1999)	2.26 2.07	151 146	169 141	614* 424**

*average precipitation in agro-meteorological years (01. Oct. - 30. Sept.) 1967-2001
**average precipitation during vegetation (veget.) (1. Oct - 30. Jun.)

At BI and IR sites grain yields of winter wheat were evaluated from the crop rotation winter wheat–maize-maize-winter wheat in the experimental years 1968-2000, which means 8.5 crop rotations. The soil type, soil properties and precipitation amounts at the experimental sites are listed in *Table 1*. Winter wheat was first sown in the autumn of 1967, first harvested in 1968. Besides an unfertilized control, nineteen fertilizer treatments, 0-N-NP-NK-NPK, were applied with increasing doses (*Table 2*.). The number of replicates was four. Detailed description of the experiments can be found in the work of Debreczeni and Németh (2009). The optimal level of NPK nutrition of winter wheat regarding the grain yield was determined. An NPK dose was regarded as optimal fertilizer level, if in comparison to it, the yield increase effected by the maximal NPK dose was lower than the significance level.

Table 2. Fertilizer treatments of winter wheat in the experiment (kg N, P_2O_5, K_2O ha^{-1}year^{-1})

Treatment codes	N1	N2	N3	N4	P1	P2	P3	K1
Doses before 1988	50	100	150	200	50	100	150	100
Doses after 1988	100	150	200	250	60	120	180	100

Results and discussion

Yield results demonstrated in *Tables 3.* and *4.* can reflect the cumulative effect of 34-year long-term fertilization, which could obviously not be separated for the case of wheat and maize. The “optimal” fertilizer levels have changed depending on the seasonal effects, soil type, water supply of the sites of different agro-ecological characteristics. The averaged optimal levels show that relatively low NPK doses proved to be sufficient at both soil types of different acidity, phosphorus and potassium contents. The yearly precipitation and its amount fallen in the vegetation period, moreover in the critical periods (not shown), markedly affected the yields. Of course, these unfavorable effects are especially remarkable in the experimental years with more or less precipitation than the average. The yields of the unfertilized control plots show the status of the soil fertility at the sites in the studied 17 experimental years of the rotation. The yield of the unfertilized treatments did not continue to decrease, which show the balanced soil fertility at the sites. The conspicuously low yields in some years are connected with the yearly precipitation amounts. Our results show, that unfertilized soils could not ensure our consumption requirements.

Table 3. The optimal nutrition of w. wheat at BI site (1968-2000)

Years	Control yields (t ha^{-1})	Optimal yields (t ha^{-1})	Optimal fertilizer levels (N, P_2O_5, K_2O, kg ha^{-1}year^{-1})			Precipitation (mm)	
						in agro-met. year	during veget.
1968	3.85	4.75	50	100	0	449	267
1971	2.40	5.20	150	100	100	447	311
1972	2.66	4.54	50	100	0	823	411
1975	1.75	3.84	100	50	100	786	594
1976	3.49	5.38	100	100	100	510	334
1979	1.35	4.11	150	100	0	572	413
1980	2.96	5.92	100	100	100	635	463
1983	1.77	5.54	150	50	100	574	400
1984	2.45	4.58	100	100	0	660	465
1987	1.66	4.34	100	50	100	788	640
1988	3.53	5.89	200	120	100	540	395
1991	3.24	6.44	100	120	100	563	446
1994	3.37	6.86	150	60	100	591	472
1995	0.98	4.51	150	60	100	809	532
1996	2.02	5.16	200	120	100	677	395
1999	2.30	4.02	200	60	100	878	607
2000	4.00	8.31	100	120	100	544	432
*total/ **averag e	*43.78	*89.39	**126	**89	**76	**634	**453

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Table 4. The optimal nutrition of w. wheat at IR site (1968-2000)

Years	Control yields (t ha^{-1})	Optimal yields (t ha^{-1})	Optimal fertilizer levels (N, P_2O_5, K_2O, kg $ha^{-1}year^{-1}$)			Precipitation (mm)	
						in agro-met. year	during veget.
1968	2.88	3.08	100	100	0	488	228
1971	2.20	4.50	150	50	0	410	283
1972	2.39	4.21	150	50	100	740	410
1975	2.32	5.32	100	100	100	840	527
1976	1.67	4.14	100	100	100	514	317
1979	1.27	2.73	100	100	0	606	453
1980	3.17	7.31	100	100	100	632	483
1983	2.37	4.16	100	100	0	518	413
1984	3.34	5.24	150	50	100	633	422
1987	2.05	3.93	150	100	100	676	495
1988	4.55	7.24	100	60	100	530	337
1991	3.81	5.93	150	60	100	570	317
1994	2.70	4.65	100	60	0	462	388
1995	1.82	5.44	100	60	100	774	595
1996	0.90	2.37	200	120	0	795	439
1999	1.45	3.01	150	120	100	840	628
2000	3.19	4.86	100	0	100	482	336
*total/ **average	*42.08	*73.26	**123	**78	**65	**614	**424

Conclusions

The seasonal effects, i.e. precipitation in the agro-ecological year and in the growing season considerably influenced the wheat yields both in the unfertilized control and in the different NPK fertilizer treatments. Extreme circumstances, precipitation amounts higher and lower than the average resulted in significant yield decreases, in particular in the unfertilized control treatments. On 17-year average of the bicultures of the studied 34 experimental years, 126 kg N, 89 kg P_2O_5 and 76 kg K_2O ha^{-1} $year^{-1}$ ensured the optimal wheat yields at BI, while 123 kg N, 78 kg P_2O_5 and 65 kg K_2O ha^{-1} $year^{-1}$ at IR.

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RELATIONSHIP BETWEEN SOIL ACIDIFICATION AND ZINC FERTILIZATION IN A MODEL EXPERIMENT

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Abstract: Zinc is an essential nutrient for living organisms. Mobile zinc ions can be taken up by plants in higher amount than their physiological need and herewith can be available for animals and human beings through food chain.
Zinc has a relatively high affinity for the soil particles, however concentration of free zinc ions can increase due to abrupt and intensive acidification. Our examinations were carried out on goethite as an adsorbent. Goethite plays an important role in ion adsorption in soils. Zinc was chosen for our experiment among those heavy metals which have similar adsorption properties.
Zn is necessary for plant growth, but in higher amount can be toxic. Our results are able to describe the parameters determining the soils Zn supply. However, the interval between the plant growth necessary and toxic amount is very narrow and further examinations are necessary for investigate the exact amount of Zn, which is needed by the plant.

Keywords: Zn adsorption, H^+ desorption, goethite, pH

Introduction

Filep (1998), Csathó (1994), Kádár and Németh (2003) give an overview of the heavy metal contamination of Hungarian soils.
The natural goethite is a peculiar formation of the surface weathering processes. In near-surface sediments and the soil goethite is a building material of the iron particles, iron films and crust, red and brown discolorations. The amorphous coatings crystallise over time (Bohn et al., 1985).
The aqua complex metallic ions of dissolved in the solution connect to the surface through the ligandum, while water molecules distant from the surface dissociate H+-ions into the solution. From the aspect of the complex metal ions a ligandum exchange reaction occurs: the free water molecules exchange on the surface to chemically combined water or OH- ions. Following the primary adsorption the combined complexes may chemisorb into stronger ions while water is released, or build into the crystal matrix of the surface. (Kinnibourgh, 1983)
Forbes et al. (1976), Bar-Yossef (1979), Padmanabham (1983), Bruemmer et al. (1988) and Brümmer et al. (1983) have explained the decrease in pH as partly due to hydrolysis of Zn^{2+} to give $ZnOH^+$ and H^+ and partly due to re-adjustment of charge on the soil colloid surfaces as $ZnOH^+$ ions are sorbed.
Rimmer and Uygur (1998) examined the Zn absorption of the precipitated ferrous oxide films that form in quantities on the $CaCO_3$ crystals of the soil. The research proved that the effect of the presence of iron oxide coatings on calcite surfaces is to increase the specific adsorption of the Zn and to decrease the formation of precipitation compared to the un-covered lime surfaces.
Schlegel et al., (1996) examined the goethite crystal-structure during Zn complex adsorption with XAFS - x-ray absorption fine-structure – methods. They concluded that

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the adsorbed heavy metal in partly build in the crystal-matrix of the surface while they loose their ligandums.
On the basis of experiments it has been concluded that adsorption of heavy metal on soil was affected by pH (Ioannou et al., 2003; Czinkota et al., 2002.) and Eh (Czinkota et al., 2006).

Material and Method

For this paper we examined the goethite with X-ray diffraction and thermo-analytical methods. The samples were examined original state and after 24 hours of heating on 100˚C and 24 hours of heating 200˚C. The final samples match the composition of the natural goethite, but it is very probable that a multi-phase iron-hydroxide / iron-oxy-hydroxide system may superpose within the otherwise well-ordered goethite-matrix, similarly to the processes in the nature.
For a proper diagram al least 7 measure points are necessary. With preliminary test experiments we determined the range of concentrations in which reliable results can be achieved. Seven different concentration solutions 0- 5 - 7,5 - 10 - 12,5 - 15 - 20 - 25 mgZn·1000 cm^{-3} as $ZnSO_4$ - were used for the research. 0,1 g synthetic goethite powder was poured in the 50 cm^3 zinc solutions, and the sample tubes were shaken for 24 hours.
The final solutions were recovered with centrifugation (5 min 5000 min^{-1} speed) and filtration. The concentrations of the equilibrium solutions were determined with atomic absorption spectrofotometric detection, using a Perkin-Elmer AAS equipment, on the 213.9 nm wavelength that equals the light absorption of zinc. The quantity of desorbed H^+ ions was determined with titration, by using 0.02 mol.dm^{-3} NaOH solution. The pH was measured with Radelkis OP 210 glass electrode pH meter.

Results and conclusions

All of concentrations (initial and equilibrium) were applied in two different dimensions (mg·dm^{-3}, mmol·dm^{-3}). The adsorbed quantities were calculated as the decrease in concentration of solution while the process of adsorption (*Table 1.*).

Table 1. The Zn concentration of the solutions, the quantity of adsorbed Zn and desorbed H^+-ions

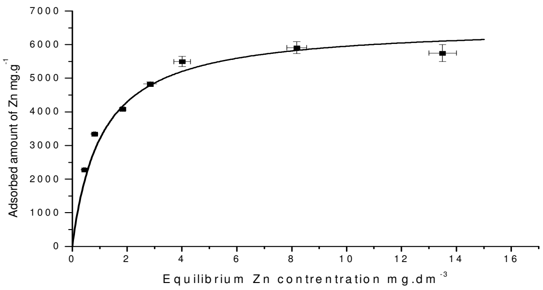
Initial Zn concentration mg·dm^{-3}	Equilibrium Zn concentration			Adsorbed Zn			Desorbed H^+	
	mg·dm^{-3}	error	mmol·dm^{-3}	mg.g^{-1}	error	mmol·g^{-1}	mmol·g^{-1}	error
0	0	0	0	0	0	0	0	0
5	$6 \cdot 10^{-2}$	0,005	$9,1 \cdot 10^{-4}$	2,46	2,33	$3,7 \cdot 10^{-2}$	0,06	0,007
7,5	$1,8 \cdot 10^{-1}$	0,013	$1,9 \cdot 10^{-4}$	3,65	6,38	$5,5 \cdot 10^{-2}$	0,15	0,010
10	$8,5 \cdot 10^{-1}$	0,058	$8,8 \cdot 10^{-4}$	4,57	29,38	$6,9 \cdot 10^{-2}$	0,21	0,003
12,5	1.8	0,138	$2,1 \cdot 10^{-3}$	5.30	69,00	$8,1 \cdot 10^{-2}$	0,21	0,024
15	3.3	0,409	$4,5 \cdot 10^{-4}$	5,80	204,76	$8,8 \cdot 10^{-2}$	0,42	0,029
20	8.8	0,417	$4,5 \cdot 10^{-4}$	5,58	208,94	$8,5 \cdot 10^{-2}$	0,45	0,090
25	14.1	0,417	$4,5 \cdot 10^{-4}$	5,42	208,88	$8,3 \cdot 10^{-2}$	0,99	0,117

Zn adsorption on goethite fitted to the Langmuir adsorption isotherm (*Figure 1.*). The form of the equation used was:

$$Q = \frac{A \cdot k \cdot c}{1 + k \cdot c}$$

WhereQ = the amount of adsorbed Zn ($mg.kg^{-1}$)
c = the equilibrium Zn concentration ($mg.dm^{-3}$)
A = the Langmuir adsorption maximum ($mg.kg^{-1}$)
k = the Langmuir energy constant ($dm^3.mg^{-1}$)

Figure 1. shows the curve matches the points of the results of the measures. As expected, Zn sorption increased with increasing added Zn concentration for goethite. Zinc and hydrogen are concurring during the adsorption process. The adsorption become less effective due to acidification caused by the hydrogen desorption. In other words the adsorption balance shifting toward desorption because of the higher quantity of the H^+-ions, i.e. less zinc can be adsorbed.



Parameter	Value	Error
A	6589	579
k	0.93	0.30
R^2	0.92	

Figure 1. The adsorption isotherm of the Zinc adsorption on the surface of the goethite and parameters of the Langmuir adsorption isotherm

Delineating the quantity of desorbed H+ ions in relation of the adsorbed Zn the first linear stage is followed by an exponential increasing step (*Figure 2.*) Greater adsorption of Zn, that is showed by increasing of H+ concentration, led to precipitation as $Zn(OH)_2$ which was evidenced by the rising of slope in the isotherm. The explanation of this phenomenon requires further research.

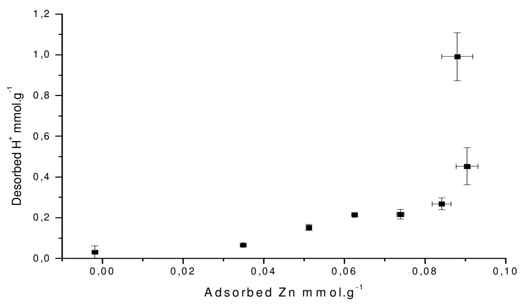
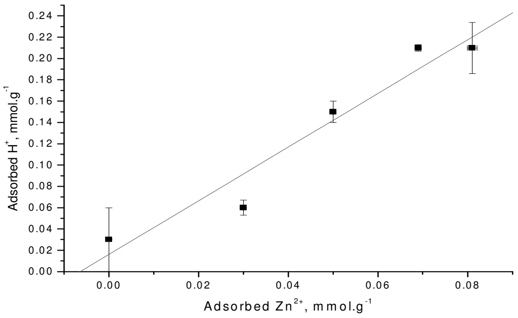


Figure 2. The quantity of desorbed H^+ ions from the surface of the goethite, in relation of the quantity of the adsorbed Zn

 DOI: 10.1556/Novenyterm.60.2011.Suppl.2

The rise of the curve about the initial stage of the ion-exchange is gradient ~2, (*Figure 3.*). An explanation for the expected two may be the proportion of the valences. The presumed process is: SURFACE=Zn + 2 H^+ > SURFACE=H_2 + Zn^{2+}



Parameter	Value
Intersection	-0,02
Gradient	2.42
R	0.96

Figure 3. The quantity of desorbed H+ ions from the surface of the goethite, in relation of the quantity of the quantity of the adsorbed Zn, the linear section of curve

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THE SOIL DEM MODEL AND IT'S VERSATILITY TO DESCRIBE THE SOIL-TOOL INTERACTION

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Abstract: The discrete element method (DEM) could be a useful tool for making a special model to describe the soil–tool (sweep) interaction. Virtual DEM models were developed simultaneous with the real tests. In this article we will introduce the methods of how DEM approach was used in developing a model for the prediction of draught force on cultivator sweeps arranged in triangle on a frame. The mechanical behavior of soil is very complex and depends on factors including water content, density, and other conditions. The conventional approach to explore the mechanical behavior of soil mainly relies on experimental shearing tests under laboratory conditions. The implementation of DEM is carried out by a series of numerical triaxial tests on granular assemblies with varying confining pressures. The results demonstrate that the numerical simulations can produce correct responses of the soil behavior in general, including the critical state response, as compared to experimental observations using the Mohr circles whitch results were compared with the soil bin tests.

Keywords: Soil, Cultivator, DEM, Modeling, 3D, Soil Bin, Forces,

Introduction

The field mulch cultivator as a conservation tillage method gets more importance nowadays. The most influencing for the energetic requirement is the tool inclined angel (β). The arrangement is quite important for each sweeps in the tillage process. The draft force volumes different in each sweep tools.

In this paper we would like to introduce the applicability of DEM (Discrete Element Method) to evaluate the tool draft force and the dependence of the arrangement on the frame after a triaxial and the shear box tests synthesis. Although, experimental study of soil-tool interaction is expensive and limited to certain cutting speeds, the results are highly dependent on the accuracy of the measuring devices (Chi, Kushwaha, 1991).

Materials and Methods

DEM is a discontinuous numerical method based on molecular dynamics (Cundall, 1971). The soil which is cut or separated by soil engaging components

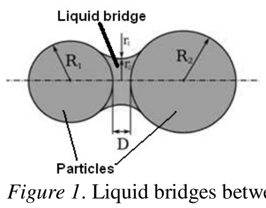

Figure 1. Liquid bridges between soil particles

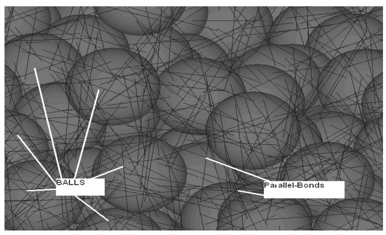

Figure 2. The balls and parallel bonds in the PFC3D.

is much more discrete, therefore DEM is an ideal method to analyze large discontinuous deformations of soil (Asaf, Z., D. Rubinstein and I. Shmulevich, 2007). Cohesive soil contains water and the presence of water can

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produce cohesion between soil particles, which makes the mechanical structure of these soils much more complex (Cundall, Hart, 1992).

The parallel-bond model describes the constitutive behavior of a finite-sized piece of cementatious material deposited between two balls. The two balls are treated as spheres. These bonds establish an elastic interaction between particles that acts in parallel with the slip or contact-bond models thus the existence of a parallel bond does not preclude the possibility of slipping. Parallel bonds can transmit both forces and moments between particles, while contact bonds can only transmit forces acting at the contact point (Bojtár, I., and K. Bagi,1989).

Triaxial Test

Although it is relatively easy to assign chosen properties to a PFC model, it is often difficult to choose such properties so that the behavior of the resulting synthetic material resembles that of an intended physical material. For codes such as PFC3D that synthesize macro-scale material behavior from the interactions of microscale components, the input properties of the microscopic constituents are usually not known.

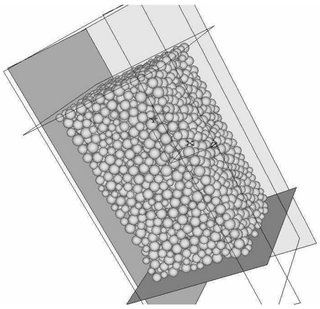

Figure 3. The specimen- collection of the discrete elements.

Table 1. Soil mechanical values (Schilling 1930)

Soil Type	Cohesion (KPa)	Internal friction angle °	Friction modulus
Sand	0-10	37-34°	0,67-0,73
Sandy silt	10-25	35-32°	0,625-0,70
Silt	25-40	32-28°	0,53-0,625
Heavy silt	40,-60	28-25°	0,466-0,53
Clay	60-100	25-20°	0,37-0,466

A series of shear tests were performed. The simulated mechanical behaviour of granular materials is compared with those observed from the laboratory tests. It seems logical to assume that the maximum value of the horizontal force (Tf) is related to the vertical force N by a relation of the form:

$$Tf = cA + N \tan \varphi,$$

where A is the area of the sample,
c is the cohesion of the material,
and φ its friction angle.

This is called the Mohr-Coulomb failure criterion. If the stress circle is completely within the envelope no failure will occur, because on all planes the shear stress remains well below the critical value (Donzé 1999). Using the results of the triaxial test (the peak

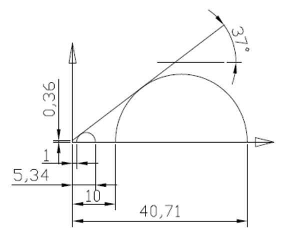

Figure 4. Mohr's circles, define the cohesion ($36x10^3$ Pa) and the internal friction angle (37°).

Table 2. Triaxial Test Results, sig_f: peak strength

Confinement	SPECIMEN
y: Pc	sig_f
($x10^5$Pa)	($x10^5$Pa)
1	5,34
10	40,71
avg.	**23,025**

strength and confining stress) we defined the Mohr's circles. Touching the circles we drew the Coulomb line. The angle of the line and the x axis we defined the internal friction angle. The intersection of the Coulomb line and the y-axis we defined the cohesion. As we can see on the Figure 4. the cohesion is 36 kPa and the internal friction angle is 37°. This soil mechanics property following the real triaxial tests is a kind of silt. With this process we can harmonize the real and the numerical methods.

Results and Discussions

Table 3. Model parameters

Parameter in DEM	Value
Bulk density (kg/m^3)	1850
Particle shape	Ball
Normal spring coefficient (K_n) [N/m]	1,00E+12
Tangential spring constant (K_s) [N/m]	1,00E+12
Coulomb damping (μ_g)	0,4
Friction coefficient between particles (μ)	0,5
damp viscous normal	0,7
damp viscous shear	0,7
Particle radius	0,06-0,1
Friction coefficient between p. and tool	0,6
Void ratio	0,75
Parallel-Bond (heavy soil)	
pb_rad	1
pb_kn	1,00E+04
pb_ks	1,00E+03
pb_nstren	1,00E+05
pb_sstren	1,00E+03
Time step of the calculation (Δt) (s)	4.0 × 10-5

The dynamic behavior of cohesive soils during the loosening process by a cultivator sweep was simulated by using the above established DEM mechanical model of cohesive soil via PFC3D. The initialization of the interaction between the tool and cohesive soils is the complete model.

Parallel bonds near the tool decrease significantly and even disappear with time going. The disturbance of cohesive soil increase and more soil bonded particle rupture and separation with the tool moving.

The established model were analysed with the above mentioned sweep configuration. The results showed significant cutting force (20 cm depth) effect of the tool setting on the frame. In this research the two front sweep has 918,97N ; 984,78N (Wall10-12) and the rear sweep share (Wall14) has 578,66N average draft forces .

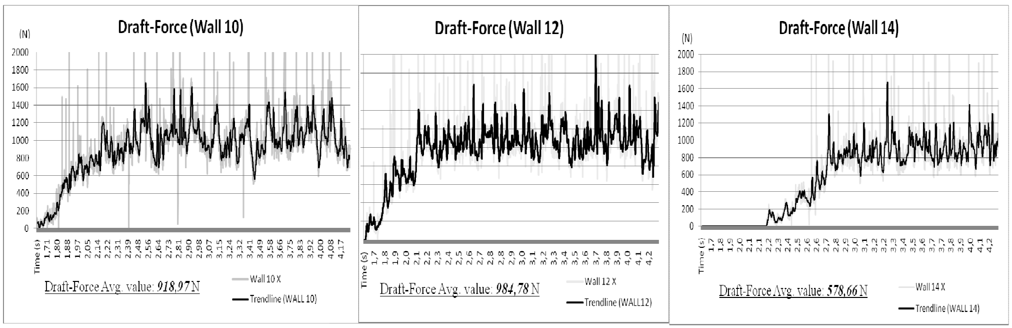

Figure 5. (Wall10-12-14) Draft Force: 918,97 N , 984,78 N , 578,66 N

 DOI: 10.1556/Novenyterm.60.2011.Suppl.2

Conclusions

As we can see on the *Figure 6.* the draft-force in DEM is similar to the measured Soil Bin draft force. In the DEM numerical approach the parallel-bond contact was used to describe the behavior of the discontinuous, cohesive soil during soil-tool interface process. After the triaxial test method with which we validated the micro properties, the established model was analyzed with a common arrangement of three sweeps. The results showed the significant effect of the tools draft forces in 20 cm depth.

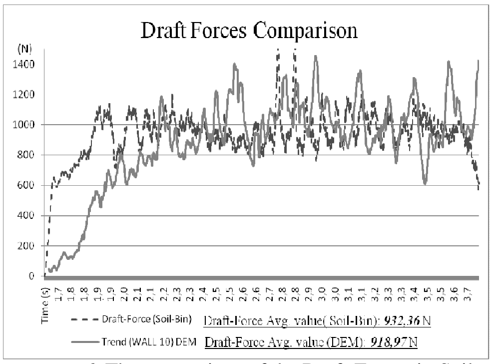

Figure 6. The comparison of the Draft-Forces in Soil Bin and in the Discrete Element Model

The discrete element method can be used for simulating the soil cutting processes in non-homogeneous soils and for the investigation of soil loosening and sweep performance in a required configuration..

Acknowledgements

The authors wish to acknowledge the instrumentation and the assistance on soil bin and in the field test for the Hungarian Institute of Agricultural Engineering Gödöllő and the grant from National Office for Research and Technology. These researches were partially supported by the Hungarian Research Fund, under grant no. OTKA 48906.

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IMPACT OF ORGANIC AND MINERAL FERTILIZATION RATES ON THE YIELD OF POTATO *(SOLANUM TUBEROSUM)*

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Abstract: The impact of organic (farmyard manuring [FYM]) and/or mineral nutrition (NP-fertilizer with or without K) was investigated in a long-term field experiment on a Eutric Cambisol in 5-years crop rotations including potato as initial crop in the rotations. Potato yield results of 15 different treatment combinations from two rotations were evaluated.
Increasing N-doses were effective only up to 90 kg ha^{-1}, but combined FYM and mineral N treatments continued to increase the potato yields. On the average FYM doses resulted in 16 % less potato tuber yield than equivalent mineral NPK doses. The N-utilization of FYM was 41 % lower than that of mineral fertilization**.** The N-utilization of potato, wheat and maize were 12, 27 and 47 %, respectively. Potassium deficient treatments significantly decreased the potato yield, while maize and wheat did not give remarkable yield responses to K deficiency.

Keywords: potato tuber yield, organic and mineral N-fertilization, N-utilization.

Introduction

With its 20-25 thousand hectares production area potato is a moderately important field crop in Hungary. The main reason for it is that our climate is less suitable for its cultivation, the production is expensive, average yields are about the half of the optimum. Potato plays, however, a very significant role in our everyday nutrition. Therefore, it is important to increase the average yields and to ensure the home consumption requirement. Besides irrigation, harmonic fertilization is an important tool to achieve this aim. Potato yields best in fertile conditions and therefore fertilizer applications are frequently high (Soffe, 2003) Despite the high K demand of potato, nitrogen is the most important yield increasing element. The amount of N fertilizer is directly related to soil – N and yield goal. On sandy soils 160, while on loess soils 250 kg ha^{-1} N is recommended as total uptakeable-N (N min) source (Hydro Agri, 1993). Following on fertile soils also relative low N doses (76 kg ha^{-1}) can ensure the optimum yield (Momirovic et al., 2010). However the crop does not remove all of the applied fertilizer and high residual amounts can leave in the soil. Namely the yields of no-irrigated potato closely correlate with weather elements (Abraham and Sarvari, 2006), (e.g. winter precipitation and average temperature of the planting period, Haberle and Ivicic, 2006), causing high yield variability and often low nutrient utilization.

Materials and methods

The long-term organic-mineral fertilizer experiment, the basis of the present investigations, was set up on a Eutric Cambisol at Keszthely/Hungary (46°40' N; 17°15' E) in 1963 with two crop rotations and different doses of farmyard manure (FYM) or equivalent NPK fertilizer and combined treatments of NPK fertilizer and FYM or straw manuring, in four replications. For the present study treatments of simple, double and triple doses of 35 t ha^{-1} FYM and equivalent NPK treatments of FYM doses and combined mineral-organic (FYM or straw) have been selected from the

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two crop rotations "A" and "B" *(Table 1.).* The crop rotations consisted of: „A": potato - maize - maize - w. wheat - w. wheat; „B": potato - w. wheat - w. wheat - maize - maize. Mean annual temperature and precipitation are 10.4 °C and 654 mm, respectively. Soil texture is a sandy loam with low organic matter and P content and medium K content, pH (KCl) = 7.1. For more information see Hoffmann et al. (2010).

Table 1. Selected treatments from rotations A and B of the experiment

Rotation/ Treatments	Codes of treatments	kg N, P_2O_5 , K_2O ha^{-1} yr^{-1}
A/1.	Control	$N_0P_0K_0$
A/8.	1 FYM (2dose)	$N_{44}P_{38}K_{49}$
A/10.	2 FYM (2dose)	$N_{88}P_{76}K_{98}$
A/12.	3 FYM (2dose)	$N_{132}P_{114}K_{147}$
A/4.	1 eqvNPK (2dose)	$N_{44}P_{38}K_{49}$
A/11.	2 eqvNPK (2dose)	$N_{88}P_{76}K_{98}$
A/9.	2 eqvNP (2dose)	$N_{88}P_{76}K_0$
A/13.	3 eqvNPK (2dose)	$N_{132}P_{114}K_{147}$
A/7.	1 eqvNPK + NPK	$N_{172}P_{110}K_{181}$
A/5.	1 FYM + NPK	$N_{172}P_{110}K_{181}$
A/6.	1 FYM + NP	$N_{172}P_{110}K_{49}$
A/14.	1 FYM + 3 eqvNPK	$N_{176}P_{152}K_{196}$
B/12	1 eqvNPK + NPK +straw	$N_{172}P_{110}K_{181}$
B/13	1 eqvNPK + NP +straw	$N_{172}P_{110}K_{49}$

Legends: 1 FYM= 35 t ha^{-1} farmyard manure in 5 years, distributed in the first and third year
1 eqvNPK = mineral NPK equivalent to 35 t ha^{-1} FYM in 5 years, (N: yearly, P and K in the first and the third year distributed) Straw= the actual maize or wheat straw yield, ploughed down in fall.

Results and discussion

Impact of fertilizer forms and doses on tuber yields

Increasing mineral N-fertilizer doses at the rate of 88 kg ha^{-1} (2eqv.) were already enough to achieve an economically optimal yield level under the given site conditions. Additional amounts of mineral nitrogen resulted in no additional yield increase. This relative low fertilizer utilization suggest, that on less suitable sites, with only increasing the mineral fertilizer doses, but without irrigation, and without soil amelioration, much higher potato tuber yield can not be achieved.

Despite the low utilization of the higher mineral N-fertilizer doses, the combined organic-mineral fertilizer treatment (1FYM+3eqvNPK) containing similar N content, could increase the tuber yield on (*Figure 1.*). It proves also, that potato responds well to applications of manure and long-term FYM use, positively affects general soil fertility. However, yields gained exclusively with FYM doses, distributed in two portions for 5 years (50-50 % in first and third year) were by 16 % lower than those achieved with mineral fertilizer doses of equivalent NPK content, but with yearly N distribution (*Figure 2.*).

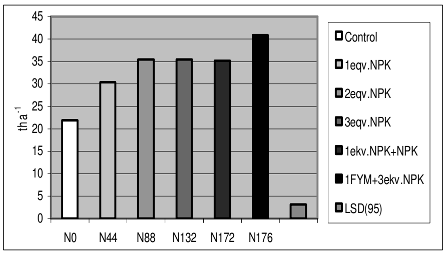

Figure 1. Potato tuber yield as a function of N-dose

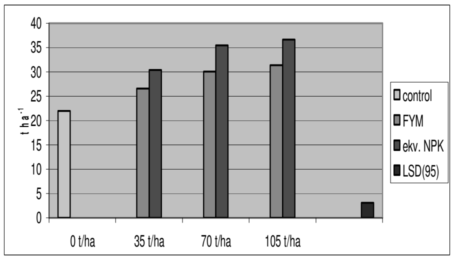

Figure 2. Yield of potato with FYM or mineral fertilization

N-utilization

The utilization of nitrogen applied in different forms, was calculated after the deduction of the N-uptake in the control plot (*Table 3.*). In order to be able to evaluate the results of potato, data of wheat and maize are presented as well. High differences could be detected in case of the three crops. The N-utilization of potato, wheat and maize were 12 %, 27 % and 47 %, respectively.

Also high differences could be detected depending on the fertilizer forms and their doses. In case of potato the average N-utilization of FYM doses was 41 % lower than that of the equivalent mineral fertilizer doses. The same results of the two other crops are also similar. That corresponds to the results of Körschens (2004) informing about utilization of FYM nitrogen to be around 30 % lower as compared to mineral N. The well-known tendency, namely the decrease in the utilization with increasing N-doses, irrespective of the fertilizer form, could be observed in our experiment, too.

Table 2. N-utilization of different N-forms and N-doses with different crops

N-forms and doses	Maize %	Wheat %	Potato %
1 FYM N 44	42.9	22.2	10.4
2 FYM N 88	35.8	27.2	9.2
3 FYM N 132	33.0	18.1	7.2
FYM average	*35.3*	*22.5*	*8.9*
1 eqv N 44	70.5	34.3	19.1
2 eqv N 88	66.6	34.9	15.3
3 eqv N 132	40.3	25.2	11.1
eqv average	*59.1*	*31.5*	*15.2*
Difference of averages *Difference of averages(% / %)*	*23.8* *40.2%*	*9.0* *28.6%*	*6.3* *41.5%*
Averages by crops	*47*	*27*	*12*

Impact of K-fertilization on tuber yield

The impact of K supply was investigated in different treatment combinations using complete and deficient K-treatments. Different rates of K-deficiency were induced by

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three different nutrient combinations Mineral (2eqvNP), mineral+FYM (FYM+NP), mineral+straw (1eqvNPK+NP+straw) *(Figure 3.).* The first combination was equivalent to total K-deficiency, while the two other included partial K-supply as well.
Total K-deficient treatment resulted in significant tuber yield decrease, while the treatments of partial K-deficiency showed only tendentious, but statistically not verified yield reduction. In case of maize and wheat, the two other crops of the rotation, there were not remarkable yield responses to K-deficiency (data are not presented here).

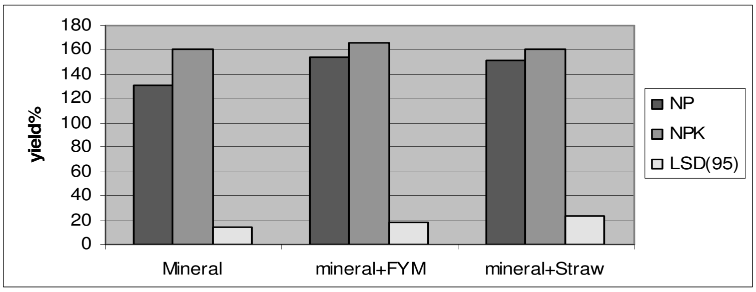

Figure 3. Yield of potato with or without K-fertilization and organic manuring

Conclusions

Potato can respond well to high fertilizer doses in case if other determinant factors as soil quality, water supply and temperature are optimal as well. Because of less effective utilization, single farmyard manuring with rational doses can not completely supply the nutrient demand of potato. However usual dose of FYM combined with mineral NPK fertilization can improve fertilizer efficiency. The N-utilization of potato is much lower than that of maize or wheat. Potato responds to K-deficiency more sensitively than maize or wheat. The probably reason for the last two observation is the relatively week root system of potato plant.

Acknowledgements

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REGULATION OF SOIL NITROGEN SUPPLY BY USING GLYCEROL AS A BIODIESEL BY-PRODUCT

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Abstract: Nitrogen fertilization is one of the most important requirements for high yields. However too high amount of nitrogen fertilization can cause decrease of yield quality and has negative environmental impacts. Since nitrogen is a very mobile nutrient in soil, nitrogen fertilization cannot be reduced on to one time application during the vegetative period. Availability of soil nitrogen to plant depends also on the C:N ratio. Addition of organic compounds with a low nitrogen content to soil, does only increase C:N ratio. As a result of this microbiological activity is increased and the amount of available nitrogen to plants can be significantly decreased. Land application of plant residues is important, but the exact regulation of their effect needs further investigations. One possible way for the regulation could be the addition of glycerol, an easily available carbon source for proper C:N ratio. Glycerol as a by-product from biodiesel production is available in high amounts. For this purpose a pot experiment with ryegrass (*Lolium perenne* L.) was performed. Plant development was detected by visual bonitation. The results show that soil nitrogen supply can be effective regulated by the addition of glycerol, either quantitative, or in time.

Keywords: regulate, byproduct, visual bonitation

Introduction

During the production of biodiesel a lot of waste is produced of which the utilization is still to be solved. Such a material is glycerol. The glycerol can be one of the important nutrients of the microorganisms in the soil. With that the nutrition of the soil can indirectly improve. The carbohydrates and similar organic materials directed in the soil have a strong effect on the nutrition providing abilities of the soil. In particular this effect shows through the change of the amount of nitrogen that can be taken from the soil by changing the C:N ratio. If the C:N ratio of the fresh material moves on a wide scale, the nitrogen gets temporary immobilized (Tisdale and Nelson, 1966). The nutrition providing ability of the soil can be tested with soil tests and plant experiments. The development rate of the plants reacts sensitively on the current nutrition supply. The development of plants, thus the dry matter accumulation, is not linear in time, in the vegetation period it is connected to certain stages of development (Lasztity et al., 1984; Waldren and Flowerday, 1979; Prew et al., 1985), shows changes which are genetically determined yet influenced by external ecological factors, it is the result of the interaction of all these (Lasztity, 2006). The growth rate depends significantly on the available nutrient (Jocic, 1981; Lásztity and Kádár, 1978). The development of the plants can be followed by visual bonitation and computer processing. Narumalani et al. (2009) and Auda et al. (2008) tried to gather information on the spread of the invasive plant species. Sanyal and Patel (2008) judged the rice plant's health and feeding conditions by the shape and size of the plant. Timmermnas and Hulzebosch (1996) used image analysis for isolating the growth stages and plat parts. Behrens and Diepenbrock (2006) scanned the development of the swede rape with the help of image analysis.

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Materials and methods

Test soil, pot experiment and image processing

The experiment was made on a sandy soil from Fót. The main attributes of this soil: saturation percentage K_A=28,33, lime content ($CaCO_3$ %) = 8 %, pH(H_2O)=8,2, humus content (H %)=1,4 %., AL-P_2O_5=95 ppm, ALK_2O= 120 ppm. For treatments we used analytical quality materials. The experiment consisted of two periods. In the first period we tested the effect of the redirected glycerol by-product on the mineral nitrogen content of the soil in an incubation experiment of 2 weeks. In the second period for 2 months we tested the effect of the redirected glycerol by-products on the development of the plants with ryegrass indicator plant. We used the following treatments:

- •0 or 100 ppm nitrogen treatment in the form of ammonium nitrate,
- •0 or 1% carbon treatment in the form of glycerol, methanol and methanol mixed with glycerol
- •constant 100 ppm phosphor (P_2O_5) and potassium (K_2O) treatment in the form of dihydrogen phosphate and potassium sulphate,
- •constant distilled water according to 60% saturation percentage

The images were made at determined times which were depend on the plant growing status. There were 64 pots and 13 treatments. Some of the treatments were repeated. 8 pictures were taken of each pots from different angles (45^0 degrees). On the plant images the image processing program counts the green pixels representing the colour of leaves. In this way we could converse the plant growing status to numerical data. After the pixel number we made a calibration which is able to transform the numbers to plant leaves mass measured in grams. In all treatments the soil samples were mixed with solutions. The calculated amount of materials for the treatments was put in the soil, dissolved in this amount of water. The observation started at the 5th day and it was ended by the dependence of the growing status (Tolner and Czinkota, 2010).

Calibration of the image process

Analyzing the relationship between green pixel numbers and the shoot mass was performed in a former experiment. The pixel numbers were not take into account after the exceed in number 100000 to be accurate. 40 pots were used to examine the parameters. Pictures were taken after the emergence in two days period. 4 pots cut off and dried after each periods than we measured shoot mass on analytical scale. The relationship between shoots mass and the number of pixels can be described by a quadratic parabola. The calibration using the number of pixels concluded from the weight of the plant. So the pixels number corresponding to the shoot mass expressed in grams. The linear relationship stands between the shoot mass and the number of pixels until the shoot mass reach 0,4 grams. This connection is able to describe the definition of shoot mass by optical observation. Logistic function was used to describe shoot mass changes over time. The correlation was determined between the parameters by nonlinear regression (Tolner, 2008).

Results and discussion

The diagrams of the various treatments resulted in leaves mass by the growth process can be seen. Each diagram represents the NPK treatment as a reference base.

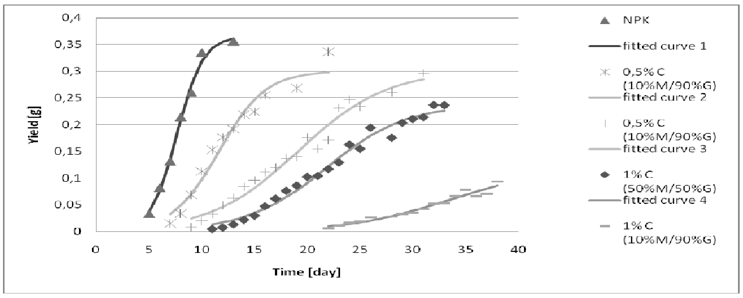

Figure 1. Shows the results of glycerol-methanol mixtures.

Using methanol mixed with glycerol there is clearly visible that the growth begins sooner and greater than pure glycerol.

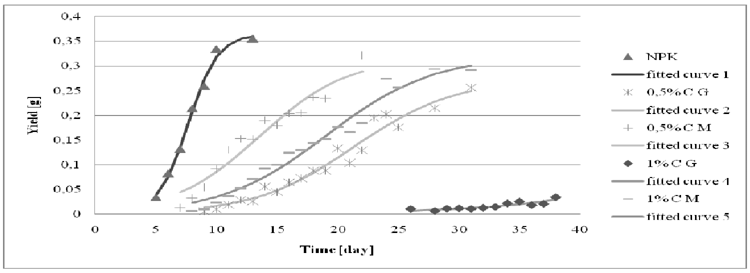

Figure 2. Shows the results of pure glycerol and methanol.

It shows that the various amounts of glycerol have a delaying effect on the growing. Micro-organisms in soil break down and use nitrogen as a nutrient source which is necessary for the plant. In the case of pure methanol treatment the growth begins sooner, because methanol kills micro-organisms.

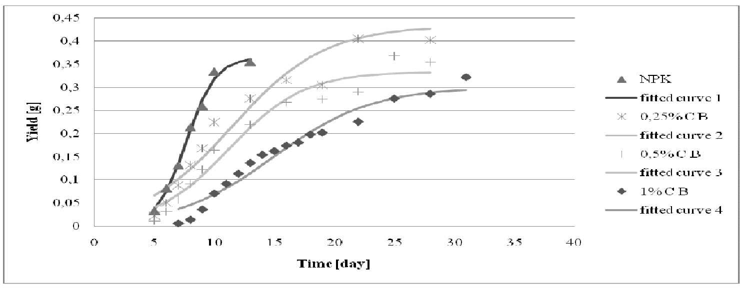

Figure 3. Shows the results of byproduct.

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Figure 3. shows that the yield product depends on the amount of additional byproduct. If we increase the quantity of the byproduct it results a decreasing plant product. More byproduct added it effects less the growth of plant production.

Conclusions

The glycerol can be one of the important nutrients of the microorganisms in the soil. With that the nutrition of the soil can indirectly improve. The carbohydrates and similar organic materials directed in the soil have a strong effect on the nutrition providing abilities of the soil. On the tested sandy soil after adding 0,25% to 1% by product, glycerol, methanol and glycerol methanol mixtures treatments, the active substance of the nitrogen fertilizer in form of ammonium nitrate gets immobilized in more then 50% after 2 days, and on the 5th day gets totally immobilized.

The immobilization of the nitrogen can be proved by the optical observation of the growth of the perennial ryegrass and after that by the image analysis.Plant production is temporarily decreasing as an effect of Glycerol treatment. The water soluble Soil-N is decreasing, because microorganisms consume the available N in soil. Methanol alone or mixed with glycerol inhibit the growth of microorganism therefore decreasing the plant depressing effect. In experiments with by-product there is no toxic effect of methanol, as a conclusion this constituted the most important influence: methanol controls microorganisms hunger for nitrogen and there remains available soluble N for plants.

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PRECISION FARMING AND ECONOMIC QUESTIONS OF FERTILISATION

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Abstract: Nowadays, one of the main objectives is to create the conditions of sustainable farming. Precision agriculture enables these conditions to simultaneously prevail. They include production site-specific growing, technologies which change within a plot, integrated crop protection, high technology, remote sensing, geographic information systems, geostatistics, the change of the mechanization of crop production and the usage of information technology achievements in crop production.
Production is carried out on 94 plots (2800 hectares) in the examined farm. Eight crops are produced, of which the five main crops are winter wheat, maize, rape, sunflower and silage maize. We divided the area of the farm to two sections (blocks). The northern block contains 34 plots (1432 ha) and there are 43 plots (1545 ha) in the southern one. In all eight examined versions, investment without machinery subsidisation can ”only” be subsidised with the precondition of different nutritional replenishment (internal rate of return (IRR) is 9%). In the other scenarios, internal rate of return varies between 9-63%, therefore the investment of the mobile target machine is absolutely advised to be subsidised.

Keywords: fertilising, precision management, net present value, internal rate of return, cost price

Introduction

One of the main objectives in our present day is to provide the conditions of sustainable development. The concept of sustainability was defined by many. It is common in each definition that soil fertility has to be preserved. Sustainable development calls for the adaptation to *ecological* and *economic* conditions also in nutritional management, that is the production site endowments have to be taken into consideration, the production needs and environmental aims have to be in harmony, minimal load has to be put on the environment and economicalness needs to be kept to the fore (Nagy, 2007b, Sulyok, 2007; Víg et al, 2008; Huzsvai and Ványiné, 2009). Precision agriculture makes the common predominance of these conditions possible. This conception includes the production adapted to the given production site, the changing technology in a given plot, integrated crop production, advanced technology, remote sensing, GIS, geostatistics, the change in the mechanisation of crop production and the use of modern IT technology in crop production (Németh et al, 2007). Using satellite navigation, the connecting rows can be tracked with high accuracy and minimal error. Therefore, overlaps, fuel surplus, fertiliser surplus and pesticide use can be reduced. It is also an important aspect that GPS-based steering significantly reduces the workload on the driver. This new technology increases efficiency and reduces costs (Nagy and Dobos, 2006; Dobos et al, 2007). Its efficiency increases by the reduction of loss, as farmers have access to a better decision supporting information system. Environmental load can be reduced and work processes can be better organised. Based on the observations of international and some Hungarian farmers – who have been using this technology for a

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longer period – 20-30% reduction can be achieved in fertiliser costs, whereas around 10% can be saved on fuel and pesticide costs (Nagy, 2007a).

Materials and methods

During our analytical work, we processed the data of an enterprise around the base of the Northern Hills in Hungary that carried out its activity on 2800 ha land. The company produces eight crops total: winter wheat, maize, sunflower, rape, winter barley, triticale, alfalfa and maize for silage. In 2008, the company performed soil sampling on 94 of their smaller (0.7 ha) – and larger (239 ha) plots. During our evaluation work, we examined three versions. Among these, the first one is the currently applied traditional nutritional management technology that is calculated on the basis of the plot average. In this case, the application of fertilisers and pesticides is done by traditional machinery. As a second version, we used differentiated nutritional replenishment – while taking into consideration the current sowing structure – in the case of plots higher than 15 hectares, 4 soil sample units, whereas in the case of plots smaller than these, the application of fertilisers was done on the basis of plot average. In the third case, we created blocks of the production sites of crops. In the smaller – northern – block (1432 hectares), we produce spring crops (maize, maize for silage, sunflower), whereas in the case of the larger – southern – crop production area, we deal with the autumn crops (winter wheat and barley). After the extended examination of soil samples taken per 5-hectare sampling units done by an accredited laboratory, we prepared the nutritional management expert advices of the 77 plots involved in the examination. Expert advices provided on the basis of the plot average were prepared in relation to all plots. In the case of plots larger than 15 hectares – while taking the crops produced so far into account – we prepared the differentiated nutritional management expert advices. Finally, we calculated newer fertiliser doses while adapting to the block position. In the case of plots smaller than 4 sampling units, we used the plot average, whereas we prepared differentiated expert advices on plots larger than these. In the „block" design, we took the crops produced in the given production area into consideration and we calculated the related necessary fertiliser doses. In all three versions, we prepared our precision calculations in relation to the phosphorus and potassium active ingredients, whereas in the case of nitrogen fertilisers, we took the application on the basis of the plot average into account – based on specialised literature data and our own experimental observations – with respect to the mobility of nitrogen active ingredients in the soil. As a next step, we determined the phosphorus and potassium doses to be applied on each plot, followed by the determination of fertiliser doses. We performed the same calculation in relation to the plot average, too. The crops to be produced had the same yield in both fertilisation treatments (maize: 8 t ha^{-1}, winter wheat 5 t ha^{-1}, rape 2.5 t ha^{-1}, sunflower 3 t ha^{-1}, maize for silage 25 t ha^{-1}). We determined the amount of fertiliser to be applied on each plot with precision methods on the basis of the sum of fertiliser to be applied on the plots, whereas we used the plot average to calculate the fertiliser dose to be applied with the traditional method. Following this, we evaluated the results on the basis of the fertiliser prices as of June 2009: 34% ammonium nitrate: 80 HUF kg^{-1}, mono-ammonium-phosphate (MAP) with 52% phosphorus active ingredient content: 120 HUF kg^{-1}, 60% potassium salt: 150 HUF kg^{-1}. We calculated the difference between the results we got with this method in relation to both the entire area and per hectare. We performed the return on investment analyses for 10 years – considering the fact that the depreciation rate of our instruments is 10%. We also showed the returns reduced by machinery subsidisation (25%) and the economically „clean" returns (without subsidisation), that is the return is realised „only" as a result of the efficiency increment of the utilised resources that derive from applying precision technology. In the examined period, we calculated with an average 8% rate of interest, also taking the standpoint of the Institute of World Economics of the Hungarian Academy of Sciences into consideration. We also calculated the internal rate of return (IRR) in all treatments.

Results and discussion

In the case of traditional nutritional management, 156.7 tons of mono-ammonium-phosphate of 52% active ingredient content and 188.8 tons of 60% potassium content potassium-chloride were needed for the production of five crops (maize, sunflower, winter wheat, rape, maize for silage). If we had performed differentiated nutritional management, we would have needed 138.2 tons of MAP and 162.4 tons of potassium chloride. If we had used the precision block sowing structure, we would have needed 127.5 tons of phosphorus and 138.9 tons of potassium fertiliser (*Table 1.*)

Table 1. Fertiliser amounts to be applied (tons)

Crop	Traditional			Precision			Precision-block		
	NH_4NO_3	MAP	Potassium chloride	NH_4NO_3	MAP	Potassium chloride	NH_4NO_3	MAP	Potassium chloride
Maize	176,9	39,3	61,0	176,9	39,8	46,0	176,9	38,2	52,1
Sunflower	191,9	24,4	46,6	191,9	20,3	43,4	191,9	19,1	36,1
Winter wheat	190,7	61,3	39,3	190,7	51,3	34,3	190,7	46,2	31,1
Rape	177	25,2	26,8	177	24,5	25,3	177	46,2	31,1
Maize for silage	36,6	6,5	15,1	36,6	2,3	13,4	36,6	23,9	19,6
Total	773,0	156,7	188,8	773,0	138,2	162,4	773,0	127,5	138,9

Source: own analyses

If we use precision nutritional management on plots larger than 15 hectares in the examined area (2507 ha) and we limit the application on the basis of plot average to plots smaller than this, we can save 5.5 million HUF on fertiliser costs (*Table 4.*). If we prepare the block design besides precision nutritional management, that is we concentrate the produced crops on the given area, we can save 11.7 million HUF on fertiliser expenditures. If we use parallel tracking instead of traditional machinery and we also use sprinklers equipped with automatic steering, we can save 10% of expenditures on all three fertiliser types applied (ammonium-nitrate, mono-ammonium-phosphate and potassium chloride). Using a precision nutritional management system, we can save 1.6 million HUF, whereas this value is 3.1 million HUF in the case of precision-block systems in comparison with traditional machinery. As for the newest self-propelled machinery, the fertiliser spreader device is provided with the sprinkler machine. The two machines can be reset in about half a day, therefore, the ratio of utilisation of the self-propelled machinery can be increased case of self-propelled machinery. This 10% improvement in the efficiency derives from the reduction of

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overlaps and the decrease of the number and duration of turns at the end of plots. There are several other aspects that contribute to these advantages. We calculated with a 5% interest rate for 10 years. After calculating the present values, we determined the internal rates of return, that is, whether it is profitable to make this investment or is it better to make use of external (e.g. bank) financial opportunities. If we use our self-propelled machinery „only" to carry out nutritional management, the internal rate of return will be 9% in the case of the precision method and 16% in the case of the precision-block method. If we also consider machinery subsidisation, the IRR values will be 20% and 29%. If we also carry out crop protection activities, the IRR values without subsidisation will be 28% and 36%, whereas the ones with subsidisation will be 47% and 63%.

Conclusions

1. We needed the same amount of nitrogen fertiliser in all three nutritional replenishment treatments (773 tons). In the traditional case, we would have needed 157 tons less of mono-ammonium-phosphate, whereas this value would have been 19 tons in the case of precision management and 30 tons if the precision-block method had been used. In the case of potassium chloride, instead of the traditionally applied 189 tons, we would have needed 27 tons less in precision nutritional management and 50 tons less in the precision-block method.
2. Of the eight examined return variations, the investment without machinery subsidisation is supported „only" if there is differentiated nutritional replenishment (IRR is 9%). In the other scenarios, the internal rate of return is between 16-63%, that is the investment of the self-propelled machinery is supported.

Acknowledgement

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SOIL LOSSES AND SOIL DEGRADATION PROCESSES CAUSED BY HARVEST OF SUGAR BEET

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Abstract: Soil loss due to crop harvesting (SLCH) leads to the reduction of substrate fertile layer. SLCH study started recently in soil erosion research. The goals of this investigation were to assess SLCH for sugar beet grown at three locations in eastern part of Croatia and to determined possible differences in nutrients decay for soil and soil tare samples. Average SLCH values were in the range from 1.3 t ha^{-1} to 2.3 t ha^{-1}. Significantly higher contents of organic matter, total nitrogen, plant available phosphorus and potassium were determined in soil tare samples than in soil samples where sugar beet grown.

Keywords: nutrient content, SLCH, soil loss, soil tare, sugar beet

Introduction

Most soil erosion investigations are focused on soil loss caused by water, wind or tillage. Also, significant amounts of soil could be lost from arable land during the harvesting of sugar beet, potatoes and chicory roots. The studies of soil loss due to crop harvesting (SLCH) were conducted in Europe (Auerswald et al., 2006; Ruysschaert et al., 2007) and Asia (Li et al., 2006). The soil tare (*i.e.* the relative amount of soil adhering to sugar beet after harvest), based on clean beet mass, is usually the highest for beet grown on heavy soils (Vermeulen et al., 2003). SLCH leads to the reduction of substrate fertile layer and that can eventually lead to the relief depression, or to complete loss of soil. Parlak et al. (2008) estimated the cost of soil and plant nutrients lost due to sugar beet harvesting in Turkey. They noted that SLCH has reduced the thickness of soil profile and that farmers should be informed about the significance of minimizing soil tare on sugar beet fields by training them to improved sugar beet growing methods and mechanization. The objectives of this research were: to assess SLCH for sugar beet grown in eastern Croatia and to determine possible differences in nutrients (total nitrogen, organic matter, plant available phosphorus and potassium) decay for soil and soil tare samples.

Materials and methods

This study was carried on three locations near Vukovar in eastern part of Croatia. Investigations were done on the following soil types: Eutric cambisol typical on loess (Nijemci location – N: 45°08´ E: 19°01´), Chernozem calcaric (Miklusevci – N: 45°15´ E: 19°04´) and Eutric cambisol (Ovcara location – N: 45°16´ E: 19°04´). Soil sampling was conducted after sugar beet (*Beta vulgaris* L.) harvest in November 2008. At each location composite soil samples were taken from one depth (0-30 cm) in four replications. For 50 roots, randomly chosen, soil tare was measured in the field immediately after harvesting by weighing gross crop mass (mass of root plus mass of moist soil), washing the roots and weighing the individual root again. The soil moisture content (SMC) was measured eight times by penetrologger (Eijkelkamp, 2007). Soil

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samples and soil tare samples for physical and chemical analysis were air dried, milled, sieved and homogenized (ISO 11464). Texture was determined by sieving and sedimentation method according to ISO 11277 (modified). Total nitrogen (TN) content was determined by dry combustion method (ISO 13878). Plant available phosphorus and potassium were extracted by ammonium lactate (AL) solution (Egner et al., 1960) and detected by spectrophotometric and flame photometric, respectively. Organic matter (OM) was determined by wet oxidation method with potassium dichromate (ISO 14325 modified). Observed data were subjected to analysis of variance (ANOVA) using SAS Institute 9.1.3 and mean values were separated by Fisher's LSD test at $P \leq 0.05$.

Results and discussion

The results of soil loss due to crop harvesting (SLCH) and soil moisture content (SMC) are shown in *Table 1.* Average SLCH varied from 1.3 t ha^{-1} at Ovcara location to 2.3 t ha^{-1} at Miklusevci location. Soil loss depends mainly on soil type, soil moisture content, characteristic of the beet and the skill of machine-operator to properly adjust the machine to the prevailing harvesting conditions. Average SLCH values in Belgium (Poesen et al., 2001), Nederland (Ruysschaert et al., 2005) and Turkey (Oztas et al., 2002) were respectively 8.7, 5.9 and 3.8 t ha^{-1}. Compared to Europe results, manual harvesting for sugar beet in northeast (NE) China leads to average soil losses of 1.0 tha^{-1} (Li et al., 2006). They concluded that differences in soil loses between Europe and China can be attributed not only to differences in harvesting technique but also to agronomic practices such as the growth of sugar beet on ridges in NE China as opposed to flat seedbeds in Europe. The highest SMC content (35.0%) was recorded at Miklusevci location where the highest SLCH value was also recorded. Li et al. (2006) reported positive correlation between SLCH and moisture content (R^2= 0.5).

Table 1. Soil loss due to crop harvesting (SLCH) and values of soil moisture content per locations

	SLCH (t ha^{-1})			SMC (%)		
	Nijemci	Miklusevci	Ovcara	Nijemci	Miklusevci	Ovcara
Average	1.5	2.3	1.3	30.3	35.0	31.3
Median	1.3	0.0	0.0	30.5	35.0	31,5
Min	0.0	0.0	0.0	28.0	34.0	30.0
Max	11.0	23.0	9.0	32.0	36.0	33.0
SD	2.806	3.852	2.123	1.488	0.756	1.165
n	50	50	50	8	8	8

n = number of observations; SMC = soil moisture content.

Soil texture for Miklusevci and Ovcara locations was silty clay (*Table 2.*), while for Nijemci location was clay loam texture. For all three investigated locations significantly higher content of coarse send was recorded in soil tare samples than in soil samples where sugar beet grown. Li et al. (2006) found out positive correlation between SLCH and sand percentage, and also negative correlation between SLCH and clay percentage. These results are in contrast with findings that were reported by Poesen et al., (2001).

Table 2. Texture and particle size distribution for soil and soil tare samples per locations

	Texture class	Particle size distribution (%)			
		Coarse sand (2-0.2 mm)	Fine sand (0.2-0.02 mm)	Silt (0.02-0.002 mm)	Clay (< 0.002 mm)
	Nijemci				
Soil	Clay loam	0.155 b*	41.7 a	32.7 a	25.8 a
Soil tare	Clay loam	0.870 a	42.5 a	32.9 a	24.0 a
	Miklusevci				
Soil	Silty clay	0.093 b	38.7 a	33.5 a	27.6 a
Soil tare	Silty clay	0.258 a	36.5 a	33.8 a	26.9 a
	Ovcara				
Soil	Silty clay	0.145 b	40.8 a	31.8 a	27.2 a
Soil tare	Silty clay	0.386 a	43.1 a	30.0 a	26.6 a

*Values are means of 4 replicates. Values in the same column for each parameter and each location followed by an identical letter are not significantly different according to Fisher's LSD test ($P \leq 0.05$).

Content of total nitrogen, organic matter, plant available phosphorus and potassium of soil and soil tare samples are shown in *Table 3.* For all three investigated locations significantly higher content of plant available potassium, organic matter and total nitrogen were recorded in soil tare samples than in soil samples where sugar beet grown. The reason is probably contribution of organic rhizodeposition. A large proportion of the photo synthetically fixed carbon can be translocated to the root system. Out of this carbon fraction, substantial proportion can be release into the root environment (Liljeroth et al., 1994). Organic rhizodeposition comprises lysates of sloughed-off cells and dead tissues as well as exudates, released from intact root cells either passively as diffusates or actively as root secretions or excretions.

Table 3. Chemical properties of soil and soil tare samples per locations

	P_2O_5 (mg kg^{-1})	K_2O (mg kg^{-1})	OM (%)	TN (%)
Nijemci				
Soil	71.2 b*	209.0 b	1.62 b	0.125 b
Soil tare	120.7 a	602.7 a	3.53 a	0.220 a
Miklusevci				
Soil	70.6 a	225.3 b	2.05 b	0.149 b
Soil tare	72.8 a	463.4 a	2.30 a	0.162 a
Ovcara				
Soil	175.3 b	257.3 b	2.00 b	0.148 b
Soil tare	323.3 a	592.0 a	2.45 a	0.177 a

*Values are means of 4 replicates. Values in the same column for each parameter and each location followed by an identical letter are not significantly different according to Fisher's LSD test ($P \leq 0.05$).

Significantly higher content of plant available phosphorus was recorded at Nijemci and Ovcara locations in soil tare samples than in soil samples where sugar beet grown. The reason is probably mucilage, which can to same extent promote phosphorus desorption from clay minerals (Matar et al., 1967). Parlak et al. (2008) also determined content of TN, OM, phosphorus and potassium in soil tare samples and calculated annual cost of these losses (US$ 204 158) in terms of fertilizer.

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Conclusions

- Soil loss due to crop harvesting (SLCH) varied from 1.3 t ha^{-1} at Ovcara location to 2.3 t ha^{-1} at Miklusevci location.
- The highest soil moisture content (35.0%) was recorded at Miklusevci location were the highest SLCH value was also recorded.
- Nutrient content in soil tare samples was influenced by root rhizosphere. Significantly higher contents of organic matter, total nitrogen and plant available potassium were determined at all three investigated locations in soil tare samples than in soil samples where sugar beet grown. Significantly higher content of plant available phosphorus was determined in soil tare samples than in soil samples where sugar beet grown for two locations (Nijemci and Ovcara).
- Nutrient decay by soil tare samples was noted and significant cost saving can be achieve by using adequate agriculture management system.

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RESIDUAL IMPACTS OF LIMING AND FERTILIZATION ON SOYBEAN YIELD AND QUALITY

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Abstract: The field experiment was conducted in the spring of 2004 by application treatments as follows: a = conventional fertilization, b = a + NPK-1, c = a + NPK-2, d = a + NPK-3 and e = a + NPK-4. The fertilizer NPK 10:30:20 was source of P and K (using in amounts 416, 1249, 2082, 2916 and 3748 kg/ha, for the treatments a, b, c, d and e, respectively). Nitrogen amount was equalized for all treatments by addition of adequate quantities of CAN (calcium ammonium nitrate with 27% N). The experiment was conducted in four replicates. In the next years the experiment has been fertilized uniformly in the level of conventional fertilization. Additional intervention was liming of the third and fourth replication by 10 t ha^{-1} with granulated fertdolomite (24.0 % CaO + 16.0 % MgO + 3.0 % N + 2.5 % P_2O_5 + 3.0 % K_2O) in autumn of 2007. Soybean (cultivar *Lucija*) was grown on the experimental field in the 2010 growing season. Soybean was sown at the end of April on the density of 650 000 seeds ha^{-1}. Harvested area was 2.0 m^2 from each basic plot. Yield was calculated on 13 % grain moisture and 600,000 plants ha^{-1} basis. As affected by liming yields of soybean were increased for 18 % (means 3279 and 3854 kg ha^{-1}, for unlimed and limed plots, respectively.) Also, grain quality parameters were improved by liming (thousand grain weight were 151.8 and 168.3 g; protein contents were 35.24 and 39.06 %, respectively), while oil contents were decreased (23.84 and 22.62 %, respectively). An impact of P and K fertilization was considerably lower in comparison with liming.

Keywords: soybean, liming, P and K fertilization, grain yield, protein and oil contents

Introduction

Acid reaction, low levels of plant available phosphorus (P) as well as unfavorable physical properties are limiting factor of soil fertility under conditions of Bjelovar-Bilogora County in Croatia. Aim of this study was testing the residual effects of ameliorative phosphorus (P) and potassium (K) fertilization (April 2004) and liming (October 2007) on grain yield, protein and oil contents in grain of soybean for the growing season 2010. Responses of maize (the growing season 2004) and soybean (the growing season 2005) were shown in the previous studies (Kovacevic et al., 2006; Rastija et al., 2006).

Material and methods

The field experiment

The stationary field experiment was conducted on Pavlovac (municipality V. Grdjevac, Bjelovar-Bilogora County) very acid soil by the application treatments as follows: a = conventional fertilization, b = a + NPK-1, c = a + NPK-2, d = a + NPK-3 and e = a + NPK-4. The fertilizer NPK 10:30:20 was source of P and K (using in amounts 416, 1249, 2082, 2916 and 3748 kg ha^{-1}, for the treatments a, b, c, d and e, respectively). Nitrogen amount was equalized for all treatments by the addition of adequate quantities of CAN (calcium ammonium nitrate containing 27% N). The experiment was conducted in four replicates and the basic plot size was 77 m^2. In the following year the plots was fertilized uniformly in the level of conventional fertilization. Crop rotation on the

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experimental field has been as follows: maize (2004) – soybean (2005) – maize (2006) – wheat (2007) – maize (2008) – maize (2009) – soybean (2010). Additional intervention in the experiment was liming of the third and fourth replicates by 10 t ha^{-1} with granulated fertdolomite (24.0% CaO + 16.0% MgO + 3.0% N + 2.5% P_2O_5 + 3.0% K_2O) in the 2007. Soybean (cultivar *Lucija*) was sown at the end of April 2010 on planned density 650 000 seeds ha^{-1}. Soybean harvested area was 2.0 m^2 from each basic plot. Plants of soybean were enumerated; pods were separated and harvested by special combine. Yield was calculated on 13% grain moisture and 600,000 plants ha^{-1} basis.

Sampling and chemical analysis

Soil sampling from each basic plot of NPK-fertilization was made at the end of the second growing season in the November 15, 2005 (Rastija et al., 2006). Nutritional status of soil was determined by extractions with AL-solution (Egner et al., 1960.) Soil reaction and organic matter were determined according to ISO (1994, 1998).

Grain samples for chemical analysis were collected after thrashing of soybean pods. Oil content in the grain was determined by nuclear magnetic resonance (NMR) spectroscopy method. Protein content in grain was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer"). These analyses were done in the Agrochemical laboratory of the Agricultural Institute in Osijek.

Data were statistically analyzed by ANOVA and treatment means were compared using t-test and LSD at 0.05 probability level.

Weather and soil characteristics

The growing season 2010 was mainly favorable for soybean growing because of adequate amount of precipitation and favorable temperature regime (*Table 1.*).

Table 1. Meteorological data (Bjelovar Weather Bureau)

Year	Bjelovar* Weather Bureau (LTM: long-term mean for 1961-1990 period)									
	Precipitation (mm)					Mean air-temperatures (°C)				
	May	June	July	Aug.	Sum	May	June	July	Aug.	Mean
2010	136	178	79	172	565	16.4	20.3	23.3	20.9	20.2
LTM	79	96	78	82	335	15.6	18.7	20.4	19.5	18.6

* Air-distance from the experimental field: 25 km in NW direction

Table 2. Soil status (0-30 cm) in autumn of 2005 (Rastija et al., 2006)

Fertilization in April 2004 (kg ha^{-1})			Soil properties (0-30 cm: sampling Nov. 15, 2005; HA = Hydrolytical acidity)					
			pH		AL-method (mg 100 g^{-1})		%	HA
	P_2O_5	K_2O	H_2O	KCl	P_2O_5	K_2O	Humus	Cmol kg^{-1}
a	0	0	4.86	3.77	11.57	17.31	2.33	6.02
b	250	168	4.90	3.43	11.70	19.57	2.22	5.86
c	500	336	4.68	3.43	12.30	18.37	2.05	5.61
d	750	504	4.35	3.38	18.60	24.24	2.16	5.97
e	1000	672	4.47	3.42	21.43	25.55	2.29	5.48
LSD 5%			n.s.	0.23	0.69	0.58	n.s.	n.s.
LSD 1%				n.s.	n.s.	n.s.		

Acid reaction, moderate P and humus contents, as well as adequate supply of plant available potassium are main characteristics of the soil. Ameliorative fertilization by

NPK 10:30:20 considerably affected on additional acidification of soil as pH in 1n KCl significantly decreased from 3.77 to 3.42 for the control and mean of ameliorative treatments, respectively, whilst soil P and K status were significantly improved (*Table 2.*).

Results and discussion

As affected by liming with fertdolomite about three years after liming, grain yields of soybean were increased up to 17% and 1000 grain weight for 11% compared to unlimed treatments. Also, by liming grain protein contents were increased for 3.82% and oil contents decreased for 1.22% (*Table 3.*). It is presumed that lime application neutralized soil acidity what have led to soybean yield increase. Woodard and Bly (2010) in an 8-year field study of liming found out that incorporated liming material increased pH faster and mean maize and soybean grain yields increased for all liming materials. However, in some studies was no effect of liming on soybean grain yield, as well as on oil or protein contents (Caires et al., 2006; Caires et al., 2008).

Table 3. Residual effects of PK-fertilization (April 2004) and liming (Oct. 2007) on soybean

Residual effects of fertilization and liming on soybean (cultivar *Lucija*) grain yield and grain quality in the 2010 growing season (PDR = plant density realization in plants ha^{-1})									
Factor B*: Fertilization (April 2004)			Factor A**: Liming (Oct. 2007)		Mean	Factor A**: Liming (Oct. 2007)		Mean	PDR
	P_2O_5	K_2O	-Ca	+Ca*	B	-Ca	+Ca*	B	Plants ha^{-1}
	kg ha^{-1}		Grain yield (kg ha^{-1})***			1000 grain weight (g)			
a	0	0	3141	3703	3422	154.5	170.3	162.4	614996
b	250	168	3231	3837	3534	149.4	167.3	158.4	616664
c	500	336	3285	4047	3666	151.4	166.4	158.9	611664
d	750	504	3352	3826	3589	150.8	166.5	158.7	594994
e	1000	672	3387	3860	3624	152.9	171.2	162.1	599994
		Mean A	***3279***	***3854***	***3567***	***151.8***	***168.3***	***160.1***	***607662***
		LSD 5%	A: 209 B: 156 AB: ns			A: 2.8 B: 3.2 AB: ns			
		LSD 1%	482 ns			6.5 ns			
	P_2O_5	K_2O	Protein contents			Oil contents			
	kg/ha		(% on dry matter basis)			(% on dry matter basis)			
a	0	0	36.12	39.24	37.68	23.70	22.49	23.10	
b	250	168	34.92	38.75	36.84	23.58	22.61	23.09	
c	500	336	35.73	39.44	37.59	23.58	22.29	22.94	
d	750	504	34.59	38.92	36.76	24.32	22.90	23.61	
e	1000	672	34.83	38.93	36.88	24.02	22.79	23.41	
		Mean A	***35.24***	***39.06***	***37.15***	***23.84***	***22.62***	***23.23***	
		LSD 5%	A: 0.63 B: ns AB: ns			A: 0.53 B: ns AB: ns			
		LSD 1%	1.46 ns			1.23			

* NPK 10:30:20; N added by NPK-fertilizer were equalized with CAN (calcium ammonium nitrate: 27% N);
** 10 t ha^{-1} of granulated ferdolomite (24.0 % CaO + 16.0 % MgO + 3.0 % N + 2.5 % P_2O_5 + 3.0 % K_2O)
** * yield calculation on 13 % grain and plant density 600000 plants ha^{-1}

Ameliorative PK-fertilization resulted by significant soybean yield increases up to 7%. With that regard, non-significant differences of yields were found by comparison of four levels of PK-fertilization. Protein and oil contents in grain were independent on

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applied PK-fertilization. The results of Tanaka et al. (1995) showed that the K fertilization increased the oil content in soybean grain and decreased the protein content, while on the opposite, liming increased the protein content and decreased the oil content, what is observed in the present study, also.

As previous mentioned, soybean was grown on this stationary experiment for the 2005 growing season. Soybean responded to PK-fertilization by yield increases up to 32% (3880 and 4930 kg ha^{-1}, for the control and mean of four steps of NPK fertilization, respectively). Among four steps of PK-fertilization non-significant differences of yields were found. Protein contents were also independent on applied fertilization, while oil contents were increased up to 0.66% (Rastija et al., 2006).

Conclusion

Ameliorative fertilization by NPK fertilizer had moderate but continuously impacts on field crop yields in crop rotation since 2004. In general, liming effects have been more expressed in comparison with NPK fertilization. Combination of liming and increased rate of P fertilization could be recommended for yield increases under acid soil conditions.

Acknowledgements

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UTILIZATION OF HYPERSPECTRAL REMOTE SENSING FOR CHARACTERIZATION OF SOIL CONDITION

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Abstract: The accurate quantitative definition of the color characteristics is possible by the application of the hyperspectral remote sensing method. Our objective is to develop a method by which the definite content characteristics of the soil may be defined with a level of accuracy required for the precision fertilization, in a spatial-oriented way by applying hyperspectral remote sensing method. High resolution hyperspectral images have been taken from the air of a cultivated land surface, and their color attributes have been determined. The humus, nitrogen, potassium and phosphorus content of the soil have been defined on the given coordinates by the use of the collected soil samples. Based on the hyperspectral images the areas where the reflectance differences are visible on the soil have been allocated. After that the sampling places at these areas have been localized, where the characteristics from 1 m^2 collected crop (e.g. quantitative characteristics, the specific nitrogen, phosphorus and potassium contents) were defined. In the given place a significant connection between the color values and some contents of the soil and plant was determined.

Keywords: hyperspectral, plant, remote sensing, soil

Introduction

It is necessary to know the site-specific internal content features of the soil and the harvested vegetation. There is a significant relationship between the shape and the band of the spectral reflectance curve and the content characteristics (Stefanovits et al., 1989). There is an even stronger relationship between the color-components that give integral information about some of the spectrum characteristics and the soil features (Yang et al., 2003). A similar connection can also be found between the color of the plant leaves, the content characteristics as well as the condition of the plant (Papp and Fenyvesi, 1992). In the case of the soil and the plant leaves it can be stated that the contents can be determined by integral optical characteristics (for example: color). The remote sensing measurement method is known for the site specific determination of the yield (Zaman et al., 2008).

Materials and methods

The AISA DUAL (Eagle+Hawk) hyperspectral sensor of our institute operates in the range of 400-2500 nm wavelength and has a high, 1 nm sensitivity inside the visual spectrum. The hyperspectral remote sensing images are able to measure the reflectance values of numerous wavelength ranges, from which so called vegetation indices may be calculated in relation to the volume, distribution, health, etc. of the flora. *Figure 1.* shows the steps of the hyperspectral image processing (Erdeiné Késmárki et al., 2009).

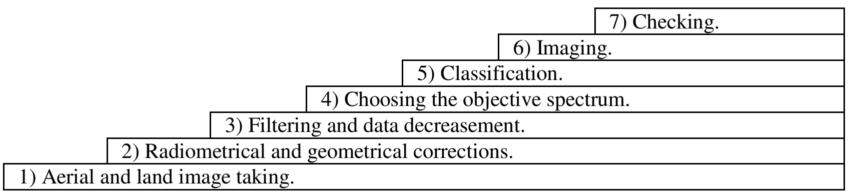

Figure 1. The steps of the hyperspectral image processing

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The above mentioned steps were made with the CaliGeo – radiometric and geometric corrections – and the ENVI 4.1 Geographical Information System Computer Softwares. Photographs were made from the B22 field (see *Figure 2.*) in Bábolna (Hungary). The detection height was 1000 meters. For the content examinations soil samples have been collected from a 100x100 m grid points from the field (see *Figure 3.*).

Figure 2. The B22 field in Bábolna

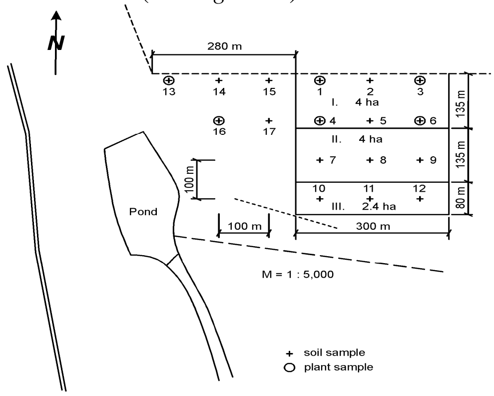

Figure 3. The position of the soil and plant samplings

The soil samples have been defined by an accredited laboratory (Szent István University, Department of Chemistry and Biochemistry). The measured parameters were as P_2O_5 and K_2O, but the simply phosphor (P) and potassium (K) will be named hereafter. Three pieces of samples weighing one kilogram each have been taken for one measurement point, which have been averaged. The nitrogen, phosphor and potassium content of the soil were established (see *Table 1.*).

Table 1. The soil characteristics

No.	Humus (g/kg)	Nitrogen (g/kg)	Phosphor (g/kg)	Potassium (g/kg)
1	2.14	0.0294	0.539	0.404
2	2.22	0.0308	0.795	0.645
3	2.18	0.0162	0.624	0.773
4	2.54	0.0101	0.783	0.633
5	2.35	0.0121	0.682	0.613
6	2.27	0.0155	0.724	0.572
7	2.61	0.0167	0.711	0.613
8	2.78	0.0176	0.873	0.645
9	2.64	0.0172	0.902	0.639
10	3.00	0.0194	0.922	0.741
11	2.94	0.0225	0.662	0.604
12	2.84	0.0214	0.060	0.863
13	3.06	0.0234	0.120	0.944
14	2.86	0.0214	1.210	0.974
15	2.68	0.0192	0.986	0.864
16	2.74	0.0204	0.921	0.883
17	2.70	0.0195	0.826	0.724

In order to define the interrelationships the composition of the yield on the different color characteristics have been measured by the use of GPS. Plant samples were taken at the soil sampling places.
On certain places the weight and the above mentioned materials (N, P, K) were measured of the collected plants from 1 m^2 (see *Table 2.*).

Table 2. The measured corn characteristics and the humus content of the soil

Humus content (g/kg)	Corn cob (kg/m^2)	Green weight (g/m^2)	Total weight (g/m^2)	Dry matter (g/kg)	Nitrogen (g/kg)	Phosphor (g/kg)	Potassium (g/kg)
2.54	0.530	1490	2020	533	9.40	4.54	11.83
2.35	0.530	1530	2060	512	9.22	4.63	9.82
2.27	0.800	1610	2410	621	11.43	5.81	9.51
2.61	1.600	2110	3710	460	7.36	3.45	4.89
2.14	2.470	3830	6300	366	5.99	2.33	3.21
2.94	3.000	4120	7120	405	6.21	3.16	3.62

Results and discussion

The different color characteristics were determined by using the taken images. The strongest connection was found between the measured humus content of the soil and the red color values on the image of the field. There is also a strong connection between the yield and the green color values of the images that were taken from the surface of the leaves. According to the soil examinations the phosphorus and potassium content was very good, the nitrogen content was only moderate. In this case the nitrogen content is determinant in the soil-plant system (Németh, 2006). Connection was established between the specific mass of corn cob, the humus content and the nitrogen content (see *Figure 4.*).

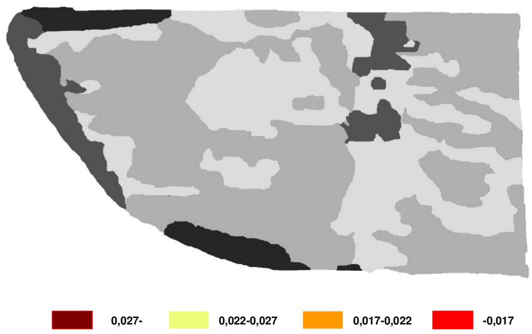

Figure 4. Nitrogen content distributions in the soil of the examined field (g/kg)

Conclusions

A site specific distribution of the soil and plant features was defined by the application of a modern remote sensing method. There is a significant connection between the integral optical characteristics, the color values and the contents of the soil and plant leaves (see *Figure 5.*).

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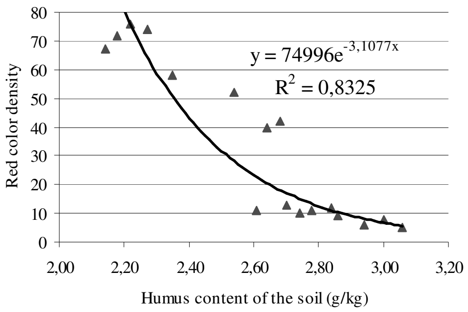

Figure 5. The connection between the red color characteristics and the humus content

By using the hyperspectral remote sensing method, the color values can be calculated to a high level of accuracy and the spatial distribution can also be determined. The method can be expanded to improve the effect of the green maturing (Lukács, 1982).

The method is a fast and accurate solution to characterize the soil of contiguous areas of production. In case of existence of the above conditions this method can also be used on other places, but we do not have a general solution that covers an arbitrary area (e.g. the different environmental – climatic – and type differences).

The results can be easily used for controlling precision operations, because these ones are collected in a spatial IT system. The shown method could be simplified in the future and make more precise by using the data of yield-measurement at harvest (Késmárki and Szűcs, 2007; Magó and Jakovác, 2005).

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POSSIBILITIES OF MEADOW AND PASTURE LAND USE ON ALKALINE AND SANDY STUDY FIELDS

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Abstract: Among land using possibilities of the heterogeneous area in sand ridges between the Danube and Tisza rivers the meadow and pasture land use has a high importance. This form of utilization can be implemented by keeping in view the nature conservation requirements both in case of sandy fields, alkaline fields and wetlands. However, we have to consider that the vegetation combination of meadows and pastures is changing from time to time beside the varying conditions and it has a significant influence on animal grazing of the area.
In this paper, our aim is to compare two study areas. The vegetation survey of these areas demonstrates the degradation processes connected to grazing, and shows the vegetation changes of Szappan-szék near Fülöpháza, which is in process of desiccation. Our results show that in case of Szappan-szék the present number of livestock in the area complies with the conditions provided by the vegetation, therefore maintaining grazing in the area at the current level is of utmost importance. The saline lake and its vicinity are extremely vulnerable, which must be taken into consideration to the highest degree in nature tolerant husbandry, especially in grazing.
On the basis of the analysis, in case of the other study area near Bugac, the number of livestock grazing near the stockyard slightly exceeds the supply capacity of the pasture as regards vegetation. This fact is revealed by the present composition of the vegetation and its changes during the past 13 years.

Keywords: meadow and pasture land use, saline lakes, vegetation

Introduction

The extreme weather of recent times has been a considerable challenge in all land use categories. It is especially true for areas that can be considered sensitive by default and are possibly also protected, such as the sandy, alkaline areas and wetlands of the Sand Ridge between the Danube and Tisza rivers where most of the land is used for grazing. Grazing is an indispensible part of natural farming. However, to determine the extent of grazing it is essential to find a balance that guarantees the subsistence of natural vegetation (Penksza et. al., 2009; Szentes et. al., 2010).
The aim of our paper is to demonstrate the effects of grazing, and the adaption of vegetation in parallel with the changing environment conditions in two study areas.

Materials and methods

The association level exploration of vegetation was executed in Szappan-szék near Fülöpháza. We had older vegetation maps of the lake basin vegetation from 1987, 1994 and 2003 (Fehér, 2004; Bagi, 1989). We complemented these maps with surveys refined by GPS-measuring and created vegetation maps in the summer and the autumn of 2010. The maps were drawn and analysed by Corel Draw and ArcGIS 9.2 software. The territorial cover of the certain vegetation association types was indicated by percent values in different years. The information about the grazed livestock was supplied by Kiskunság National Park.
On the sandy study area, lying farther from Szappan-szék, a coenological recording was executed. The recording spots became marked near or inside stockyards. The earliest

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coenological records originate from 1997. These recordings were repeated in 2005 and 2010. Recordings were executed in three groups:

1. The first group included areas located near to stock-raising yards (0-50 meters).
2. The second group included intensively used areas, lying 50-150 meters from stock-raising yards.
3. The third group included areas more than 150 meters away from stockyards.

During the coenological recording we evaluated the social behaviour forms suited to the categories of Borhidi A., and we also classified the environmental categories based on Simon T. Coenological records were taken by the Braun-Blanquet method, applying 2 x 2 meter quadrates.

Results and discussion

Szappan-szék was an open lake until the 1960s. Then, in the 1980s it desiccated several times when groundwater level was low. For this reason the vegetation map made of the lake basin in 1987 shows an already rearranged state that differs from the water-connected vegetation typical of saline lakes.

In case of Szappan-szék most of the lake basin was covered by continental succulent saline vegetation in 1987. This was bordered by *Puccinellia limosa* and saline meadow in form of narrow zones. The succulent saline vegetation settled in the lake basin occupying about one third of the surveyed land. This area decreased gradually in the following period, and by 2003 it disappeared completely from the study area. In contrast, *Puccinellia Limosa* increased gradually its territorial share between 1987 and 2003.

The state of the area in 1994 shows the spread of *Puccinellia limosa* in the lake basin, which was primarily due to the further desiccation and partly probably due to the increasing organic material content of the lake basin. As a result of the gradual desiccation of the lake, the drier saline meadow category occupied a significant area by 1994. This rate did not change considerably until 2003 (about 23-26%).

As a consequence of the droughty summers after 2000 (primarily in 2003) – when the groundwater level decreased more than 1 meter from the water surface of the lake – the zonation of the lake basin reversed. During this period, in the former basin, vegetation appeared that cannot be classified into associations. The areas that were not affected by the short water cover in 2000 became occupied by a fresher and drier saline meadow at a similar rate (21% and 26%). Succulent saline vegetation, however, disappeared. Among the associaton types, the territorial share of *Puccinellia limosa* remained significant in the north-western part of the lake (about 22%), but a great part of the lake basin was occupied by vegetation that cannot be classified into associations (*Table 1.*).

In 2010, due to the high amount of precipitation the open water surface appeared again, and remained during the whole year. In addition, the fresh saline meadow, a reflection of wetter conditions, spread over almost the entire lake basin (with a 77% share). Exception from the above is the border line of the basin, where there is a relative sharp transition towards the dry habitat, and the saline marsh together with *Reed phytocoenosis* appearing at places (primarily in the southern and south-western part of the lake). The open water surface appeared in smaller spots mainly in the western part of the lake and in the northern part. The succulent saline vegetation and the habitat of the transition between saline meadow and dry habitat are confined to the narrowing north-eastern part of the lake (*Figure 1.*).

In the closer environment of the lake, there are also invasive species appearing. Using the area as a meadow can play an efficient method to displace them. In case of Szappan-szék grazing can be considered as a tradition. In the 1980s, when annual precipitation was around 400 mm in several years, grazing (primarily with sheep) also spread over the area of the lake basin, because the appearing vegetation provided favourable conditions for this activity. Therefore, in this period, the number of livestock exceeded 200.

Table 1. Percentage of the association types in Szappan-szék

Vegetation	1987	1994	2003	2010
Succulent saline vegetation	37,6	9,5	0	0,9
Puccinellia limosa	10,5	31,1	21,8	0
Fresh saline meadow	12	10,2	21,2	77,6
Drier saline meadow	16,5	23,7	26,4	0,3
Dry habiat	23,4	24,6	8,5	5,6
Transition between saline meadow and dry habitat	0	0,9	0	2,8
Transition between saline marsh and saline meadow	0	0	0	0,8
Saline marsh	0	0	0	2,6
Reed phytocoenosis	0	0	0	6,1
Not classifiable	0	0	22,1	0
Open water surface	0	0	0	3,3

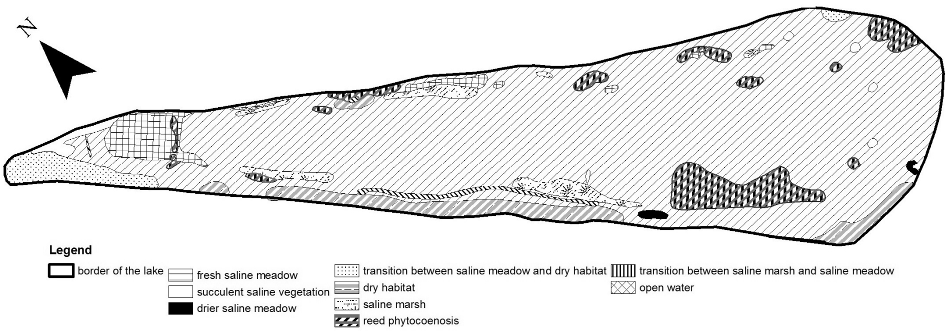

Figure 1. The vegetation of Szappan-szék in 2010.

Since the mid-1990s the number of sheep grazing in the area has decreased to about half of the former value and it has remained at that level. During most of the year, grazing spreads not only over the dry lake basin, but also over the out of crop areas, abandoned plough-lands, around the lake, where re-grassing is in process. Sheep grazing has a key role in displacing invasive weeds appearing in the closer surroundings of Szappan-szék, therefore the current number of livestock is desired and appropriate for an environmentally sustainable management of the study area.

Besides grazing, the reaping of the study area also has an important role in preserving the nature close vegetation and preventing the spread of adventive weed species. This reaping can be executed in accordance with the management plans of Kiskunság National Park.

On the sandy, intensively grazed survey area located around Bugac, the vegetation shows the following picture as regards the social behaviour types of the species:

 DOI: 10.1556/Novenyterm.60.2011.Suppl.2

In the areas near the stockyards, during the surveyed periods, disturbance-bearing and ruderal competitor species continue to appear at high rate. In addition to this, an increase in the rate of natural weed species can be observed. Natural pioneers are present at approximately the same rate in all the three surveyed years. However, the rate of natural competitors, generalists and specialists decreased during the past 13 years. In the more outlying areas the rate of ruderal competitors has started to decrease, but the natural disturbance-bearing species are present here also at a high rate. In the first and third categories, in 2005, aggressive species also appeared at a non-significant rate.

Analysing the vegetation from the aspect of natural conservation value categories, it can be stated, that in the category of 0-50 m, around 60% of the plants bear the low level disturbance, and the rate of weeds approaches 40%. Among the species referring to the natural states, only a few pioneer species appear. In the medium category, disturbance-bearing species have the highest rate. However, beside weeds the association composing species, accompanying species and pioneer species also appear. In the most outlying categories the rate of species referring to natural states increase further.

The proliferation of disturbance-bearing, ruderal competitor and weed species near the stockyards indicates a higher number of livestock. In more outlying areas, the rate of disturbance-bearing species can also be considered high, but the higher rate of species referring to naturality signals less intensive grazing.

Conclusions

The vegetation of the desiccating Szappan-szék went under significant changes during the period between 1987 and 2010. The rapid and in many cases contrary changes mean a great challenge for the vegetation, to which it is more and more difficult to adapt. For this reason, natural vegetation associations ceased to exist, the vegetation distribution became homogeneous, and in parallel, adventive species may gain larger ground. To avoid their dispersal grazing has an extremely important role in case of Szappan-szék.

In case of the other study area, the number of livestock grazing near the stockyard slightly exceeds the supply capacity of the pasture as regards vegetation. The disturbing effect of grazing can be traced well by considering natural conservation value categories. Most of the vegetation species of areas near the stockyards cannot be classified into the species referring to natural states, and pioneer species appear only at a low number.

The survey of the vegetation of grazed fields has revealed the degrading effect of the higher livestock number. In these areas, it is an important task for the future to set a limit to grazing in accordance with the supply capacity of the pasture. In this manner, nature close state of the vegetation can be achieved.

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IMPACTS OF FERTILIZATION ON YIELD AND QUALITY OF MAIZE (*ZEA MAYS* L.) GRAIN

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Abstract: Effect of different fertilization recommendation systems on the composition and quality of maize grain was studied in 2006 in a nutrient supply field experiment in ecological conditions of Mátra Region. The field experiment was set up at the model farm of Károly Róbert College on a chernozem brown forest soil in randomized block design and in four replications. Four treatments were applied in the experiment: (1) control, (2) usual fertilizer rates in the region, (3) balanced nutrition level and (4) integrated nutrition level. The protein content was increased significantly by "balanced level" and "integrated" treatments compared to the control. The same tendency could be experienced in changes of oil content, but it cannot be influenced by fertilization very much. The starch content of maize grain was somewhat decreased by abundant nutrient supply, mainly the negative impact of increasing nitrogen doses was observed in the experiment. Quality parameters of maize can be evaluated according to its utilization. Higher nitrogen fertilizer doses are favorable for fodder maize production, and they are unfavorable in case of maize production for bioethanol manufacturing. Protein, starch and oil yields were determined mainly by grain yield. In spite of significant differences in grain yields, only positive tendency were experienced in impact of fertilization on yield of these components.

Keywords: fertilization, quality of corn, protein, oil, starch

Introduction

Plants need balanced nutrition for normal growth and good health. Crops growing in a good quality soil and having balanced nutrient supply yield better, because nutrient balance results in increased nutrient and water use efficiency. When nitrogen is balanced with phosphorus and potassium crop yields increase and so does nitrogen use efficiency. That means more nitrogen is used by the crops and les left in the soil as a potential pollutant (Fodor et al., 2001; Cruse et al., 2004; Németh, 2006; Kádár, 2007). The quality of corn is determined first of all by genetic background of hybrids, although it can be modified by ecological and agrotechnical factors. The most important modifying factors are soil fertility and nutrient supply (Szabó and Fodor, 1996; Futó et al., 2003). Organic and inorganic fertilizers are used to maintain and increase soil fertility. In field crop production commercially produced inorganic fertilizers are more manageable than organic sources. Their impact on both crop and environment can be controlled through proper selection of rates, sources, placement and timing. Through careful management, it is possible to supply nutrients close levels and time of crop needs for best economic and environmental efficiency (Cruse et al., 2001; Fodor et al., 2002; Izsáki, 2007). Depending targets of crop production, farmers can chose recommendations of different fertilization advisory systems in Hungary. For example aims of the intensive fertilization advisory system ("MÉM NAK") are to have maximum yield and to get and maintain good – very good PK-supply in the soil, while the environment friendly fertilizer recommendation system ("RISSAC – RIA") strives for economic yield and medium-good PK-supply (Csathó et al., 2007). The aim of this work is to test recommendations of the "RISSAC-RIA" cost-saving and environmental

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friendly system in ecological condition of the North-Hungarian Region in the corn production.

Materials and methods

The field experiment

Maize (hybrid Hunor) was grown under field conditions at Tass-puszta model farm of Károly Róbert College (8 km west of Gyöngyös) during the 2006 growing season. Four fertilization treatments were applied by the fertilizers Genezis NPK 15:15:15, Genezis Ammonium-nitrate (34% N), Genezis Urea (46% N), Genezis Pétibór and Genezis "Mikromix" (*Table 1.*). The field trial was conducted by 4x4 randomized block design in four replicates. The basic plot size was 45 m^2. Maize was sown on the16th of April and harvested on the 22th of October.

Table 1. Fertilization treatments of the field experiment

Treatment		Fertilizer (trade mark Genezis): * bp = before planting, td = top-dressing	Fertilization kg ha^{-1}		
			N	P_2O_5	K_2O
1	Control	Unfertilized plot			
2	Usual f.	NPK 15:15:15 (300 kg ha^{-1}) bp* Ammonium-nitrate 34% N (200 kg ha^{-1}) td*	45 68	45	45
3	Balanced f.	Urea 47% N (300 kg ha^{-1}) bp* Genezis Petibor (3 l ha^{-1})	138		
4	Integrated f.	NPK 10:20:10 (150 kg ha^{-1}) bp* Urea 47% N (300 kg ha^{-1}) td* Genezis Petibor (3 l ha^{-1}) Genezis Mikromix Zn (3 l ha^{-1})	15 138	30	15

Sampling, chemical and statistical analysis

Grain samples were taken at harvesting. Methods of determinations: protein, starch and oil. Oil content in the grain was determined by nuclear magnetic resonance (NMR) spectroscopy method. Protein and starch content in grain was determined by Near Infrared spectroscopic method on Foss Tecator ("Infratec 1241 Grain Analyzer"). Statistical analysis of data was conducted by analysis of variance and $SD_{5\%}$ was calculated

Weather and soil characteristics

The growing season 2006 was favorable for maize growing because of adequate precipitation and temperature regimes (*Table 2.*). The soil type of the experiment field is a neutral chernozem brown forest soil of relative favorable agrochemical properties (*Table 3.*).

Table 2. Precipitation and temperature data in the growing season 2006 (Gyöngyös)

Month	March	April	May	June	July	Aug.	Sept.	
	The growing season 2006							
Precipitation mm	59	21	128	133	37	126	19	Σ 523
Mean air-temp. C°	3.5	12.3	15.4	19.3	23.0	18.7	17.8	X 15.7
Number of rainy days	16	13	21	13	12	19	7	

Table 3. The main soil characteristics of the experimental plots

Characteristics	Measure	Data	Comment
$pH_{(KCl)}$		7.05	Neutral
Plasticity (K_A)		46	Silty-clay soil
Humus	%	2.11	Low
$CaCO_3$ content	%	0.1	Susceptible to acidity
Salinity	%	0.05	
NO^-_3+NO^-_2-N	mg kg^{-1}	3.45	Low N-supply
AL-P_2O_5	mg kg^{-1}	301	Very good P-supply
AL-K_2O	mg kg^{-1}	315	Very good K-supply

Results and discussion

Each fertilization treatment resulted in higher protein content in maize grain (*Table 4.*). Mainly positive effect of increasing nitrogen doses was experienced. The protein content was enhanced significantly both by "balanced level" and "integrated" treatments compared to the control. The usual fertilizer treatment (that represents the generally used nutrient rates in the North Hungarian Region) resulted in as much enrichment in protein content as the significant difference. The same tendency could be experienced in oil content of maize grains. The difference between the highest (balanced and integrated treatments) and the lowest (control) oil content was only 0.15%. The oil content and fatty acid composition in corn seeds is very stable (genetically determined) so it cannot be influenced by fertilization very much. The starch content of maize varied between 68.08-66.77% in the experiment. It was somewhat decreased by increasing fertilization. Mainly negative effect of increasing nitrogen doses was observed on starch content of maize grain. In respect of starch content of grain, higher nitrogen fertilizer doses are favorable, if the maize is produced for feeding animals and they are unfavorable in case of maize production for bioethanol manufacturing.

Table 4. Effect of fertilization on grain yield and quality parameters of maize

Fertilization (Table 1)		Percent in grain			Yield kg ha^{-1}			
		Protein	Starch	Oil	Grain	Protein	Starch	Oil
1.	Control	8.43	68.08	3.83	5.24	442.7	3563.5	200.7
2.	Usual f.	8.65	67.80	3.88	6.20	536.7	4202.8	240.4
3.	Balanced f.	8.98	65.85	3.98	5.89	527.9	3872.5	234.3
4.	Integrated f.	8.95	65.35	3.98	5.65	504.7	3692.7	224.4
	Mean	8.75	66.77	3.91	5.75	503.0	3832.9	224.9
	$SD_{5\%}$	0.24	1.83	0.05	0.55	153.7	983.1	69.3

In 2006 the weather conditions were favorable for maize growing, for this reason the positive effect of nutrient supply could be proved on the yield. The highest grain yield was harvested in the usual fertilizer treatment. The protein yield, starch yield and oil yield, that were calculated on grain yield multiplied by protein or oil content (%), are economically important indicators. The yields of these components were determined mainly by grain yield. In spite of significant differences in grain yields, only positive

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tendency of impact of fertilization on protein, starch and oil yield were experienced. The changes were not provable statistically compared to the control.

Conclusions

The composition of maize grain can be evaluated according to its utilization. The high protein content is advantageous in fodder maize but it is disadvantageous in maize grown for bio-ethanol manufacture. The protein content of maize grain can be enhanced by fertilization, particularly positive effect of increasing nitrogen supply was observed in this field experiment. But starch content in maize grain was somewhat lower in fertilization treatments compared to the control. Oil content could only be slightly influenced by nutrition. The protein yield, the starch yield and the oil yield are determined mainly by grain yield of corn. Although the starch content of corn was decreased in NPK treatments, even so the starch yield could be augmented by fertilization, because of increasing grain yield. This is favorable mainly in case of energy (bio-ethanol) purpose utilization of corn.

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ENHANCEMENT OF NUTRIENT UPTAKE OF PLANT BY BIOFERTILIZER UNDER ALKALINE CONDITIONS

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Abstract: One of the most central aims of nutrient-management is to determine the amount of available nutrients in the soil and compensate if it is necessary. It is important to have knowledge about environmental factors and the features of soil in order to the best utilization of given fertilizers. The pH of soil and rhizosphere determine the mobility and solubility of nutrients. The exudates organic acids of plant are able to modify the pH, as well as the microorganisms also take part in mobilization of nutrients. The aim of this study was to examine the effect of pH and bacteria based biofertilizer (Phylazonit MC®) on nutrient uptake and some other physiological parameters of maize and cucumber seedlings in laboratory experiments. Bicarbonate was used to have alkaline conditions, which induce iron-chlorosis of leaves.
According to our results the microorganisms containing fertilizer decreased the bicarbonate caused high pH and induced better root differentation supporting larger availability of nutrients. The excretion of organic acids of roots was examined using a qualitative fast screening test. It was observed, that the applied biofertilizer reduced the amount of excreted organic acids by the root of plants. The contents of photosynthetic pigments were also measured, which increased, when biofertilizer was applied.
The use of this biofertilizer can take the utilization of fertilizers more effective and due to this process the production of crops getting more successful.

Keywords: biofertilizer, root morphology, root exudates organic acids, alkaline pH, photosynthetic pigments

Introduction

The environmental factors influence the mobility and amount of nutrients, which important for plant, as a result the efficiency of crop production (Wolf, 1999). The pH of soil, respectively rhizosphere, determines the uptake of nutrients, which a plant can also modify by secreted organic compounds. The changes in pH by excreted organic acids are in many cases responses of root to the nutritional status of plant (Marschner et al., 1987). The microorganisms also can produce organic acids throw their metabolism. To apply bacteria (PGPR - Plant Growth Promoting Rhizobacteria) as biofertilizer become conspicuous, because the animal keeping and the utilization of organic fertilizer decrease, thus the soil is getting poor in useful bacteria. The PGRB enhance the formation of Fe-complex by excreted extracellular siderophores (Klopper et al., 1980).

Materials and methods

The experimental plants were maize (*Zea mays L. Dekalb DKC 4490*) and cucumber (*Cucumis stativum L. cv. Delicatess*). The seeds were germinated on moistened filter paper at 25 °C. The seedlings were transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1 mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. The nutrient solution of cucumber contains 10µM H_3BO_3. The pH was measured of the fresh nutrient solution (basic pH) and after 3 days also (changed pH). The iron as Fe-EDTA was added to the nutrient solution in a

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concentration of 10^{-4}M. Bicarbonate was added in form OF $NaHCO_3$ in the following concentration: 10, 20, 40, 80 mM. 1.25 g agar-agar mixed with 3 ml Bromcresol Purple indicator (in 100 ml) was used to visualizing pH changes by excreted organic acids by roots. The agar-agar mixed with indicator was set to pH 6.0 with NaOH and H_2SO_4 to show the negative or positive changes in pH.
The applied biofertilizer (1 $ml \cdot l^{-1}$) was PHYLAZONIT MC®, which contents two bacteria stain: *Bacillus megatherium var. phosphoricum* and *Azotobacter chroococcum*. The pH of nutrient solution was measured with Optima 200A (USA). Root differentiation and its excreted organic acids were investigated with special agar-agar method and the contents of photosynthetic pigments (chlorophyll-a,-b, total carotenoids) with METEREK SP-830 spectrophotometer. The seedlings were grown under controlled environmental conditions (light/dark regime 16/8 h at 20-25 °C, 65–75 % relative humidity and a photosynthetic photon flux density 300 µmol $m^{-2}s^{-1}$).

Results and discussion

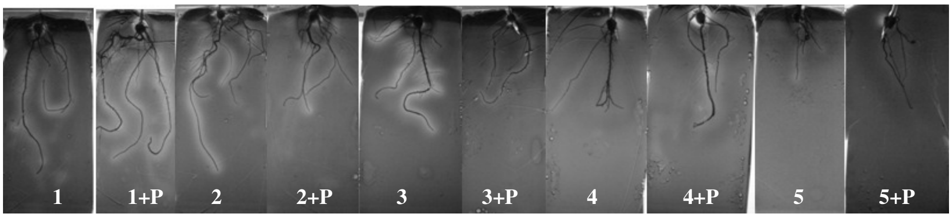
The pH of soil is one of the most important factor determine the solubility and mobility of nutrient. The effect of bicarbonate and biofertilizer was measured on the pH of nutrient solution (*Table 1.*).

Table 1. The effect of different treatments on pH of nutrient solution in case of maize seedlings (n=3±s.e.). Significant difference comparison to the control: *p <0.05, **p<0.01, ***p<0.001. Significant difference comparison to the basic pH: [a]p <0.05, [b]p<0.01, [c]p<0.001. Biofertilizer: Phylazonit MC®

Treatments	2nd day		8 th day	
	basic pH in 0th hour	changed pH in 72th hour	basic pH in 0th hour	changed pH in 72 th hour
control	7,06±0,23	6,44±0,16	4,86±0,06	7,04±0,24[c]
control+ biofertilizer	6,94±0,45	5,75±0,12	4,85±0,03	7,01±0,45[c]
10mM $NaHCO_3$	6,50±0,43	8,08±0,50***[c]	6,86±0,14***	7,53±0,15
10mM $NaHCO_3$+ biofertilizer	6,43±0,42	7,71±0,46**	6,84±0,10***	7,53±0,03
20mM$NaHCO_3$	7,89±0,09*	8,08±0,03***	7,74±0,03***	8,23±0,63*
20mM $NaHCO_3$+ biofertilizer	7,81±0,08	8,06±0,34***	7,70±0,06***	8,18±0,32
40mM $NaHCO_3$	8,21±0,07***	8,65±0,38***	8,09±0,01***	8,31±0,04**
40mM $NaHCO_3$+ biofertilizer	8,20±0,07***	8,03±0,34***	8,06±0,04***	8,25±0,17*
80mM $NaHCO_3$	8,22±0,02***	8,70±0,10***	8,36±0,03***	8,96±0,31***
80mM $NaHCO_3$+ biofertilizer	8,18±0,21***	8,43±0,31***	8,33±0,07***	8,80±0,52***

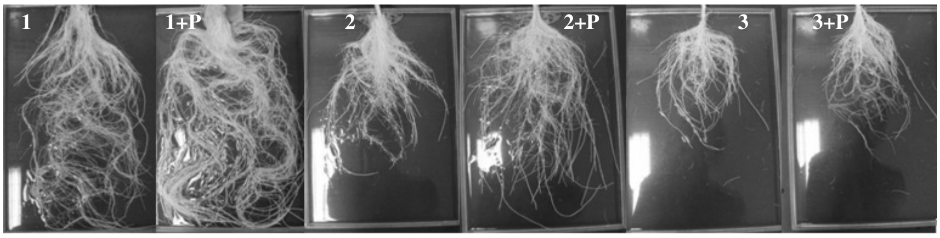
The application of bicarbonate affected the pH of nutrient solution; as a result the pH significantly increased in case of basic and changed nutrient solution as well. This effect depends on the concentration of bicarbonate, higher bicarbonate concentration causes higher pH. The high pH (pH 8.0) retard the solubility of most important macro-, and micronutrient – e. g. Fe, Zn – which can reduces the growth and several metabolism process, because the alkaline condition inhibits the solubility of element and therefore the uptake of nutrient as well (Terbe, 2009).
When biofertilizer was added to the nutrient solution the pH generally decreased. The biofertilizer Phylazonit MC® could compensate the pH increasing the effect of

bicarbonate. The secreted organic acids by microorganisms decreased the pH and can help to make soluble the nutrients (Bowen and Rovira, 1991).
The released organic acids by roots play an important role in reduction of unfavorable environmental condition – e.g. alkaline pH – and the mobilization of nutrients. It was measured the effect of different treatments on the amount of excreted organic acids by monocot maize and dicot cucumber (*Picture 1.*).



Picture 1. The demonstration of effect of different treatments on secreted organic acids by 5-day-old maize seedlings after 12 hour. Treatments: 1: control, 2: 10 mM $NaHCO_3$, 3: 20 mM $NaHCO_3$, 4: 40 mM $NaHCO_3$, 5: 80 mM $NaHCO_3$; +P: Phylazonit MC®

The Bromcresol Purple indicator shows the change in pH. The bluish discolouration of Bromcresol Purple indicates the pH increasing effect of bicarbonate, which depend on the bicarbonate concentration. The roots secreted organic acids until concentration 20 mM $NaHCO_3$. In the case of higher $NaHCO_3$ contents (40 mM) there were no changes in pH. The biofertilizer Phylazonit MC® decreased the pH and the amount of secreted acids by microorganisms.
Several differences between root morphology of experimental plants were observed under alkaline conditions (*Picture 2.*).



Picture 2. The effect of different treatments on root morphology of cucumber seedlings. Treatments: 1: control, 2: 10 mM $NaHCO_3$, 3: 20 mM $NaHCO_3$; +P: Phylazonit MC®.

The bicarbonate retarded the development in order to the length and growth of the roots in line the increasing bicarbonate treatment. The monocot maize was more tolerant, because the response of dicot plants was more sensitive to the alkaline pH. Cucumber seedlings died after 9, 4 days in case of treatment 4 and 5. The application of Phylazonit MC® could compensate the bicarbonate caused stress via useful soil bacteria, which release organic acid as a result decrease the pH and make the nutrient more available for the plants. The high pH induce iron-chlorosis of leaves, therefore the effect of bicarbonate and biofertilizer on contents of photosynthetic pigments were also measured (*Table 2.*).

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Table 2. The effect of bicarbonate and biofertilizer on the contents of chlorophyll-a (chl-a), chlorophyll-b (chl-b) and carotenoids (car) of maize's leaves ($mg \cdot g^{-1}$) (n=3±s.e.). Treatments: 1: control, 2: 10 mM $NaHCO_3$, 3: 20 mM $NaHCO_3$, 4: 40 mM $NaHCO_3$, 5: 80 mM $NaHCO_3$; +P: Phylazonit MC®. Significant difference comparison to the control: *p <0.05, **p<0.01, ***p<0.001. Significant difference comparison to the treatment without biofertilizer: [a]p<0.05, [b]p<0.01, [c]p<0.001. Biofertilizer: Phylazonit MC®

Treat.	chl-a	chl-b	car	chl-a/chl-b	chl-a/car	total chl/car
1	16,31±0,91	5,78±0,63	3,85±0,37	2,84	4,26	5,74
1+P	16,55±0,58	5,82±0,53	4,03±0,34	2,86	4,13	5,55
2	10,91±1,08	3,07±1,07*	2,59±0,85	3,68	4,31	5,40
2+P	15,48±0,82[b]	4,77±0,56[b]	3,81±0,17[a]	3,27	4,07	5,31
3	13,56±1,81	3,94±0,90*	3,25±0,54	3,52	4,19	5,38
3+P	13,98±1,16	4,07±0,46*	3,35±0,41	3,44	4,20	5,39
4	9,02±5,74*	2,55±1,57*	2,21±1,29*	3,25	3,65	5,24
4+P	9,56±0,75*	2,80±0,97** [a]	1,81±0,86**	3,32	5,48	6,83
5	6,36±0,62***	1,85±1,01***	1,43±0,66**	3,30	3,98	5,74
5+P	4,16±1,18***[b]	1,54±0,54***	1,00±0,36***	2,47	3,81	5,70

The bicarbonate dramatically decreased the contents of investigated pigments. The chlorophyll-b was the most sensitive one for increasing pH. In the case of maize the 80 mM bicarbonate treatment decreased the content of chlorophyll-a with 62%, the chlorophyll-b with 68% and the carotenoids with 63%. It has observed the favourable effect of biofertilizer Phylazonit MC® increased the contents of pigments comparison to the control. The ratios of chlorophyll-a/chlorophyll-b and total chlorophyll/carotenoids show the bicarbonate as a stress factor affected the contents of photosynthetic pigments.

Conclusions

According to our result the bicarbonate caused alkaline conditions modified the development of roots, which were retarded, although the microorganisms have a compensation effect. The amount of released organic acids increased under high pH until 40 mM bicarbonate concentration. The alkaline media significantly decreased the content of investigated pigments, which the application of biofertilizer could compensate.

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THE APPLIED SOIL PROTECTIVE CULTIVATION SYSTEM – A METHOD TO REDUCE AND PREVENT THE SOIL DEGRADATION PROCESSES

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Abstract: The examination of new soil use methods started in 1997, at the University of Debrecen CAAES RISF Karcag Research Institute. Our goal was to prevent or reduce the soil degradation processes in Karcag. A lot of areas in this microregion are occupied by the "minute soils", which can be characterized by a very short period for optimal cultivation due to their unfavourable hydrological features and heavy texture. Any tillage operations applied out of this optimal period involve the risk of soil degrading effects. The cumulative effect of the past improper operations has resulted in formation of a physically degraded and dusty cultivated layer. The consequences of the structural degradation of the soil: unfavourable hydrological features, decreased nutrition supply capacity, moderated microbiological activity effects of soil protective cultivation technologies – involving direct seeding and residue management – on the soil, crop and economy of production are examined in a multiple long-term field experiment on a heavy textured soil. . The changes in quality and quantity of the organic material of the soil (humic matter) are monitored through laboratory examinations According to the research achievements of the first thirteen years of the experiment the applied treatments have not always significantly influenced the yield of the indicator crops (maize, winter wheat, peas, canary-grass), but considerably decreased the energy consumption and costs of cultivation. The soil structure and the soil organic substance improved.

Keywords: Soil Protective Cultivation System, humic matter fractions .

Introduction

Two of the major elements of sustainable development in Hungary are the rational utilization, protection and maintenance of the status and versatile functions of our soil stocks, as well as the preservation of our surface and subsurface waters. This is the common task of environmental protection and agriculture (Várallyay, 1996). Any soil cultivation or sawing methods can be considered as the element of conservation tillage that results in more than 30% of crop residues remain on the soil surface for soil protective reasons. In EU-countries methods without soil turning (non-ploughing) are classified as conservation tillage. The wide spread of these techniques was aided by the increase of soil erosion damages and the requirement to decrease the soil water losses. In order to reach these goals, several soil cultivation and sawing methods can be applied: no-tillage, slot planting, strip tillage, ridge tillage, non-turning systems like chisel system, disk system, rotary tillage system, stubble mulch system. The Hungarian situation slightly differs from the international one regarding the perception of conservation tillage, as mainly the energy- and cost saving requirements were the motors of the change in the soil cultivation systems. Two thirds of the carbon content of the organic materials getting into the soil by disturbing it is emitted as carbon-dioxide into the atmosphere thus increasing the global warming (Birkás, 2002). The organic material content of the soil has to be considered as one of the most important carbon stocks that influence the carbon-dioxide and methane contents of the atmosphere. Conservation tillage methods, especially direct seeding, increase the carbon storage capacity of the soil, enrich it with organic materials. Soil cultivation conduces to the better aeration, hence the faster microbiological decomposition of soil organic matters. As the result of decomposition, high amount of CO_2 is generated that contributes to the

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global climatic change (CTIC study). The research results and practical experiences of the last few years prove that conventional soil cultivation methods and their tools cannot meet the requirements of sustainable agricultural soil utilization in case of heavy textured soils of the Great Hungarian Plain. The main reason of this is the presence and speed-up of the soil degradation processes (structure degradation, dusting, compaction, wind erosion). During our research work we could just partly answer these questions, as the self-controlled mechanism of the decreased load and disturbance of the soil appearing in almost each element of the plant production technology reaches such a degree that can be detected in the increase of the soil fertility only after 10-15 years. That is why such research studies have to be based on long-term experiments.

Materials and methods

Location of the experiment: 16 ha plots with meadow chernozem soil on the territory of the Karcag Research Institute. The treatments were as follows: conventional tillage on 3.5 hectares and soil protective reduced tillage on 12.5 hectares. The main goal of the soil cultivation experiment set in 1997 was to determine the application possibilities and the efficiency of the applied reduced tillage system that can stop the physical degradation of the soil. The tractive power demand of these tools is measured with the permanent detection of the GPS co-ordinates of the pulling tractor. The data processing was done with software that can handle GPS data too. The organic carbon content of the samples was determined by the Tyurin method. Fractions of the humic substances and humus quality were examined according to Kononova and Hargitai (Kovács et al., 2010). The effect of the changes in the soil structure and the soil cultivation system on the carbon-dioxide emission of the soil has been studied since 2004. The plots of this experiment provide good opportunity to measure the CO_2-emission from the soil (Zsembeli et al., 2005). Soil moisture content (necessary for the evaluation of CO_2-emission results and soil compaction) was determined by gravimetric method.

Results and discussion

After processing the data bases of the measurement series it was proved that the tractive power demand of plough and disc representing conventional tillage is very high, it can be as high as 80 kN in the case of ploughing. Nevertheless, we measured higher tractive power values when Disk Ripper was used, if compared with disc application. These results can be cozening as the moving speed of the two tractor-tool connections was almost the same, contrary to the fact that the Disk Ripper is heavier with its ripper shanks behind the disc gangs. Furthermore, the high quality and even work of the Disk Ripper must be emphasized and also the fuel consumption was lower when this tool was used. While ploughing, the high horsepower tractor sometimes lost some speed, contrary to the fact that it has high performance reserves, some slip often occurred. In this case the even moving speed needed for the continuous, high quality soil work could be maintained only by changing to lower gears.

All these are well demonstrated in the data base of the measurement series, the tractive power demand values moving hectically up and down indicate the performance lost of the tractor very well. In case of Disk Ripper application, the curve is more even, slip seldom occurred during the measurements. Taking all these into account and analysing the fuel consumption data, the advantages of the application of Disk Ripper are obvious. We have established that the Disk Ripper can be considered as the basic tool of primary tillage of the new, conservation tillage methods and can fully substitute plough and heavy discs applied in conventional tillage. Based on our measured data it can be concluded that the tractive power demand of Disk Ripper is only 35% of the tractive power demand of the plough, while 38-40% of the disc (*Table 1.*).

Table 1. The tractive power demand of the investigated tools

	Volume of cultivated soil along 1 m length (m^3)	Average tractive power demand (kN)	Specific tractive power demand (kN)
Plough RW Kondor 6/5	0.5625	80	142.22
Disc IH-6.6	1.296	70	54.01
JD-510 Disk Ripper	0.95+0.57=1.52	30	19.73

The organic carbon content of the soil samples and of the isolated fractions of humic matter. In the *Table 2.* can be seen there was no significant difference between the total amount of organic carbon of the soils cultivated with different tillage systems.

Table 2. Organic carbon content of the different fractions

	Conventional tillage – CT (m/m) %	Reduced tillage - RT (m/m) %
Total Organic Carbon	2.18	2.11

Figure 1. shows that the ratio of extinction of the NaF and NaOH extracts (humus stability number) at different wave-length was significantly higher in the case of the reduced cultivation.

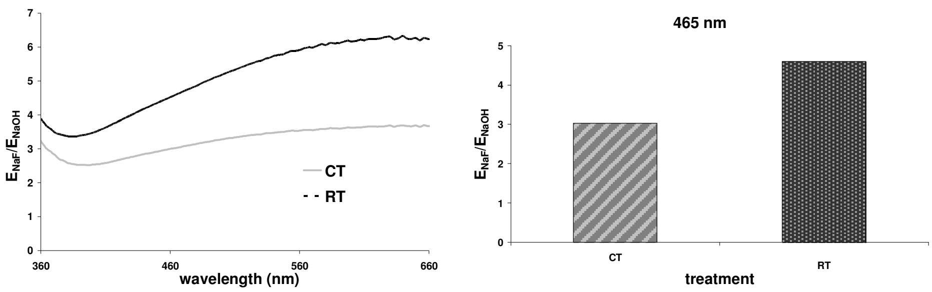

Figure 1. Effect of cultivation on the Ext. NaF/Ext. NaOH ratio of humic acids

Figure 2. shows the CO_2-emission values determined for the treatments of the soil tillage experiment in 2009. Three measurement dates are indicated, the first measurement was done after the harvest and before the relevant tillage application. In July, a higher emission was detected in the reduce tillage system. In August, the measurements were done after the tillage application. This period was very dry (*Figure 3.*) and that could explain the very low CO_2-emission values. The meteorological conditions and also the emission levels were similar in September. Of course, the

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shortness of the investigated period does not allow us to conclude general conclusions, but there is no doubt that we have gained remarkable results about the correlation between the soil status and the CO_2-emission from the soil. Experimental data provided information about the length of the time period when CO_2 emission increasing effects of soil cultivation are observable.

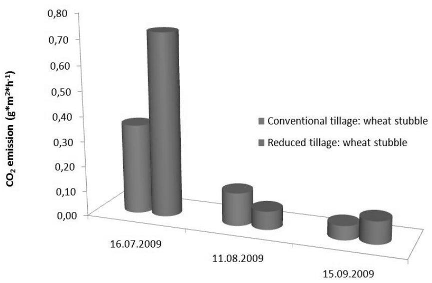

Figure 2. CO_2-emission values in the soil tillage experiment in 2009

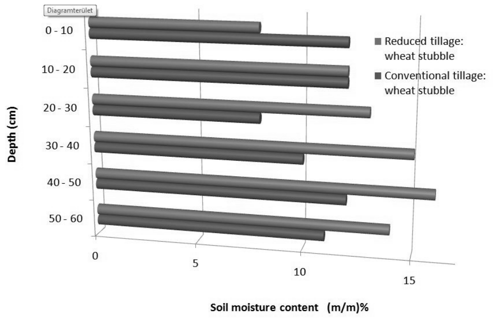

Figure 3. Soil moisture content values in august 2009

Conclusions

After processing the measured data it can be established that there was a big difference in the pulling resistance of the machinery applied in conventional and conservation tillage. As the number of tillage operations is much lower in case of conservation tillage, the soil compaction caused by the machinery as well as fuel consumption are lower resulting in decreased environmental load, lower costs and labour use (higher profitability). Analysing the amount and fractional composition of the soil organic matters we found that reduced tillage produced an increased ratio of the stabile humic materials that bound to the soil minerals taking part in the formation of a more favourable soil structure. Based on our results it can be concluded that the application of reduced cultivation supported the soil in approaching its natural equilibrium state that manifested in the investigated factors of the soil carbon cycle. Under favourable soil moisture conditions, microbiological activity (indicated by the level of CO_2-emission) was increased where conservation tillage system was applied, that can be the results of the decomposition of crop residue that remained on the experimental site.

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POSSIBLE EFFECTS OF CADMIUM CONTENT OF SOILS ON CERTAIN PHYSIOLOGICAL PARAMETERS OF MAIZE

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Abstract: Problems are caused in many countries of the world by the high cadmium (Cd) content of cultivated soils. Cadmium absorbed easily by plants; therefore their use might result in significant economic damages; on the one hand through the decrease of plant production, on the other hand because of the cadmium content of the product exceeding the permitted limit- thus hindering sales. Moreover, the consumption or forage use of plants originating from cadmium contaminated areas might result in serious health issues. In the course of our work the effect of Cd presence on certain physiological parameters (absolute chlorophyll content and root growth) of some selected maize hybrids was monitored. The Cd significantly decreased both the quantity of photosynthetic pigments and the root growth.

Keywords: cadmium, chlorophyll content, root growth

Introduction

As a result of human activities, the heavy metal – among which cadmium – content significantly increased in our soils under agricultural use. Their toxic effect and accumulation in the plants depend on numerous factors like soil conditions, their concentration, the duration of the pollution, the presence of complex forming materials in the rhizosphere and the plant species itself. Organic acids are important constituents of the soil, as they dissolve the metals in the soil that can otherwise be found in an insoluble mineral form, thereby increasing these metals' mobility close to the root and improving their availability for plants (López-Bucio et al., 2000). There are indirect evidences in relation to the fact that the Cd uptake is being done through the Zn, Fe and Ca transporters / channels of the root cells that have wide substrate specificity, therefore, cadmium is in competition with potassium, calcium, iron, manganese, zinc, copper and nickel for the same transmembrane carrier/channel proteins (Clemens, 2006). Cadmium reduces the growth and weight of the root and the shoot (Mench et al., 1994; Gupta and Dixit, 1992; Reddy and Prasad, 1993; Kádár, 1993). Ferretti et al. (1993) reported the reduction of photosynthesis and the decrease of the amount of sugars and chlorophyll.

Materials and methods

Maize (*Zea mays, L. cv. Mv 277, Mv 343, Mv 500, De 285*) seeds were germinated between moistened filter papers at 25°C in dark. The seedlings were transferred to a continuously aerated nutrient solution (10 plants/pot), when the coleoptiles and hypocotyls were 4–5 cm. The composition of the nutrient solution was as follows: 2.0 mM $Ca(NO_3)_2$, 0.7 mM K_2SO_4, 0.5 mM $MgSO_4$, 0.1 mM KH_2PO_4, 0.1 mM KCl, 1µM H_3BO_3, 1µM $MnSO_4$, 0.25 µM $CuSO_4$, 0.01 µM $(NH_4)_6Mo_7O_{24}$. Iron was added to the nutrient solution as the form of Fe-EDTA in a concentration of 10^{-4}M. When Cd treatment was applied, the concentration of $CdSO_4$ was 10, 20 mg l^{-1}. In all cases three repetitions were made.

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The seedlings were grown under controlled environmental conditions (light/dark regime 8/16 h at 24/20^{o}C, 65–70% relative humidity and a photosynthetic photon flux of 300 molm^{-2}s^{-1} at plant height). The contents of photosynthetic pigments were measured with Metertek SP-830 UV/VIS (Japan) according to the method of Moran and Porath (1980) in the 3rd leaves of the plants. The length of root (cm) was measured with millimeter scaled ruler after 3 weeks far different cadmium treatments.
Statistical analysis (ANOVA) was conducted using the Sigma Plot 11.0 statistical package. Separation of means was performed by post hoc (Scheffe test) comparison at the 0.05 significance level.

Results and discussion

During our experiments, we examined the effect of cadmium on the absolute chlorophyll content of maize leaves. We were growing the plants for three weeks using nutrient solutions that had different cadmium concentrations and then we measured the chlorophyll content of the third leaves of the 21-day-old plants. The change in the amount and proportion of the maize hybrids' photosynthetic pigments as a result of the cadmium treatments are shown in the following tables (*Tables 1-2.*).

Table 1. Changes in absolut chlorophyll contents (mg g^{-1}) influenced by different Cd treatments 21 days old maize (Mv 277; Mv 343) plants on 3. leaf (n=6, average values ± standard deviation, significant difference comparison to the control p<0.05*, p<0.01**, p<0.001***)

Control	10 mg l^{-1} Cd	20 mg l^{-1} Cd	Control	10 mg l^{-1} Cd	20 mg l^{-1} Cd	
3th leaf (Mv 277)			*3th leaf (Mv 343)*			
15.523±1.87	10.596±0.66**	9.645±2.16**	15.726±0.91	11.380±0.88**	9.846±1.46***	Chl a
5.882±1.38	3.568±0.48***	3.246±0.50***	6.053±0.53	3.606±0.56***	3.062±0.54***	Chl b
3.258±0.45	2.051±0.12*	1.854±0.49**	3.952±0.32	2.226±0.19**	1.939±0.35***	Carotin
2.64	**2.97**	**2.97**	**2.6**	**3.16**	**3.22**	**Chl a/b**
4.76	**5.17**	**5.2**	**3.98**	**5.11**	**5.08**	**Chl a/car.**

Table 2. Changes in absolut chlorophyll contents (mg g^{-1}) influenced by different Cd treatments 21 days old maize (De 285; Mv 500) plants on 3. leaf (n=6, average values ± standard deviation, significant difference comparison to the control p<0.05*, p<0.01**, p<0.001***)

Control	10 mg l^{-1} Cd	20 mg l^{-1} Cd	Control	10 mg l^{-1} Cd	20 mg l^{-1} Cd	
3th leaf (De 285)			*3th leaf (Mv 500)*			
11.881±1.06	9.631±0.50*	8.192±0.61**	15.216±0.51	9.304±2.10**	7.642±0.60***	Chl a
4.096±0.26	3.33±0.27*	2.790±0.31**	5.975±0.27	3.208±0.46***	2.622±0.17***	Chl b
2.454±0.24	2.044±0.08*	1.800±0.11**	3.319±0.15	1.946±0.46**	1.783±0.18**	Carotin
2.9	**2.89**	**2.94**	**2.55**	**2.9**	**2.91**	**Chl a/b**
4.84	**4.71**	**4.55**	**4.58**	**4.78**	**4.29**	**Chl a/car.**

We observed significant reductions in the case of all four maize hybrids concerning the examined pigment groups in comparison with the control. The chlorophyll-b reacted the most sensitively to cadmium treatments, showing a nearly 50% reduction in comparison with the control.

The structure of the maize root grown on the nutrient solution (*Figure 1.*) shows rather significant differences as a result of the cadmium treatments. As the Cd concentration increases, the root length significantly decreases, similarly to the amount and size of the secondary root-branches, therefore, the nutrient uptake surface of the plants significantly decreased.

Control 10 mg l^{-1} Cd 20 mg l^{-1} Cd

Figure 1. The effect of the cadmium treatments on the root structure of the 21-day-old maize (*Zea mays L.cv. Mv 343*)

During the assessment of the results we analyzed the changes of root growth of maize as a result of $CdSO_4$ treatment, as a function of cadmium concentrations (*Figure 2.*). As a result of increasing concentrations the relative difference between the root growths of the maize hybrids has shown an increasing tendency, namely it reacted more sensitively for the increase of treatment duration.

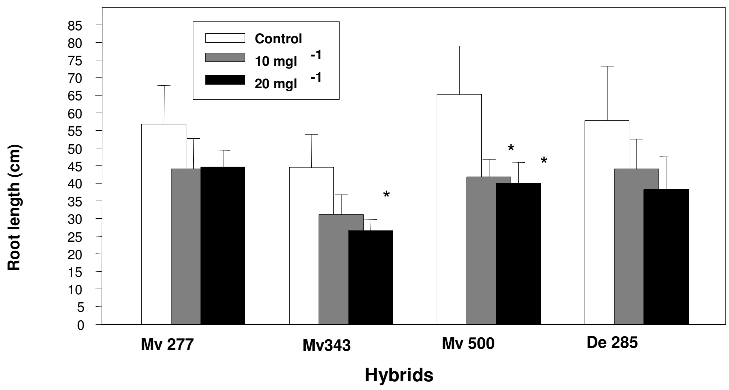

Figure 2. Maize hybrids rooth lenght (cm) influenced by different Cd treatments (n=6± s.e.) significant difference comparison to the control $p<0.05$*

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Conclusions

Based on our analyses, we established that the cadmium added to the nutrient solution significantly decreased both the quantity of photosynthetic pigments and the root growth. In all treatments, decreased of root length with increasing concentrations of cadmium. This phenomenon is likely to be explained by the fact that a part of the organic matter produced during photosynthesis was used up for growth.

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GEOCHEMICAL CHARACTERIZATION OF SOILS OF SLOPE SEDIMENTS FROM CALCIC CHERNOZEM AND RED CLAY RENDZINA

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Abstract: Nowadays the geochemical investigation of soils has received increasing attention owing to the significant role played by both their mineral and organic composition in the processes of pedogenesis, in the migration of contaminants and in the global carbon cycle. This work was performed as part of a project aiming at the geochemical characterization of the organic matter stored in the major soil types of Hungary. This paper investigates mineral and organic geochemical characteristics of soils of slope sediments came from calcic chernozem (CCH) and red clay rendzina (RCR) on the basis of element distributions in the soil profile, soil organic matter characterization by Rock-Eval pyrolysis and examination of climatic conditions effects in connection with weathering processes. Temperate climatic conditions are indicated by proportion of main mineral elements during pedogenesis in CCH and both warm tropical and temperate climatic conditions in RCR. The source material of RCR was generated by long, multi-phased weathering processes taking place in different micro-environment on the strength of inorganic geochemical results. According to results of komplex geochemical investigations geochemical lines are at 10 and 50 cm in RCR and at 20, 50 and 60 cm in CCH. The signs of pedogenesis in the upper 40 cm of studied RCR profile suggest the lack of reworking during sliding down on the slope. Mixed character was proved in the CCH profile. The field of CCH has been an undisturbed buffer zone for a long time so nowadays redepositioned layers are overwritten by new soil-chemical processes, geochemical border-lines change.

Keywords: geochemistry, soil organic matter, Rock-Eval pyrolysis, mineral composition, XRF

Introduction

During the last decade besides their agrochemical characterization, the geochemical investigation of soils has received increasing attention. Study of different soil-chemical processes and determination of geochemical lines are established by full knowledge about organic and inorganic geochemistry of soils. Adsorption characteristic of organic and inorganic matters in soils and recent sediments (soil buffer capacity) determines the mobility of organic and inorganic pollution thus effects the quality of surface and groundwater. Weathering of rocks and pedogenesis processes are influenced by soil organic matter (Clark and Fritz, 1997). These processes are influence by groups of soil organic matter with different thermic stability in different measure.

Materials and methods

Samples of RRC came from a soil profile, which can be found in a red clay filled doline on karst-plateau of Aggtelek-Rudabánya Mountain (N 48°28'; E 20°32'). The vegetation is dominated by closer deciduous forest of beech and oak in the area. Samples of CCH came from Pilot Farm of Szent István University (Józsefmajor) from an alluvial cone of Northern Plain. The studied soil is an eroded chernozem which evolved on Pleistocene loess. This field is a grassy buffer zone. We took samples from main horizons and every 10 cm of the soil profiles. Chemical data were measured on the basis of Hungarian Standards and Dean-method (Dean, 1974). Magnesium, natrium, potassium (MSZ 20135:1999; atomic absorption spectrophotometry) and phosphate

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(MSZ 448-18:1977; spectrophotometry) contents determined from Lakanen-Erviö (1971) extract of soil (mass-volume ratio 1:10). Nitrate (MSZ 448-12:1982) and sulphate (MSZ 448-13:1984) content spectrophotometric measurements were carried out in 1 mol dm^{-3} KCl extract (mass-volume ratio 2:5). Mineral elements of soil samples were measured by Horiba Jobin-Yvon XGT-5000 X-ray fluorescence apparatus with half quantitative method (30 kV, Rh ray-source, 100 μm ray-pile, 900 sec time period). Organic geochemical bulk data was measured by a Delsi Oil Show Analyzer Rock-Eval pyrolyser apparatus (180-600 ^oC; 25 $^oCmin^{-1}$). Mathematical deconvolution of Rock-Eval pyrograms can be used for evaulate the relative contribution of the fraction with different stability (Nyilas, 2009).

Results and discussion

RCR soil is susceptible to acidification in spite of ~4% carbonate content (*Table 1.*). Carbonates neutralize just next to pieces of source rock. Great potassium content is typical of grass-covered fields, because grass vegetation accumulates potassium in the upper 20 cm of studied CCH profile. There is a weak eluviation in the RCR soil, because potassium and magnesium are in the soil solution in A-horizon but adsorbate on clays in lower horizons.

There is eluviation effect in the CCH profile, because magnesium and sodium content increased with 26% and 63% as a function of depth (*Table 1.*). Accumulation of sodium and nitrate in the C_1-horizon of RCR profile is because of bad transmissivity of deeper layers. Greater phosphate, nitrate and sulphate contents of some horizon derived from decay of organic content of litter layer. Weak increased sulphate content is possible because of anion change and adsorbtion effects of Fe-and Al-oxides in the acidic soil. Reason for little phosphate content is undissolved ferric-phosphate precipitation in the acidic and ferriferous RCR samples.

Table 1. Chemical data measured on studied soil samples. (nm: non measurable)

Soil of slope sediment of red clay rendzina (RCR)											
	Depth	pH_{KCl}	pH_{H2O}	OM	$CaCO_3$	PO_4^{3-}	K^+	Na^+	Mg^{2+}	SO_4^{2-}	NO_3^-
	cm			m/m%		mg kg^{-1}					
A	1-5	5.4	6.1	5.15	3.7	0.59	393.9	19.2	465.4	99.5	38.8
C_1	5-35	3.9	5.4	1.27	4.2	nm	132.2	34.9	347.1	46.5	2.7
C_2	35-60	4.1	5.7	0.82	4.0	0.33	119.3	25.7	278.5	51.0	3.4
C_3	60-100	4.3	5.9	0.48	4.2	0.60	112.9	26.8	209.2	76.8	2.6
Soil of slope sediment of calcic chernozem (CCH)											
A_p	0-20	7.4	7.6	2.50	2.1	225.8	455.3	15.6	581.7	200.5	22.3
2A	20-70	7.5	7.8	1.60	3.4	193.2	419.0	21.0	639.5	183.8	10.9
$3A_b$	70-120	7.1	8.1	0.97	8.2	13.8	185.7	42.7	783.1	53.3	nm

Temperate climatic conditions are indicated by proportion of main mineral elements (*Figure 1.*) during pedogenesis in CCH and both warm tropical and temperate climatic conditions in RCR. Tropic climatic conditions are bare out contrary tendency in the change of Si and Al concentrations (bauxite formation), kaolinite content in latosol and red clay residuum and the presence of hematite which give the red colour to RCR. Vermiculite and smectite were detected by XRD in large quantities near kaolinite in C_1-

horizon (Czirbus et al., 2010) so we supposed that magnesium came not only from dolomite but mostly from Fe-Mg-silicates which could also be the source of the Fe-content of the hematite. Relative proportion of calcium decreased because of silicon, potassium and magnesium content increasing in CCH (*Figure 1.*). Calcium and potassium pattern show redepositioned layers in CCH. Peaks of potassium, manganese and zinc (~ 40 cm) were detected by XRF appeared owing to rooty zone of plants in RCR. Immobile zirconium and titanium perfect indicators for conditions before starting of pedogenesis processes. If the excavation redeposites in large proportion, the Si and Al patterns will show the same fluctuant tendency as Ti (Barczi et al., 2006). Relative accumulation of zirconium has anthropogenic origin in the top layer of RCR (nuclear tests and accidents). All Cu-, Zn- and Pb content exceed the Hungarian norm (10/2000 (VI.2.) Government Order) in the whole RCR profile. This load is natural because Cu, Zn, Pb together indicates mineralization (Gondi et al., 2004). However some higher values in the CCH profile suggest anthropogenic origin, they can come from herbicides and pesticides through the intensive cultivation.

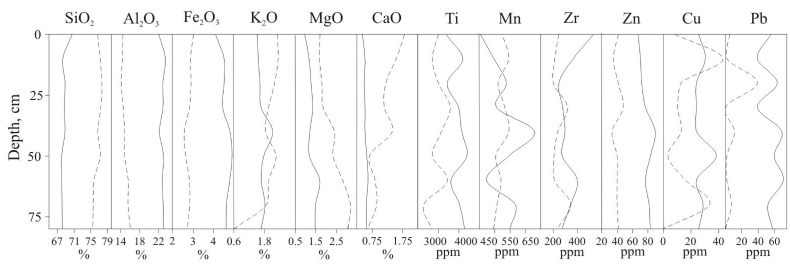

Figure 1. Element distribution profile (RCR: line, CCH: broken line)

Organic geochemical Rock-Eval pyrolysis bulk data (total organic carbon - TOC, hydrogen index - HI and the pirolized part of organic carbon (reactive organic carbon) - OC_r) show decrease depth trends to 40 cm in RCR profile and to 20 cm in CCH profile. Parallel with these results the proportion of inert carbon (OC_iTOC^{-1}) increases in TOC in the profiles. These trends accord with general soil organic matter evolution trend (rooty zone, great biological activity). Decreasing values of HI point the early stage of transformation of bio-macromolecules (B_L, B_S) into humic substances.

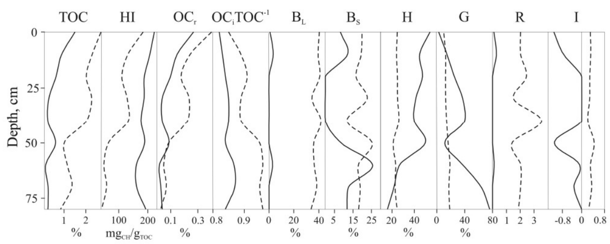

Figure 2. Depth profiles of bulk Rock-Eval data and results of mathematical deconvolutions of Rock-Eval pyrograms (RCR: line, CCH: broken line)

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Proportion of refractory geo-macromolecules (G) increases as a function of depth but there is a break point on the line at ~ 50 cm. Changes on the curves of organic geochemical parameters are in accord with XRD results. Results of the mathematical deconvolution of Rock-Eval pyrograms mark biomass differences perfectly. R value (B_L/B_S ratio) illustrates the relative evolution of the „two bio-macromolecule" classes. Sebag et al. (2006) proved that R values of grassland soils are large as R values of forest soils after examination of many soil samples from all parts of the world. I index marks differences of the organic source matters (plant cover) and local hydrological conditions between two soil profiles. There is water infiltration on the field of CCH profile, but water has flowed on soil surface on the field of RCR.

Conclusions

The source material of RCR was resulted in by long multi-phased weathering processes. These processes started in warm tropical environment. On the basis of organic and inorganic geochemical examinations geochemical lines are at 10 and 40 cm in RCR. The signs of pedogenesis in the upper 40 cm of studied profile suggest the lack of reworking during sliding down on the slope. Mixed character is missing. Mixing is demonstrable in CCH profile, which evolved on carbonate rock too under temperate climatic conditions. Geochemical lines are at 20, 50 and 60 cm in this soil profile. Redepositioned layers are overwrite by soil-chemical processes (new equilibriums), because this field is an undisturbed buffer zone for a long time.

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INFLUENCE OF DIGESTATE AND FARMYARD MANURE ON SOIL MOISTURE REGIME

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Abstract: This paper analyzes the influence of fertilization using the anaerobically processed biosludge (digestate) after continuous biogas production on soil moisture regime. Experiment was carried out at the field condition of the research and experimental site of the Slovak University of Agriculture located in Kolinany (Slovakia). Experimental site belongs to the maize growing region with the 30-year climatic normal (1961-1990) of average annual air temperature 9,8 °C, and average annual precipitation 539 mm. The soil is sandy loam soil. The soil moisture was studied on the plots fertilized with the two variants of organic fertilizers: (1) plot with application of digestate, made from farmyard manure; (2) plot fertilized with farmyard; (3) and control plot fertilized only with mineral fertilizers. The results of measurements were analyzed during years 2002, 2004 and 2008. This paper reveals the results of the soil moisture courses under the sugar beet (*Beta vulgaris*) during years 2002, 2004 and 2008. According to the results can be concluded, that the continuous application of digestate had a positive effect on the soil moisture regime after couple years of its application (2004 and 2008).

Keywords: digestate, soil moisture regime

Introduction

Continual supply of organic matters in forms of organic fertilizers (slurry and farmyard), composts and crop residues play a key role in a land improvement. Significant decrease of farm organic wastes production which causes a deficit of soil organic matter (SOM) also with the problem of increasing prices of mineral fertilizers call for a utilization of alternative sources of organic fertilizers to hold the soil fertility on a required level. Using the wastes after continuous fermentation of animal and plants wastes (aim of biogas production) is also environment friendly and is one of the alternative source of organic fertilizers. Latest research indicated that the digestate (D) as an organic fertilizer has specific positive effects (no smell, improve the soil structure, hydrophysical, chemical and biological soil properties, decrease the germinative capacity of weeds, increase the nutritional and hygienic quality of production) and basically has a similar manurial effect compared to the farmyard (FYM). D is an immediate resource of nitrogen (N), has a pH from 7,6-8,5, do not acidify the soil, increase the cohesion of soil aggregates, improve soil protection from erosion on light and inclinable soils on erosion, and also extend vegetative period of planted crops, thereby there is a time for a consistent harvest. There was also found the significant influence of D and FYM amounts as an organic substrate on occurrence of soil fauna (Pospíšil et al., 2010). Soil Water is also very important for plant growth and the same holds true for the groundwater. Once water enters the soil, it fulfils several simultaneous functions. Beside its direct influence on microbial turnover processes, soil water controls oxygen availability, which in turn regulates key processes in the N cycle,

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namely nitrification and denitrification (Machefert et al., 2002). Furthermore, when water move through the soil it relocates nutrients, thus influencing the overall fertility of the soil. The main objective of this study was to analyze the influence of fertilization using the anaerobically processed digestate after continuous biogas production on soil moisture regime at the selected experimental station of the Slovak University of Agriculture in the maize growing region in the Slovak Republic (Kolíňany-near town Nitra) during years 2002, 2004 and 2008.

Materials and methods

Experimental site

The site of the study undertaken during years 2002, 2004 and 2008 is located at the field condition of the research and experimental site of the Slovak University of Agriculture located in Kolinany (Slovakia). Experimental site (160 – 180 m above the see level) belongs to the maize growing region with the 30-year climatic normal (1961-1990) of average annual air temperature 9,8 °C, and average annual precipitation 539 mm (Špánik et al. 2000). The soil is brown soil with a sandy-loam texture with the clay content in range of 20-30 % (Akp horizon) with the significant content of silt, which is typical for soils created from loess eolian sediments (Pospíšil et al., 2010).

Field experiment

The soil moisture regime was analyzed under the sugar beet (*Beta vulgaris*) on the plots fertilized with the two variants of organic fertilizers: (1) plot with application of digestate (D); (2) plot fertilized with farmyard (FYM) (*Table 1.*); (3) and control plot (CP) fertilized only with mineral fertilizers NPK 15-15-15 with the same amount of 250 kg ha^{-1} every year. All three plots were equally pre-fertilized before beginning of the field research (2001) with mineral fertilizers.

Table 1. Amounts of organic fertilizers applied to sugar beet (*Beta vulgaris*)

Year	CP (t ha^{-1})	D (t ha^{-1})	FYM (t ha^{-1})
2002	0	100	50
2004	0	50	50
2008	0	50	40

Nitrogen in the digestate is built in ammonium form, because its production is an anaerobic process with no running denitrification processes. This ammonium form of nitrogen is easily accessible for plants causing no problems with its leaching. Even the D is a liquid and FYM is solid, the amount of water in the D wasn't sufficient compared to amount of water present in the FYM (D- 11 % and FYM- 21 % of dry mater). These differences are negligible also considering the soil moisture, because these organic fertilizers were applied only once a year (in autumn), which can't sufficiently influence the soil moisture with different addition of water present in the fertilizers during evaluated period of growing season. The soil water content (vol. %) at the soil depth of 30 cm was measured using electromagnetic sensor of soil moisture VIRRIB (produced by AMET – Veľké Bílovce, Czech Republic) working on TDT principle (Time domain reflectometry) with the measurement accuracy of ±1 %. The sensor was placed in the upper third of the slope, because there were found the average soil water contents for the whole experimental site.

Evaluation of the measured results

The evaluated period was determined by growing season of sugar beet (IV.-IX.). The soil water content available for plants is in range determined by the field capacity (θ_{FC}) and wilting point (θ_{WP}) which were determined from the retention curve and the values are θ_{FC}=*0,*29 cm^3 cm^{-3} and θ_{WP}=0,11 cm^3 cm^{-3}, respectively. It is generally known that there is sufficient amount of water for potential evapotranspiration (E_{pot}) between these two intervals until it reaches the hydrolimit called point of decreased availability (θ_{PDA}). The evapotranspiration deficit (E_{pot} - E_{act}) is equal to 0 between this interval ($\theta_{FC} \sim \theta_{PDA}$) which means that the plant isn't limited during its growth by water deficit. Therefore, there were analyzed number of days and maximum deficit of water content in mm below the hydrolimit point of decreased availability (θ_{PDA}) in this study. This value of θ_{PDA} was also determined from the retention curve and equals to 0,20 cm^3 cm^{-3}.

Results and discussion

As it results from *Figure 1.* and *Table 2.*, the highest average soil moisture (28 vol. %) was observed at the beginning of the experiment (2002) on the plot fertilized with FYM. There wasn't found decrease of soil moisture below θ_{PDA} on the plots fertilized with FYM and CP during the whole growing season of the sugar beet since there was enough precipitation (378 mm) during this evaluated period (IV.-IX.) (*Figure 1.* and *Table 2.*).

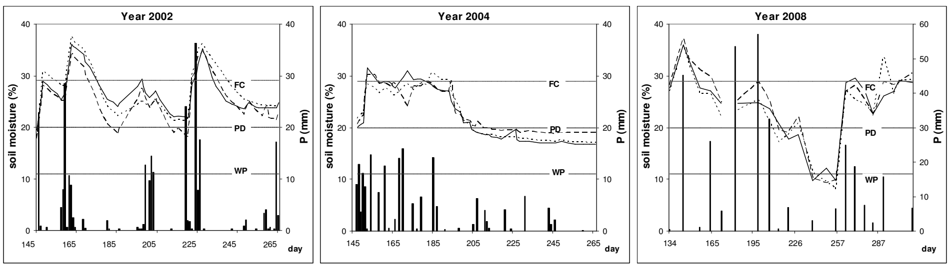

Figure 1. Soil moisture courses on the plots planted with the sugar beet and fertilized with two organic fertilizers: (1) (D; ----); (2) (FYM; ·······); (3) (CP; ——)

Table 2. Average soil moisture at the 30 cm soil depth; number of days and maximum deficit of water content (mm) below the point of decreased availability (θ_{PDA}) on the plots planted with the sugar beet and fertilized with the two organic fertilizers: (1) (D); (2) (FYM); (3) (CP)

Year	D			FYM			CP		
	$\theta<\theta_{PDA}$		Average soil moisture (vol.%)	$\theta<\theta_{PDA}$		Average soil moisture (vol.%)	$\theta<\theta_{PDA}$		Average soil moisture (vol.%)
	Number of days	Max. deficit (mm)		Number of days	Max. deficit (mm)		Number of days	Max. deficit (mm)	
2002	26	5,8	25,5	0	0	27,5	0	0	27,1
2004	54	2,9	22,7	64	24,5	21,8	64	10	21,8
2008	26	32,4	22,8	32	35,2	22,0	30	31,4	22,4

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On the plot fertilized with D was observed the lowest average soil moisture (26 vol. %) with the period of 26 days below the θ_{PDA} with the maximum deficit of 6 mm (*Table 2.*). These findings changed after two years (2004) where there was observed the highest average soil moisture (23 vol. %) with 54 days below the θ_{PDA} and maximum deficit of 3 mm on the plot fertilized with D compared to lower average soil moistures of 22 vol. % and 22 vol. % for the plots fertilized with FYM and CP, respectively. There were observed longer periods of days (both 64 days) below the θ_{PDA} with the maximum deficit of 25 and 10 mm on the plots fertilized with FYM and CP, respectively compared to plots fertilized with D. The growing season of the year 2004 was the driest of all with the precipitation of 257 mm. The highest average soil moisture (23 vol. %) was also found in 2008 after continuous D application compared to soil moistures of 22 and 22 vol. % for plots fertilized with FYM and CP, respectively. There was observed shorter period of 26 days below the θ_{PDA} with the maximum deficit of 32 mm compared to longer periods of days 32 and 30 with the maximum deficit of 35 and 31 mm for plots fertilized with FYM and CP, respectively. The precipitation during this growing season was found to be 329 mm.

Conclusions

Except several published specific positive effects of digestate (e.g. no smell, improve the soil structure, hydrophysical, chemical and biological soil properties, decrease the germinative capacity of weeds, increase the nutritional and hygienic quality of production, etc.), our study resulted in another positive influence which is that the continuous application of digestate (D) imporved soil moisture regime after two years of its application (2004 and 2008). The results of this study are used for irrigation regulation in condition of the research and experimental site of the Slovak University of Agriculture located in Kolinany (Slovakia).

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