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GRAIN YIELD AND SOIL BACTERIAL COMMUNITIES AFFECTED BY THE RATIO OF CEREALS IN CROP ROTATION

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Abstract: The stationary multi-factor trial was established in 1974 on experimental station of Borovce. There are 40%, 60% and 80% share of cereals. Grain yield by 40% share of cereals was statistically higher (6,50 t ha^{-1}) than by 60 in the crop rotations trial % and 80% share of cereals (6,23 t ha^{-1}). Grain yield of spring barley by 80% share of cereals was statistically lower (4,05 t ha^{-1}) than by 40% (5,04 t ha^{-1}) and 60% share of cereals (5,03 t ha^{-1}). Different proportion of cereals in a rotation system had a significant effect on the abundance of rhizobia, cellulolytic and denitrification bacteria. At combined fertilization (mineral plus organic) we observed higher abundance of bacterial spores, *Azotobacter* spp., denitrification, cellulolytic and nitrification bacteria in comparison with the variant without organic fertilization. The highest metabolic diversity and average utilization of carbon sources by microbial communities was recorded in soil samples collected from crop rotation system with 40 % contribution of cereals and combined fertilization with added organic fertilizer Veget.

Keywords: proportion of cereals**,** crop rotations**,** grain yield, soil bacterial communities**,** metabolic diversity

Introduction

The systems of crop rotation are always one of the main agrotechnical measures which contribute to increased agricultural production. Crop rotations with comparable proportion of fertilizing crops improve soil structure and protect the soil, influence soil biodiversity with after-yield remains as well as the content of soil organic matter. They affect the uptake of nutrients from soil positively and have beneficial effect on the environment (Lipavský, 2008). Changes in metabolic profiles of soil microbial communities possess a potential for use as indicators of the impact of agricultural management and environmental perturbations on soil functioning and quality. Analysis of the diversity of soil microorganisms is particularly important when considering the ability of ecosystems to respond to changing environmental conditions, the need for conservation of the microbial gene pool and the links between diversity, ecosystem processes, functional and physiological diversity, resilience and sustainability (Prosser, 2002). The aim of our research was to determine the influence of crop rotations with higher share of cereals on the grain yield of cereals and on soil bacterial communities.

Materials and methods

The stationary trial was established in 1974 in the experimental station Borovce near Piešťany, Slovakia. The field experiment was located on Luvi-Haplic Chernozem on loess. The trial occurs in the area of continental climate. There are crop rotations with 40, 60 and 80 % share of the cereals in field trial. In crop rotations two levels of fertilization were applied: H_1 – mineral fertilization + organic manure Veget; H_2 – only mineral fertilization. Bulk soil sampling was accomplished at the milky ripe stage (BBCH 75) of winter wheat (*Triticum aestivum* L.) cv. 'Petrana'. The samples were processed for microbiological analyses as suggested by Ikeda et al. (2006).

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Microbiological analyses involved the detection of the presence of *Azotobacter* spp. in soil aggregates incubated on Ashby's agar and expressed as percent of fertile aggregates, determination of the abundances of cellulolytic bacteria on medium using a filter paper as a C-source, ammonifying bacteria cultured on MPA (meat-peptone agar, IMUNA, SR), native rhizobia on selective media (Biomark Laboratories, India), nitrifying and denitrifying bacteria, all expressed as colony forming units (CFU) per 1 gram of soil dry weight, and the count of bacterial spores after pasteurization of the sample. Biochemical analyses of single carbon source utilization patterns of soil microorganisms were performed employing the Biolog® microtiter plates (Biolog, Inc., Hayward, USA) and the results were expressed as average metabolic response (AMR) and community metabolic diversity (CMD) values according to Sigler (2004).

Results and discussion

The statistically higher winter wheat grain yield (*Table 1.*) was recorded by 40% share of cereals in crop rotation (6.50 t ha^{-1}) than by 60% (6.23 t ha^{-1}) and 80% share of cereals (6.23 t ha^{-1}). The grain yield of spring barley in crop rotation with 80% proportion of cereals was statistically lower (4.05 t ha^{-1}) than the grain yield in crop rotation with 40% (5.04 t ha^{-1}) and in crop rotation with 60% share (5.03 t ha^{-1}).

Table 1. Multifactorial variance analysis of winter wheat and spring barley grain yield

Factor	Winter wheat				Spring barley			
	AS	f	P	$LSD_{0.05}$	Average	f	P	$LSD_{0.05}$
F	0.079	1		0.16	0.001	1		0.19
SC	0.800	2	++	0.24	10.297	2	++	0.28
F x SC	0.059	2		0.41	0.047	2		0.49
Years	12.902	3	++	0.30	43.197	3	++	0.36
F x years	0.583	3	+	0.50	0.361	3		0.60
SC x years	0.610	6	++	0.67	1.340	6	++	0.79
Sum	0.615	95			1.860	95		
RD	0.155	69			0.219			

AS – average squares f – degree of freedom; P – effect of a factor significant at the level $\alpha = 0.05$; $LSD_{0.05}$ – limit significant difference at the level $\alpha = 0.05$; SC – share of cereals in crop rotation; F – fertilization; RD - residual dispersion

Different proportion of cereals in the crop rotation system (40, 60 and 80%) had a statistically significant effect on the abundances of cellulolytic ($P < 0.05$), rhizobial and denitrifying ($P < 0.01$) bacteria. Fertilization significantly affected the counts of bacterial spores, rhizobia, cellulolytic and denitrifying bacteria ($P < 0.01$). In comparison to variant without organic fertilization the application of organic fertilizer Veget increased the abundances of bacterial spores, *Azotobacter*, denitrifying, cellulolytic, and nitrifying bacteria. The highest abundances of ammonifying bacteria and rhizobia (by 16 to 53% more than the total mean) were observed in soil samples originating from crop rotation system with 40% proportion of cereals and mineral fertilization without organic fertilization. The highest abundances of cellulolytic and denitrifying bacteria per 1 gram of soil (by 19 to 29% more than the total mean) were found in soil samples collected from crop rotation system with 60% proportion of cereals and amendment of organic fertilizer Veget. Nitrifying bacteria, bacterial spores and *Azotobacter* showed the highest values of CFU per 1 g of soil in samples taken from crop rotation with 40% proportion of cereals and application of organic fertilization (*Table 2*.). Both the metabolic diversity of microbial communities (CMD), and the average utilization of C-sources by microbial communities (AMR) were statistically significantly affected by crop rotation systems as well as fertilization types ($P < 0.001$). The highest metabolic diversity of soil bacterial communities was observed in soil samples collected from crop rotation system with 40% proportion of cereals and amendment of organic fertilizer Veget, whereas the highest average C-source utilization was determined for soil microorganisms from the crop rotation system involving 60% of cereals and application of organic fertilizer Veget (*Table 2*.). The recommended combined use of organic and inorganic fertilization is considered useful to maintain high microbial biomass, soil biological activity and soil fertility. Ge et al. (2010) detected significant differences in soil microbial biomass after application of organic manure and inorganic fertilizer. Organic fertilization significantly ($P < 0.05$) increased the soil microbial biomass, whereas a decrease in this parameter was observed after application of inorganic fertilizer. Our results showed statistically significant differences in abundances of several groups of microbial communities between soils treated with inorganic fertilizer or a combined use of inorganic and organic fertilizers. These differences were pronounced in rhizobia and bacterial spores in soil samples collected from crop rotations with 60% proportion of cereals, and in cellulolytic bacteria in soil samples from crop rotations involving 40% and 80% proportion of cereals.

Table 2. Abundance of selected cultivation groups of microorganisms, metabolic diversity and average utilization of C-sources by bacterial communities in crop rotations with 40, 60 and 80% proportion of cereals and two variants of fertilization

Parameter	% of cereals in crop rotation system x fertilization					
	40% x H_1	40% x H_2	60% x H_1	60% x H_2	80% x H_1	80% x H_2
Ammonifying bacteria ($CFU.10^3.g^{-1}$ soil dry weight)	43.60	64.24	61.58	62.55	47.49	51.52
Rhizobium spp. ($CFU.10^4.g^{-1}$ soil dry weight)	30.62	96.65	36.84	43.98	82.28	87.76
Denitrifying bacteria ($CFU.10^4.g^{-1}$ soil dry weight)	26.76	47.62	74.23	51.41	72.06	72.48
Cellulolytic bacteria ($CFU.10^2.g^{-1}$ soil dry weight)	48.29	29.86	52.23	46.84	37.94	47.56
Nitrifying bacteria ($CFU.10^5.g^{-1}$ soil dry weight)	7.99	6.47	4.66	4.85	7.63	2.82
Counts of bacterial spores ($CFU.10^3.g^{-1}$ soil dry weight)	97.41	65.09	63.78	77.69	81.62	78.14
Azotobacter spp. (%, n=50)	79.00	72.00	75.00	72.00	69.00	75.00
CMD	62.91	53.91	57.66	53.41	55.00	60.08
AMR	1.01	0.88	1.04	0.82	0.79	0.87

CFU – colony forming units, H_1 – combined mineral fertilization and organic fertilization using Veget, H_2 – mineral fertilization without organic fertilization, CMD – metabolic diversity of bacterial communities, AMR – average utilization of C-sources by bacterial communities

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After combined use of mineral and organic fertilization higher abundance of bacterial spores, *Azotobacter*, denitrification, nitrification and cellulolytic bacteria were observed in comparison to application of inorganic fertilizer. In general, the use of balanced amount of mineral and organic fertilizers increases the soil enzymatic and respiration activity (Kanchikerimath and Singh, 2001; Tu et al., 2006). In our experiment, the catabolic utilization of C-sources by bacterial communities increased by 11 % in soils treated with combined mineral and organic fertilization. Such relative sensitivity of microbial community metabolism on soil management and the assessment of soil microbiological parameters are, according to Bending et al. (2000), a convenient tool for use as indicators of early changes in biological quality of soils. The authors conclude that patterns of microbial substrate utilization and metabolic diversity are more sensitive to the effects of management than are soil organic matter and biomass pools, and therefore have value as early indicators of the impacts of management on soil biological properties, and hence soil quality.

Conclusions

The highest grain yield of cereals was reached in crop rotation with 40% of cereals. The highest metabolic diversity and average utilization of carbon sources by microbial communities was recorded in soil samples collected from crop rotation system with 40% participation of cereals and combined fertilization with added organic fertilizer Veget.

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CROP SITE AND AGRONOMIC VARIATIONS IN SWEET SORGHUM *(SORGHUM BICOLOR* L. MOENCH) PRODUCTION INFLUENCING THE LEVEL OF ENERGY CROPPING

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Abstract: The time is near when we reach the maximum rate of global petroleum extraction (peak oil) and the rate of production enters into a terminal decline. The global energy demand forces the international scientific community to seek new alternative energy sources. Agricultural crops can produce carbohydrates for ethanol, fuel for biodiesel and dry matter for combustion, pyrolysis and gasification. As one of the non-grain energy crops, sweet sorghum *(Sorghum bicolor* L. Moench) has great abilities to become a potential material for the second generation bioethanol plants. Crop site and agronomy of production highly influence the level of energy cropping. This study is intended to establish the most adaptable tillage of sweet sorghum in Hungary and to determine the optimum plant nutrition levels. Field trials were carried out in 2009 and 2010 in the Biomass Utilization and Crop Production Demonstration Centre of Szent István University. The soil of the trial field is classified as a rust-brown forest soil (*Chromic Luvisol*). Both humus content and N-supply of the topsoil are poor. Potassium and phosphorus supply of the soil is sufficient. Seven rates of nutrition were tested in combination with four tillage treatment. Sorghum hybrid Sucrosorgo was sown. Year 2009 was a typical drought year in the experimental field; only 133 mm of precipitation was measured. We got the best biomass results in case of ploughing. In 2010, the average rainfall was higher in the vegetation period than usual. In 2010 the ploughing, cultivating and disk harrowing treatments showed the same biomass results. The results demonstrate that the amount of precipitation and the suitable tillage are very important in growing sweet sorghum. The task of tillage is to infiltrate precipitation into the soil and preserve it for cultivated crops.

Keywords: sweet sorghum, biomass, Brix

Introduction

Renewable energy sources have received great attention from the international community during the last decades. Biomass is one of the oldest and the most promising energy sources and includes organic and animal wastes, waste-water, energy crops, agricultural and industrial residues that can be used for the production of biofuels (Antonopoulou et al., 2008). Nowadays, one of the prime sources investigated as energy crops is sweet sorghum. It can be harvested within 4-5 months after sowing even in temperate areas and can produce 70-100 tons of green mass and 20-30 tons of dry matter annually (Grabner, 1942; Józsa, 1976). It was found to contain 43.6-58.2% soluble sucrose, glucose and fructose and 22.6-47.8% insoluble cellulose and hemicellulose in the stalk (Dolciotti et al., 1998). Therefore, it is a promising crop as a raw material for the fermentation industry because it can grow in arid and semi-arid areas. In general, sorghum has stronger drought resistance than maize (Tsuchihashi and Goto, 2004). The amount of precipitation, the suitable cultivation and plant fertilization is very important in sweet sorghum growing. Ouédraogo et al. (2007) reported that deep tillage allows maximum absorption of rain water and reduces weed populations at the initial stage of crop growth, which ultimately increases crop yields. Nitrogen increases stalk yield and potassium increases sucrose content in sweet sorghum (Leible and Kahnt, 1991). This study was designed to determine the optimal nitrogen treatment and

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tillage system of sweet sorghum for obtaining highest stalk yield and brix value under Hungarian climatic conditions.

Materials and methods

2 year field experiment was carried out at the Biomass Utilization and Crop Production Demonstration Centre of Szent István University (47°46'N and 19 °21'E, 227 m elevation) during 2009-2010. The sorghum plants were grown on Luvic Calcic Phaeozem. The soil parameters (0-40 cm) were as follows: $pH_{(H2O)}$ 6.76; organic matter content 1.32%; phosphorus content 371.1mg kg^{-1} and potassium content 184.0 mg kg^{-1}. Both the humus content and the N-supply of the topsoil are poor. Potassium and phosphorus supply of the soil is sufficient. The upper 40 cm layer of the soil contains 53% sand, 26% loam and 20% clay fraction. The mean annual rainfall is 550 mm, two-thirds of that falls in the summer term (April-September). In 2009 the mean annual precipitation was 133 mm, and 850 mm in 2010. The experiment was laid out in a 4 x 7 factorial arranged in a strip-plot design with three replications. The trial included cultivation and fertilizer treatment. The chemical fertilisers being used were ammonium nitrate for nitrogen (N) and potassium chloride for potassium (K) and the application rates were: 0 (N_0), 50 (N_1), 100 (N_2) kgN/ha for nitrogen and 0 (K_0), 40 (K_1), 80 (K_2) kgK/ha for potassium. Therefore, there were 7 fertilization treatment combinations: N_0K_0, N_1K_0, N_2K_0, N_0K_1, N_0K_2, N_1K_1 and N_2K_2. The following tillage treatments were made: ploughing (PL, 25-35 cm), disc harrowing (DS, 15-20 cm), cultivation (CU, 10-15 cm) and direct seeding. The tillage was made in the autumn after the pre-crop harvest. Sorghum hybrid Sucrosorgo was used as a test crop. The seeds were sown at a row distance of 70 cm and at a plant distance of 10 cm. Weeding was carried out one-time, 3 weeks after emergence. Weeding was no longer needed once the crop plants achieved high amount of leaf area per plant to cover the ground. The used plot size was 10 x 8 meters with a two-meter walking path between the plots. The biomass at harvest time was determined at the complete maturity of sweet sorghum. Plants from 10 running meters were cut from each treatment plot to determine the biomass. Then the plants were measured on industrial tare scales type Kern De.6 plant samples were cut at random from each plot. Each plant was divided into stems, leaves and a panicle for brix estimation. Stems were squeezed and the juice was measured for brix values by Atago 0-60% digital refractometer. The data obtained were statistically analysed by the ANOVA method using Microsoft Analysis Tool Pack.

Results and discussion

Biomass outcome are shown in *Table 1*. The results showed that the largest amount of above-ground biomass was achieved with PL in 2009 (56.11 t ha^{-1}) and 2010 (63.52 t ha^{-1}). The smallest amount was achieved with DS (12.14 t ha^{-1}) in 2009. Direct seeding was unfavourable for development of sweet sorghum in both the experimental years. Laddha et al. (1997) found that there is a strong interdependence between yield and cultivation methods in sweet sorghum crops. Our trial has proven the same. Deep tillage treatments (PL, CU, and DH) increased the soil volumetric water content in the surface, sub-surface and deeper soil layers at sowing as well as at harvest during both years. The various nutrition levels were significantly different compared to the control in both years. The largest amount of biomass (63.52 t ha^{-1}) was achieved with N_2K_2 treatment in

2010. In 2010 there were no appreciable differences between the 50 and 100 kgN/ha nutrition treatments, in comparison of 2009. The high amount of precipitation in 2010 leached nitrogen to deep soil layers.

Table 1. Biomass at harvest time. (Gödöllő, 2009-2010)

Treatments	Cultivation methods				Mean
	PL	CU	DH	DS	
2009					
N_0K_0	26.51	21.43	22.86	14.52	21.33
N_1K_0	40.63	25.56	28.33	13.73	27.06
N_2K_0	56.11	35.24	34.13	15.16	35.16
N_0K_1	39.76	18.97	19.76	13.97	23.12
N_0K_2	37.94	22.70	26.03	14.21	25.22
N_1K_1	42.78	24.60	26.98	12.14	26.63
N_2K_2	46.35	48.97	30.24	21.19	36.69
Mean	41.44	28.21	26.90	14.99	
2010					
N_0K_0	45.19	44.10	42.76	27.29	39.83
N_1K_0	60.10	51.05	52.71	36.81	50.17
N_2K_0	63.43	55.90	55.24	37.67	53.06
N_0K_1	46.48	43.76	47.57	27.38	41.30
N_0K_2	47.52	44.57	42.76	28.24	40.77
N_1K_1	61.38	50.48	52.48	35.86	50.05
N_2K_2	63.52	50.81	53.86	36.52	51.18
Mean	55.37	48.67	49.63	32.82	

2009 $LSD_{5\%\ fertilization}$ = 2.6; $LSD_{5\%\ cultivation}$ =3.7; $LSD_{5\%\ fertilization \times cultivation}$ = 6.4
2010 $LSD_{5\%\ fertilization}$ = 2.2; $LSD_{5\%\ cultivation}$ =3.0; $LSD_{5\%\ fertilization \times cultivation}$ = n. s.

Table 2. Refractometric dry matter (Brix) at harvest time. (Gödöllő, 2009-2010)

Treatments	Cultivation methods				Mean
	PL	CU	DH	DS	
2009					
N_0K_0	15.92	13.81	15.76	13.72	14.80
N_1K_0	18.03	16.21	16.57	15.26	16.52
N_2K_0	17.15	18.21	17.96	17.65	17.74
N_0K_1	14.95	13.44	16.87	13.89	14.79
N_0K_2	16.96	16.67	16.81	17.43	16.97
N_1K_1	17.94	17.23	17.44	14.75	16.84
N_2K_2	16.39	17.93	15.63	15.07	16.26
Mean	16.76	16.21	16.72	15.40	
2010					
N_0K_0	7.72	8.31	8.53	6.41	7.74
N_1K_0	7.45	9.01	7.93	7.03	7.86
N_2K_0	6.15	7.25	8.20	6.48	7.02
N_0K_1	7.93	7.99	7.71	6.99	7.65
N_0K_2	6.68	7.54	7.30	5.87	6.85
N_1K_1	6.83	7.94	6.18	7.38	7.08
N_2K_2	7.93	7.87	7.87	5.03	7.18
Mean	7.24	7.99	7.67	6.45	

2009 $LSD_{5\%\ fertilization}$ = 1.3; $LSD_{5\%\ cultivation}$ =1.0; $LSD_{5\%\ fertilization \times cultivation}$ = n. s.
2010 $LSD_{5\%\ fertilization}$ = 0.8; $LSD_{5\%\ cultivation}$ = n. s.; $LSD_{5\%\ fertilization \times cultivation}$ = n. s.

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Brix value was used to determine sugar content in the stem of sweet sorghum. The results are shown in *Table 2*. After evaluating the data the highest Brix values relative to the control (N_0K_0) nutrition level were found in the N_2K_0 treatment in 2009. In 2009, the measured brix value ranged from 13.44 to 18.21%. In 2010 it ranged from 5.03 to 9.01%. Statistic evaluation showed that there was no significant difference between the cultivation methods in 2010. The fertilization had supportable effect on the brix - value of the sweet sorghum.

Conclusions

The experiment showed that the biomasses of sweet sorghum were less in dry than in the rainy season; however the brix-value showed opposite results. To prevent the nitrogen leaching it's advisable to split it into 2-3 doses. Our trial confirmed that water storing capacity of less-favoured production areas can be preserved with the help of appropriate soil preparation. Based on our results, PL is proved to be the best agricultural method. According to our studies the most optimal nutrient levels were N_1K_0, N_1K_1 and N_2K_2. Agricultural measures must always be in line with the demands of the plant and the soil.

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EFFECT OF FERTILIZATION AND LIMING ON NUTRITIONAL STATUS OF BARLEY GRAIN

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Abstract: The effect of fertilization and liming on grain nutritional status in four barley winter cultivars (Jagodinac, Rekord, Kristal and Premijum) was evaluated. The trial was carried out on pseudogley soil at the experimental field of Dr. Đorđe Radić High School of Agriculture and Chemistry in Kraljevo, Serbia, during 2007/08. The experiment included control and three fertilization treatments ($N_{80}P_{80}K_{60}$; $N_{80}P_{160}K_{60}$; $N_{80}P_{80}K_{60}$ + 4tha^{-1} $CaCO_3$ + 20tha^{-1} manure). Regular use of NPK resulted in an increased content of nutrients, primarily N (+37%), Fe (+77%), Mn (+13%) and P (+12%), in barley grain, as compared to the control. A significant increase in grain Mg (+70%) and Cu (+48%) content relative to the control and fertilization treatments was obtained with NPK fertilizer having a higher P concentration. The combined treatment with NPK, lime and manure gave the highest Ca content in barley grain but significantly decreased the content of tested micronutrients (Fe, Mn, Zn and Cu). The content of N, P, K, Ca and Fe in barley grain was highest in cv. Kristal, and that of Mg, Mn, Zn and Cu in cv. Premijum.

Keywords: barley**,** fertilization, grain, liming, nutritional status

Introduction

Barley (*Hordeum vulgare L.*) is extremely sensitive to both low soil pH and deficiency of certain plant nutrients. Being characterized by specific mineral nutrient requirements, distribution and accumulation, barley and its genotypes exhibit substantial differences in the content and distribution of biogenic macro- and micronutrients. Variability of mineral nutrient content is induced not only by genetic factors but also by different soil nutrient supplies (Užik and Žofajova, 2006; Györi, 2007; Hussein et al., 2009).

Changes in soil micronutrient content affecting the nutritional status of cereal grains are becoming a global problem, leading to reductions in grain yield and quality. Deficiency of Fe in plants and that of Mn in some parts of the world (a substantial part of Northern Europe) are known to have an adverse effect on about half the world's population (about 3.5 billion people) (Husted et al., 2005). In addition, the increased solubility and content of Fe and Mn in acid soils result in a proportional increase in the content of these nutrients in crops (Rezai and Farboodnia, 2008; Walker and Connolly, 2008). Also, Zn deficiency can occur in extremely acid soils due to increased leaching of Zn into deeper soil layers. World Health Organization (WHO) attributes 800,000 deaths worldwide each year to Zn deficiency, and over 20 million healthy life years are lost due to it. It is estimated that Zn deficiency affects one-third of the world´s population.

The objective of this study was to evaluate the effect of regular fertilization and amelioration treatments, and genotype on the content of biogenic nutrients, particularly heavy metals, in the grain of winter barley grown on pseudogley, in terms of plant nutrition optimization and food quality and safety.

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Materials and methods

The trial was conducted at the experimental field of the Dr. Đorđe Radić High School of Agriculture and Chemistry, Kraljevo, on acid pseudogley during the growing season of 2007-2008. The trial was set up as a randomized block design in three replications with a plot size of 100 m^2. Control (A_1) and three fertilization and liming treatments (A_2- $N_{80}P_{80}K_{50}$; A_3- $N_{80}P_{160}K_{50}$; A_4- $N_{80}P_{80}K_{50}$+4t ha^{-1} $CaCO_3$+20t ha^{-1} manure) were employed.
Four winter barley cultivars (Jagodinac, Kristal, Premijum and Rekord) were evaluated. Sowing was performed at an optimum date in mid-October at a rate of 500 germ. grains m^{-2}. Grains were sampled for analysis at full maturity stage during barley harvest.
The Kraljevo pseudogley is a heavy-textured soil low in pH and available phosphorus, characterized by unfavourable physical and chemical properties (*Table 1.*).

Table 1. Soil characteristics at the beginning of the experiment

Depth (cm)	Soil properties								
	pH		Humus (%)	mg 100^{-1}g		Texture (%)*			
	H_2O	KCl		P_2O_5	K_2O	C. sand	F. sand	Silt	Clay
0-20	5.4	4.5	2.2	8.0	13.8	3.54	42.7	28.9	24.9
20-30	5.5	4.6	1.7	7.0	18.0	0.56	45.9	29.7	23.8
30-50	5.6	4.8	1.1	1.3	24.6	0.88	37.2	35.1	26.8

*diameters of soil particles (mm): >0.2 mm (coarse sand), 0.2-0.02 mm (fine sand), 0.02-0.002 mm (silt), <0.002 (clay)

The average air temperature during the 2007-2008 growing season was considerably higher than the long-term mean (LTM). Total rainfall during the same growing season was about 5% above the LTM. The autumn of the 2007-2008 growing season (October and November) had 86 mm more rainfall than the LTM, and mean air temperature was below the LTM. December was the coldest month in the growing season (0.2^{0}C).

Table 2. Weather characteristics

Rainfall (R mm) and mean air temperatures (t ^{0}C) for 2007/2008 and long-term means (1961-1990)									
Period	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	∑/x
2007/08 R mm	117	116	39	33	22	72	63	40	73	575
2007/08 t ^{0}C	10.6	3.2	0.2	1.6	4.5	8.0	12.4	17.2	21.1	8.7
LTM R mm LTM	58	89	50	42	38	48	54	86	83	548
t ^{0}C	11.1	4.2	1.2	-0.2	1.7	6.8	11.5	16.8	19.6	8.1

However, as regards the LTM for Kraljevo, January was the coldest month, with an average mean air temperature of -0.2^{0}C. One part of the 2008 growing season (May and June) was characterized by decreased rainfall and increased air temperature relative to the LTM
Nitrogen content in barley grain was determined by Kjeldahl method, phosphorus by vanadate-molybdate method, and potassium by flame photometry. Contents of calcium, magnesium and heavy metals were determined by AAS using a Varian AA-10. Readily available phosphorus and potassium in the soil were determined by Egner-Riehm Al

method. The obtained data were evaluated using analysis of variance and the significance between mean values was performed according to Mead (1996).

Results and discussion

This study showed a significant effect of different fertilization and liming treatments on the nutritional status of barley grain (*Table 3.*).

Table 3. Effect of treatment (factor A) and genetic effect (factor B) on chemical composition of barley grain

Factor		Barley grain (on dry matter basis): A_1- control, A_2- NP_1K, A_3- NP_2K, A_4- NP_1K+$CaCO_3$+manure								
		Percent			mg kg^{-1}					
A	B*	N	P	K	Mg	Ca	Fe	Mn	Zn	Cu
A_1		1.20	0.16	1.84	1.75	7.3	47.6	35.9	51.5	5.0
A_2		1.65	0.18	1.91	2.31	12.2	81.5	40.5	55.0	6.4
A_3		1.49	0.17	1.94	2.97	12.1	61.9	37.7	55.2	7.4
A_4		1.58	0.17	1.95	2.56	12.8	44.3	32.6	52.5	4.8
LSD A 5%		0.008	0.008	0.026	0.026	0.16	1.68	1.48	0.66	0.46
LSD A 1%		0.011	0.011	0.035	0.035	0.22	2.27	1.99	0.89	0.62
	B_1	1.50	0.16	1.86	2.08	10.7	61.9	31.4	37.6	4.5
	B_2	1.51	0.21	2.12	2.42	11.9	69.7	38.1	55.0	5.8
	B_3	1.46	0.16	1.90	2.65	11.1	54.3	43.0	64.8	7.9
	B_4	1.43	0.15	1.76	2.44	10.9	49.5	34.2	56.7	5.3
LSD B 5%		0.008	0.008	0.026	0.026	0.16	1.68	1.48	0.66	0.46
LSD B 1%		0.011	0.011	0.035	0.035	0.22	2.27	1.99	0.89	0.62
Interaction AB (treatments x cultivars)										
A_1	B_1	1.21	0.15	1.83	1.61	6.9	50.0	28.9	35.5	4.0
	B_2	1.23	0.20	2.06	1.93	8.3	54.5	38.3	58.5	5.2
	B_3	1.20	0.16	1.78	1.97	7.2	46.0	41.4	59.0	6.7
	B_4	1.14	0.15	1.68	1.47	7.0	40.0	35.2	53.0	4.0
A_2	B_1	1.90	0.17	1.90	1.94	11.9	89.0	32.0	40.0	4.7
	B_2	1.77	0.21	2.12	2.37	13.4	94.5	41.4	52.5	6.5
	B_3	1.45	0.17	1.80	2.58	12.1	75.0	49.8	67.5	8.0
	B_4	1.47	0.15	1.84	2.36	11.5	67.5	38.9	60.0	6.5
A_3	B_1	1.34	0.16	1.88	2.62	11.6	62.5	31.9	38.0	6.0
	B_2	1.54	0.20	2.10	3.06	12.9	77.5	40.4	57.0	7.0
	B_3	1.55	0.17	2.05	3.12	11.9	52.5	46.2	67.7	10.5
	B_4	1.52	0.16	1.72	3.09	12.1	55.0	32.2	58.0	6.2
A_4	B_1	1.56	0.15	1.84	213	12.4	46.0	31.0	37.1	3.2
	B_2	1.51	0.22	2.20	2.32	12.9	52.2	32.3	52.0	4.7
	B_3	1.62	0.16	1.96	2.93	13.2	43.7	34.6	65.0	6.5
	B_4	1.61	0.15	1.80	2.84	12.9	35.5	30.7	56.0	4.7
LSD AB 5%		0.016	0.016	0.053	0.053	0.32	3.37	2.95	1.32	0.92
LSD AB 1%		0.022	0.022	0.071	0.071	0.44	4.53	3.97	1.78	1.24
Average		1.48	0.17	1.91	2.40	11.1	58.8	34.8	53.5	5.9

*B_1- Jagodinac, B_2- Kristal, B_3- Premijum, B_4- Rekord

Namely, fertilization with NP_1K (A_2) induced a significant increase in grain N (+37%), P (+12%), Fe (+71%) and Mn (+13%) content as compared to control (A_1). Barley treatment with NP_2K having an increased P content (A_3) gave a significantly higher content of Mg (+70%), Cu (+48%) and Zn (+7%) relative to control (A_1). However, the

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combined use of NP_1K, lime and manure reduced the grain Fe, Mn and Zn content by 62%, 20% and 5%, respectively, as compared to the fertilized treatments. The highest grain K and Ca content was obtained with the combined use of NP_1K, $CaCO_3$ and manure (A_4). Moreover, significant differences were observed among cultivars in mineral nutrient content of barley grain (*Table 3.*). The content of N, P, K, Ca and Fe was highest in cv. Kristal (B_2) and lowest in cv. Rekord (B_1). The highest grain Mg, Mn, Zn and Cu content was determined in winter barley cv. Premijum (B_3). However, grain P concentration in all winter barley cultivars was very low (0.15-0.21%).
The obtained results comply with the literature data reporting that grain mineral nutrient concentrations in barley genotypes result from the effect of internal (genetic and physiological) and environmental factors (Dick et al., 1985, Sager and Hoesch, 2005). Dick et al. (1985) also underline that the level of P and certain micronutrients (Mn, Zn and Cu) in the grain of different barley genotypes is largely dependent upon soil pH.

Conclusions

Improvement in winter barley production technology in terms of plant nutrition on pseudogley soil involves the use of certain soil ameliorative measures (liming, humification, phosphorus treatment) and fertilization (NP_1K+$CaCO_3$+manure) aimed at increasing the concentration of mineral nutrients, primarily P and Ca, in barley grain up to the optimum, as well as the content of Fe, Mn and Zn in some genotypes.

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VARIABILITY OF GRAIN YIELD AND QUALITY OF WINTER BARLEY GENOTYPES (*HORDEUM VULGARE* L), UNDER THE INFLUENCE OF NITROGEN NUTRITION

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Abstract: The variability of grain yield, thousand grain weight, hectolitre mass of grain, grain protein contents in winter barley genotypes (G-3003, G-3020, G-3007-1/02 and G-3019) were investigated. These barley lines are tested in different environmental conditions during two seasons by application of different rate of nitrogen (control=0, N_1=20, N_2=40 and N_3=60 kg ha^{-1}). The highest average grain yield for both year was established in G-3019 (6200 kg ha^{-1}) and the lowest yield in G-3020 (5760 kg ha^{-1}). The highest average yield for all tested genotypes was found in the first year on variant of nutrition by N_3=60, and in the second year on variant of nutrition by N_2=40. In average for all variant of N nutrition and season the line G-3019 had the highest value of TGW (45.1g) and the lowest contents of protein (12,1%) what is advantages of malting barley. Differences of trait values in two diffrent growing season are indicating adaptability of barley lines.

Keywords: barley, genotype, yield, quality, nitrogen

Introduction

The year and scientific farming technology play main role of determining yield and quality of barley (Macak et al., 2008). Components of yield and quality are under genetic control, but interaction genotype/environment have influence to efficiency of absorption and accumulation of nutrient (Jolankai and Nemeth, 2002; Petrovic et al, 2008). The barley genotype respond differently to agro-ecological factors, primarly - soil fertility, precipitation, temperature etc (Kovacevic et al. 2006; Malesevic et al., 2010). Changes in soil fertility tillage under the effect of different metods of tillage (Birkás et al., 2007) can affected yield but less than N fertilization (Angás et al., 2006). The adjusted technology of fertilization in terms of used tillage system effected to yield. N application affected the accumulation up to heading in barley. N uptake during grain filling did not show any correlation to N applied in barley (Delogu et al., 1998), while it is markedly correlated in wheat (Knezevic et al., 2007). The way for increasing of barley yield and quality is developing genotype with improved eficiency for N uptake on environment and its accumulation (Madic et al., 2009). The N rates, the timing of N application has an important effect on grain yield. The protein composition depends on genotype, environment and their interactions (Przulj and Momcilovic, 2005).

The aim of this paper is investigation of effect applied different rates of N on grain yield thousand grain weight, hectolitre mass and protein content in four promising genotypes of two-row winter barley.

Materials and methods

The four winter barley selected lines (G-3003, G-3020, G-3007-1/02 and G-3019) were tested, on soil type smonitza with humus content 2.34%, in field experiment on 5m^2 plots and 4 repetitions under different rate of mineral nutrition. During two years of

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experiment for analysis were evaluated grain yield, thousand grain weight (TGW), hectoliter mass (HM) and grain protein content (GPC) of barley genotypes grown, under different doses of nitrogen nutrition (control N_0=0, N_1=20, N_2=40 and N_3=60 kg ha^{-1}). The analysis of variance was calculated according to randomize complete block design with three factors: A (genotype), B (year) and factor C (N-dose), using ANOVA (MSTAT-C program, 1989). The significant differences among the means were grouped according to least significant difference (LSD).

Results and discussion

The grain yield of investigated barley genotypes was different in two experimental years and in dependence of applied rates of nitrogen (*Table 1.*). In first year the grain yield of barley was lower than in second year of experiment. In this investigation, N application had significant effects on grain yield. In generaly, the average values of grain yield, thousand grain weight, hectoliter mass were lower in first than in second growing season of barley genotypes (*Table 1.* and *2.*). In both years of experiment, value of grain yield was a response to the increase in N (*Table1*). However, in some cases this increase is not necessary (Cantero-Martinez et al., 2003) and that form of N is very important (Pagola et al., 2008) and that environmental and management factors have influence to variation of yield and yield components (Macak et al., 2008).

Table 1. Average values of grain yield and protein content of two-row winter barley

Genotypes	Year	Grain yield (kg)				Protein content (%)			
		N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
G-3003	2007	2748	2944	3824	3882	11.3	12.3	12.5	12.7
	2008	7445	8340	9357	8540	11.9	12.3	12.5	13.2
	Average	**5096**	**5642**	**6590**	**6211**	**11.6**	**12.3**	**12.5**	**12.9**
G-3020	2007	2588	3120	3788	3848	11.8	12.3	12.5	13.3
	2008	6923	8170	9040	8630	11.5	11.7	12.2	12.6
	Average	**4755**	**5645**	**6414**	**6234**	**11.6**	**13.0**	**12.4**	**12.9**
G-3007-1/02	2007	2645	3338	4800	4895	11.8	12.3	12.4	13.0
	2008	6805	7970	8710	8505	11.5	11.7	12.2	12.7
	Average	**4725**	**5654**	**6755**	**6700**	**11.6**	**12.0**	**12.3**	**12.8**
G-3019	2007	3145	3661	4760	4868	10.7	11.5	11.9	12.3
	2008	7528	8233	8725	8443	11.3	11.5	11.7	12.0
	Average	**5336**	**5447**	**6742**	**6655**	**11.0**	**11.5**	**11.8**	**12.1**

Application of N affected TGW and HM.. Average value of TGW was over the 41g at analyzed barley genotypes. TGW response to increase N rate, but TGW values was similar in N_2 and N3 variant of N application in analyzed barley lines (*Table 2.*). Investigation of Malesevic et al. (2010) showed that N application over the 80kg ha^{-1} had no effect to TGW.
Protein content in grain showed increasing to the highest N rate in all lines. The lowest protein content had G-3019 barley line (12.1%) what is advantage for malting barley. The analysis of variance reveals significant differences in grain yield among genotypes and N application rates in both years (*Table 1.*). The variability of grain yield in both years was influenced by N, followed by line, and the line/nitrogen interaction. This indicates that analyzed traits are significantly dependent to scientific farming. During the first year, the barley lines showed significant differences of grain yield, TGW and HM. The expressed values of traits were the highest in G-3019 and G-3007-1/02, and

the lowest in G-3020 (*Table 2.*). Significant differences among the barley lines in grain yield, TGW and HM observed in the second year (*Table 2.*). The increase in N application rates up to 40kg N ha^{-1} in the first year resulted in a significant increase in grain yield, TGW and HM (*Table 2.*) in all barley lines. The grain protein content depends on genotype and rate of N nutrition, the interaction of these two factors being significant only in the second year (*Table 3.*). Similar results reported by (Paunovic et al. 2007; Kilic et al. 2010) that N nutrition is often the major nutrient factor determining crop yield.

Table 2. Average values of analyzed traits of two-row winter barley

Genotypes	Year	Thousand grain weight (g)				Hectoliter mass (kg hl^{-1})			
		N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
G-3003	2007	40.7	41.1	42.1	42.9	67.9	68.5	68.8	68.9
	2008	42.1	43.1	45.7	44.7	68.8	71.0	71.3	71.0
	Average	**41.4**	**42.1**	**43.9**	**43.8**	**68.4**	**69.8**	**70.0**	**69.9**
G-3020	2007	39.5	40.2	40.4	41.2	67.2	67.8	67.9	68.4
	2008	40.2	41.7	44.5	42.8	67.4	69.0	69.5	70.4
	Average	**39.9**	**40.9**	**42.4**	**42.0**	**67.3**	**68.4**	**68.7**	**69.4**
G-3007-1/02	2007	40.6	41.1	41.7	42.2	70.2	71.3	71.7	72.3
	2008	44.7	45.5	46.7	46.0	71.3	71.8	72.9	72.5
	Average	**42.6**	**43.3**	**44.2**	**44.1**	**70.8**	**71.6**	**72.3**	**72.4**
G-3019	2007	41.3	42.3	43.1	43.7	70.7	72.4	73.2	73.3
	2008	44.9	45.9	47.2	46.5	70.7	71.3	72.7	71.6
	Average	**43.1**	**44.1**	**45.2**	**45.1**	**70.7**	**71.8**	**72.9**	**72.4**

Table 3. Mean values (kg) and analysis of variance for grain yield and GPC of barley

		Grain yield of barley				Grain protein content			
Source	DF	Mean squere	F value	$LSD_{0.05}$	$LSD_{0.01}$	MS	F value	$LSD_{0.05}$	$LSD_{0.01}$
Cultivar(A)	3	933766.8	238955	157.3	288.7	2.74	31.02	0.24	0.43
Year (B)	1	664492676	17004.6	-	-	0.20	2.27	-	-
(AxB)	3	228411.8	58.453	222.4	408.2	0.94	10.67	0.33	0.61
Rate (C)	3	18175087.4	465.108	157.3	288.7	9.55	108.0	0.24	0.43
AxC	9	227624.8	5.8250	223.6	321.0	0.06	0.76	0.33	0.48
BxC	3	680212.4	17.407	224.4	408.2	0.42	4.84	0.34	0.61
AxBxC	9	244854.2	6.2659	316.2	454.3	0.08	0.99	0.47	0.68

Table 4. Mean values and analysis of variance for TGW and HM of barley

		TGWof barley				Hectoliter mass			
Source	DF	MS	F value	$LSD_{0.05}$	$LSD_{0.01}$	MS	F value	$LSD_{0.05}$	$LSD_{0.01}$
Cultivar(A)	3	53.838	303.20	0.335	0.61	95.572	490.22	0.35	0.64
Year (B)	1	289.953	1632.9	-	-	20.042	102.80	-	-
(AxB)	3	10.484	59.044	0.474	0.87	11.375	58.347	0.49	0.91
Rate (C)	3	32.784	184.62	0.335	0.61	21.935	112.51	0.35	0.64
AxC	9	0.527	2.966	0.447	0.685	0.484	2.482	0.49	0.72
BxC	3	4.968	27.98	0.474	0.87	0.564	2.894	0.49	0.91
AxBxC	9	0.701	3.950	0.679	0.96	1.120	5.745	0.70	1.01

Analysis of variance showed highly significant differences among genotypes (A) for all analyzed traits. Differences between investigated years (B), N rates (C) and all analyzed interactions (A x B, A x C, B x C, A x B x C) were also high significant for all analyzed

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traits. The strongest particular influence to yield, TGW and HM of grain had year, than genotype and N-rates, while interactions of factors had less effect (*Table 3.* and *4.*).

Conclusions

The variability of values of analyzed yield components and protein content significantly were established and due to genotypes, environment and their interaction. Interactions between genotypes, applied rates of nitrogen and years were also highly significant, which means that new genotypes are positive reacted on nitrogen applying. The best values of yield, TGW, HM and protein content of grain were expressed on applid N variants N_2 (40kg ha^{-1}) and N_3 (60kg ha^{-1}). On the base of values of analyzed trait the G-3019 is promising barley lines.

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YIELD STABILITY OF MAIZE HYBRIDS ORIGINATED FROM DOUBLED HAPLOID LINES

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Abstract: The annual variation of maize yield has been a common constrain in Hungary. In this context, it is important to adapt hybrids to regional conditions. The main task, from a breeding point of view, is the development of genotypes with improved adaptability to environmental conditions and soil properties. Irrespective of whether maize hybrids are developed *via* conventional or biotechnological means, it is these traits that largely determine the success of a new genotype in commercial cultivation. In this study, the response of maize hybrids of doubled haploid (DH) origin to different locations and soils was therefore examined over 3 years. The performance of twenty-two hybrid combinations was compared to that of two standard hybrids with commercial value in order to investigate how hybrids of DH origin responded to changes in various environmental factors. The results indicated that the individual genotypes exhibited diverse reaction in different years and locations. In general, the majority of hybrids performed below the level of the standard mean, though it was possible to find a DH line that resulted in a hybrid with yields equivalent to that of the standards. The significance of these results is that DH lines developed via *in vitro* anther culture were field tested in multilocation performance trials after a long period of selection.

Keywords: maize, adaptability, doubled haploid, moisture, yield

Introduction

Abiotic stress factors exerting the most decisive effect on maize yield are soil–plant interaction, quantity and distribution of annual rainfall and temperature during the critical late June - early July period. Maize plants are extremely sensitive to these factors, and do not generally adapt quickly. In years with favourable water supply, maize hybrids have a yield of 8-10 $t \cdot ha^{-1}$, while in dry ones it amounts to only 3-4 $t \cdot ha^{-1}$ (Nagy, 2006). This yield variation can partially be reduced by ensuring adequate tillage as well as water and nutrient supplies (Nagy, 2007). The main task, from a breeding point of view, is the development of genotypes with better adaptability to environmental conditions and soil properties. Irrespective of whether the hybrids are developed *via* conventional or biotechnological means, it is these traits that determine whether the new genotype will prove satisfactory in commercial cultivation. This is also true for maize hybrids involving DH parent developed by *in vitro* tissue culture or *in vivo* methods. DH lines produced by laboratory methods are utilised for favourable morphological and agronomical traits during several years of *per se* selection (Barnabás et al., 2005). A number of DH lines selected in this way before have been tested for their field performance in the present experiments.

Materials and methods

Twenty-two maize hybrids compared to two standards were tested at three locations (Martonvásár, Szarvas, Mezőkövesd) in 3 years (2006-2008) in a randomised performance trial (with three replications) on different soil types with varying water supply. The soil types were as follows: loamy chernozem with lime deposits and good

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water supply (Martonvásár), clay-loam chernozem (Szarvas), and clay-loam meadow soil subject to rapid drying (Mezőkövesd). Ten DH lines were developed *via in vitro* plant regeneration from anther culture (Spitkó et al., 2006). At their origin lies an exotic Chinese line with good DH induction ability and Iodent-type Martonvásár inbred lines with commercial value. IN the DH lines the commercial lines were present in various ratios (F_1 and BC_1 combinations). The testers were Martonvásár sister line crosses (SLC) of Iodent (ISLC), Lancaster (LSLC) and Iowa Stiff Stalk Synthetic (ISSLC) origin, together with a fourth SLC tester not related to any of the above (NRSLC). FAO 390 and FAO 450 standards were included in the experiment. The traits evaluated included grain yield ($t \cdot ha^{-1}$) and grain moisture at harvest (%). Yield data were converted to 15% grain moisture content and subjected to three-way (genotype, year and location) analysis of variance (Sváb, 1981).

Results and discussion

In present study three-locational data collected over three years were compared to the standard yields (*Figure 1.*). The grand mean of yield (8.89 $t \cdot ha^{-1}$) was significantly lower than the standard mean (9.78 $t \cdot ha^{-1}$), but one combination (DH56×NRSLC: 9.94 $t \cdot ha^{-1}$) did not differ significantly ($LSD_{5\%}$=0.63 $t \cdot ha^{-1}$) from the mean of the commercial hybrids. The yield of this genotype was comparable to the standard mean in 2 years at all locations (2006: 11.13 $t \cdot ha^{-1}$ vs. standard mean: 11.46 $t \cdot ha^{-1}$; 2007: 7.77 $t \cdot ha^{-1}$ vs. standard mean: 7.98 $t \cdot ha^{-1}$). However, this yield was coupled with a mean grain moisture content at harvest of 20.11%, which was significantly higher than the standard mean: 18.49% ($LSD_{5\%}$=0.51%, the grand mean for the moisture was 19.61%).

Hybrids with DH parental components were more similar to the FAO 450 standard, having a longer vegetation period and higher grain moisture content at harvest, but in most cases grain yield did not come up to expectations.

The yield in 2006 and 2008, which were favourable for maize production, were more than 50% higher than in 2007. The considerable differences in the mean summer temperature and rainfall in the three years (data not shown) resulted in substantial yield variations. The rapid drying down of the plants and the rainfall deficiency in 2007 led to faster withering, so the grain moisture at harvest was lower in this year. A heat wave, with temperatures of 40-42°C for several consecutive days, experienced during maize flowering in 2007 had a negative effect on pollen production and on their viability. The pollen production of inbred maize lines is greatly influenced by the genotype and year (Rácz et al., 2006). This suggests that yield losses in 2007 were due not only to the drying out of the soil, but to an even greater extent by atmospheric drought at flowering.

The effect of the location (soil) and year on the yield and moisture content is demonstrated in *Table 1*.

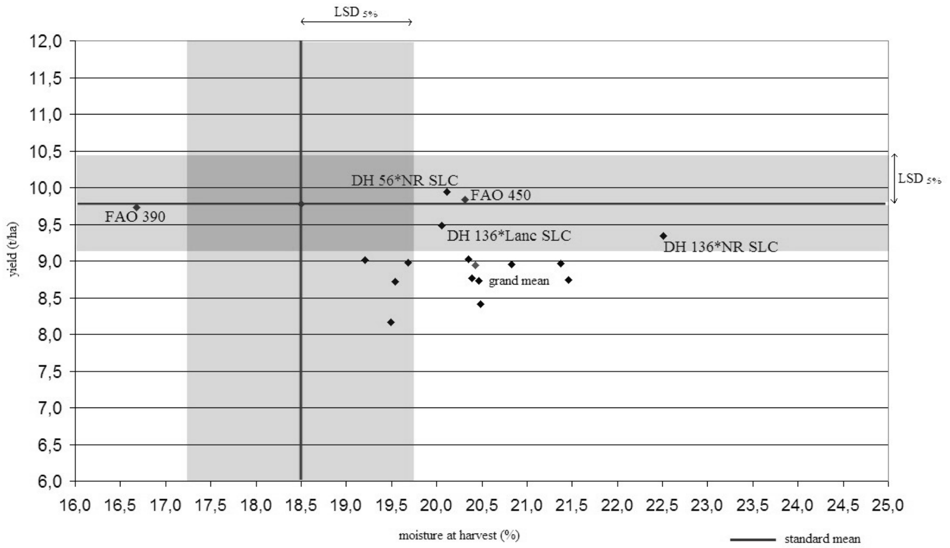

Figure 1. Combined yield and moisture content of hybrid combinations containing DH lines or the control MvLine, and of FAO 390 and FAO 450 standards (2006-2008). Horizontal and vertical lines indicate standard means for yield and moisture, respectively.

The better seed setting and higher yield averages achieved on the moderately heavy chernozem soils at the excellent maize-growing locations in Martonvásár and Szarvas could be attributed in part to their good water management. The rapid drying out of the otherwise high-quality meadow alluvial soil in Mezőkövesd resulted in yield losses of 25-30% for the given combinations.

Table 1. Average yield and moisture content at harvest in three locations and years

Yield ($t \cdot ha^{-1}$)		Moisture (%)	
2006	10.52	**2006**	20.46
2007	6.71	**2007**	19.30
2008	9.92	**2008**	20.79
$LSD_{5\%}$	0.27	**$LSD_{5\%}$**	0.53
Martonvásár	8.92	**Martonvásár**	21.07
Szarvas	9.17	**Szarvas**	19.30
Mezőkövesd	5.82	**Mezőkövesd**	18.98
$LSD_{5\%}$	0.22	**$LSD_{5\%}$**	0.44

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Conclusions

The yield of the combinations, including that of the standards, was found to be significantly influenced by both the year and the location, which is a general characteristic of maize production in Hungary.

The yield stability of the hybrids can be estimated from variation over years and locations (Szél, 1998). Yield stability was investigated on a group of DH hybrids in field performance trials with three replications set up at three locations in three consecutive years (2006-2008). The 14 DH lines and 2 standards were sown in Martonvásár, Szarvas and Mezőkövesd, situated in regions with diverse climatic and soil conditions. Most of the hybrids (11 combinations) did not yield as much as the standard mean, but three combinations had yields that were statistically on par with those of the standard hybrids. The mean yield produced by the standards at multiple locations (9.8 t ha^{-1}) was lower than that recorded in the experiment on the full series of hybrids in Martonvásár (10.5 t ha^{-1}), while the grand mean of the yields for DH hybrids was the same in both performance trials (8.9 t ha^{-1}).

Among the hybrids, 10 had higher grain moisture content than the standard mean, while four were statistically on par with the standards. However, none of these four hybrids regarded as satisfactory for this trait was comparable to standards in terms of yield. Among the combinations tested, the only genotype that satisfied the criteria was DH 56×NR SLC, which slightly (but not significantly) surpassed the yield of the standards, while its grain moisture content at harvest was only slightly higher than the standard. The limited set of DH hybrid combinations tested in the present work was similar, mostly not exceeding the standard mean, indicating that if the studies are expanded to include more and a wider range of genetic sources, the *in vitro* DH technique could become viable for the purposes of hybrid development.

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EFFECT OF CU AND ZN CORN SEED-DRESSING ON THE ELEMENT COMPOSITION OF MAIZE PLANT

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Abstract: We made experiments to decrease the Phosphorus caused Zinc uptake inhibition in maize. Based on our previous experiments and examinations we have reported both the chemical product (metal-ligand) and its necessary dose suitable for seed coating. This paper presents results on the element composition of different parts of harvested plant, grown on two experimental sites on calcareous chernozem soil. We established that seed coating treatments had crop year dependent significant effect on the Cu and Zn content of the leaf front to the cob, tassel and grain.

Keywords: corn, Cu, Zn, seed-dressing, chelate compound

Introduction

Various amounts of nutrients are added to the soil by regular NPK fertilization complying with advisory services. Utilization (bioavailability) of these can be different and is influenced by factors based on the interactions of elements (Schmidt et al., 2008). One of the strongest manifestation of these interactions is inhibition of zinc uptake induced by phosphorus (P-Zn stress) (Adriano, 2001). Zinc deficiency caused by Phosphorus significantly influences the development of sensitive corn hybrids (Kádár and Pusztai, 1982; Kádár and Shalaby, 1986). It reveals in chlorotic symptoms in early (3-5 leaves) phenophase (Auber and Pinta, 1977; Stiles, 1961). Nevertheless the plants often grow out this inhibition for later phenophases, but as it is known from literature yield or quality losses resulted in graver cases (Smith and Gawthorne, 1975). Moderating this effects, there are several possibilities are available from the Zn fertilization of soil or young plants to leaf fertilization in different development stages. Unfortunately the efficiencies of these treatments are rather slight, only leaf fertilization can be successful only in the case of developed plants, especially if it is coupled with plant protection treatment.

For this reason we made laboratory analyses and field experiments to find new solution to solve this old problem. We gave an account of our previous results on chemical analysis of preparations suitable for soil and plant treatment. Experiments made by young maize plants were presented on the Alps-Adria Scientific Workshop in 2009 (Győri and Ungai, 2009). This paper summarizes the results of field experiments set up on calcareous chernozem soil.

Materials and methods

Experiments were set up in the Látókép Experimental Stations of Centre for Agricultural and Applied Economic Sciences, University of Debrecen and in the Demonstration Field of Institute of Plant Sciences in Debrecen. Both soils have similar physical and chemical properties, thus we can state about the Látókép Experimental Station that the type of its soil is calcareous chernozem soil with a 70-90 cm deep humic layer, the humus content 2.8-3%. The soil characteristics score as defined by Arany is

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43. The groundwater level is between 6-8 m. This soil has medium level nitrogen and phosphorous and high level potassium supplies. The pH measured in KCl is 6.2.
We set up the experiment by Burton maize hybrid seeds treated specially before planting with seed-coaters (metal-citric acid complex) with five treatments and four repeats. The metal concentration for 1 kg seed were 500 mg Zn, 200 mg Cu and 500+200 mg Zn+Cu respectively. Samples were collected in 3-5 leaves and 10 leaves stage (whole plant respectively), then we sampled leaves front to cob at flowering. We take full plants at harvest separately stalk, leaves, cob, enfolding sheaths, tassel and grains. Samples were grinded by Retsch SK1 grinder using 1 mm sieve after drying at 105°C. Mineral element composition was determined by Perkin Elmer Optima ICP-OES after nitric acid-H_2O_2 destruction by the method of Kovács et al. (1996, 2000). We analysed this huge number of samples but we represent four plant parts results only.

Results and discussion

According to our previous results micronutrient fertilization applied in the 3-5 leaves stage of maize increased its Cu and Zn content. This effect was also detectable in 10 leaves stage in element composition. Following it this question comes up: to what extent can we find this effect in different plant parts and in different development stages? We applied two controls in fact during our examinations as the grains treated with complex forming were the second control by the untreated grains. Metal ions (Cu and Zn) were applied in itself and also in combination (Cu+Zn).
Examined treatments exerted influence on the Cu and Zn content of different plant parts, but the effect depended on crop year. We found significant differences in Cu and Zn content of both leaves and tassel according to both controls (untreated, treated with complex forming) on both experimental sites. There is no significant difference between the results of two cropping sites, while the deviation of means is significantly lower in Debrecen than in Látókép (*Table 1.*).

Table 1. Effect of coat-dressing treatment Cu and Zn content of leaf and tassel of maize crop, mg kg^{-1} (2008)

	Cu		Zn	
Coat dresser	Látókép	Debrecen	Látókép	Debrecen
	Leaves at harvesting			
Control	5.24	5.37	8.89	8.40
Cu	6.34	8.91	11.35	9.27
Zn	7.51	9.09	14.65	8.63
Cu + Zn	8.63	9.58	15.90	9.52
Citric acid control	4.61	5.00	8.02	8.11
LSD 5%	1.00***	0.23***	0.74***	0.48***
	Tassel at harvesting			
Control	6.14	5.39	25.00	25.35
Cu	7.24	6.40	34.13	34.05
Zn	7.14	7.01	35.60	39.90
Cu + Zn	8.42	8.70	46.70	43.75
Citric acid control	5.40	4.99	18.43	16.60
LSD 5%	0.81***	0.68***	5.15***	6.58***

Legend: *** the effect of treatment is significant at p=0,1%;

According to the results of the analysis of grains, the Cu content showed significant increase as an effect of treatments on both sites (*Table 2.*). This effect made appearance only on Látókép in the case of Zn while this slight change is statistically cannot proved on Debrecen.

The results show that the Cu content of cob significantly increased by the application of Cu treatments on Debrecen while it was not found on the other site. However, spectacular increase of Zn content was observed on the other cropping site resulting more than 10 mg kg^{-1} increase in Zn content as an effect of treatments on Látókép, whereas only a slight decrease was found on Debrecen.

Table 2. Effect of coat-dressing treatment Cu and Zn content of grain and cob of maize crop, mg kg^{-1} (2008)

	Cu		Zn	
Coat dresser	Látókép	Debrecen	Látókép	Debrecen
	Grain			
Control	1.13	1.06	16.85	15.6
Cu	1.32	1.19	19.08	15.95
Zn	1.32	1.31	19.85	16.15
Cu + Zn	1.43	1.35	20.80	16.05
Citric acid control	1.06	1.03	15.92	15.55
LSD 5%	0.09***	0.16**	0.57***	0.56
	Cob (without grain)			
Control	3.49	3.81	16.39	17.7
Cu	3.53	5.23	30.50	15.7
Zn	4.32	3.61	35.20	15.4
Cu + Zn	3.12	5.70	29.00	14.6
Citric acid control	3.07	3.73	17.05	16.45
LSD 5%	0.31***	1.62*	1.03***	0.92**

Legends: * the effect of treatment is significant at p=5%; ** the effect of treatment is significant at p=1%; *** the effect of treatment is significant at p=0.1%

None of the Cu content of tassel, leaves, cob and grains were significantly influenced by the treatments on Látókép in 2009. We found a slight increase only in the case of grain and tassel. Regarding Zn content, our findings are the same as they were in the case of Cu content. On Debrecen the Zn content of leaves and tassel increased moderately.

Conclusions

Results are remarkable from several considerations. One the one hand they emphasizes the crop year-dependence of treatments, on the other hand points to the dangers of field experiments. This case it is necessary to increase the number of repeats and also the volume of samples. On the other hand this method would be suitable after its improvement to supply these plants with the required amount of Cu and Zn ions in the early development stages. Hereby we can harvest grains and plant products with higher amounts of these elements.

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COPPER-CARBOHYDRATE COMPLEXES IN WHEAT PRODUCTION

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Abstract: FAO investigations also prove copper deficiency in most of the soils in Hungary. Copper deficiency can mainly be detected in chernozem and alluvial soils, which are the best arable land for wheat growing.
Copper supply ability of soils, which is mainly determined by weather conditions, cohesion, pH and organic matter content, is very important in the qualitative and quantitative wheat production. Different copper compounds, first of all salts and complex compounds are used for copper replacement, which can be carried out in two ways: via soil and leaves. In our experiments we applied a new environmental friendly copper complex, the copper-sucrose for foliar fertilization.
In 2008 the experiments were launched on 10m^2 large plots of copper deficient Danube-alluvial soil in randomly designed blocks with 4 repetitions in Győr-Szentiván. At the time of tillering we applied the following copper doses: 0.1; 0.3;0.5;1.0; 2.0 kg ha^{-1}. We analyzed the harvested samples and observed that the higher the copper doses were the higher the yields got. We achieved a significant yield increase at 2.0 kg ha^{-1} copper doses. Though as a result of the copper treatment the raw the protein content increased, but it was not significant. Investigating the gluten content we got that higher copper doses increased the gluten content and we achieved a significant result at copper doses of 1.0 and 2.0. Our tests proved that the application of the new type copper sucrose compound as a foliar fertilizer benefitted the qualitative and quantitative parameters of wheat.

Keywords: copper, complex, winter wheat, foliar fertilizer

Introduction

Hungary's natural resources provide excellent opportunities to qualitative and quantitative winter wheat growing (*Triticum aestivum L.*). In the last years the deterioration of the quality cause for concern, which cannot only be led to the bad weather conditions but the deficient nutrient supply (Vida and Jolánkai, 1995; Győri and Győriné, 1998; Szabó, 2010). Sir Hugh Plat realized right in 1590 that materials washed out from manure affect the plants' growth. Woodvard proved in 1699, the more leached materials (salt) the nutrient medium contained, the better developed the plants. (Kádár, 1996). At the end of the 1800s the classical 10 macro-elements were regarded as essentials for plants. Until the end of 1930s further 5 elements were included, which were called micro-elements as they were present only in smaller quantities (Kádár 1996). Such a micro-element is copper (Kádár, 2007). In the soils of Hungary copper deficiency is often a case besides zinc. The deficiency symptoms appear even on chernozem soils with good cropping potential and high humus content (Schmidt and Matus, 2010). But copper deficiency can also very often be observed in Danube alluvial soils with very high $CaCO_3$-content and also on sandy soils.
The copper content in soils, that is available for plants, is determined by soil-forming rock and its weathering intensity. Copper is bound by high organic content, first of all by the humic acid content in a complex compound, which is not available for the plants.

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Soil pH value has a great impact on the availability. The copper-ion supply ability of soils increases if the pH-value reduces, i.e. acid soils can supply more copper ions (Kádár, 2008). We should consider the cohesion and the percentage of humus content in soils if we want to know, if there is a need for copper fertilization.
Copper has an important role in plant nutrition. Its role is essential in the biochemical processes, too. Copper acts as an activator for several enzymes, but it takes part in photosynthetic electron transport as well. We can find it in larger quantities in the chloroplasts, bound to proteins therefore plants rich in protein are richer in copper, too. Its presence is also essential in the carbohydrate metabolism besides protein synthesis (Kádár, 2007). Quality improving effect of nitrogen fertilizers has been known for a long time (Varga et al., 2007). But of course copper is necessary to good nitrogen utilization.
Plants take up a little amount of copper: 2-20 $mgkg^{-1}$ calculated on dry matter in the form of Cu^{2+} ions or organic complex compounds. Because of hindered transportation there is very often a deficiency of copper even in wheat grown on well supplied soils (Schmidt et al., 2002).
Copper replacement can be carried out either via soil or leaves. In soil applications we need larger quantities, so we mainly use metal salts. In foliar fertilization copper is needed in smaller quantities, so we can use better utilizable less toxic complex compounds (Schmidt et al., 2005).

Material and methods

Wheat is very sensitive to copper deficiency. Copper deficiency results in yield decrease and quality deterioration. We carried out copper replacement experiments with the application of copper-carbohydrate complex compounds on winter wheat at the phenological phase of tillering. We applied doses of 0.1, 0.3, 0.5, 1.0, 2.0 kg/ha. The experiments were launched in Győrszentiván on Danube alluvial soil in 2008. *Table 1* shows the average soil composition.

Table 1. Soil analysis results (Győrszentiván)

pH		K_A	$CaCO_3$ %	Humus %	AL-soluble			Mg	EDTA-soluble			
					P_2O_5	K_2O	Na		Zn	Cu	Mn	Fe
H_2O	KCl				$mgkg^{-1}$							
7.85	7.48	34	7.6	2.1	175	157	39.4	53.5	1.1	0.91	32.4	34.6

The experiments were launched randomly on 10 m^2 – large plots in 4 repetitions. We applied solutions of 6 dm^3 on each plot. The harvested samples were analyzed on mass, raw protein and gluten content.

Results and discussion

The copper complex compound fertilizer applied on the leaves in the tillering phase influenced the yield and chemical composition of winter wheat as follows:

1. Effect of copper treatments on the yield

The application of copper-carbohydrate complex in small doses during tillering did not increase the yield (*Table 2*). Even a copper dose of 0.3 kgha^{-1} – did not exceed the yield of the control. But we got yield increase if we further raised the copper doses. The highest yield increase was achieved by copper doses of 2.0 kgha^{-1}. In these treatments the yield increase was 0.4 tons higher per hectare than the control. The increase in yield was at this doses significant, $LSD_{5\%}$ = 0.28 .

Table 2. The results of the copper fertilization experiment

Cu kgha^{-1}	Yield tha^{-1}	Raw protein %	Gluten %
0	4.2	12.4	30.8
0.1	4.1	12.4	30.2
0.3	4.2	12.5	30.9
0.5	4.3	12.9	31.8
1.0	4.4	13.5	33.4
2.0	4.6	13.6	33.9
$LSD_{5\%}$	0.28	NS	2.46

2. Changes in raw protein after copper treatments

Changes in raw protein content are shown as a result of copper sucrose complex treatments in *Table 2*. We could observe that the higher the copper doses were, the higher the raw protein content was. If the copper doses were small in quantity it resulted in minor increase. Doses of 0.5 a 0.3 kg ha^{-1} – or higher brought considerable increase in raw protein. The highest increase in raw protein was achieved with copper doses of 2.0 kg ha^{-1}. At these doses the rate of increase was lower, which could be explained by the toxicity of this high copper content. When we applied copper complex at such high doses it burnt the leaves. In spite of the substantial increase in raw protein the efficiency of the treatment was not significant.

3. Changes in gluten content after copper treatments

Besides protein content the quantity of gluten also influences the quality of flour. *Table 2* shows the changes in gluten as a result of copper treatments. Copper doses at a 0.3 kgha^{-1} or higher resulted in higher gluten contents compared to the control. The highest increase was achieved with a copper dose of 2.0 kg ha^{-1}. Although we observed burnt leaves at this high dose the gluten content of the crop increased massively. Compared to the control copper doses of 1.0 and 2.0 kg ha^{-1} significantly increased the gluten quantity ($LSD_{5\%}$ = 2.46).

Conclusions

A part of Hungary's soils shows copper deficiency. Winter wheat is sensitive to copper. Winter wheat can only be grown in right quantity and quality if we can ensure the copper supply at an adequate level. In 2010 we carried out copper replacement tests on small plots on the copper deficient Danube-alluvial soils of Győrszentiván. We applied

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copper sucrose complex in foliar treatments. Treatments were applied at tillering with copper doses of 0.1, 0.3, 0.5, 1.0, 2.0 kg ha^{-1} .
Yield at harvesting increased only after higher doses of copper were applied. Doses of 2.0 kg ha^{-1} produced significant increases in yield only.
We also analysed the raw protein and gluten quantity, which influences the quality of flour. Raw protein content rose gradually with the increased copper doses. We achieved the highest increase in raw protein at a copper dose of 2.0 kg ha^{-1}. Despite the major increase in raw protein content the treatments were not significant at all. The gluten content increased considerably only at higher doses. We achieved significant increase as a result of copper treatments at doses of 1.0 and 2.0 kg ha^{-1} only.

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Interreg / HUSKUA /05/02/158 /project assured the launching of experiments in 2006. Another Interreg project and TAMOP 4.2.1/B promotes the continuation of the tests in 2010.

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BIOCONTROL POTENTIAL OF ENTOMOPATHOGENIC NEMATODE SYMBIOTIC BACTERIA AGAINST PROKARYOTIC PLANT PATHOGENS

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Abstract: The increasing incidence of plant diseases caused by bacteria makes it necessary to develop new antimicrobial agents against these pathogens. The entomopathogenic nematode-symbiont bacteria (EPB) of the genus *Xenorhabdus* are potential sources of compounds effective against multi-resistant pathogens. They exhibit a variety of molecular tools enabling the maintenance of monoxenic conditions in colonized insect cadavers in soil condition. The conditioned-medium from *X. budapestensis* and *X. szentirmaii* are active against several Gram-positive and Gram-negative bacteria. To specify the target scale of pathogens we have gradually been extending our studies on *Pseudomonas, fluorescens, P. syringae, P. corrugala*, *P. aeruginosa, Xanthomonas campestris*, *Agrobacterium tumefaciens*, *Clavibacter flaccumfaciens*, *C. michiganense, Erwinia amylovor*a.

Keywords: biological control, EPB, plant pathogenic bacteria

Introduction

From human clinical aspects the increasing incidence of infections by methicillin-resistant *Staphylococcus aureus* (MRSA) (Barnes and Sampson, 2011) and potential danger pose by *Francisella tularensis* (Wagar et al., 2010) make it essential to develop new antibacterial agents to combat these pathogens. From agricultural aspects the invasion of several plant pathogens (Fodor et al., 2008) justifies the efforts toward searching for new antagonists effective against bacteria belonging to *Pseudomonas, Xanthomonas, Clavibacter* and *Erwinia* genera. Entomopathogenic symbiotic bacteria (EPB) produce antibacterial compounds (Paul et al., 1981; Akhurst 1982) to provide monoxenic conditions for the EPN-EPB symbiotic complexes in the colonized cadaver in the soil (Thaler et al., 1998). The final goal is to discover efficient environmentally friendly EPB antibiotics. We are to characterize the antibacterial activity of the EPB strains deposited at the EPN/EPB Stock Center at the Institute of Plant Protection, Georgikon Faculty University of Pannonia with the support of TÁMOP 4.2.2.

Materials and methods

Antibiotics producing bacteria: nematode symbiotic *X. budapestensis* DSM 16336 and *X. szentirmaii* DSM 16338 and *Photorhabdus luminescens* ssp. *laumondii* HP88 bacteria were stored, cultured in solid and liquid media as described previously (Furgani et al., 2008; Böszörményi et al., 2009). The majority of the EPB strains originated from the Fodor Laboratory (ELTE) and now they are deposited at the Georgikon Entomopathogenic Nematode/Bacterium (EPN/EPB) Stock Center in Keszthely, Hungary. The list of plant pathogenic bacteria used in this study is summarized in *Table 1*. All of them are kindly provided by Hevesi, M., which have been deposited at

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The National Collection of Agricultural & Industrial Microorganisms (NCAIM), Hungary (http://web.uni-corvinus.hu:8089/NCAIM/frameset.jsp) and the Georgikon (EPN/EPB) Stock Center in Keszthely, Hungary.

Test bacteria: used in this study belonged to *Pseudomonas fluorescens; P. corrugala*; *P. syringae*; *Xanthomonas campestris; Bacillus subtilis*; *B. cereus; Erwinia amylovora*. The standard bioassay technique was adapted for plant pathogenic bacteria (see *Table 1*.) The comb test was used as described in Böszörményi et al. (2009). The overlay bioassays (*Table 2*.) have been carried out as described by Furgani et al., (2008). *Escherichia coli* OP50 were used for overlaying tests (Brenner, 1974).

Results and discussion

The antimicrobial effect of EPB on Gram negative test organisms were proved by comparative statistical analyzes (Fisher test). *Xenorhabdus szentirmaii* and *X. budapestensis* were significantly more efficient, than the *Photorhabdus* species. Under the same conditions both *X. szentirmaii* and *X. budapestensis* produced extremely large inhibition zones (*Figure 1*.).

Table 1. Antibacterial activities of 50 v/v % conditioned cell-free media of *X budapestensis* (EMA) and *X. szentirmaii* (EMC) on *E. amylovora* strains detected by agar diffusion technique

Erwinia amylovora strains	Origin		Diameter of the inhibition zone (mm)		
	country	plant	*X. budapestensis*	*X. szentirmaii*	Streptomycin
Ea1 rifS strS	Hungary	Apple	23	18	26
Ea 110 rifR strS	USA	Apple	26	25	28
Ca11 rifS strR	USA	Apple	26	25	22
Ea88 rifS strR	USA	Pears	24	25	0

These data clearly demonstrated that resistances to other antibiotics were unable to protect *Erwinia* strains against *Xenorhabdus* antibiotics, which were as effective as the 200 ppm streptomycin treatment.

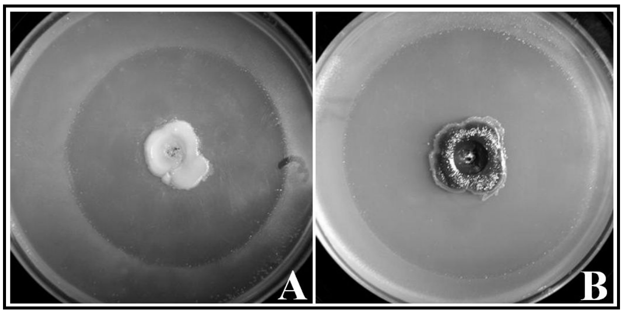

Figure 1. Inhibition zone in overlay bioassay: *Xenorhabdus budapestensis* DSM 16336 (**A**). *X. szentirmaii* DSM16338 (**B**). Test organism: *Escherichia coli* OP50

Table 2. Antibacterial activities of 50 v/v % conditioned cell-free media of *X budapestensis* (EMA) and *X. szentirmaii* (EMC) on some agriculturally important plant pathogenic bacterium strains detected by agar diffusion technique

Test organisms	Diameter of the inhibition zone (mm)		
	X. budapestensis	*X. szentirmaii*	Streptomycin
Xanthomonas vesicatoria Xv73	25	24	45
Xanthomonas vesicatoria XvS08	28	25	45
Xanthomonas fragariae Xfw	28	28	26
Pseudomonas syringae pv. syringae P53	25	24	39
Pseudomonas savastanoi pv. phaseolicola E1356	22	25	40
Erwinia amylovora Ea1	25	24	40

Conclusions

The final goal of our research is to find good candidates for biocontrol of agriculturally important bacterial pathogens amongst the EPB strains what we have deposited at the Georgikon Stock Center of the University of Pannonia. Although there are ongoing research on EPB antibiotics for more than 30 years which resulted in a wide variety of publications and dozens of US patents, but no commercial products based on EPB antibiotics. Vast majority of our results proved the antimicrobial activity on Gram-positive targets (*Bacillus cereus, B. subtilis*). The tested *Photorhabdus* strains were less effective than the most effective *Xenorhabdus* strains against Gram-negative targets. The strikingly high level of interspecies diversity of small-molecule antibiotics are considered to inhibit a range of bacteria and fungi (Webster et al., 2002). Many of them are of pharmaceutical and/or agricultural importance, including *Staphylococcus* (Furgani et al., 2008) and *E. amylovora* (Böszörményi et al., 2009). In contrast, macrobiomolecules such as bacteriocins (xenorhabdicins) used to be considered as inhibiting the growth of closely related *Xenorhabdus* species (Boemare et al., 1992; Thaler et al., 1995; Webster et al., 2002). In our bioassay the *Photorhabdus* HP88 strains showed the most significant effects on the Gram-negative *E. coli.* In spite of this we may not recommend HP88 as a candidate. The bioassay tests conducted here with *X. szentirmaii* and *X. budapestensis* showed a strong antibacterial activity in line with previous studies (Lengyel et al., 2005; Furgani et al., 2008).

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STATISTICAL ASSESSMENT OF CLIMATIC IMPACTS ON THE NITROGEN NUTRITION OF MAIZE (*ZEA MAYS* L.) CROP

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Abstract: In the 20th century maize was one of the most important crop plants in Hungary and in the last few years it developed to be a crop harvested on the biggest area. Among agro-technical parameters nutrient management is one of the most important factor and for all the cereals, just as maize, the management of nitrogen has the highest importance. As the uptake and usage of nitrogen by crops is a biochemical process, it is affected by temperature. Since all elements like nitrogen is taken up from soil in a water soluble form, water availability should be considered also a major factor. Both temperature and water balance are characterized by the climate, so it plays a significant role in nitrogen process.
In small plot experiments run at the Szent István University's Nagygombos experimental site in long term series, treatments were the combinations of hybrids and the doses of nitrogen given. Statistical evaluation could be made on the yields depending on cropyear's climatic factors, such as precipitation and average temperature, and the dose of nitrogen given. Along these factors a multidimensional model has been designed, that can be used to predict the efficiency of nutrient management depending on cropyear's meteorological characteristics.

Keywords: maize, *Zea mays*, climatic factors, N fertilisation

Introduction

Agricultural production has long been a major enterprise in Hungary because more than 60% of the country's land is arable. For centuries, winter wheat was the most commonly cultivated crop but by now, maize has the biggest cropping area. The aim of maize production is twofold: to provide quantity and quality. Both the yield quantity and quality are determined by ecological and agro-technical factors, as well (Izsáki, 2010; Jolánkai et al., 2010; Tarnawa and Jolánkai, 2010). Temperature and precipitation are the most important environmental factors during the life of this crop and may influence both the quantity and quality of the yield. Among agro-technical parameters nutrient management is one of the most important factor and for all grain crops including maize, and the management of nitrogen has the highest importance. As the uptake and usage of nitrogen by crops are biochemical processes, they are affected by temperature and the water balance (IPCC, 2007; Nagy and Ján, 2006), so these factors have an interaction with N management. Both of them are characterized by the climate, so it plays a significant role in nitrogen process, mostly the efficiency of N fertilizer given (Sárvári and Boros, 2009; Tóth and Kismányoky, 2010).
Environmental impacts are seen by the public to be a primary factor of food-chain processes and the performance of agricultural crops (Jolánkai et al., 2006). Sustainable approaches are those that are the least toxic and least energy intensive, and yet maintain productivity and profitability (Várallyay, 2006).
In this paper we studied the connection between main climatic factors (temperature, precipitation) and the most important agronomical factor (N supply) and the level of maize yield.

Materials and methods

In long term field trials a wide range of high quality maize hybrids were examined under identical agronomic and monitored climatic conditions in the experimental years

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of 2004-2008. From the hybrids used we have made an average, because that gives the impact of weather in each year on maize. The small plot trials were run at the Nagygombos experimental field of the SZIU Crop Production Institute. Soil type of the experimental field is chernozem (calciustoll). Experiments were conducted in split-plot design with three replications. The size of each plot was 25 m long with 5 rows and plots were solved and harvested by plot machines and by hand-job. Various agronomic treatments were applied on plots, and for this work, nutrient management was chosen. Precipitation and temperature records from the database of the Hungarian Meteorological Service (OMSZ) have been evaluated in relations with yield. The "climatic factor" calculated from the combination of these two (precipitation × temperature) was also used as an aggregated variable.

In the statistical evaluation the regression was represented first for each of climatic factors as independent variable and yield as dependent variable, and in the second step the depending variable was yield again but N supply and climatic factor together were the independent factor. The functional surface was estimated by the use of minimal squares method (Ezekiel and Fox, 1970; Sváb, 1981).

Results and discussion

Basic data are collected in *Table 1*.

Table 1. Collected basic data on maize yield and clime for each year at Nagygombos, and the calculated climatic factor (precipitation × temperature)

	Average of yields (kg ha^{-1})			Total precipitation from April to September	Average temperature from April to September	Climatic factor
	N0	N80	N120			
2004	5459,986	9873,309	12886,63	278,3	16,06667	4471,353
2005	8473,312	12883,3	15566,63	460,4	16,35	7527,54
2006	10791,08	16311,07	18088,84	362,9	16,8	6096,72
2007	8471,09	10266,64	11511,08	290,8	17,85	5190,78
2008	17355,51	19822,17	17444,4	370,7	16,91667	6271,008

By the data in *Table 1* three figures can be made showing the relation between each of the climatic series (precipitation, average temperature, "climatic factor") and the average yield of maize at each N level in the experimental area (*Figure 1-2-3*).

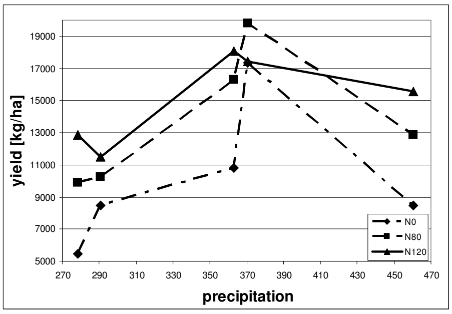

Figure 1. The relation between precipitation and the average yield of maize at each N level.

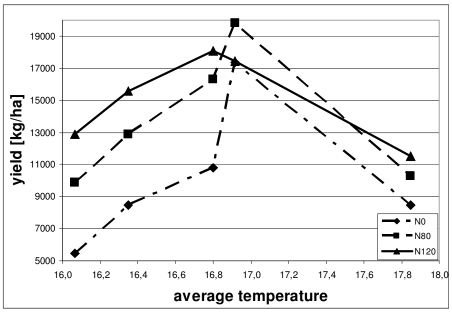

Figure 2. The relation between average temperature and the average yield of maize at each N level.

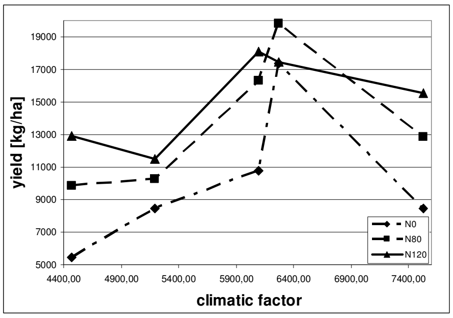

Figure 3. The relation between calculated climatic factor and the average yield of maize at each N level in the area of Nagygombos.

As the use of these models for evaluation is quiet difficult, it seems to be good to aggregate them in a three dimensional model, where the depending variable is yield again and N supply and climatic factor together are the independent factors. The functional surface can be estimated by the use of minimal squares method in a general form of:

$$Y= a + b_1X_1 + c_1X_1^2 + b_2X_2 – c_2X_2^2 + dX_1X_2.$$

If we calculate and fit the surface by the use of our basic data, we gain the following equation:

$$Y= -72341,0291 + 42,2792X_1 + 0,0000X_1^2 + 26,7631X_2 - 0,0021X_2^2 + 0,0000X_1X_2.$$

With the use of that model we can intrapolate for missing data and can represent continuously the adequate results for each combinations (*Figure 4*).

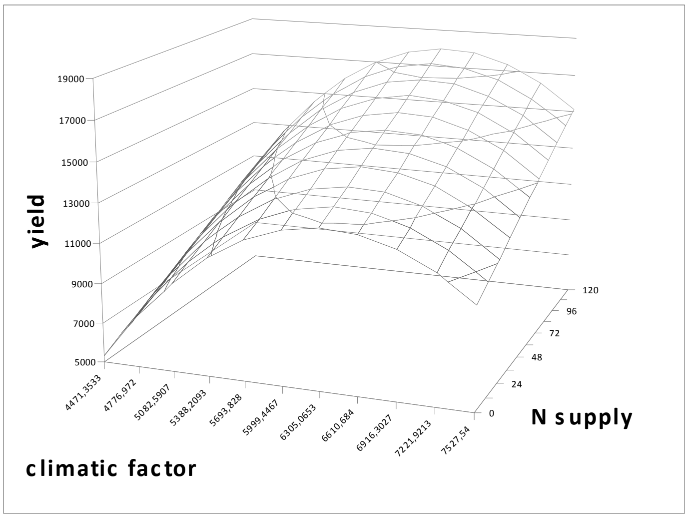

Figure 4. The three dimension relation between calculated climatic factor, the N supply and the average yield of maize in the area of Nagygombos.

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Conclusions

According to the fourth figure it can be stated, that the climate on our experimental field is suitable for maize as the optimum point is in the observed range, but the N doses used are lower than that could be used as there is no depression in that orientation. In the equation of the surface it can be found, that two of the coefficients (c_1 and d) is equal to zero, but in fact they are just too small numbers (in the magnitude of 10^{-6}-10^{-7}) and that is the reason why they seem to be zero, but it can be treated as it is just a quasi linear part of the N effect.

It can also be seen, that in case of average weather conditions the quantity of the maize yield could be estimated from this model, with the use of fitted surface we can estimate the yield from simple climatic and agronomic data in advance. On the other hand, we can use our estimation to find out whether the yield level of given year was formed by climatic factor and N supply (on the surface) or other variables (out of the surface). It can be useful for the practical work and enhance to find weaknesses in the method of current cropping management.

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EVALUATION OF A DEEP-SALINE CROP SITE'S EXTENSIVE GRASSLAND

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Abstract: The grasslands in natural or near-natural conditions are very important habitats from the view-point of both farming and nature protection. The human food production activities are related mainly to areas of these vegetation types or rather to areas that involve such vegetation. That is why it is very important to examine and evaluate this sort of grasslands, since its fodder production and nature protection functions are both important.
In our research work the lawn, with small fescue-grass (*Festuca pseudovinetum)* as leader plants, on a site labelled by dry-situated, saline in the deep soil layer was examined.
At the evaluation of the grassland the annual dry matter yield, the changes of the chemical composition and among the relative ecological indicators the repartitions of social behaviour types were considered. As a result we can state that the yield quality of Bösztör small fescue-grassland principally, was influenced significantly by the crop year. The frequency of the exploitation had no effect neither on the mass of forage nor on the net lactation energy value of the fodder. During the examination of social behaviour types the species relating to the natural conditions (C, S, G, NP) are present in a greater number at the site than the plants marking the agitation. The natural competitors (C) are on nearly 50 % of the territory. The yearly three hay-making was the most favourable in case of survival of the near-natural canopy of plants. The lawn, which can be found on a deeply saline soiled site, has limited forage-producing ability, but the value is increased by its near-nature, various, rich in species vegetation. It is suggested to keep the existing conditions and that is possible by three-utilization yearly, carried out in the right time.

Keywords: deep-saline crop site, dry matter yield, Net Energy Lactation, social behaviour types

Introduction

In Europe during the past decades the methods of grass management concentrated on some very productive usage and they reacted well to the high doses of mineral fertilizers. As a consequence of this, the productivity of animals and the fields increased, but hereby often the environmental values, the diversity of the flora and the fauna was damaged (Minns et al., 2001). At present the function of forage producing grass-management in Central Europe decrease continuously. The current direction is to develop a multi-functional land-use, where the utilisation objective is not exclusively related to the maximized yield and the amelioration of forage quality (Laser, 2006; Bajnok, 2010).
In Hungary after 2000 the animal number decreased significantly that is why the increment of the fodder-productivity of grassland was not necessary any more. The plant composition degraded on 40 % of lawns due to the irregular utilization. The ecological and the nature-protective grass-management came into prominence early in 2000's (Tasi and Szemán, 2006). The National Agri-environment-managing program has a goal to involve more and more grasslands to some kind of protective programs (Natura 2000 program) The nature-protective situation in Hungary could be better if on these grasslands or at least on the more valuable regions may be nature-lover management (Penksza, 2009).
The grasslands in natural or near-natural conditions are very important habitats from the view-point of both farming and nature protection. The human food production activities are related mainly to areas of these vegetation types or rather to such areas, that involve

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such vegetation (Póti, 2009). That is why it is very important to examine and evaluate this sort of grasslands, since its fodder production and nature protection functions are both important.

Materials and methods

Experiments were carried out in 2006, 2007 and 2008 on flat ground, in Bösztör (near Kecskemét, it is situated on part of Kiskunsági National Park). In our research work the lawn, with small fescue-grass (*Festuca pseudovinetum*) as leader plants, on a site of dry-situated, saline in the deep soil layer was examined. The experimental site is managed organically; no mineral fertilisers are applied. The grassland was utilised at 3 levels of intensity, represented by the number of cuttings (*Table 1.*).

Table 1. Details of treatments

	2 cuts/year	3 cuts/year	4 cuts/year
1st growth	19 Jun.	17 May	17 May
2nd growth	10 Oct.	28 Jul.	19 Jun.
3rd growth		10 Oct.	28 Jul.
4th growth			10 Oct.

Treatments were applied in 3 replicates. Vegetation composition was surveyed using the quadrat method Balázs, where the areas occupied by the different species inside the quadrat are expressed as coverage, or dominance value (DB). The dominance value is proportional to the area utilised by a given plant species. The highest possible value for DB is 32, standing for a surface coverage of 100 %.
To define fodder quality, energy concentration is indicated by Net Energy Lactation (NEL) (calculated with Tilley-Terry technique; 1963).
Among the relative ecological indicators (Borhidi, 1993) the repartitions of social behaviour types (SBT) were considered.

Results and discussion

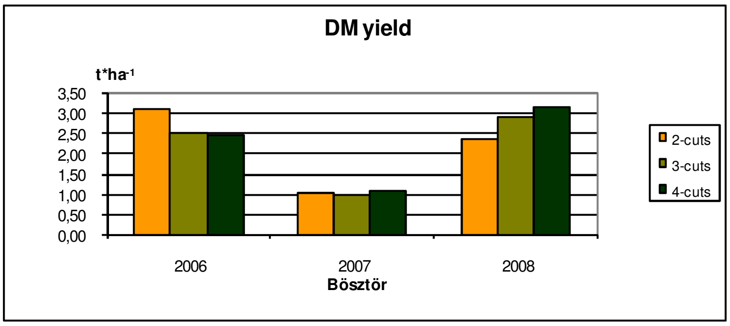

Figure 1. DM yield depending on utilisation frequencies in Bösztör. ($LSD_{5\%}$ 2006: 1.17; 2007: 0.5; 2008:1.58)

The *Figure 1.* shows the dry-matter yields of the three examined years. It can be seen, that the area has a very low – 1-3 t ha^{-1} – production. Only the vintage has a significant effect. In 2007, when the weather was very drought, the yields decreased radically. The change of cutting down frequency did not influence significantly the amount of yield.

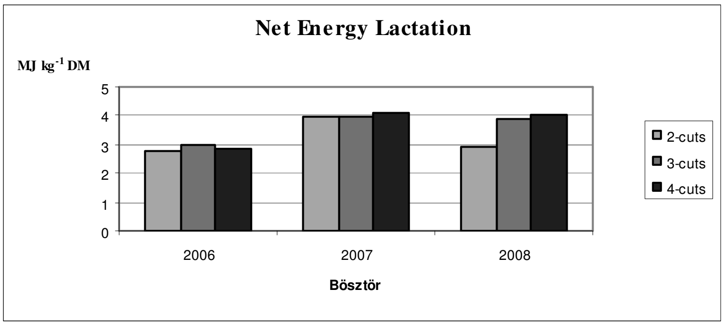

Figure 2. Net Energy Lactation values depending on utilisation frequencies in Böször. ($LSD_{5\%}$: 1.2)

The quality of forage was characterised by the net lactation energy. In the *Festuca pseudovinetum* the calculated values ranged from 2.82 MJ kg^{-1} d. m. to 4.02 MJ kg^{-1} d. m. The change of cutting down frequency has not influenced significantly the energy concentration of harvested yield. Exclusively the vintage influenced the net lactation energy value of the forage. We got the lowest energy concentration in 2006. In 2007 and 2008 the determined values were rather similar.

Upon these findings we can state that the Bösztör lawn on the deeply saline site has a limited productivity, there are only little effects of the utilization intensity on it.

On the other hand it is important to evaluate the lawns on the basis of other points of view.

In 2006 and 2008, species indicating natural condition (C, S, G, NP) were found in higher numbers than species indicating disturbance (*Figure 3.*). Natural competitors (C) occupied almost 50% of the area. Endemic weed species were found only in low numbers. Rural competitor species of the endemic flora benefited from the cutting frequencies of 2 and 4 (16,5% and 13,7%, respectively) as opposed to 3 cuttings/year (8,5%).

For the grassland characterised by a high number of species and low nutrient supply, indicator values were between 350-402. As a result of cutting the grass 2 or 4 times a year, indicator values decreased (to 350 and 354, respectively) whereas the treatment with 3 cuttings resulted in significantly higher values (402). According to the results of the examined 3 years, we may conclude that from the 3 different utilisation frequencies, the treatment with 3 cuttings/year had the most significant beneficial effect on maintaining or establishing a near-natural vegetation. Further research is needed to confirm long time impacts.

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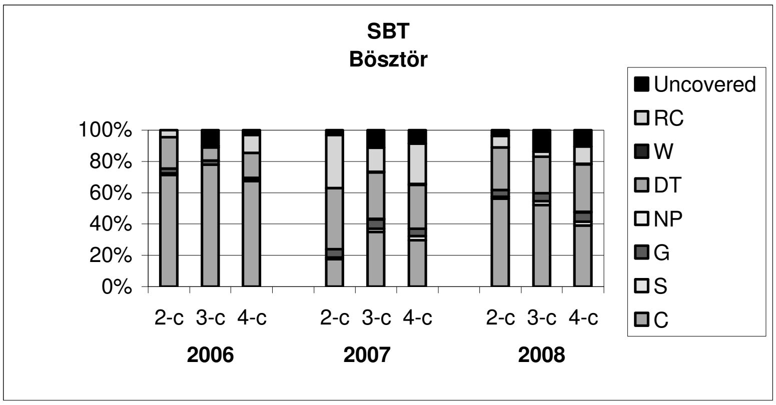

Figure 3. Distribution of plant species according to social behaviour types (SBT) in Bösztör

Conclusions

The lawn, which can be found on a deeply saline soiled site, has limited forage-producing ability, but the value is increased by its near-nature, various, rich in species vegetation. It is suggested to keep the existing conditions and that is possible by three-utilization yearly, carried out in the right time.

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CROP YEAR EFFECT IN SUMMER BARLEY (*HORDEUM VULGARE* L.) BREEDING WORK

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Abstract: In this paper we studied and introduce the results of our investigations on the environmental adaptability of lines in the summer barley breeding programme of the Károly Róbert Collage – Rudolf Fleischmann Research Institute in Kompolt, Hungary. Lines have been investigated in a small-plot experiment with four replications and the same agrotechnical treatment of each plot. The results of the years 2009 and 2010 are interpreted in this paper. The growing season 2009 was drier than the average. The crop year of 2010 was extreme wet. From our results it can be revealed that the yields of different summer barley lines have been significantly affected by the precipitation in different crop years. In the year 2009 the average yield of the investigated lines was 4,72 t ha^{-1}. Contrarily the average yield of the experiment was only 0,92 t ha^{-1} in 2010. We can state upon the data of the table that only the yields of lines 'M-03/24-2'and 'M-03/96-2' were significantly higher than the average yield of the standard varieties. Based upon the results we can state that – from the aspect of yield amount – the two best lines had the highest deviation in the yield of the two crop years. The comparison of extreme years with appropriate methods enables plants breeders to select the to the season effects most adaptable lines, variety candidates.

Keywords: summer barley, yield, season

Introduction

Among cereals barley production still plays an important role in nowadays' agricultural production system. Due to its use in brewing, summer barley production may be one of the most profitable plant production branch for farmers. But summer barley is the cereal that is the most sensitive for environmental effects (Kádár, 2009). This fact has high significance under nowadays' changing environmental circumstances. Therefore the main and the most important task of breeders is to breed new varieties with adequate environmental adaptability (Bakó et al., 2010). From the aspect of brewing summer barley it is basic point to reach the quality standard of the brewing process. Contrarily, from the aspect of effective production yield amount and yield stability are the main points. So the use of varieties with good quality and high productivity, just as stable production are the main criteria in the selection of varieties of summer barley (Kismányoky, 2005). In case of cereals it has been proven that not in all cases meet the requirement of the highest yields that of the best production stability of varieties (Ágoston and Pepó, 2005). Therefore we have to strengthen efforts to reach a balanced rate of these two parameters already in the breeding process and breed new varieties from lines with the highest adaptability.

Materials and methods

In this paper we studied and introduce the results of our investigations on the environmental adaptability of line in the summer barley breeding programme of the Károly Róbert Collage – Rudolf Fleischmann Research Institute in Kompolt, Hungary. We introduce the results from the 'D'-line experiment of the breeding programme. This is a small-plot experiment, whereas the same agrotechnical practise and four replications are used for each plot. In this 'D'-experiment lines from the end phase of the breeding work (generations F8-F10) are investigated in each year. We have

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preceded our investigations in both years (2009 and 2010) on the basis of twenty different lines. The results of the different lines have been compared to the average of the yield results of three standard varieties, used in the evaluation experiments of the Hungarian Central Agricultural Office.

The weather conditions of the two years were significantly different. 2009 was drier than the average. From the aspect of summer barley production it is a rather significant fact that in the vegetative period (from February till July) there has been an almost two month period (March to May) without any precipitation. The crop year of 2010 was extreme wet. During the vegetation period of summer barley almost twice as much precipitation had fallen than the 30-year average. The precipitation of the above mentioned two years are introduced in *Table 1*.

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

Crop year	Kompolt: Precipitation (mm) and mean air-temperature (°C)							Total	Mean
		The growing season (2009-2010)							
		Febr.	March	April	May	June	July		
2009	mm	40	43	3	36	97	37	256	43
	°C	1.0	5.4	14.8	20.1	22.5	22.5		14.4
2010	mm	55	22	74	160	97	164	572	95
	°C	0.7	5.2	14.4	17.8	19.5	22.8		13.4
		Long-term mean (LTM): 1961-1990*							
LTM	mm	30	34	42	59	80	65	310	52
	°C	0.2	5.1	10.7	15.8	18.7	20.3		11.8

*national mean

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

For the statistical evaluation of our results we have used the method of one-way ANOVA.

Results and discussion

From our results it can be revealed that the yields of different summer barley lines have been significantly affected by the precipitation in different crop years. In the year 2009 the average yield of the investigated lines was 4.72 t ha^{-1}. Contrarily the average yield of the experiment was only 0.92 t ha^{-1} in 2010. So the difference between these two crop years' average was 3.8 t ha^{-1}. These results show that the far over-average precipitation amount of 2010 and the anaerobic soil circumstances caused by this factor resulted in higher yield decrease of summer barley than the below-average precipitation amount and the almost two month drought period in the previous year.

Yield results of 2009 and 2010 are listed in *Table 2*.

We can state upon the data of the table that only the yields of lines *'M-03/24-2'and 'M-03/96-2'* were significantly higher than the average yield of the standard varieties. Based upon this we can conclude that these two lines have extraordinary environmental adaptability beside their high productivity, as well.

In 2009 the lines coded *'M-01/29-6'* and *'M-01/29-13'* produced significantly higher grain yield amount than the average of the standard varieties. Therefore we can characterize these lines also lines as lines with excellent productivity. Still, their environmental adaptability is smaller than that of the previously mentioned two other lines and their adaptability is rather restricted to their drought tolerance.

In the crop year of 2010 the line coded *'M-02/2-3'* produced statistically significantly higher yield than the average of the standard varieties. Therefore we can conclude that this line has higher adaptability rather in wet crop years.

Table 2. Grain yield (t ha^{-1}) of summer barley lines in 2009 and 2010

Lines	Grain yield 2009 (t ha^{-1})						Grain yield 2010 (t ha^{-1})					
	Replication				Average	%	Replication				Average	%
	1	2	3	4			1	2	3	4		
M-03/24-2	5.61	5.14	4.18	5.98	5.23	115.1	1.52	0.88	1.70	2.14	1.56	191.2
M-03/96-2	6.04	5.59	5.12	5.19	5.49	120.8	1.74	1.51	1.12	1.03	1.35	165.5
M-02/2-3	5.80	5.10	4.42	4.94	5.07	111.5	1.59	1.67	1.50	1.05	1.45	178.0
M-01/26-21	5.24	4.08	4.93	5.20	4.86	107.0	1.02	0.80	1.18	0.78	0.95	115.8
M-01/29-6	5.54	5.20	5.16	5.28	5.30	116.6	0.92	0.86	0.78	0.52	0.77	94.4
M-01/29-13	5.40	5.38	5.23	5.15	5.29	116.5	0.92	1.08	1.01	0.80	0.95	116.8
M-01/64-13	4.76	3.30	4.48	4.48	4.26	93.7	1.07	0.90	0.72	0.85	0.89	108.5
M-01/110-7	4.90	3.42	4.37	5.27	4.49	98.8	0.84	0.68	0.74	0.54	0.70	85.8
M-01/110-9	4.25	3.60	4.42	4.62	4.22	93.0	0.75	0.80	0.48	0.71	0.69	84.0
M-01/125-11	4.29	3.92	4.80	3.78	4.20	92.4	0.58	0.54	0.31	0.41	0.46	56.4
M-01/125-20	4.67	3.17	4.60	4.78	4.31	94.8	0.62	0.55	0.70	0.54	0.60	73.9
M-01/125-35	4.52	3.58	4.32	4.56	4.25	93.5	0.62	0.78	0.44	0.60	0.61	74.8
M-30	4.58	4.42	4.24	3.58	4.21	92.6	0.89	1.18	0.77	1.00	0.96	117.7
M-31	4.82	3.47	4.42	4.94	4.41	97.1	0.65	1.18	0.94	0.74	0.88	107.6
M-00/11-1-1	5.10	4.49	4.07	5.03	4.67	102.9	0.52	1.18	1.27	0.88	0.96	118..0
M-27	4.38	4.80	4.62	4.13	4.48	98.7	1.00	1.44	1.00	0.80	1.06	129.9
M-32	4.17	4.78	4.95	4.60	4.63	101.8	0.50	1.54	1.26	0.55	0.96	118.0
M-28	4.89	5.17	5.06	5.08	5.05	111.2	0.53	1.16	0.87	0.59	0.79	96.5
Pas E-2	4.93	4.97	5.63	4.92	5.11	112.6	0.94	1.50	1.08	0.56	1.02	125.0
Pas E-2	5.20	5.14	4.90	4.68	4.98	109.6	0.72	0.99	0.93	0.57	0.80	98.4
Standard average	4.65	4.29	4.67	4.56	4.54	100.0	0.69	1.07	0.84	0.66	0.82	100.0
Experiment average	4.94	4.43	4.69	4.80	4.72	103.8	0.89	1.06	0.94	0.78	0.92	112.2
$LSD_{5\%}$					0.63						0.35	

The investigation of the yield stability of the different lines has an interesting result. Based upon the results we can state that – from the aspect of yield amount – the two best lines had the highest deviation in the yield of the two crop years.

The data regarding the yield stability of different lines are shown in *Table 3*.

In the investigated two crop years the difference between the yields of line coded *'M-03/24-2'* – compared to the average of the yield of the standard varieties – 76.14 %. This deviation was 44.73 % in case of the line coded *'M-03/96-2'*.

This effect can be explained by the fact that compared to the other lines in the experiment these two lines not only have high drought tolerance, but they have high adaptability to the circumstances of wet crop years, as well. This adaptability resulted in a lower yield decrement compared to the previous year, than in case of other lines and varieties of the experiment.

Within this experiment we have also investigated our variety candidates (*M-27, M-28, M-30, M-31, M-32*). The candidate coded *M-32* was the best among them. In both crop

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years it has produced higher yield than the average of the standard varieties – even this fact is not statistically significant. The deviation of the yield in the investigated two years was only 16.16 %. The smallest deviation in the experiment of 0.3 % was produced by the line coded *'M-01/29-13'*. After all, this line produced almost 16 % higher yield than the average of the standard varieties in both crop years.

Table 3. Yield stability of the investigated lines

Lines	Grain yield (t ha^{-1})						Deviation between the yields of the two crop years (%)
	2009	%	2010	%	Average	%	
M-03/24-2	5.23	115.08	1.56	191.22	3.39	100.00	76.14
M-03/96-2	5.49	120.75	1.35	165.47	3.42	100.00	44.73
M-02/2-3	5.07	111.50	1.45	178.04	3.26	100.00	66.54
M-01/26-21	4.86	107.04	0.95	115.83	2.90	100.00	8.79
M-01/29-6	5.30	116.57	0.77	94.38	3.03	100.00	-22.18
M-01/29-13	5.29	116.46	0.95	116.75	3.12	100.00	0.30
M-01/64-13	4.26	93.67	0.89	108.48	2.57	100.00	14.81
M-01/110-7	4.49	98.84	0.70	85.80	2.60	100.00	-13.04
M-01/110-9	4.22	92.96	0.69	83.96	2.45	100.00	-8.99
M-01/125-11	4.20	92.41	0.46	56.38	2.33	100.00	-36.02
M-01/125-20	4.31	94.77	0.60	73.85	2.45	100.00	-20.92
M-01/125-35	4.25	93.45	0.61	74.77	2.43	100.00	-18.68
M-30	4.21	92.57	0.96	117.67	2.58	100.00	25.10
M-31	4.41	97.14	0.88	107.56	2.65	100.00	10.42
M-00/11-1-1	4.67	102.86	0.96	117.98	2.82	100.00	15.12
M-27	4.48	98.68	1.06	129.93	2.77	100.00	31.25
M-32	4.63	101.82	0.96	117.98	2.79	100.00	16.16
M-28	5.05	111.17	0.79	96.53	2.92	100.00	-14.65
Pas E-2	5.11	112.55	1.02	125.03	3.07	100.00	12.48
Pas E-2	4.98	109.63	0.80	98.37	2.89	100.00	-11.27
Standard average	4.54	100.00	0.82	100.00	2.68	100.00	0.00
Experiment average	4.72	103.81	0.92	112.19	2.82	100.00	8.38

Conclusions

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

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STUDY ON THE BIOMASS AND SEED PRODUCTION OF RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) ON WINTER WHEAT STUBBLE

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Abstract: In the time of the first national weed survey (1947-1953) ragweed was the 23rd in the order of importance of weed species. However, by the time of the fourth national survey (1996-1997) it had already stepped forward to the first place and nowadays it is the most widely spread and most harmful weed species in Hungary. Problems caused by its cover and spread are several-fold: damages and economic losses in the agriculture, public health and nature and environmental conservation issues. Ragweed rarely occurs in well developed cereal crops but in row crops and in cereal stubbles it may appear as a carpet-like cover. Our experiments were carried out on winter wheat stubble near Keszthely. Weeds were surveyed and plant samples were taken in order to determine the biomass production, the number of male flowers and nutrient content of ragweed plants.

Our weed survey and studies on weed densities showed that in untreated stubbles a "pure" stock of ragweed can fully cover the field (average density of ragweed was 54 plants per square meter). Statistically significant correlations were found between the plant density and biomass production, the density and seed production and dry weight. In addition, a negative correlation was found between the number of male flowers and the weed density.

Keywords: *Ambrosia artemisiifolia* L., winter wheat stubble, biomass, seed production, thousand seed weight

Introduction

Ambrosia artemisiifolia L. ranked 23rd on the list of the most important weeds on arable fields at the first National Weed Survey (NWS) of Hungary, which was conducted between 1947 and 1953 (Ujvárosi, 1973). Ragweed was identified as the No. 1. weed at the 4th NWS in Hungary (1996-97) and remains the most dangerous weed on arable fields according to the 5th NWS (2007-2008) (Novák et al., 2009).

Seeds of ragweed were transported from North-America to Europe at the beginning of the 19th century, most probably with cereal seeds. The plant was identified by Lengyel in Hungary in 1920 in Somogy County (Béres and Hunyadi, 1991). The reasons for the rapid spread of this weed are complex, where biological and human factors equally play roles (Béres and Hunyadi, 1980; Lehoczky, 2004a, 2004b; Lehoczky et al., 2005, 2006). Today in Hungary, ragweed covers about 5.3% of the arable fields, i.e. about 240 000 hectares.

The noxious weed and its allergenic pollen cause problems in the agriculture, ecology, and human health. Growth of ragweed is most problematic in row crops, and in cereal stubbles.

Ragweed occurrence, biomass and seed production were studied in this experiment. Results (population density, biomass weight, seed number, seed weight) were statistically analyzed to identify possible interactions.

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Materials and methods

An experimental field heavily infected with ragweed was chosen near to the city of Keszthely. Studies were carried out in 4 replicates in September 2009 on an undisturbed cereal stubble field. Plot size was 2000 (12,5x160) m^2. Weed sampling was made on September 29, when weeds produced ripened seeds. Weed biomass and seed production were examined. Four sampling areas were selected (1 m^2 each), where weed height was measured (10 plants) and weed density was determined (number of weeds m^{-2}). Shoots were also collected form the sampling areas.

Fresh and dry weights of plants were measured and the number of the staminate flowers (shoot branches) was also counted. The number and weight of seeds per plant were recorded, and the thousand gram weight was measured. Correlation and variance analyses were made with the statistical tool of MS Excel.

Results and discussion

The results showed that the average population of ragweed was 54 plants m^{-2} on the undisturbed winter wheat stubble giving a carpet-like cover on the soil (*Table 1*).

The average fresh weight was 1351 $g{\cdot}m^{-2}$, indicating high biomass production (13.5 $t{\cdot}ha^{-1}$). Average dry weight was 516 $g{\cdot}m^{-2}$ (5.16 $t{\cdot}ha^{-1}$). Moisture content of seeds was 61%: a relatively low value due to the fact that mature plants were collected.

Table 1. Population density, biomass and seed production of *A. artemisiifolia* on winter wheat stubble

	Mean	Deviation, ±
Density, plants·m^{-2}	53.9	8.6
Fresh weight, g·m^{-2}	1351.5	112.0
Dry weight, g·m^{-2}	516.3	10.2
Fresh weight, g·$plant^{-1}$	28.0	5.6
Dry weight g·$plant^{-1}$	10.6	1.8
Staminate flowers, number·$plant^{-1}$	34.7	6.8
Seed weight, g·m^{-2}	57.4	8.3
Seed weight, g·$plant^{-1}$	1.3	0.4
Seed, number·$plant^{-1}$	295.5	86.2
Shoot height, cm	55.0	4.2

The thousand seed weight was 4.4 grams, which is approximately two times higher than published by Béres (2003).

Seed weight gave approximately 11.12% of the total dry biomass (g per plant). The number of seeds per plant varied between 67 and 894, with an average of 295, characteristic of small plants (Béres and Hunyadi, 1980).

Positive correlation was found between the plant dry biomass ($g{\cdot}plant^{-1}$) and the number of seeds, $y=33.38x-78.937$ $n=16$ $r=0.8636$ $p<0.01$ (*Figure 1.*) showing that plants with larger biomass produce larger number of seeds.

A good exponential correlation was found between the ragweed population ($plants{\cdot}m^{-2}$) and the individual seed weight, indicating that larger weed populations produce less seeds per plant (*Figure 2.*).

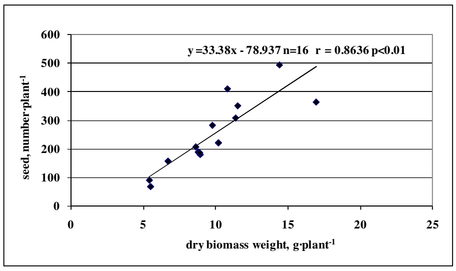

Figure 1. Correlation between number of seeds and dry biomass weight of plants

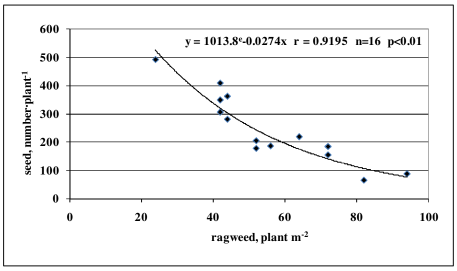

Figure 2. Correlation between density of ragweed and number of seeds

Our study shows that the number of staminate flowers is reduced at higher weed population density, giving a negative linear correlation (*Figure 3.*).

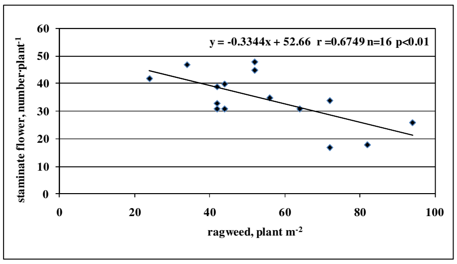

Figure 3. Correlation between density of ragweed and number of staminate flowers

Conclusions

Studies conducted on an undisturbed cereal stubble field near the city of Keszthely showed that ragweed infestation was very dense (54 plant·m^{-2}) and almost no other weeds were present.

Correlations were found between the density of ragweed population and the biomass, seed and dry weight production. A negative linear correlation was found between the number of staminate flowers and plant density.

The conditions provided by the undisturbed cereal stubble are very favorable for the flower and seed production, which significantly increases the soil seed content.

Our study shows that the seed production varies between 5500 and 30400 seeds·m^{-2} with an average of 13238 seeds·m^{-2}.

Dry matter weight of plant shoot was on average 516 g·m^{-2}. On average, 11% of the total biomass was the seed.

It can be concluded that cultivation of cereal stubbles is very important in ragweed control and provides a non chemical solution to prevent flowering and pollen production.

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EFFECT OF THREE HERBICIDE COMBINATIONS ON AGRONOMIC AND MORPHOLOGICAL TRAITS OF FLUE-CURED TOBACCO (*NICOTIANA TABACUM* L.)

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Abstract: In flue-cured tobacco (*Nicotiana tabacum* L.) production the most important agronomic traits are yield and cured leaf quality. They depend on cultivar and cultural practices. Weeds in tobacco reduce plant growth by competing with the crop for light, nutrients and water. They also serve as a host for tobacco diseases and pests. Beside crop rotation, early stalk and root destruction and cultivation, herbicides have been regularly applied in tobacco production. Inadequate and excessive use of herbicides is costly, environmentally detrimental, and can have negative effect on yield and value of produced crop. In order to investigate the effect of three herbicide treatments (pendimethalin 1980 g ha^{-1} + clomazone 288 g ha^{-1}; pendimethalin 990 g ha^{-1} + clomazone 288 g ha^{-1}; 288 g ha^{-1} clomazone) on agronomic and morphological traits of flue-cured tobacco, a field trial was conducted during the 2009 growing season. The experiment with two Croatian flue-cured tobacco cultivars and the three herbicide treatments was set up as a randomized complete blocked design (RCBD), at two locations in northern Croatia. Differences among the three herbicide treatments were not significant in any of the studied traits. However, decrease of pendimethalin rate from 1980 to 0 g ha^{-1} resulted in a tendency of yield, price and value increase (8,97%, 2,47% and 11,66% respectively). Results of this study indicate that application of 288 g ha^{-1} of clomazone alone might be sufficient for successful weed control and achievement of high yield and good quality in flue-cured tobacco production in northern Croatia.

Keywords: flue-cured tobacco, weed management, herbicides

Introduction

Improvement of important flue-cured tobacco (*Nicotiana tabacum* L.) agronomic traits, yield and cured leaf quality, is achieved by development of better cultivars and adjustment of cultural practices. Weed control is an important production practice in tobacco since weed competition for light, moisture and nutrients may result in yield losses. (Collins and Hawks, 1993). Weeds also serve as a host for diseases and insects that attack tobacco. In addition to reduced yields, weeds may also be a source of foreign material in mechanically harvested tobacco (Moore, 2010).

Production of flue-cured tobacco traditionally has had high labor requirements. As hand labor became scarce and expensive, growers increased mechanization and management of larger allotments. Consequently, interest in more effective and efficient weed control in the tobacco-producing countries increased (Worsham, 1970). Good weed control in tobacco is best achieved by utilizing all available methods of weed control in an integrated program that uses crop rotation, early root and stalk destruction, cultivation, and appropriate use of herbicides. Herbicide use should be based upon the specific weeds present in each field, the weed-control program that integrates best with overall farm management practices, herbicide cost in relation to performance and crop safety, and anticipated rotational crops (Johnson, 2008). Inadequate and excessive use of some herbicides in tobacco caused stunting of tobacco plants and negative effects on the crop that followed tobacco (Worsham, 1970; Collins and Hawks, 1993).

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Total reliance on herbicides only is costly, less effective, environmentally detrimental, and unsound weed management (Collins and Hawks, 1993; Parker et al., 2010). The purpose of this study was to assess the effect of three herbicide combinations on agronomic and morphological traits of flue-cured tobacco and, to find out the possibility of reducing the present herbicide use without affecting tobacco cured leaf yield and quality.

Materials and methods

The experiment with two Croatian flue-cured tobacco cultivars (DH17 and DH27) and three herbicide treatments (pendimethalin 1980 g ha^{-1} + clomazone 288 g ha^{-1}, pendimethalin 990 g ha^{-1} + clomazone 288 g ha^{-1}, 288 g ha^{-1} clomazone) was conducted at two locations (Virovitica, Kutjevo) in northern Croatia during the 2009 growing season. Active ingredients of herbicides used in this study, pendimethalin and clomazone, are allowed for weed control in tobacco in many countries (Flower, 2001; Muhammad et al., 2009; Moore, 2010; Parker et al., 2010). At the location Virovitica, soil is sandy loam, pH 5.11, and at the location Kutjevo, soil is silt loam, pH 5.70. Experiments were set up as Randomized Complete Block Design (RCBD) with four replications and three 22-plant rows per each experimental plot. Five days before planting, experimental plots were treated with herbicides by a hand sprayer. Planting, fertilization and other cultural practices were performed as recommended in flue-cured tobacco production in Croatia (Budimir et al., 2007; Bukan et al., 2010). In June, weed composition of experimental plots was determined and afterwards the experiment was hand cultivated. Twenty plants of the middle plot row were analyzed for plant height, leaf number per plant, and 9th leaf area and harvested. Harvesting was done by hand. Curing was in bulk curing barns with heated air. After curing, yield (kg ha^{-1}) of each experimental plot was determined. Average price (kn* kg^{-1}) was ascribed by a tobacco cooperative agronomist to the cured tobacco of each plot. Total value (kn ha^{-1}) for each experimental plot was calculated by multiplying its yield and respective average price (* 1 €= 7.40 kn).
Agronomic and morphological traits were modeled as General Linear Model (GLM) with cultivars, locations, and herbicide combinations as fixed explanatory variables. Pearson's correlation coefficients were determined among the agronomic flue-cured tobacco traits (yield, price and value) grouped by the herbicide combinations. Statistical analyses were performed by SAS Release 9.2 (SAS Institute 2001 – 2003) computer program.

Results and discussion

Dominant weeds observed in the experimental fields were annual broadleaf species *Amaranthus retroflexus, Amaranthus hybridus, Ambrosia artemisiifolia*, *Chenopodium album, Galinsoga ciliata, Matricaria chamomilla, Polygonum aviculare, Polygonum persicaria* and *Sonchus arvensi,* perennial broadleaf species *Convolvulus arvensis*, and annual grasses *Echinochloa crus galli* and *Poa annua.* Differences among the three studied herbicide combinations were not significant for any of the studied traits (*Table 1.*). Cultivars differed significantly in number of leaves, 9th leaf area, price and value as expected and, locations significantly differed in all studied traits. No significant interaction cultivar x herbicide or location x herbicide was found.

Table 1. GLM results for plant height (cm), number of leaves, and 9th leaf area (cm^2) yield (kg ha^{-1}), price (kn kg^{-1}) and value (kn ha^{-1})

Source of Variation	n-1	Plant height	No of leaves	9th leaf area	Yield	Price	Value
Cultivar, (C)	1	n.s.	**	**	n.s.	**	**
Location, (L)	1	**	**	**	**	**	**
Herbicide, (H)	2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
CxL	2	n.s.	n.s.	n.s.	n.s.	**	n.s.
CxH	2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
LxH	2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
CxLxH	2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

**- significant at p<0.01; n.s.- not significant

All the studied traits except 9th leaf area, showed a tendency to increase as pendimethalin rate decreased from 1980 to 0 g ha^{-1} (*Figure 1.*).

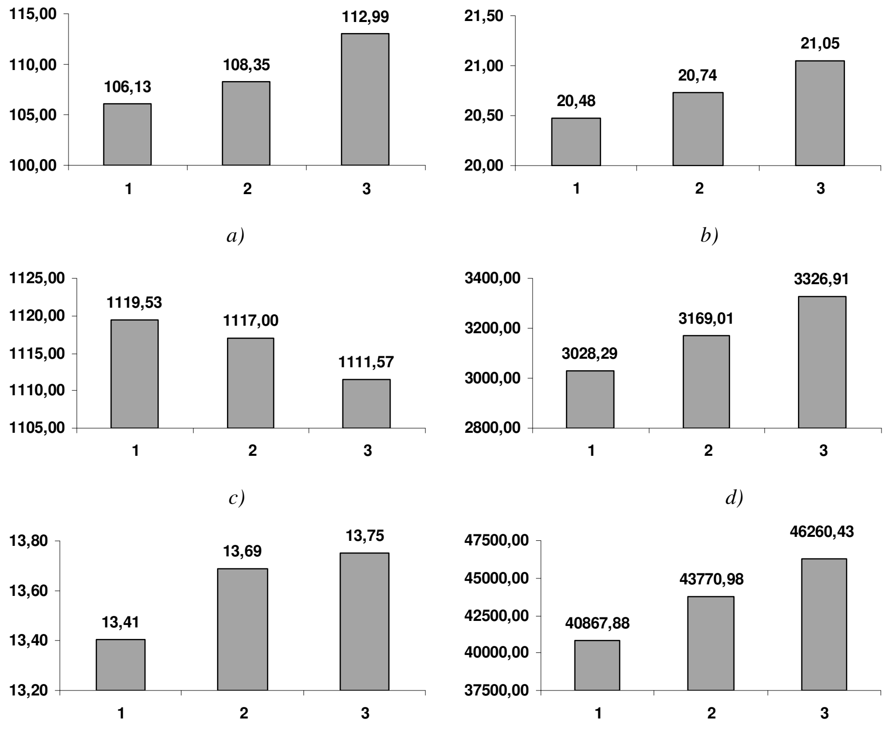

Figure 1. Mean values of a) plant height, cm, b) leaf number, c) 9th leaf area, cm^2, d) yield, kg ha^{-1}, e) price, kn ha^{-1}, and f) value, kn ha^{-1} across the three herbicide combinations (1= pendimethalin 1980 g ha^{-1} + clomazone 288 g ha^{-1}, 2= pendimethalin 990 g ha^{-1} + clomazone 288 g ha^{-1}, 3= 288 g ha^{-1} clomazone only)

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Plant height, leaf number, yield, price and value increased 6,00%, 2,70%, 8,97%, 2,47% and 11,66% respectively. The 9th leaf area decreased 0,70%.
Positive and significant Pearson's correlation coefficients among yield, price and value, were not affected by herbicide treatment (data not shown).

Conclusions

Response of two flue-cured tobacco cultivars in morphological and agronomic traits, to three herbicide treatments was studied at two locations during one growing season. No significant differences in the studied traits were found among the herbicide treatments, neither were significant interactions cultivar x herbicide nor location x herbicide. As the pendimethalin rate decreased from 1980 g ha^{-1} to 0 g ha^{-1} the average plant height, number of leaves, yield, price and value increased 6,00%, 2,70%, 8,97%, 2,47% and 11,66% respectively. The herbicide treatment did not affect the value of Pearson's correlation coefficients among the agronomic traits. Thus, application of pendimethalin in combination with clomazone might not be necessary for successful weed control in flue-cured tobacco in northern Croatia.

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SPECTRAL ANALYSIS OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) ACCORDING TO DIFFERENT NUTRITION LEVELS IN SMALL PLOT TRIAL

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Abstract: The rapidly growing demand toward data and information cannot be satisfied any longer sufficiently by the conventional sampling methods. There has been a need for a measuring technology that provides broad opportunities of evaluating local or global processes or balances according to the various aspects. The dynamic development of the different remote sensing technologies creates new perspective for data acquisition. Among the versions of optical remote sensing, one developed technology is the hyperspectral remote sensing, which works in the optical wavelength range. With the adaptation of the hyperspectral technology in several application fields such as the agricultural production, the environment protection, or others different quantity and quality parameters can be obtained in a fast, precise and economic way. This technology is adequate to analyse vegetation cover by evaluating average radiance spectra of the electromagnetic radiation reflected from surfaces occupied by them. These reflectance spectra depend on the absorption and transmission characteristics of the surface cover. By detecting the electromagnetic waves beyond the visible range, we can reveal those phenomena that are invisible for the human eye. In this study, we are analysing samples of variously treated winter wheat using FieldSpec 3 MAX spectroradiometer in the wavelength range of 350 nm to 2500 nm. The experimental arrangement was set by broadcasting different nutrition levels applied on 10 m^2 replicated field plots which were studied according to different quantity and quality parameters. Beyond the spectral analysis, we evaluated correlations including additional parameters, such as plant height (cm), ear size (cm), yield (kg/10m^2) and quality parameters to make comparations. Preliminary results of the spectral characteristic of the samples showed reflectance differences due to the various nutrient supply. After clarifying all decisive correlation the spectral methodology can greatly assist in describing and tracking the current dynamics of nutrient supply and plant up-take.

Keywords: spectroradiometer, winter wheat, nitrogen fertilizer

Introduction

In the modern agriculture, beyond the productiveness and profitability, the environment protection must be kept in mind as well. The inappropriate nitrogen fertilization threatens the mankind indirectly by damaging the ecosystem (Nagy et al., 2008) and directly endanger through the nitrate accumulation in plants (Nádasy and Nádasy, 2006). According to the plant produced, beside the climate and weather aptitudes (Erdélyi, 2008, 2009; Erdélyi et al., 2009; Kulpács et al., 2010; Szentpétery et al., 2010), the correctly chosen production site (Tarnawa and Klupács, 2006) and agro-technology (Balla et al., 2010), or rather the harmony among the individual demands or resilience of the certain variety (Szalay et al., 2010) and the applied nutrient supply are determinative. In order to achieve the optimal plant nutrition and to avoid, or minimize the environment pollution we have to know the exact nutrient supply and plant up-take system. In the following trial beyond the conventional examinations we carried out '*ex situ*' spectral analysis to study the nitrogen treated and untreated samples of the 'Alföld 90' winter wheat variety. Measuring laboratory we can exclude the natural light environment by which we can gain fundamental results that can be expanded with '*in*

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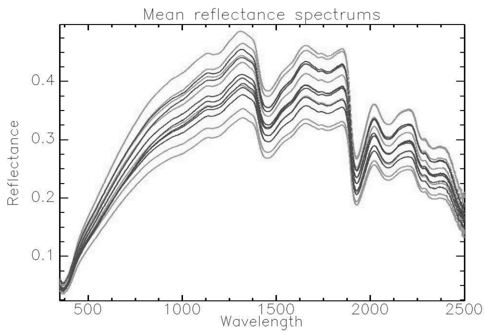
situ' field measurements. Collecting data in laboratory, or in field with spectroradiometer gives the so called ground reference to the airborne hyperspectral remote sensing that is one developed technology among the optical remote sensing systems. Using this method we are measuring the radiations intensity and the spectral distribution reflected by the evaluated object that depends on the absorption, the transmission referred to the certain material characteristic. Concerning to these data we can gain information according to the examined targets quantity and quality parameters. By using modern remote sensing technologies (Jung et al., 2006a; 2006b) we can gain several times more pieces of information, those would not be visible for the human eye (Kristóf, 2005) and makes possible the sampling on large areas collecting data from different surface processes (Csorba and Jordán, 2010) including several monitoring possibilities (Kardeván, 2010). This technology is adequate to analyse vegetations in a fast, precise way (Fenyvesi, 2008; Milics et al., 2008; Yang et al., 2009; Milics et al., 2010).

Materials and methods

The 'Alföld 90' winter wheat variety was studied in agronomic replicated blocks. Experimental plots were sown on chernozem soil (calciustoll) at Hatvan- Nagygombos, (Central Hungary). The half of the plots received 80 kg ha^{-1} nitrogen fertilizer in form of ammonium nitrate (0-0-36), the others did not received any mineral fertilizer. The plot size was 10 m^2. The experimental plots were evaluated concerning plant height (cm), ear size (cm), yield (kg/plot), and quality parameters – such as wet gluten content (%), protein (%), furthermore thousand kernel weight (g). Beyond these, wheat ears from all plots were gathered and analysed according to its spectral characteristic with an ASD Fieldspec 3 MAX spectroradiometer with 'ex situ' method in the wavelength of 350 to 2500 nm. The measuring process was made in the Hungarian Institue of Agricultural Engineering, in a light isolated laboratory cabinet. The reflectance of the samples, which originates in the irradiation of the laboratory lamp that illuminates the object and the radiation reflected by the surface of the examined wheat ears was recorded.

Results and discussion

By forming the plant height to ear size ratio, the data show, that the nitrogen fertilized wheat's ear size and plant height ratio became smaller, than the untreated parallel's. Nitrogen also resulted in higher yield. Studying the quality, such as the protein and the wet gluten content, we found that as a result of the mineral fertilizer both parameters increased. In case of thousand kernel weights the nitrogen fertilized variants also resulted in higher values. Evaluating the wheat ears with spectroradiometry, we computed the mean reflectance spectra of the treatments. Red colour represents the nitrogen fertilized, while green the unfertilized parallel. According to these curves the spectral characteristic of the different treatments are diverge (*Figure 1.*), but the deviation of those seems independent according to the differences generated by the mineral fertilizer. By removing the continuum of the curves we found a characteristic interval between 1700 nm and 1800 nm (*Figure 2.*).



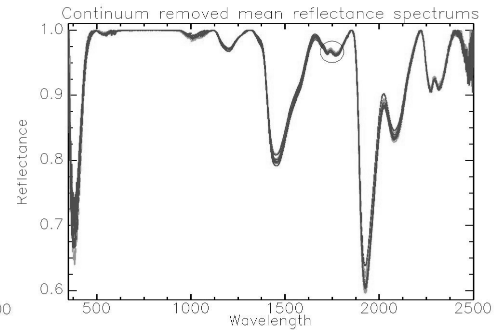


Figure 1.
Mean spectral curves

Figure 2.
Continuum removed mean spectral curves

After removing the continuum we performed Principal Component Analysis on the dataset of the relevant interval to find the hidden information in the data (*Figure 3.*).

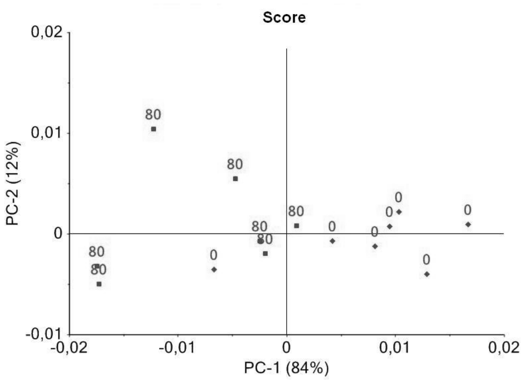


Figure 3.
Principal component analysis

The plot of the Principal Component score values show pronounced separation between the samples of the two nutrition levels which means that those are spectrally separable as well. The 84 % of the variability is explained by the first Principal Component.

Conclusions

The differing quantity and quality parameters of the wheat variety generated by the diverse nitrogen fertilizer treatment resulted in such spectral differences as well which was detectable with spectroradiometer. Among the analysed reflectance curves we found a characteristic interval at the wavelength range of 1700 nm to 1800 nm at which the treatments became distinguishable. After clarifying the interrelation between spectra and nutrition application, the spectral methodology can greatly assist in describing and tracking the current dynamics of nutrient supply and plant up-take.

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FIELD AND LABORATORY EXAMINATIONS OF CORN PLANTS BY MEANS OF HYPERSPECTRAL IMAGING TECHNOLOGY

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Abstract: Hyperspectral Imaging provides many possibilities to collect useful information about our environment however the measurements are affected by several circumstances (clouds, wind, sun angle, etc.). This method is widely used as a diagnostic tool in many agricultural applications, namely detection of soil characteristics weed patch determination and identification, diagnosis of pathogens, in addition to that estimating disease severity and finally yield estimation. Investigations were performed in corn fields by the University of West Hungary, Mosonmagyaróvár together with The VMMI Hungarian Institute of Agricultural Engineering, Gödöllő within the confines of an effective teamwork. Airborne hyperspectral images were taken in 2010 before harvest in order to reveal the potential relationships between different vegetation indices and yield data. Furthermore field investigations were carried out to identify and characterize several field objects (soil, road, weeds, etc.) and to collect radiometric data in different vegetation phases. Ten successive spectral measurements were carried out of each location. Spectroradiometer (ASD Field Spec 3 max) was used with four step procedures of field calibration. Cob samples were collected (natural and artificially infected with *Fusarium verticilloides*) from a research field in Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár. Symptoms of *Fusarium* cob rot were analyzed in laboratory conditions in two different ways (Plant Pro, Pro Lamp). View Spec Pro software (ver. 5.6) was used to evaluate the radiometric data

Keywords: hyperspectral imaging, radiometric data, artificially infection

Introduction

Milics et al., (2010) announced that comparison of various field measurements and hyperspectral images proved that there is a possibility of pattern recognition by the visualization of different wavelengths. For yield estimation (Yang et al., 2004) demonstrated that airborne hyperspectral imagery can be a useful data source for mapping crop yield variability. Principal component analysis is an effective tool to eliminate the redundancy in hyperspectral data, but it is unable to directly quantify the contributions of individual bands for yield mapping (Morschhauser and Milics, 2009). Technical background of the yield data collection by an on board computer system is reported by Neményi et al., (2006). Hyperspectral imaging was evaluated from the point of view ragweed detection (Kardeván et al., 2005). Diagnosis of pathogens and estimating disease severity can be performed by major advantages of HA approach namely; simplicity and low computational load which makes it suitable for real-time on-vehicle applications. (Yang, 2010; Hamid Muhammed, 2005). Hyperspectral technology can be fitted exquisitely in the agricultural production, in the environment protection and in several other industrial applications according to quantity and quality evaluation methodology (Szalay et al., 2010). Xing et al., (2010) reported that the average spectra of sprouted and severely sprouted kernels had higher reflectance responses compared to sound kernels in the wavelength region above 720 nm. The ratio

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of the reflectance at 878 nm to that at 728 nm could be used to identify sprouted from nonsprouted kernels.

Materials and methods

The experimental field is cultivated by precision agriculture management technology since 2001 by University of West Hungary. The field is located near Mosonmagyaróvár, Hungary. Field measurements were performed in July 2010. Testing activity took place between the period of 11:00 am and 3:00 pm. A spectroradiometer (ASD FieldSpec 3 Max) was used with spectral range 350-2500 nm. Spectral resolution was 3 nm between 350-1000 nm, and 10 nm between 1000-2500 nm. Scanning Time was 100 milliseconds. Field measurements were performed on different objects like soil, plant, weed and road. Each object was checked on the following procedures (white reference, white reference with sunshade disk, expected target and finally white reference again). For the airborne measurements AISA DUAL hyperspectral instrument was used, which is able to collect information in more than 350 wavelengths between 400 and 2450 nm. Arial pictures were taken in 2010. November 23. The yield data was recorded by Agrocom on board computer to a standard PCMCIA card in every 5 seconds together with the geographical coordinates. The raw data was exported to *.txt file format from Agro Map Basic 3.0 software. The coordinates were transformed to Hungarian EOV with the help of EHT software. Evaluation was made by Arc GIS 9.2 software. The false yield data (zero, extremely high or low) was deleted from the data line. With the help of interpolation technique a raster based yield map was made. Eight different yield categories (t ha^{-1}) were determined based on collected data. For comparison, another yield map was generated by the means of spectral angle mapper (SAM) classification technique from hyperspectral data. A special spectral library was built from the reflectance value of selected pixels from the hyperspectral image, which was prepared from 36 selected wavelengths (from 1175nm to 2205 nm). The yield data layer was added to the image as a vector. The selected yield data and the average of reflectance spectrum were matched and saved as an endmember collection. The above mentioned yield categories were used, and a new hyperspectral data based map was generated. Corn Cob samples were collected (natural and artificially infected with *Fusarium verticilloides*) from two different genotypes (M017, HMV5334), from a research field in Agricultural Research Institute of the Hungarian Academy of Sciences in 14th of November. The corn cobs were artificially inoculated according to Young (1943) method, at the end of July. Symptoms of *Fusarium* cob rot were analyzed in laboratory conditions in two different ways (Plant Pro, Pro Lamp) in VMMI Hungarian Institute of Agricultural Engineering. Corn cobs were rotated and measured in four different positions to get radiometric data from the whole surface. Before examinations White Reference (WR) spectrum were recorded. View Spec Pro software (ver. 5.6) was used to evaluate the radiometric data.

Results and discussion

Visual comparison of the on board computer data based and the hyperspectral data based yield map shows strong correlation (*Figure 1.*).

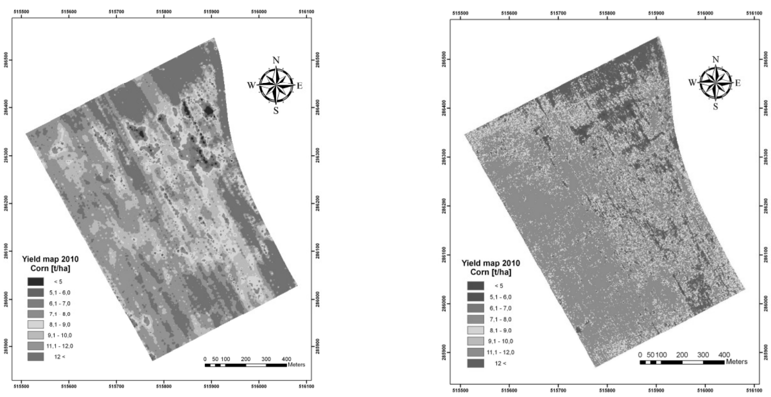

Figure 1. The on board computer data based and the hyperspectral data based yield map [t ha^{-1}]

The left sides of the maps show good yield results (9,2-12 t ha^{-1}) and on the top areas high yield(>12 t ha^{-1}) could be recognized. Although on the left map, more regions with low yield value (<5 t ha^{-1}) could be found. The differences between the two maps could be caused by the data recording method of the Agrocom Yield Monitoring System or could be caused by the process of supervised classification.

In course of the evaluation of the *laboratory measurements* the radiometric data was transformed to reflectance with the help of View Spec Pro software. By the mean function of the software spectral curves were generated to represents each genotypes and analyzing methods. In case of analyzing the natural and artificially infected corn cobs by using Pro Lamp, significant differences could be recognized between the reflectance curves of the natural (blue) and artificially infected (red) corn cobs in the infra-red wavelengths from 1400nm to 1850 nm (*Figure 2.*).

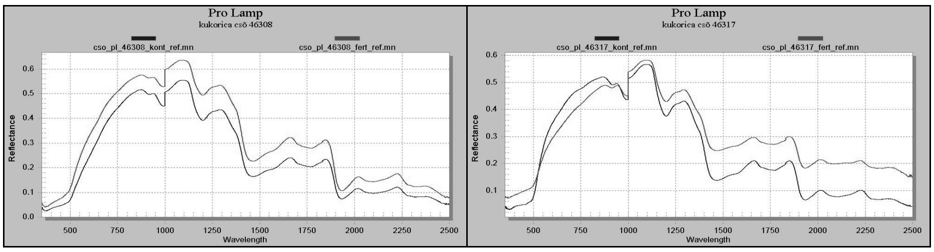

Figure 2. Reflectance (%) of natural (blue) and artificially infected (red) corn cobs

By the *field measurements*, the extracted values of hyperspectral signatures of objects were based on average calculation of ten measurements performed in 100 milliseconds. Ten successive spectral measurements were carried out of each location as a representative of an object. The obtained data were processed by the software included statistical function of mean. Within the interval of visual and infrared bands, four different curves of spectral means were plotted. Between the visible spectrum (390-750 nm), the four curves suffocated at the point of 720 nm. The weed curve altered from the

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lowest value of digital number to the peak in 760 nm preceding the other three curves. The four curves jumped dramatically to the peak in 770 to record (7000, 9500, 12000 and 17000) DN respectively. Sharp declination of the four curves within the interval of 770-820 nm appears to diminish the values of DN to be (4000, 6000, 7000 and 10000) respectively.

Conclusions

By generating yield maps from the recorded data by field monitors, hyperspectral information could be taken into consideration to reveal the mistakes of the conventional yield mapping methods. The differences in the reflectance of bare soil, crops and weeds provides many possibilities for the analyzing process of hyperspectral data, however reflectance is changing in different vegetation phases. In this way field measurements and airborne imaging has to be made simultaneously. By improving the hyperspectral laboratory techniques to find the most suitable analyzing methods to determine the rate of the infection in case of different plant diseases, a very useful tool could be given for plant breeding.

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TRIAL ON THE OPTIMAL COMPOUND OF WINTER WHEAT CULTIVAR MIXTURES TO ENHANCE THEIR ADAPTABILITY

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Abstract: Numerous experiments have already affirmed the successful use of the cultivar mixtures to increase the yield stability of the different cultivated plant species by many mechanisms. This paper demonstrates an optimization trial with two different 3-way mixtures and a 3-way multiline of winter wheat. The components of the mixtures were selected on the basis of their resistance to powdery mildew (*Erisyphe graminis*), red rust (*Puccinia recondita*), leaf spot diseases (mainly *Dreschlera triciti-repentis*) and their quality parameters. The mixtures with seven different mixing constitutions, the multiline and their pure stands were set in a common randomized field plot trial in Szeged. The levels of diseases, yield, TKW and some quality parameters were determined of each plot. Both mixtures and the multiline showed some mixing ratios with higher yield than weighted average of the pure stands, one of them represented significant over yield. The usefulness of mixtures for disease management was markedly presented in the case of powdery mildew and the leaf spot diseases. In spite of the extremely high pathogen pressure, the mixing effect on the leaf rust disease level was not obvious. The quality parameters of the 3-way mixture seed samples were similar or non-significantly higher than those of the pure stands. These results confirmed the former opinions in accordance with which the mixtures will likely play an increasingly important role as we develop more sustainable agricultural systems.

Keywords: wheat, cultivar mixture, multiline

Introduction

Cultivar mixtures (CMs) are common in subsistence farming systems, offering growers of stability of income and reduced losses of pests. Disease reduction and yield stability could have to be the most important reason of use cultivar mixtures. Also effects on soil borne diseases, weeds and insects, soil fertility, lodging and better over wintering survival of plants are also commonly reported. CMs may also offer the advantage of different components complementing one another in their adaptation to yield limiting factors and environmental variation (Finckh and Wolfe, 1997).General and specific mixing abilities have been analyzed for two-cultivar mixtures compared to pure stands (Gallandt et al., 2001), although in practice, CMs are composed of more than two ones.
Few studies have focused on harvested grain quality. Complementarity among wheat cultivars has been demonstrated with the protein content (Sarandón and Sarandón, 1995).

Materials and methods

In 2010, two 3-way winter wheat “cultivar” mixtures and a multiline were set in a common field trial in four replications. The components of the mixtures were not registered varieties, except *GK Körös*. However, the level of their uniformity and the phenotypic difference among them permit to use them as cultivars, experimentally. The mixture *A* consists of the line *2446.09* moderately resistant to leaf rust and powdery mildew with medium yield power and good quality parameters, the genotype *30.09* with similar resistance, lower yield level and excellent quality. The cv. *GK Körös* resistant to *P. recondita* and *E. graminis,* high yielding ability and moderate technical quality was the third component.

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The mixture *B* includes the resistant wheat line *34.09* with very high yield and medium quality; the high yielding and quality line *2451.09* moderately resistant to leaf rust and powdery mildew. The third component was the moderately susceptible genotype *2368.09* with low yielding capacity, having excellent quality parameters. Neither of the CMs have close relative genotypic components.

The components of the multiline – line *2365.09*, *2366.09* and *2370.09* - derived from the same crossing combination, evidently, they were close relatives. The components have a high level of phenotypic similarity; however, have differences in resistance, yielding and quality parameters among them. Each mixture was planted in seven mixing ratios (1:1:1, 1:2:4, 1:4:2, 2:1:4, 2:4:1, 4:1:2, 4:2:1). The parts of the multiline had evenly proportioned. The pure lines as standards were also planted in the same field trial. The area of the plots was 6.5 m^2, they were randomized in Latin Square method. Neither of the plots has been treated by fungicide.

The yield and the thousand kernel mass (TKM) of seed samples of each plot were measured. The disease symptoms caused by leaf rust, powdery mildew and complex leaf spot diseases were evaluated visually. Data were in terms of the percentage of leaf area covered with the pathogens. The extraction rates, wet gluten (G) and protein content (P), gluten spreading (GS), farinograph value (FV), stability (ICC) and falling number (FN) were determined on the basis of the whole milling products. Hardness index (HI) was calculated with Perten method tester. One factor variance analysis was used to evaluate of the yield, resistance and quality data.

Results and discussion

In the growing season in 2010, the climatic condition in South Hungary was extremely humid, favorable to the formation of the strong pathogen pressure. These circumstances could promote to enforce the physiological differences of the component genotypes as parts of CMs which manifested in the important yield anomalies. The yield of the CMs varied between 86 and 117% in the weighted average as per the mixing ratios. The yield strongly depended on the mixing ratio. The mixture A111, A412, B124, B421 and the multiline have some extra yield, which of the A412 was significant (*Figure 1.*). Conversely, at other mixing ratios various yield losses were measured according to the weighted average of the pure lines.

Neither of the mixing ratios showed significant mixing effect on the TKW. It would seem another yield components (heads/m^2, seeds/head) preferably have become the tools of the cultivar-specific compensation/competition mechanism. Julian BT et al. (1993) obtained similar results. The effect of the mixture decisively depends on the competitive relation system among the components. First of all, the competition levels *in* the pure lines and *between* them (cf. *intraspecific* and *interspecific* competition) are determined genetically. However, our results indicated that mixing ratio is also a very important factor in forming the competition patterns, and the various yield levels of the mixtures with diverse mixing ratios, simultaneously. In consequence, in the case of 3-way mixtures, it is possible to set optimal mixing ratio of each CMs, at which their mixing advantages allow to be utilized in practice in as high degree as possible.

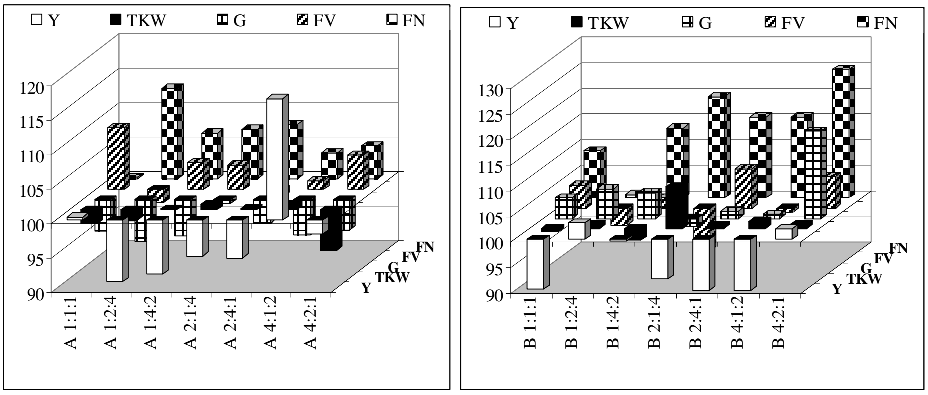

Figure 1. Mixture effects on some yield and quality parameters of the winter wheat at different mixing ratios. Ratios of the mixture ***A*** (left) in order of genotypes ***2446.09:30.09:GK Körös***; those of mixture ***B*** (right) in order of ***34.09:2451.09:2368.09***. Y-yield, TKW- 1000 kernels weight, G-wet gluten content, %, FV-farinograph value, FN – falling number. Data was calculated as the percentage of the weighted average by the mixing ratio of the components. Szeged, 2010.

The results on the mixing effect on the seed quality data were miscellaneous. First, the two mixtures were very different in this respect. The mixture *A* showed a squarely negative mixing effect on the wet gluten content, while positive mixing effect was described at the mixture *B* almost at all mixing ratio. Mostly positive mixing effects have detected in point of farinograph value, however there were no significant. In the case of falling number, remarkable positive mixing effect has been demonstrated at each mixing ratio. The synergic compensation effect was significant of the CMs A124, B214, B241, B412 and B421 (*Figure 1.*). Although certain results have not certified mixing advantage on gluten but without fertilizers, in a low input agriculture (Sarandón and Sarandón, 1995), our data showed a very strong dependence of the mixing effectiveness on the pure genotypes themselves and their ratio in the CMs.

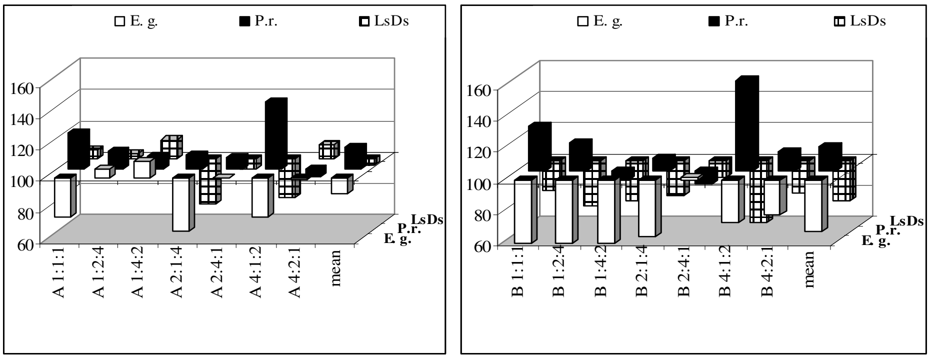

Figure 2. Mixture effect on important leaf diseases of winter wheat at different mixing ratios. E.g.-powdery mildew, P.r.- leaf rust, LsDs- leaf spot diseases. Szeged, 2010.

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Despite of relatively good resistance parameters of the pure genotypes, the average severity of leaf rust, powdery mildew and leaf spot diseases were 36, 9 and 14 %, respectively.
Significant negative mixture effect was detected on the powdery mildew and leaf spot diseases at most of the cases of mixture *B*. The decrease of the disease severity varied between 0 and 55 % in the case of *E. g.* and between 19 and 51 % in the case of the leaf spots. Averagely, the members of mixture *A* also had a disease moderating effect on the powdery mildew and leaf spots development, however, they were mostly no significant.
Unexpected results on the mixture effect on leaf rust were obtained. In most cases, the mixing effect increased the disease severity; moreover, significant enhancement also occurred (A111, A412, B111 and B412).
Evidently, one-year experiment like this cannot verify and reveal the explanation of this phenomenon. The majority of studies of mixtures of partially resistant hosts (like wheat lines in our CMs) have shown low level of disease control or disease increases. Year by year, the changeable mixing effect can return owing to interactions of resistance components with environments (Mundt CC, 2002). Besides, according to an old experience, there is negative correlation between the occurrence of leaf rust/powdery mildew and leaf rust/leaf spot diseases, respectively. Possibly, this incompatibility has merely been enhanced by the mixture effect giving place to the competitor pathogen leaf rust.

Conclusions

Mixtures of pure cultivars are planted in low proportion in developed countries, despite considerable researches suggesting that intraspecific diversity may contribute to yield, abiotic and biotic stress management. The complex explanation of his phenomena has economical, practical, variety registration, variety maintenance and human aspects. The way to introduce a mixture to the market first resembles that of a hybrid plant. But, the advantages of the mixtures does not become obvious but under a few year long growing period in practice, in contrast to the heterozygote superiority of the F_1. However, the agronomic and marketing considerations must be carefully evaluated when implementing mixture approaches to cereal crop breeders' and growers' management.
To optimize a cultivar composition with enforcing the mixture effect supremely we have to follow the breeders' steps. Similarly to the traditional crossing procedure and variety development, studious assemblage of the CMs and complex selection work in multi-location and multi-year experiences need to create successful CMs.

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COMPARATIVE PEST DAMAGE ANALYSES IN MAIZE CULTURE IN THE CASE OF DIFFERENT CULTIVATION TECHNOLOGIES

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Abstract: To determinate the pests' damage values and their proportions in different cultivation technologies maize acreages, we examined the well seen damage illustrations of the most important phytopatogen microfungi (*Fusarium spp., Ustilago maydis*) and arthropod pests (*Helicoverpa armigera, Ostrinia nubilalis*). The investigations were carried out both in monoculture and first year maize field in September 2010, which is located side by side. Both technologies were characterized by homogenous soil conditions, and the same agrotechnical elements. The soil disinfection were applied against the western corn rootworm in the case of monoculture.

According to our investigation the damage percentages were influenced by cultivation technologies in the case only some pests. We observed the higher damage values of *O. nubilalis* and *Fusarium spp*. in monoculture maize field, which can be explained their overwintering places. Beside all these, the higher percentage values of *H. armigera*'s and *U. maydis'* damage manifestations were not confirmed in the case of monoculture, because the ecological and the overwintering needs of these species cannot be associated with maize residue remaining from the previous year.

Keywords: monoculture-, first year maize field, pest, damage proportions

Introduction

Maize belongs to those plant species which can be cultivated successfully in monoculture (Bocz, 1996). The widespread utilization of this technology is supported above all by the economic features of maize.

Beside, cultivation in monoculture raise several problems, anxieties. The unilateral usage of the soil can cause direct crop depression (Ángyán and Menyhért, 1997; Tóth and Kismányoky, 2001). The monoculture can promote the increase of some weed species, as well as the development of herbicide resistance (Győrffy, 1993; Ubrizsy, 1968). The main problem seems to be that monoculture promotes the increase of phytopathogenous, generalist and specialist pests, too (Széll and Dévényi, 2009). The wheat and maize preceeding crop, respectively the increase of masticating pests can induce the increased appearance of Fusarium species and the fusariotoxin level increase in the grain (Mesterházy, 1974; Mesterházy and Vojtvics, 1977).

The main vegetation pests are western corn rootworm (*Diabrotica virgifera virgifera* LeConte), cotton bollworm (*Helicoverpa armigera* Hbn.) and European corn borer (*Ostrinia nubilalis* Hbn.) (Dömötör et al., 2009; Keszthelyi, 2010). The protection against western corn rootworm is an obligatory element in monoculture (Nagy et al., 2003). In this way the restraint of the damage caused by the two moths is to be expected from the protection against western corn rootworm. So it is undecided the objective survey of the damages caused by these two species.

Fusarium species and corn smut fungus /*Ustilago maydis* (DC.) Corda/ can be mentioned as fungi which can affect the crop results, and their qualitative parameters (Szél, 2007).

Our aims were more accurate knowing of the mentioned pests damage manifestations and their percentage proportions in view of different cultivation technologies maize

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acreages. Beside, we wondered how will be formed the pests damages in maize monoculture.

Materials and methods

To determine the damage caused by the different maize pests a survey was made in 2010 in Fészerlak (Somogy county) in an 11 ha acreage grown both in maize monoculture and first year maize. These two technologies were partaken in 50-50% from the experimental field. In the field a silage maize hybrid, GK-521(FAO 560) was sown on 21 April 2010. The cultivation of maize was both in rotation and in monoculture in the experimental fields in this year. Soil disinfection (Force 1.5G®; 13.5 kg/ha) against the western corn rootworm was carried out in monoculture maize fields. Insecticides were not applied in the case of rotation maize fields, neither in vegetation periods of different technologies.

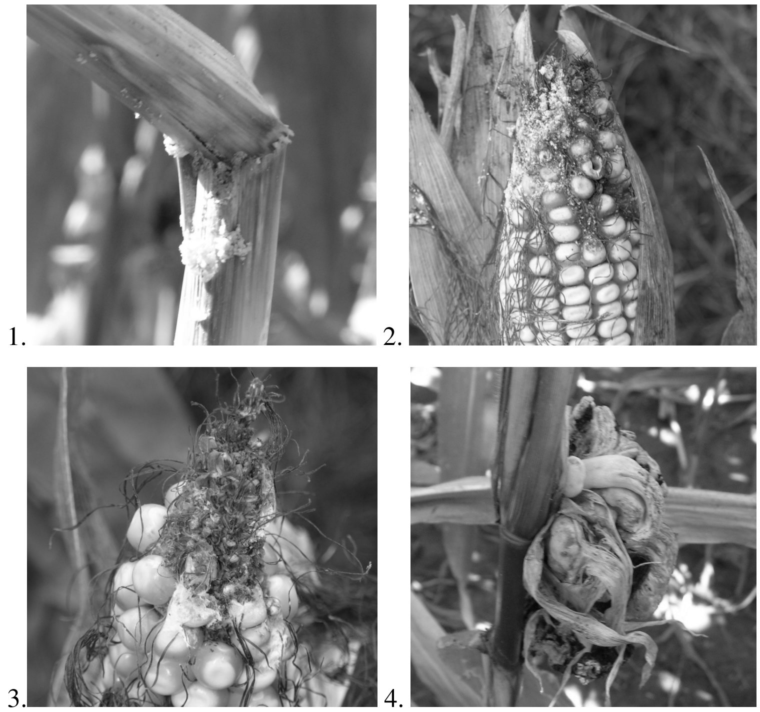

Figure 1. Damage illustrations of examined pests. 1. *O. nubilalis*; 2. *H. armigera*; 3. *Fusarium spp.*; 4 *U. maydis* (photos: S. Keszthelyi)

We examined the well seen damage illustrations of the most important phytopatogen microfungi (*Fusarium spp., Ustilago maydis*) and arthropod pests (*Helicoverpa armigera, Ostrinia nubilalis*) (*Figure 1.*) in 13. October 2010. We noticed the health condition and the numbers of damaged plants caused by different pests of 100 maize plants in one row. We applied 10, random rehearsals in the case of both technologies.

By data comparison of numbers of damaged plants with different cultivation technologies Student t-probe ($P \leq 0.05$) was applied to ascertain the occurrent significant differences with the help of Microsoft Excel 2007.

Results and discussion

The percentage of the damaged maize individuals by the different pests are compiled in *figure 2*. The three main pests affecting the examined maize individuals were the cotton bollworm, the European corn borer and the *Fusarium* spp. The differences between the damages occurring in the case of the two different cultivation technologies are clearly observable. In monoculture the damages caused by European corn borer (1,3x higher) and ear fusariosis (1,43x higher) were more dominant. These differences proved to be significant (European corn borer: p= 0,0315; *Fusarium* spp.: p= 0,0141). Beside, another significant difference was observable in the first year maize in the case of the damage caused by cotton bollworm (1,74x higher; p= 0,0223) than in monoculture. The corn smut fungus affection was higher in the first year maize, too, however because of the few affected individuals this difference (3,54x higher) was not significant (p=0,2254).

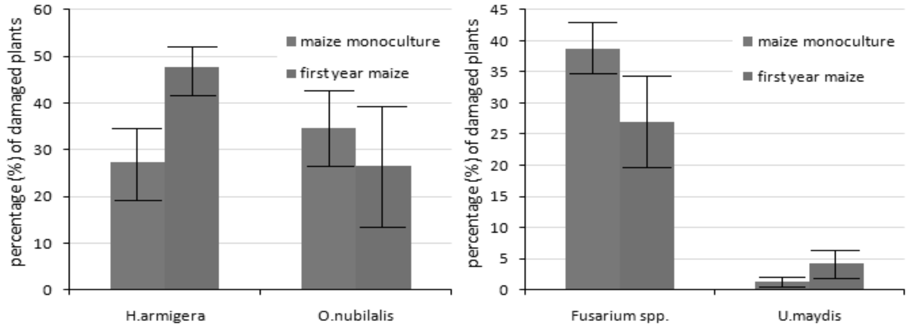

Figure 2. Percentage of damaged plants in different maize cultivation technologies

Conclusions

From the four examined pests, the damage of cotton bollworm, European corn borer and *Fusarium* spp. occurred dominantly in the case of both cultivation technologies. This fact coincides with the investigations published in the national and international scientific literature.

The unquestionable presence of European corn borer and ear fusariosis damages in monoculture can be explained unambiguously by the hibernation of these pests in the remains of the early year's maize. The appearance and damage of cotton bollworm and corn smut fungus was independent by the applied cultivation technology, due to their ecological and phytopathogenous features.

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Our experimental results unequivocally proved, that the chosen cultivation technology basically influences health condition of the crops. The appearances and injuries of pests overwintering in maize residue are more emphatic in monoculture, than first year maize acreage. So it is easy to see that the destroying of the plant residue, and the correct choice of the applied technology basically effect on the appearance and injuries of pests in given year.

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GRAIN YIELD QUALITY OF WINTER BARLEY *(HORDEUM VULGARE* L.) AS AFFECTED BY NITROGEN FERTILISATION

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Abstract: Mineral fertilisation field experiment was carried out to study the influence of the N supplies (0, 80, 160, 240 kg N ha^{-1}) on the protein content and amino acid composition of winter barley grain. The protein content increased significantly by 4.5% up to 160 kg ha^{-1} N application rate. The ratio of all amino acids expressed in g 100 g^{-1} dry matter showed considerable increase in relation with the better N supplies. Expressed the amino acids ratio in g 100 g^{-1} protein only the arginine and histidine increased significantly, while threonine, aspartic acid, cisteine, glycine and serine ratio declined as the result of N fertilisation.

Keywords: winter barley, N fertilisation, protein content, amino acid composition

Introduction

The protein content of barley changing from 8 to 15% as affected by variety, location and level of N-fertilization. The main components of barley proteins are the hordeins (25-50% of the total protein) and glutelins (30-54%). The albumins (3-12%) and globulins (8-20%) occur in lower amounts (Oscarsson et al., 1998). Kirkman et al. (1982) found that the proportions of different fractions generally change with increasing total protein content of barley grains. Izsáki and Német (2007), Kádár (2000 a, b, 2009) observed close positive correlation between N nutrition status of winter barley and the protein content of grain as well as the major agronomic traits. The amino acid composition of the total protein of barley is similar to that of other cereal grains. High glutamic acid and proline content, relatively low amount of basic amino acid, and considerable cystine and methionine. The amino acid composition and biological value of the protein shows some changes depending on the level of N supplies (Nierle, 1985; Lásztity, 1999).

The aim of the present research was to study the influence of the N supplies on the protein content and amino acid composition of the winter barley for developing of its N fertilizer recommendations.

Materials and methods

The long-term mineral fertilization experiments were set up at the Experimental Station of the Crop Production Department, Faculty of Agricultural Water and Environmental Management, Tessedik Sámuel College, Szarvas, in 1989 on chernozem meadow soil. Fertilization was carried out in all possible combinations of four levels each of N, P and K, giving a total of 64 treatments, set up in a split-split plot design with three replications, with K fertilization as the “A” factor, P fertilization as the “B” factor and N fertilization as the “C” factor. The following fertilizer rates were applied: nitrogen: N_0 = 0, N_1 = 80, N_2 = 160, N_3 = 240 kg N ha^{-1} $year^{-1}$; phosphorus (P_2O_5): P_0 = 0, P_1 = 100 kg ha^{-1} $year^{-1}$, P_2 = 500 kg ha^{-1} in 1989, 1993 and 2001, P_3 = 1000 kg ha^{-1} in 1989, 1993 and 2001; potassium (K_2O): K_0 = 0, K_1 = 300 kg ha^{-1} $year^{-1}$ between 1989 and 1992, 100 kg ha^{-1} $year^{-1}$ from 1993, K_2 = 600 kg ha^{-1} in 1989 and 2001, 1000 kg ha^{-1} in 1993,

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K_3 = 1200 kg ha^{-1} in 1989 and 2001, 1500 kg ha^{-1} in 1993. The high rates of P and K replenishment fertilization were used to create clearly distinct supply levels in the soil in order to investigate plant responses to nutrient status. The N fertilizer was split, 50% being applied prior to sowing and 50% as top-dressing at the end of tillering. In the long-term experiment all four crops in the crop sequence were planted each year. Fibre hemp was the forecrop for winter barley. The two-row barley variety GK Stramm was used in the experiment.

Results and discussion

The protein content of winter barley grain ranged from 9.3-14.0% according to N supplies. An evaluation of the N fertilization effect shows that the 80 kg ha^{-1} N application rate increased the protein content significantly by 2.8 percentage points compared to the N control. Further considerable increase (1.7%) was detected in the protein content at 160 kg N ha^{-1} application level. At higher N supply level (240 kg ha^{-1}) no further change was observed (*Table 1.*).

Table 1. Effect of N supplies on the protein content and amino acid composition (g 100 g^{-1} dry matter) of winter barley grain (Szarvas, 2010)

Components	Nitrogen application rate, kgha^{-1}				$LSD_{5\%}$	Average
	0	80	160	240		
Protein content	9.3	12.1	13.8	14.0	0..87	12.3
Amino acid (AA)						
Essential AA						
Arginine	0.39	0.54	0.66	0.71	0.19	0.58
Phenyalanine	0.48	0.59	0.72	0.71	0.22	0.63
Histidine	0.28	0.44	0.52	0.38	0.09	0.40
Isoleucine	0.41	0.52	0.58	0.70	0.70	0.55
Leucine	0.72	0.90	0.96	1.06	0.09	0.91
Lysine	0.38	0.52	0.61	0.52	0.18	0.51
Methionine	0.15	0.18	0.22	0.20	0.03	0.19
Threonine	0.37	0.42	0.45	0.47	0.07	0.34
Valine	0.56	0.68	0.72	0.81	0.07	0.69
Total EAA	3.74	4.80	5.44	5.56	-	4.89
Non-essential AA						
Alanine	0.45	0.53	0.53	0.65	0.11	0.54
Aspartic acid	0.60	0.69	0.74	0.81	0.09	0.71
Cysteine	0.20	0.23	0.26	0.26	0.03	0.24
Glicine	0.40	0.48	0.51	0.54	0.08	0.48
Glutamic acid	2.10	2.64	2.76	2.89	0.46	2.60
Proline	0.76	0.96	1.08	1.21	0.29	1.00
Serine	0.44	0.52	0.55	0.57	0.08	0.52
Tyrozine	0.30	0.34	0.43	0.39	0.09	0.36
Total NEAA	5.25	6.39	6.86	7.32	-	6.45
Total EAA + NEAA	8.99	11.19	12.30	12.88	-	11.34
EAA/NEAA	42/58	43/57	44/56	43/57	-	43/57

As regards the amino acid composition of the protein (expressed in g 100 g^{-1} dry mather) the all amino acids showed significant increase in relation with the better N supplies. Of the 17 amino acids examined at 10 amino acids were observed significant increase at 80 kg ha^{-1} N application rate compared to the N control. Six amino acids (isoleucine, lysine, methionine, threonine, cysteine, proline) responded to 160 kg ha^{-1} N supply with a considerable change. Only the alanine was where significant increase was detected only the highest N supply level (240 kg ha^{-1}). The ratio of essential amino acids exhibited a slight increase in relation with the N fertilisation (*Table 1.*).

The influence of the N fertilisation on the amino acid composition of the barley protein (expressed in g 100 g^{-1} protein) is presented in Table 2. Of the 17 amino acids examined only the arginine and histidine ratio increased significantly at higher N supply levels. Threonine, aspartic acid, cisteine, glycine and serine ratio declined as the result of N fertilisation. The N supplies had no effect on the ratio of essential amino acids. While the non-essential amino acids ratio showed lower level (49-53%) in N fertilized treatments compared with the N control (57%). The ratio of the total amino acids expressed in the crude protein content exhibited lower level as the result of N fertilisation.

Table 2. Effect of N supplies on the amino acid composition (amino acid g 100 g^{-1} protein) of winter barley protein (Szarvas, 2010)

Amino acid (AA)	Nitrogen application rate, $kgha^{-1}$				$LSD_{5\%}$	Average
	0	80	160	240		
Essential AA						
Arginine	4.16	4.48	4.86	5.10	0.68	4.65
Phenyalanine	5.12	4.87	5.27	5.05	NS	5.07
Histidine	3.08	3.66	3.75	2.70	0.60	3.29
Isoleucine	4.47	4.35	4.18	4.29	NS	4.32
Leucine	7.25	7.49	6.99	7.61	NS	7.33
Lysine	4.15	4.33	3.74	3.74	NS	3.99
Methionine	1.63	1.44	1.56	1.44	NS	1.51
Threonine	3.98	3.44	3.27	3.36	0.46	3.51
Valine	6.03	5.57	5.24	5.78	NS	5.65
Total EAA	39.87	39.63	38.86	39.07	-	39.32
Non-essential AA						
Alanine	4.87	4.39	3.88	4.62	NS	5.19
Aspartic acid	6.51	5.70	5.34	57.4	0.59	5.82
Cysteine	2.20	1.87	1.89	1.83	0.37	1.97
Glicine	5.36	3.95	3.72	3.84	0.50	3.96
Glutamic acid	22.56	21.81	20.06	20.59	NS	21.25
Proline	8.23	7.88	7.77	8.61	NS	8.12
Serine	4.76	4.28	3.99	4.08	0.54	5.02
Tyrozine	3.26	2.80	3.14	2.70	NS	2.97
Total NEAA	56.75	52.68	49.79	52.01	-	
Total EAA + NEAA	96.62	92.31	88.65	91.08	-	
EAA/NEAA	41/59	43/57	44/56	43/57	-	

Conslusions

The protein content and amino acid composition of protein showed some changes depending on the level of N supplies.

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The protein content increased significantly by 4.5% up to 160 kg ha^{-1} N application rate. The ratio of all amino acids expressed in g 100 g^{-1} dry matter showed considerable increase in relation with the better N supplies. Expressed the amino acids ratio in g 100 g^{-1} protein only the arginine and histidine increased significantly, while threonine, aspartic acid, cisteine, glycine and serine ratio declined as the result of N fertilisation.
The N supplies had no effect on the ratio of essential amino acids. While the non-essential amino acids ratio showed lower level (49-53%) in N fertilized treatments compared with the N control (57%). The ratio of the total amino acids expressed in the crude protein content exhibited lower level as the result of N fertilisation.

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INCREASING BIOGAS YIELD PER UNIT AREA BY USING NEW TYPE OF SILAGE MAIZE HYBRIDS

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Abstract: Nowadays more than half the energy used in the European Union is imported. In Hungary this ratio is greater than 66%. The production of biogas will not only replace fossil fuels, but will also help to achieve the obligations laid down in the Kyoto Protocol. Experiments have been underway in Martonvásár for many years to develop leafy silage hybrids, which have a greater aboveground mass than conventional silage hybrids. The best hybrids for biogas production would be those that produce a large quantity of biomass and are rich in starch. The chief characteristic of leafy hybrids is that they have more leaves than normal hybrids. Due to this enhanced leaf area above the ear, the vegetative period of leafy genotypes is shorter, while the grain-filling period is longer, which has a positive effect on both yield and grain quality. The results of the present experiment show that during the anaerob fermentation of the silage, leafy hybrids produced more biogas (640 l per 1000 g dry matter) compared to conventional hybrids (606 l per 1000 g dry matter). A strong positive correlation was found between biogas yield and the starch content of the silage, and a moderate positive correlation between biogas yield and the sugar content. The correlation between biogas yield and the lignin and protein content was negative, in accordance with other literary data.

Keywords: silage hybrids, leafy, biogas, quality

Introduction

The invention of biogas has a history of many centuries. Shirley discovered the marsh-gas in 1677 and Volta revealed it to be combustible in 1776 (Bai, 2007). The greatest advantage of biomass-based energy production is that it is a renewable energy source, it can be reproduced year by year. Biomass can be originated directly from agricultural crop production, such as maize or potatoe. The common characteristic of energy plants is that they contain granular starch as the raw material of fermentation. Maize, especially silage maize can be one of the most important renewable energy sources, because it has a great dry matter yield, high protein and energy content, good digestibility and optimal dry matter content at harvest for the fermentation (Carter et al., 1991). The higher ratio of the leaves in the total plant dry matter and the greater carbohydrate content of the leaves above the ear (Andrews et al., 2000) have a favourable influence on the quality and fermentability of the silage. The range of chemical components to analyze is wider in the case of silage maize than in grain maize. The crude protein, crude ash, crude fat and crude fibre content of the whole plant is also important for the forage. Instead of starch content the water soluble carbohydrate content (including mono- and oligosacharides) is measured for silage. This influences fermentability in a great extent. Examples from other countries show that biogas plants based on silage maize exclusively have a reason for existence because the raw material production can be integrated easily in the existing agricultural system (Rácz et al., 2009). The results of the experiments on silage maize hybrids show that leafy hybrids produce more biogas than the conventional hybrids (Hegyi et al., 2009). The objective of biogas production is to reach high concentration of methane in the fermentation end-product. The good quality biogas contains at least 60% of methane (Herrmann and Taube, 2006).

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Materials and methods

An experiment on leafy and non-leafy silage hybrids was set up in a randomised complete block design with four replications in 2009 and 2010 in Martonvásár, Hungary. The experiment was sown according to 80.000 plants per hectare. During August one row of each of the four leafy (Limasil, Mv Dunasil, Mv Siloking, Mv Massil) and four non-leafy (Maros, Mv NK 333, Mv TC 434, Maxima) varieties was cut, and chopped samples were prepared from the whole aboveground part of the plants. Part of each sample was used to analyse biogas yield in the BETA Research Institute in Sopronhorpács. Biogas formation consists fundamentally of two processes, fermentation and methane formation. During the phases of fermentation (hydrolysis, acidic phase) the large-molecule organic matter is decomposed with the help of enzymes and fermentation bacteria. The other part of the samples were measured by NIR spectroscopy and analyzed using "INGOT calibration of maize silage" software for chemical composition traits such as dry matter, ash, lignin, fat, starch, protein. This technique is also suitable for measuring *in vitro* digestibility as well. We also determined the NDF (Neutral Detergent Fibre), WSC (Water Soluable Carbohydrate), NDICP (Neutral Detergent Insoluble Crude Protein), ADICP (Acid Detergent Insoluble Crude Protein) values of the samples.

Results and discussion

The biogas production of leafy and conventional hybrids was studied during two years. We concluded that, as a result of anaerob fermentation of silage maize, leafy hybrids produced more biogas (640 l per 1000 g dry matter) compared to conventional hybrids (606 l per 1000 g dry matter) (*Figure 1.*). The difference was statistically significant.

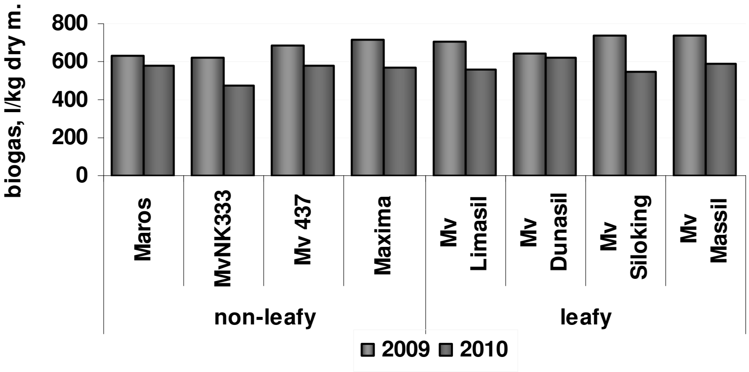

Figure 1. Specific biogas yield by leafy and non-leafy hybrids (l per 1000 g dry matter) averaged over years 2009 and 2010

In both years the least biogas production was recorded for the same hybrid (Mv NK 333, 546 l per 1000 g dry matter) and two leafy hybrid produced the most biogas yield (Mv Siloking, Mv Dunasil) (*Figure 2.*). The best quality biogas contained 64.4% of methane (Mv Massil). Biogas fermented from leafy hybrids had a higher methane content than that of conventional hybrids. The process of outgassing passed off in three weeks. The rate of outgassing was 87% averaged over years and hybrids.

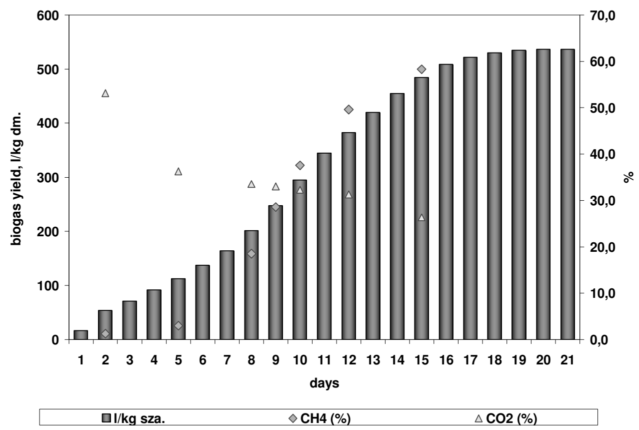

Figure 2. Specific biogas yield from the maize hybrid Mv Dunasil averaged over years 2009 and 2010

A strong positive correlation was found between biogas yield and the starch content of the silage, and a moderate positive correlation between biogas yield and the sugar content (*Table 1.*). The correlation between biogas yield and the lignin and the protein content was negative, in accordance with other literary data.

Table 1. Chemical composition of the silage and correlations with biogas yield averaged over years 2009 and 2010

non-leafy	Starch	Protein	Lignin	ADICP	NDF	NDICP	WSC	biogas
Maros	36.56	8.80	4.44	4.13	53.60	2.42	5.41	601.50
MvNk333	32.93	9.70	4.24	4.22	53.40	2.40	5.48	546.00
Mv 437	34.33	8.50	4.15	4.17	54.48	2.28	5.36	633.00
Maxima	35.60	9.70	4.23	4.20	53.00	2.48	5.75	642.50
mean	**34.86**	**9.18**	**4.27**	**4.18**	**53.62**	**2.40**	**5.50**	**605.75**
correlation	0.59	-0.36	-0.23	-0.34	0.17	-0.04	0.31	

leafy	Starch	Protein	Lignin	ADICP	NDF	NDICP	WSC	biogas
Limasil	36.18	8.90	4.27	4.17	54.75	2.35	5.04	629.50
MvDunasil	36.50	9.49	4.02	4.07	54.80	2.38	5.57	630.50
MvSilóking	35.40	8.82	4.21	4.20	53.17	2.51	5.95	640.50
MvMassil	37.50	8.87	4.07	4.06	55.36	2.28	5.60	659.00
mean	**36.40**	**9.02**	**4.14**	**4.13**	**54.52**	**2.38**	**5.54**	**639.88**
correlation	0.61	-0.48	-0.32	-0.40	0.26	-0.38	0.41	

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Conclusions

In Western Europe areas removed from cultivation have been utilised for the production of renewable energy sources, which also has the effect of preventing rural migration. Hungary is poor in fossil fuels, but has good agricultural potential. According to KSH data the cropping area of silage maize was 350.000 hectare in 1983 and reduced to only 89.000 hectares in 2008. Biogas production could provide a new perspective to this sector, especially using new type of silage maize hybrids which produce more biogas yield per hectare with high outgassing rates due to their good fermentability. In our experiment the biogas yield of leafy hybrids was greater than that of conventional hybrids in both years. A strong correlation between the biogas yield and the chemical composition of the silage was found. The starch and sugar content of the silage are in positive correlation with biogas yield, while lignin and protein content influences fermentability and the rate of outgassing in a negative direction.

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VARIABILITY OF YIELD COMPONENTS AND YIELD OF MAIZE DUE TO FERTILIZATION AND WEATHER CONDITIONS

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Abstract: Field polyfactorial experiment with maize, hybrid NK Thermo (FAO 370) was carried out from 2008 to 2010 Experimental basis of FAFR SUA Nitra - Dolna Malanta in Slovakia. Fertilization as a one of the key factor in experiment showed statistically significant influence on grain weight of cobs and grain yield. There were showed no statistically significant differences between variants of fertilization to number of plants per unit area and number of grains per plant. Significant differences in grain weight and thousand kernel weight (TKW) were between plough down unfertilized variant and post harvest residues + fertilizer application. Statistically significant difference in grain yield was between variants of fertilization (unfertilized and fertilizer application variant calculated to 7 tons of grain yield). Weather conditions in year have shown statistically highly significant influence on number of plants per unit area, number of grains per plant, grain yield and TKW. Multifactor analysis of variance confirmed a significant impact of weather condition on number of plants per unit area and TKW in year 2010 and year 2008 respectively in 2009.

Keywords: maize, fertilizer, weather conditions, yield forming elements

Introduction

Plant nutrition, in addition to direct effects on photosynthesis may also have an indirect impact, particularly by possibility of reducing the transpiration about 50 % or more. Fecenko (2003) found that water consumption of plants need to create unit of dry matter is reduced by better plant available nutrients in the soil. In case of more fertile soils with higher organic content the accessible forms of nitrogen are released more readily what should be taken into account in fertilization planning (Bízik and Balog, 2004). Babulicová et al. (2004) state that the highest grains yield of maize was reached for the variant with organic and synthetic fertilizers. There was found that weather conditions highly statistically significantly affect weight of grain in the cobs and thousand kernel weight (TKW) was highly statistically significantly affected by weather conditions and fertilization. According to Priadka (2001) year´s conditions highly statistically significantly changed the number of plants per unit area and had negligible effect on the number of grains per cob and TKW. Analysis of variance confirmed the significant effect of hybrid and stand density on grain yield (Zatkalík, 2002; Žembery et al., 2003 and 2005). The weather conditions as one of the key factor for crop production (Rodny et al., 2010) may be characterized by hydrothermal coefficient (H_C) for particular month (phenological phase intervals) of vegetation. This rough indicator is used for description of agro-climatic conditions for crop production (Špánik ai., 2000; Kurpelová, 1983).

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Hydrothermal coefficient is assumed as a representative indicator for determining the conditions of temperature and consumptive water demand of crops. For grain maize cultivation are suitable territories with rainfall totals above 500 mm, i.e. about 300 mm for vegetation period. Rainfall totals in June should reach from 70 to 80 mm, in July from 100 to 120 mm and in August from 70 to 80 mm (Karabinová et al., 2001).

Materials and methods

Field polyfactorial experiment with maize, hybrid NK Thermo (FAO 370) type of grain dentiformis, was carried out from 2008 to 2010 on land EXBA FAFR SUA Nitra - Dolna Malanta in Slovakia. Geographically is the territory located in the western part of the Zitava Uplands with flat terrain geomorphology with elevation 175 m AMSL and with geographical coordinates 48°19' N and 18°09' W. Soil type is represented by brown soil, humus content is in the range from 1.95 to 2.60 %, changeable soil reaction (KCl) is from 5.03 to 5.69 (Hanes et al., 1993). The territory belongs to the very warm agro-climatic area with totals of average daily air temperatures (TS ≥ 10 °C) in main growing season 3000 °C and more. Agro-climatic sub-area is very dry with irrigation index in summer months $K_{VI - VIII}$ = 150 mm. The experiment was based on method of long strips with a square block cutting. Basic ways of farming: O1 - conventional soil preparation (conventional tillage from 0.20 to 0.25 meters) O2 - low tillage (to a depth of 0.15 to 0.18 meters) and O3 - minimized soil preparation (disc plowing to a depth of 0.10 to 0.15 meters). The variants were used fertilizer nutrient levels: H1 - no fertilizer, H2 - fertilizing with mineral fertilizers on yield level of 7 t ha^{-1}, H3 - mineral fertilizers + post-harvest remains. Evaluation of studied crop yield forming components and yield of grain maize is regardless of tillage. Preceding crop of grain maize was pea + intercrops white mustard. Hydrothermal coefficient (H_C) was calculated according to:

$$H_C = 10(\Sigma z)(\Sigma t)^{-1}$$

H_C – hydrothermal coefficient in given time interval (vegetation period), Σz – rainfall totals in given time interval (mm), 10 – conversion factor, Σt – sum of average daily air temperatures in given time interval (°C). Dates of sowing: 25th April 2008, resp. 28th April 2010. Dates of harvesting: 11th September 2008, resp.13th October 2010).

Results and discussion

We analyzed temperature and soil moisture conditions for the years with maximum (2010) and minimum (2008) grain yield expressed by hydrothermal coefficient (H_C). Low values of H_C at the beginning and the end of vegetation period are affected by dates of sowing and harvesting. During the months of May, June and July were achieved the balance between rainfall totals and sum of temperatures with the values of HC equal 1.117, 1.441 and 1.423. Rainfall deficits in months of August and September accelerated the aging process and maize was harvested on 11th September 2008. Over the whole experiment, we achieved yield 9.41 t ha^{-1} with sum of temperatures 2667.2 °C and with rainfall totals 249.4 mm. Despite the extremely wet April in the year 2010 with rainfall totals of 95.3 mm maize was sown on 28th April 2010. H_C values for May and June was 3.32 and 2.62. August and September show the balance between precipitation and temperatures with H_C values 1.708, respectively 1.820 (*Table 1.*). However the crucial is the distribution of rainfall in different growth stages in interaction with temperature (Špánik et al, 2000; Karabinová et al., 2001). Our results proved that the year with maximal grain yield - 2010 has achieved with nutrition with fertilizers (H2) what confirmed the conclusions of Bízik and Balog (1994) (*Table 2.*).

Table 1. Hydrothermal coefficients in the years with extreme grain yields Ymin and Ymax

Years	Parameter	Month of vegetation IV	V.	VI.	VII.	VIII.	IX.	X.	Sum	Grain yield t ha^{-1}
Y min 2008	Σt (°C)	78	495.9	598.3	632.4	636.5	226.1		2667.2	9.41
	Σz (mm)	1.5	55.4	86.2	90.0	9.8	6.5		249.4	
	H_C	0.19	1.117	1.441	1.423	0.154	0.287			
Ymax 2010	Σt (°C)	45.45	470.1	604.1	713.4	604.7	421.3	119.5	2978.41	12.51
	Σz (mm)	0	156.3	158.3	51.9	103.3	76.7	6.1	552.6	
	Hk	0	3.325	2.621	0.728	1,708	1.820	0.511		

Table 2. The influence of yield forming elements for grain maize average from 2008 to 2010

Nutrition	$\bar{x}$ number Plants.ha^{-1}; pieces.ha^{-1}	Grain.plant^{-1} pieces.plant^{-1}	Grain weight g. plant $^{-1}$	TKW g	Grain yield t ha^{-1}
H1	**64741**	515.26	150.27	308.21	10.02
H2	63778	545.55	180.69	332.71	11.51
H3	63518	**546.97**	**180.88**	**338.97**	**11.37**

Table 3. Analysis of variance of fertilization effect on the yield forming elements and maize yield

Yield forming elements	Fertilization	Weather conditions
Number of plants per hectare	-	++
Number of grains on plant	-	++
Weight of grains	++	+
Weight of thousand grains	++	++
Grain Yield	++	++

Fertilization as a factor of the experiment showed the statistically significant influence on grain weight of cobs, grain yield and TKW (*Table 3.*). There were no statistically significant differences between variants of fertilization on number of plants per unit area and number of grains per plant. Significant differences arose in grain weight and TKW between unfertilized variant (H1) and ploughing post harvest residues in together with fertilizer application (H3). Statistically significant difference in grain yield was between H1 and H2 variants of fertilization (unfertilized and application of fertilizers calculated for 7 tons grain yield). Weather conditions statistically highly significantly influenced the number of plants per unit area, number of grains per plant, grain yield and TKW and statistically significant on weight of the cob grains. Multifactor analysis of variance confirmed a significant impact of weather conditions on number of plants per unit area and TKW between year 2010 and years 2008 respectively 2009, Significant was the impact of weather condition in particular years on number of grains per plant and grain yield (*Table 3.*).

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Conclusions

The results of the polyfactorial experiment proved that fertilization has the statistically significant influence on grain weight of cobs and grain yield. There were found no statistically significant differences between variants of fertilization to the number of plants per unit area and number of grains per plant. Significant differences in grain weight and TKW were between plough down unfertilized variant and post harvest residues + fertilizer application. Statistically significant difference in grain yield was between H1 and H2 variants of fertilization (unfertilized and fertilizer application variant calculated to 7 tons of grain yield). Weather conditions as factor in an experiment have shown statistically highly significant influence on number of plants per unit area, number of grains per plant, grain yield and TKW. Multifactor analysis of variance confirmed a significant impact of weather conditions on number of plants per unit area and TKW in year 2010 and year 2008 respectively in 2009.

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EFFECT OF FOLIAR FERTILIZERS ON THE INTENSITY OF PHOTOSYNTHESIS AND CHLOROPHYLL CONTENT INDEX IN POTATO LEAF

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Abstract: The purpose of this study was to determine the effect of three foliar fertilizers (Epso Salt, Megagreen and Drin) and control treatment (with no foliar fertilizer) on the intensity of photosynthesis and chlorophyll content index in potato leaf. Research was conducted on a variety "*Courage*" in a greenhouse during two growing seasons (2006 and 2007). Foliar fertilizers were carried out five time during the growing seasons in the ten-day intervals in the period from the beginning of tuber formation to the stage of full tuberization. During the same period at intervals of five days measuring of the intensity of photosynthesis and chlorophyll content index have been conducted. The highest intensity of photosynthesis achieved control treatment and Megagreen. Foliar application of Epso Salt and Drin brought about significantly lower intensity of photosynthesis compared to control. Chlorophyll content index varied under the influence of treatments during the vegetation seasons. In 2006 there was no significant difference in chlorophyll content index between treatment Drin and control. Epso Salt and Megagreen achieved significantly lower chlorophyll content index in relation to control. In 2007 treatment Drin achieved significantly higher chlorophyll content index compared to control. There were no differences in chlorophyll content index between Epso Salt, Megagreen and control.

Keywords: potato, foliar fertilizers, intensity of photosynthesis, chlorophyll content index

Introduction

Foliar nutrition presents adoption of nutrients by leaves and stems (Fernandez and Eichert, 2009). Nutrient supply through leaf fertilization acts rapidly as through the leaf surface the ions can join metabolism directly (Takacs et al., 2007). Foliar fertilizers are often mixtures of micronutrients and secondary nutrients which application is recommended to increase intensity of photosynthesis, yield and quality of crops (Horvat et al., 2010). However, there are limited research informations based on their effectiveness on the plants metabolism. Horvat et al., (2006) have not found a positive effect of foliar fertilizer Megagreen (Ca) on chlorophyll content in potato leaf. Chapagain and Wiesman (2004) determined a significant increase of chlorophyll content in tomato leaf after foliar application of Nutri-Vant- PeaK (95% monocalcium-phosphate). Physiological reaction of potatoes to the application of foliar fertilizers is not sufficiently known. The goal of this experiment was to determine the effect of foliar fertilizers on the intensity of photosynthesis and chlorophyll content index in potato leaf.

Materials and methods

The experiment was conducted in the greenhouse of the Faculty of Agriculture, Zagreb during two growing seasons (2006 and 2007). Sprouted tubers of variety "Courage" were planted in 25 L pots filled with a mixture of soil and perlite at a ratio of 3:1. The basic fertilization, calculated per pot, was carried out with 750 kg ha^{-1} NPK 7:20:30 and 250 kg ha^{-1} KAN before planting. The experiment consisted of three foliar fertilizers

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(Epso Salt (Mg, S, B, Mn), Drin (alpha amino acid), Megagreen (Ca) and control treatment (with no foliar fertilizer)) was arranged as a split-plot or split-split plot design, depending on the number of investigated factors, with three replications. Each fertilizer treatment was presented with six plants in six pots. Foliar fertilizers were carried out five time during the growing seasons in the ten-day intervals in the period from the start of tuber formation (50 days after planting (DAP)) to the stage of full tuberization (90 DAP) as instructed by manufacturers (Epso Salt at a dose of 25 kg ha^{-1}, Drin 0,5 l ha^{-1} and Megagreen at a dose of 2 kg ha^{-1}) with the water consumption of 300 l ha^{-1} calculated per pot. During the same period at intervals of five days measuring of the intensity of photosynthesis by LCpro apparatus and chlorophyll content index by CCM 200 chlorophyll meter (ADC, Bio Scientific Ltd. Great Britain) have been conducted. The measurements were made on the youngest, fully developed leaf on three plants per treatment. Three measurements were carried out for each plant. The intensity of photosynthesis was measured in two daily maximum of intensity of photosynthesis (from 10:00-12:00 hours, and 14:00-16:00 hours). The measurements of the intensity of photosynthesis were carried out under constant light conditions (PAR 910 µmol $m^{-2}s^{-1}$) and CO_2 concentration of 380 µmol mol^{-1} air. Data were analyzed with analysis of variance. Mean separation was obtained using a protected LSD test at the 0,05 probability level when significant F-tests ($P \leq 0.05$) were observed.

Results and discussion

The analysis of variance (*Table 1.*) showed that the impact of days after planting (DAP) on the intensity of photosynthesis was different depending on the growing season, what confirms the significance of interaction between growing season and DAP. In 2006 the largest intensity of photosynthesis was recorded 55, 60 and 70 DAP while in 2007 the highest intensity of photosynthesis was 50 DNS (data none shown). The intensity of photosynthesis was significantly different depending on the time of measurement during the day in certain DAP which indicates the significance of interaction DAP × TM (*Table 1*).

Table 1. Combined analysis of variance for intensity of photosynthesis in potato leaf

Source of variation	n-1	Intensity of photosynthesis
Growing season (GS)	1	**
Days after planting (DAP)	8	**
GS × DAP	8	**
Time of measurement during the day (TM)	1	**
GS × TM	1	NS
DAP × TM	8	**
Treatment (T)	3	*
GS × T	3	NS
DAP × T	24	*
TM × T	3	NS

NS Not significant; * Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

Significantly higher values of the intensity of photosynthesis were determined 55, 70 and 80 DAP in the morning compared with afternoon maximum (*Figure 1.*). In other measurements there were not significance differences in the intensity of photosynthesis in the morning and afternoon maximum although there was a greater intensity of photosynthesis in the morning maximum in all DAP except 50 DAP. The reason of the lower intensity of photosynthesis in the afternoon maximum was probably the detention of stomata due to intensive process of transpiration because of the very high temperatures in the greenhouse and accelerates photorespiration process.

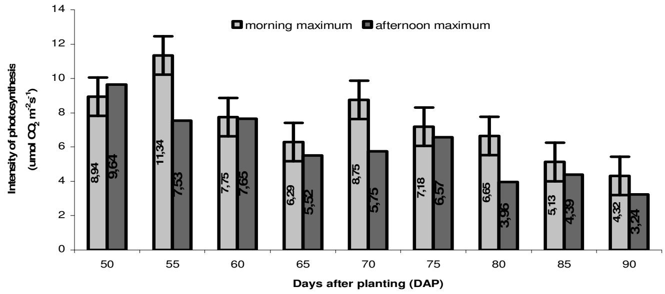

Figure 1. The average intensity of photosynthesis in the morning and the afternoon maximum at different days after planting. LSD 0,05=1,12 µmol CO_2 $m^{-2}s^{-1}$, bars apply for comparing the time of measurement during the day within the same days after planting.

The intensity of photosynthesis was affected by foliar treatments (*Table 1.*). The highest intensity of photosynthesis achieved control and Megagreen (*Figure 2.*). Megagreen contains 44% Ca, Ghanotakis and Yocum (1990) stated that Ca is fundamental element in the process of photosynthesis; it affects the permeability of electrons and protons, photosystem II and water oxidation. Treatments Drin and Epso Salt achieved significantly lower intensity of photosynthesis compared to control.

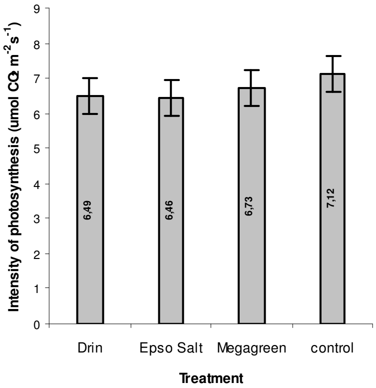

Figure 2. The average intensity of photosynthesis after foliar application of treatment compared to control. LSD 0,05= 0,51µmol CO_2 $m^{-2}s^{-1}$.

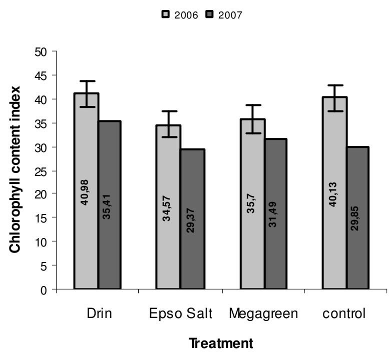

Figure 3. Average chlorophyll content index of foliar treatments in growing seasons 2006 and 2007. LSD 0,05 =2,83, bars apply for comparing treatments within the same growing season

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Chlorophyll content index was different depending on the treatment in specific growing season (*Figure 3.*). In 2006 there was no significant difference in chlorophyll content index between Drin and control. Epso Salt and Megagreen achieved significantly lower chlorophyll content index compared to control. In 2007 the highest chlorophyll content index achieved treatment Drin. There were no differences in chlorophyll content index between Epso Salt, Megagreen and control. Treatment Drin contains amino acid that contains nitrogen. Poljak et al., (2008) and Varga et al., (2007) stated that nitrogen is a limiting factor for growth and development, chlorophyll content and photosynthetic activity of crops. Chlorophyll content in the vegetation depends on the accessibility of nitrogen.

Conclusions

Foliar treatment Megagreen and control achieved the highest intensity of photosynthesis. Foliar treatments Epso Salt and Drin realized significantly lower intensity of photosynthesis compared to control. Chlorophyll content index varied under the influence of treatments during the growing seasons. In 2007 treatment Drin achieved significantly higher chlorophyll content index compared to control while in 2006 there was no significant difference in chlorophyll content index between Drin and control. Epso Salt and Megagreen achieved significantly lower chlorophyll content index in 2006 compared to control while in 2007 there were no differences in chlorophyll content index between Epso Salt, Megagreen and control.

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VARIABILITY OF PLANT HEIGHT OF WINTER BARLEY GROWN UNDER THE DIFFERENT SUPPLY OF NUTRITION

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Abstract: The variability of plant height in winter barley genotypes (G-3003, G-3020, G-3007-1/02 and G-3019) was investigated. These barley lines were tested in designed experiment on 5m^2 plots and 4 repetitions during two seasons with application of different rate of nitrogen (control=0, N_1=20, N_2=40 and N_3=60 kgha^{-1}). The average height of plant varies in investigated barley genotypes in dependence on supplied rate of N fertilizer. In the barley genotypes, the values of plant height were significantly different in two growing seasons. The significant higher values of plant height of barley genotypes with applied nitrogen rate of 40 kg ha^{-1} and 60 kg ha^{-1} were established in relation to other variants of mineral nutrition. In average for all year and variant of N nutrition, the biggest average plant height was found in G-3003 (68.65cm).

Keywords: barley, genotype, plant height, nitrogen

Introduction

Barley is considered the oldest cultivated grain. Barley grain has great biological value and high quality as fodder and raw material for industrial processing; it is also partly used in human nutrition. Barley is highly important in beer and whiskey production (Knežević et al., 2004). Utility value of barley grain for various purposes implies specific growing technology which should be adjusted to the requirements of grown genotype (Jelić et al., 2006).

Growth and development of plants are closely connected to physical, chemical and biological properties of soil. The soil represents a poly-phase system in which mobilisation processes occur constantly. The total quantity of nutrients in soil and the velocity of conversion of inaccessible forms into accessible ones determine largely the method and period of plants nutrition as well as the need for fertilisation. Plants nutrition is closely connected to interaction among soil, plant and fertilizer (Ubavić et al., 2008).

Mineral fertilizers influence physical, physiological and productive properties of winter barley (Stanković et al., 2000). High yield of winter barley can be accomplished if the plants are provided with sufficient quantity of fertilizers that will provide all the elements necessary for plants nutrition, N, P and K to start with. Deficiency of fertilizers at any moment of growth and development influences the reduction of height and quality of yield. Fertilizers are added before the beginning of sowing as the starting or pre-sowing fertilizer, and then later, for plant nutrition. For food nutrition, nitrogen fertilizers KAN and UREA are used most often. In the initial phases of plant development, phosphor is the most needed element (that needs decreases as the plant grows older). The greatest need for potassium occurs in the period between germination and flowering. Barley absorbs N most of all, then K and P. The efficiency of nitrogen exploitation has the purpose of increasing yield and quality of crops (Perin et al., 2009).

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Winter barley needs nitrogen mostly in pheno-phases – end of tillering and beginning of stem extension. These phases are calendar - connected to the first nutrition period. Nutrition starts earlier, because nitrogen fertilizers need certain time to start acting. In pheno-phases, when nitrogen is most needed, spikes, the number of spikelets in a spike, number of flowers in spikelets and over-ground vegetative mass are formed. Because of everything aforementioned, it is necessary to provide plants with sufficient quantities of nitrogen. In our agro-ecological conditions, significant differences between genotypes regarding needs for nitrogen were observed. (Malešević et al., 2010). Mineral nutrition is a complex system susceptible to the influence of climate-soil conditions. Temperature and water regime have the highest influence (Refay, 2009). Weather conditions influence the plant directly and indirectly, through soil. Temperature course and its extremes can modify yields up to 40% (Malešević, 2008). The ability of genotype to preserve genetic yield potential and high quality in various environmental conditions, usually stressful ones, depends on growing technology factors (Lalić et al., 2006). All agro-technical elements can influence on yield, but, next to optimal sowing term, nutrition is the factor through which the influence of weather conditions on the plant is most often manifested. The height of winter barley stem has a significant, positive and direct influence on the yield (Lalić and Kovacevic, 2010) but it can also have the indirect influence, through biological yield, harvest index and number of grains.
The aim of this paper is research of genotype reaction to different dose of mineral nutrition and effect of nitrogen to variability of stem height of barley.

Materials and methods

Two-year researches were carried out on experimental field during two years period. The subjects of researches were four winter barley genotypes (G-3003, G-3020, G-3007-1/02 and G-3019). These barley lines were tested in designed experiment on $5m^2$ plots and 4 repetitions. The soil on which the researches were carried out is smonitza type. It is characterized by weak acid reaction. For crops nutrition, the following amounts of nitrogen were used: 20, 40 and 60 kg ha^{-1}. The control was a variant without nutrition. In the course of two vegetations, the height of winter barley plant was measured.

Results and discussion

Varying of plant height of investigated barley genotypes in dependence on genotype, nutrition variant, repetition and investigation year was determined by the researches (*Table 1.*). Line G-3003 showed the highest values of plant height (86.4cm) in relation to other investigated genotypes in variant of nutrition by nitrogen 40 kg ha^{-1} (N_2). The average values of plant height in this variant for line G-3003 are the highest as well (85.47cm). The smallest height of winter barley plant (44.85cm) was measured in third repetition of control variant for line G-3020. The same line had smaller values of height in all nutrition variants in relation to other investigated genotypes.
The importance of nutrition by nitrogen in tillering and stem extension phases and its influence on development and height of plant are also indicated by values of winter barley plant height, which are, in all nutrition variants, higher in relation to the investigated characteristic in control variant. In all analysed genotypes of winter barley in control variant (without nutrition), those values are significantly lower. In the first

year of experiment, for lines G-3020 and G-3019, in N_3 nutrition variant (60 kg ha^{-1}), the biggest heights of plants were measured. This indicates that the effect of nitrogen on the investigated characteristic depends on applied quantity of N. For the other two analysed genotypes, G-3003 and G-3007-1/02, the biggest height of winter barley plants, on average, occurred in variant N_2 (40 kg ha^{-1}). With the increasing quantity of nitrogen (variant N3= 60 kg ha^{-1}), in the second year of experiment, the positive effect on plant height also decreases. For all the analysed genotypes, in all repetitions, the biggest heights of plants were measured in variant N2 (40 kg ha^{-1}). The exception is line G-3007-1/02 in third repetition where the value of plant height is still the highest in variant N_3.

The smallest differences between plant heights are within one line, same nutrition variant, same year, and different repetitions. Despite slight differences between the investigated characteristics in dependence on repetition, we can observe that in the first year of the experiment the average values of winter barley plant height are the highest in first repetition and in the second year in fourth repetition.

Table 1. Varying of plant height of investigated winter barley cultivars

Years	2006/07					2007/08					two-year average value
Cultivar	Nitrogen (kg ha^{-1})					Nitrogen (kg ha^{-1})					
	0	20	40	60	Average	0	20	40	60	Average	
G-3003	53.86	54.34	56.89	56.09	**55.30**	77.05	81.6	85.47	83.87	**82.00**	**68.65**
G-3020	45.15	45.78	53.04	54.35	**49.58**	78.58	80.3	83.57	82.92	**81.34**	**65.46**
G-3007 -1/02	55.64	56.25	58.02	57.55	**56.86**	74.25	78.85	81.62	80.7	**78.85**	**67.86**
G-3019	56.03	59.18	61.15	62.9	**59.81**	75.27	76.96	79.25	77.37	**78.85**	**68.51**

Table 2. Analysis of variance for height plants of barley

Source	Degree freedom	Sum of Squere	Mean squere	F value	LSD 0.05	LSD0.01
Reps	3	7.588	2.52970.215	2.1708		-
Cultivar(A)	3	210.645	19150.469	60.2611	0.8587	1.576
Year (B)	1	19150.469	304.863	16435.6338		-
CvxY (AxB)	3	914.589	205.964	261.6447	1.214	2.229
Rate (C)	3	617.892	5.784	176.7658	0.8587	1.576
CvxR (AxC)	9	52.057	9.053	4.9642	1.727	2.480
YxR (BxC)	3	27.159	12.075	7.7697	1.214	2.229
CvxYxR(AxBxC)	9	108.677	**1.165**	10.3634	1.221	1.754

The values of height of winter barley plant differ mainly between years 2006/07 and 2007/08, even though it is the same line, repetition and nutrition variant, which indicates that the weather conditions in the second vegetation period were more favourable and enabled more efficient nitrogen exploitation from soil.

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Conclusions

Based on obtained researches results, we determined that varying of plant height of analysed winter barley genotypes exists in agro-ecological conditions of Sumadija.
The application of mineral fertilizers in variants N_2 (40 kg ha^{-1}) and N_3 (60 kg ha^{-1}) led to higher values of height of winter barley plant in comparison with other variants of mineral nutrition.
The highest values of height of winter barley plant (86.4 cm) in comparison with other investigated genotypes were observed in line G-3003 in nitrogen nutrition variant N_2 (40 kg ha^{-1}).
Variability of height of winter barley plant was also determined in two different vegetation periods. For all the investigated lines, in all nutrition and repetition variants – higher values of plant height occurred in the second year of experiment.

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LEAF RELATIVE CHLOROPHYLL CONTENT AND PLANT SAP NITRATE-NITROGEN CONCENTRATION AS INDICATORS FOR PREDICTING NITROGEN STATUS IN MAIZE (*ZEA MAYS* L.)

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Abstract: Nitrogen (N) management is critical in optimizing maize yield and reducing environmental pollution. Several field tests were proposed for assessment of N status in crop plants. Aim of this study was to determine adequate leaf chlorophyll content and nitrate-nitrogen (NO_3-N) concentration in stem sap in order to predict maize N needs in different growth stages. Completely randomized block design experiment with three replications was conducted in north-west region of Croatia in 2008 and 2009 growing seasons on Pioneer A24 maize hybrid. At preplant 50 kg N ha^{-1} was applied. Treatments were four sidedressed N levels, 0, 50, 100 and 150 kg ha^{-1}, applied at three fully expanded leaves growth stage. Dynamics of chlorophyll and NO_3-N were measured by Chlorophyll content meter and Cardy twin nitrate meter, respectively, in three (V3) and seven (V7) fully expanded leaves and at silking (R1). Strong relationships between grain yield and chlorophyll content were obtained in V7 and R1 in both years (r^2= 0,78 and 0,63 in 2008 and r^2= 0,77 and 0,72 in 2009). In addition, strong relationship between grain yield and NO_3-N concentrations was observed in 2009 (r^2= 0,82 in V7 and 0,75 in R1). Chlorophyll meter readings above 31,4, 58,2 and 52,5 in 2008 and 30,3, 62,0 and 60,5 in 2009, as well as NO_3-N concentration readings above 539, 961 and 704 ppm in 2008 and 515,5, 473,9 and 478,3 ppm in 2009 at V3, V7 and R1, represented adequate values for achieving high yields.

Keywords: maize, nitrogen status, chlorophyll content, nitrate-nitrogen concentration

Introduction

To maximize grain yield, farmers often apply higher amount of N fertilizer than the minimum required for maximum crop growth (Lemaire and Gastal, 1997). However, the application of N at rates exceeding plant utilization presents an unnecessary input cost for producer and may harm environment. Assessment of several soil and plant test methods that could improve N management in maize and other crops has been reported in literature (Piekielek and Fox, 1992; Waskom et al., 1996; Schröder et al., 2000; Olfs et al., 2005). Usage of plant analysis is based on idea that the plant itself is the best indicator of N supply from soil within the growth period (Olfs et al., 2005). Actual plant N status is the result of current N status of the soil and N uptake by the plant (Olfs et al., 2005). Chlorophyll content of a plant is a good qualitative indicator for leaf N concentration due to strong correlation between chlorophyll and leaf N concentration (Olfs et al., 2005). The usage of portable chlorophyll meter (SPAD 502) for assessment of maize crop N status was tested in several studies (Waskom, 1996; Argenta et al., 2004). Plant sap nitrate test is widely accepted for assessment of vegetable crops N status, especially in potatoes (Olfs et al., 2005). Generally, when measuring N status of a crop, sap nitrate tests are more sensitive, compared to tissue analysis (Olfs et al., 2005). The aim of this study was to determine the adequate content of N in maize tissue in different growth stages, based on plant sap NO_3-N concentration and chlorophyll content measurements (CCM), and to establish the adequate N content for maize developmental stages.

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Materials and methods

Field experiment was conducted in north-west region of Croatia in 2008 and 2009 growing seasons on Pioneer A24 maize hybrid grown on Gleysol. The experiment was set out as completely randomized block design with three replications. At preplant 50 kg N ha^{-1} was applied as NPK 7:20:30 fertilizer. Treatments were four sidedressed N levels, 0, 50, 100 and 150 kg ha^{-1}, applied to soil surface at three fully expanded leaves growth stage. Potassium ammonium nitrate (KAN 27%) was used as N source. Dynamics of chlorophyll and NO_3-N were measured by Chlorophyll content meter (CCM-200 by Opti-Sciences, Inc.) and Cardy twin nitrate meter (Spectrum Technologies, Inc.), respectively, in three (V3) and seven (V7) fully expanded leaves and at silking (R1). Grain yield was determined at the harvest. Statistical analysis was performed using the SAS 9.1 statistical program (SAS Institute Inc. Cary, NC, USA, 2002/2003). In order to determine CCM and NO_3-N readings that represent adequate tissue N content for each evaluated growth stage, quadratic regression analysis between grain yield and CCM and between grain yield and NO_3-N was performed. For the growth stages in which F test of the regression was not significant, adequate CCM and NO_3-N readings were obtained following methodology proposed by Argenta et al. (2004). For the growth stages in which F test for the regression was significant, adequate reading values for CCM and NO_3^-N were calculated following methodology proposed by Waskom et al. (1996). The Cate-Nelson's graph (Cate and Nelson, 1987), modified by Piekielek et al. (1995), was used to group treatments with N deficiency and adequate N content. The 0,92 of the relative grain yield, suggested by Piekielek and Fox (1992), was used as critical level for relative grain yield. Adequate CCM and NO_3-N readings calculated for each growth stage were used as critical levels for the CCM and NO_3-N readings, respectively. Data located in upper right and lower left quadrants corresponded to treatments with N deficiency and N adequate content, respectively.

Results and discussion

The regression between grain yield and CCM readings, as well as between grain yield and NO_3-N, was not significant at V3 growth stage in both years. These results indicate that preplant N fertilization (50 kg N ha^{-1}) was sufficient for early development of maize crop. Similar results were obtained by Waskom et al. (1996) and Argeta et al. (2004). The CCM reading values of 31,4 in 2008 and 30,3 in 2009 (*Figure 1A* and *1B*) and NO_3-N reading values of 539 ppm in 2008 and 515,5 ppm in 2009 (*Figure 2A* and *2B*) corresponded to the adequate tissue N level. The adequate CCM reading values was lower in comparison to 45,4 obtained by Argeta et al. (2004) at V3-V4 stage. The regression between grain yield and CCM readings in 2008 (r^2= 0,78) and in 2009 (r^2= 0,77), as well as between grain yield and NO_3-N readings in 2008 (r^2= 0,49) and in 2009 (r^2= 0,82) was significant at V7 growth stage. The CCM reading values of 58,2 in 2008 and 62,0 in 2009 (*Figure 1C* and *1D*) and NO_3-N reading values of 961 ppm in 2008 and 473,9 ppm in 2009 (*Figure 2C* and *2D*) corresponded to the adequate tissue N level. The adequate CCM reading values were higher than 43,4 and 52,1, obtained by Piekelek and Fox (1992) and Argeta et al. (2004), respectively.

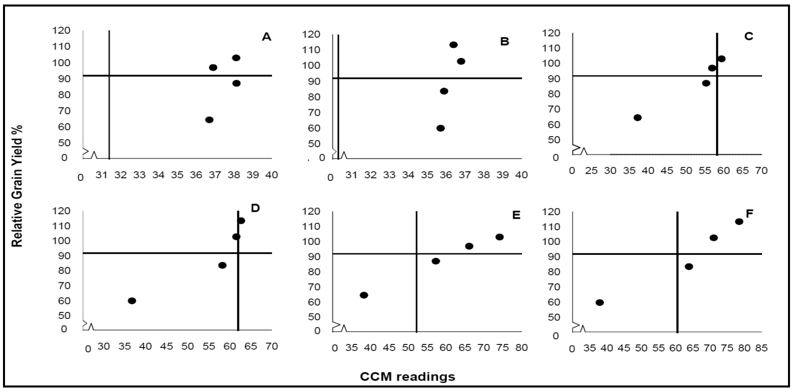

Figure 1. Relationship between maize relative grain yield and CCM readings for the estimation of adequate N level, with nitrogen deficient and sufficient levels at V3 stage in 2008 and 2009 (A and B), V7 stage in 2008 and 2009 (C and D) and R1 stage in 2008 and 2009 (C and D).

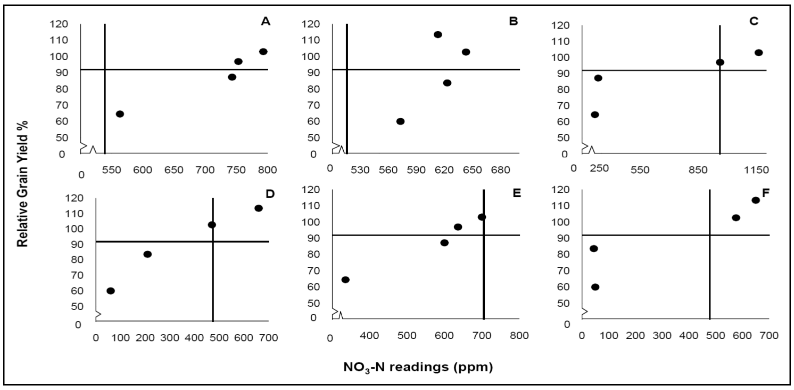

Figure 2. Relationship between maize relative grain yield and NO_3-N readings for the estimation of adequate N level, with nitrogen deficient and sufficient levels at V3 stage in 2008 and 2009 (A and B), V7 stage in 2008 and 2009 (C and D) and R1 stage in 2008 and 2009 (C and D).

The regression between grain yield and CCM readings in 2008 (r^2= 0,63) and in 2009 (r^2= 0,72) as well as between grain yield and NO_3-N readings in 2008 (r^2= 0,55) and in 2009 (r^2= 0,75) was significant at R1 growth stage. The CCM reading values of 52,5 in 2008 and 60,5 in 2009 (*Figure 1E* and *1F*) and NO_3-N reading values of 961 ppm in 2008 and 473,9 ppm in 2009 (*Figure 2E* and *2F*) corresponded to the adequate tissue N level. The estimated CCM value was lower in 2008 (52,5) and higer in 2009 (60,5) than 57,9 and 58,0 obtained by Sunderman et al. (1997) and Argeta et al (2004), respectively. Binford et al. (1992) proposed concentration of 700 ppm in stalk as NO_3-N critical level at maize maturity, while Hooker and Moris (1999) reported stalk concentration of 500 ppm as NO_3-N critical level at maize silage stage. The differences in obtained results between two studied years, as well as between our and other researcher's results, could be the result of various factors influencing leaf chlorophyll content and N uptake. Chlorophyll content can differ due to water stress (Schepers et al.1997), cultivation site

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and hybrid type (Waskom et al., 1996). Piekelek and Fox (1992) have found that colour differences may exist along the leaf blade, and that the meter types and batches may differ in their output. According to Schröder et al. (2000), factors like time of sampling in the season, plant age and day time can affect plant NO_3-N concentration.

Conclusions

The modified Cate-Nelson graph showed that the estimated CCM and NO_3-N values, wich indicate adequate N level, corresponded to the group treatments with N deficient and N sufficient levels, at all evaluated growth stages. Considering the average of two studied years, CCM readings representing the adequate N level estimated maize grain yield with accuracy of 50, 87,5 and 75%, while NO_3-N readings representing the adequate N level estimated maize grain yield with accuracy of 50, 100 and 87,5%, of the treatments in V3, V7 and R1 growth stages. When using chlorophyll and sap nitrate measurements for N-fertilizer management it is necessary to take into account possible sources of variation and strictly stick to the measurement protocol.

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GAS EXCHANGE CHARACTERISTICS OF MISCANTHUS × GIGANTEUS AS A C4 ENERGY CROP AND SOME BREEDING SUGGESTION

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Abstract: Leaf gas exchange parameters of *Miscanthus × giganteus* as environment-dependent information are discussed. Instantaneous and light response data are analyzed under natural and optimal water supplied climatic conditions of a 5-year-old plantation, in South-Transdanubia region of Hungary. Deter mining relative effect of environmental variables for assimilation and transpiration, air humidity and illumination proved to be the most effective in the regulation of gas exchange, temperature turned to be a modifying variable. Additionally, seasonal maximum and average values of assimilation, transpiration, water use efficiency and stomatal conductances were evaluated to summarize cropping tasks for a more successful cultivation.

Keywords: assimilation, transpiration, water use efficiency, stomatal conductance, Hungary

Introduction

Miscanthus × giganteus is a large perennial rhizomatous grass (Poaceae) hybrid of *M. sinensis* and *M. sacchariflorus*, native to East Asia. It is widely and currently used in numerous countries of the European Union as well as the United States as a commercial energy crop. Yield varies between 10-30 t ha^{-1}, according to climatic region, site variables, irrigation or harvesting time. Production is characterized by low fertilizer requirements making it a relatively benign crop environmentally (Lewandowski et al., 2000; Heaton et al., 2004). Miscanthus is a cool climate C4 crop, and displays a good combination of radiation, water and nitrogen use efficiency for biomass production. Plant exhibits greater photo-synthetic rate and efficiency than other kind of crops (e.g. maize) or energy plants, especially by high light interception and conversion. It has low nutritional requirements, therefore it is capable of growing well on various lands without heavy fertilization. The most important limitations for assimilation and biomass production is the overwintering and insufficient water supply in the environment (Rawson and Begg, 1977; Beale et al., 1996; Dohleman and Long, 2009; Zub and Brancourt-Hulmer, 2010). In our study assimilation, transpiration, water use efficiency and stomatal conductances related to leaf gas exchange of *Miscanthus × giganteus* are discussed. Additionally, average and maximum values of these variables as relative capacities are also presented to propose some breeding tasks for cultivation in Hungary.

Materials and methods

In situ field measuring was executed in South-Transdanubia of Hungary near Szalánta (45°57'25.6"N, 18°14'00.8"E) on luvisol soil type under natural environmental conditions, without any irrigation and heavy fertilization (*Table 1.*). Precipitation in 2010 (above 1000 mm) was 1.5 times higher as compared to 30-year-average, so that gas exchange processes must not have been under environmental water stress. Stand was planted in 2006 as a

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monocultural experimental field at the size of 0.72 ha. Leaf gas exchange measurements were carried out in the growing period of 2010 of a 5-year-old plantation. Data had been recorded on the upper fully expanded leaves by portable IRGA equipments (LCA-2 and LCA-Pro+, ADC UK, Pearcy et al. 1991), by three replicates during the growing period. Correlations by Pearson coefficient were examined between abiotic environmental variables and main gas exchange parameters based on instantaneous datasets (*Table 2.*). Statistical probability is marked by * if p<0.1, ** if p<0.05, *** if p<0.01, negative correlations by brackets, lack of significance by ns. Figures are constructed to display correlations of gas exchange rates and stomatal conductances to air humidity, photosythetic photon flux density and temperature. Seasonal maximum and average values of gas exchange were also calculated from steady-state responses under light saturation (PPFD>1500 µmol m^{-2} s^{-1}).

Abbreviations: MT, mean temperature of a month (°C); MP, mean precipitation of a month (mm); MAT, mean annual temperature (°C); MAP, mean annual precipitation (mm); RH, relative air humidity (%); Ca, ambient carbon dioxide concentration (ppm); PPFD, photosynthetic photon flux density (µmol m^{-2} s^{-1}); T_{leaf}, leaf temperature (°C); A, net assimilation rate (µmol m^{-2} s^{-1}); E, transpiration rate (mmol m^{-2} s^{-1}); g_s, stomatal conductance for water vapour (mmol H_2O m^{-2} s^{-1}); g_c, stomatal conductance for carbon dioxide (µmol CO_2 m^{-2} s^{-1}); RH, relative air humidity (%); WUE, photosynthetic water use efficiency as the ratio of A/E (µmol/ mmol).

Table 1. Soil parameters (local analysed data) and climatic conditions (http://www.worldclim.org/bioclim, http://vissycd.glia.hu/atlasz.html) in the experimental field

Soil parameters (2010)		Climatic conditions (1960-1990)			
pH (H_2O)	6.43	MAT	10.9 °C	MAP	636 mm
pH (KCl)	5.87	MT April	11.4 °C	MP April	55 mm
$CaCO_3$ (m/m %)	0.85	MT May	19.2 °C	MP May	63 mm
NO_2+NO_3 (mgN/kg)	1.20	MT June	20.9 °C	MP June	82 mm
N total (mg/kg)	1500	MT July	20.5 °C	MP July	63 mm
K (K_2O) mg/kg	227	MT August	17.1 °C	MP August	64 mm
P (P_2O_5) mg/kg	168	MT September	12.0 °C	MP September	46 mm
Mg (mg/kg)	307	MT October	6.0 °C	MP October	38 mm

Results and discussion

Among abiotic environmental parameters, relative air humidity and photon flux density turns to be the most significant for gas exchange parameter (*Table 2.*). Ambient carbon-dioxide concentration of the air and leaf temperature is not strongly correlated with the assimilation, besides it they are effective for transpiration. Water use efficiency is strongly correlated only with air humidity, and there is no immediate significant correlation with any other environmental variable.

Table 2. Correlation between abiotic environmental variables and gas exchange parameters

	RH	Ca	PPFD	T_{leaf}
A	***	(*)	**	*
E	***	(**)	**	***
WUE	***	ns	ns	ns
g_s	***	ns	*	ns
g_c	***	ns	*	ns

Relative air humidity is the most effective abiotic environmental variable, showing a strong linear correlation all of gas exchange parameters (*Figure 1. A-B*). Among them net assimilation rate has the highest humidity efficiency by the slope of the linear. Transpiration rate and water use efficiency have a significant moderate response to air humidity, being similar and comparable to each other by their slopes. Stomatal conductances have rather low values in their range of interpretation, conductance for carbon dioxide has lower efficiency than the one for water vapour by the air humidity.

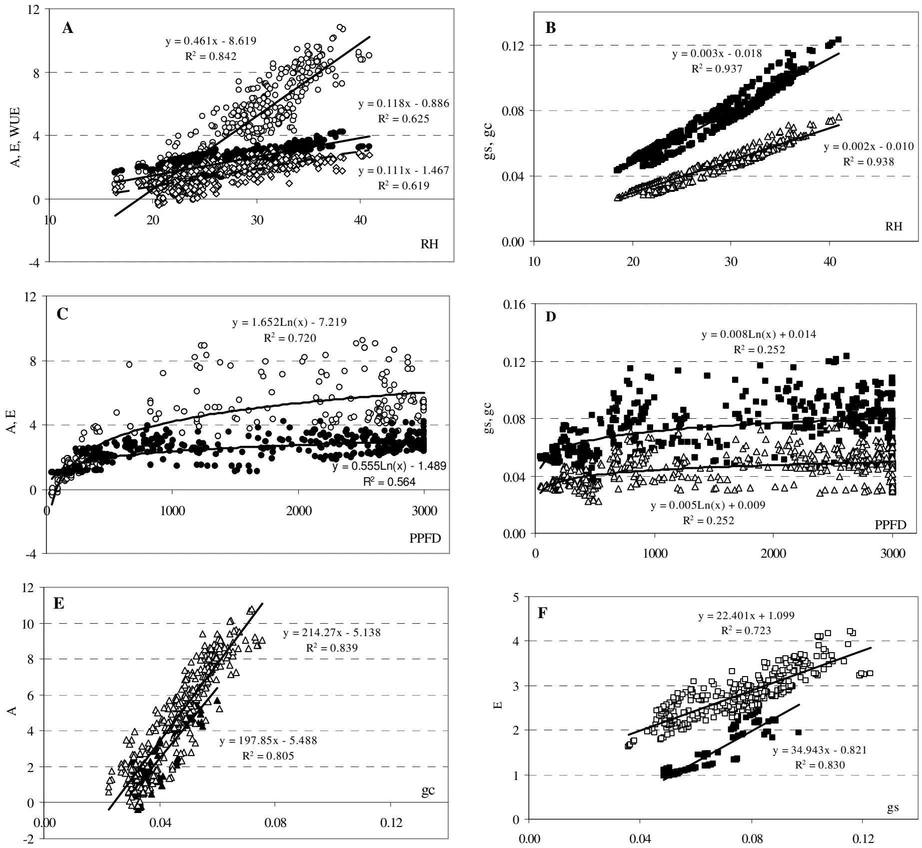

Figure 1. A) Instantaneous assimilation (○), transpiration (●), water use efficiency (◇). B) Stomatal conductance for carbon dioxide (Δ), for water vapour (■) to relative air humidity. C) Instantaneous assimilation (○), transpiration (●). D) Stomatal conductance for carbon dioxide (Δ) and water vapour (■) to photosynthetic photon flux density. E) Temperature effect on stomatal conductance to assimilation and F) transpiration, filled symbols indicate lower temperatures (■, ▲, T<30 ºC), unfilled symbols indicate higher ones (□, Δ, T>30 ºC).

Photosynthetic photon flux density has a reduced effect for gas exchange rates and conductances (*Figure 1. C-D*). Stomatal conductance for water vapour is much higher than conductance for carbon-dioxide at every illumination value, contrasted to effect for assimilation and transpiration. A strong positive correlation with diversed temperature control has been revealed between stomatal conductances and gas exchange rates (*Figure 1. E-F*). Carbon input and water output are both highly regulated by the stomatal function. Assimilation is realized under low stomatal conductance with a slightly modifying

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temperature effect, transpiration rate is controlled by high values and different temperature efficiency of stomatal conductance. Seasonal assimilation, transpiration and stomatal conductances are the highest in spring, maximum of water use efficiency is similar in summer (Table 3). Assimilation is higher with a magnitude than transpiration in every season, likewise the stomatal conductance for water vapour than for carbon-dioxide.

Table 3. Seasonal maximum and average values of analyzed gas exchange parameters.

	Spring		Summer		Autumn		Average	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A	25.77	± 1.10	16.71	± 0.56	9.81	± 0.47	17.43	± 8.00
E	6.58	± 0.18	2.56	± 0.10	1.69	± 0.05	3.61	± 2.61
WUE	3.96	± 0.19	6.49	± 0.22	5.82	± 0.24	5.42	± 1.31
g_s	0.40	± 0.01	0.17	± 0.01	0.10	± 0.01	0.22	± 0.16
g_c	0.25	± 0.01	0.11	± 0.01	0.06	± 0.01	0.14	± 0.10

Conclusions

According to our results, air humidity plays the essential role in gas exchange regulation, especially assimilation, modified by temperature function of stomatal conductances, similar to other C4 crops (Rawson and Begg, 1977; Anda and Lőke, 2003). By reasons of environmental correlations, moderate temperature and sufficient water supply are advisable for cultivation. Seasonal gas exchange values of *Miscanthus* × *giganteus* and climatic variables suggest, that abiotic environment has a great importance during spring for assimilation, and summer for transpiration to increase biomass production.

Acknowledgements

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LONG–TERM YIELD STABILITY IN MAIZE (*ZEA MAYS* L.) CROPPING

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Abstract: The objective of this study was to access adaptation of the maize cropping in the long-term experiment at the experimental field of the Institute of Field and Vegetable Crops in Novi Sad (N 45° 19`, E 19° 50`). The stability analyses were performed to evaluate interaction year by treatment and relative stability for comparing selected treatments versus yield difference of the investigated treatments. The analyses of variance for maize grain resulted with differences between treatments, while significantly higher yield was observed at 3-year crop rotation (7095 kg ha^{-1}). Stability analyses ($p < 0.05$) showed great response when linear regression was applied, and yield increasing effect of crop rotation on maize yield was inversely proportional to the ratio of the maize in the sequence. Relative stability showed that higher yield response to favorable agro-ecological condition would be with 3-year rotation ($r = 0.53^*$), along with this unfertilized rotations showed descending yield trend. The results demonstrated that a stability analysis is an appropriate method for interpretation of environment x treatment interaction observed in a long-term experiment.

Keywords: maize, yield, yield stability, environment.

Introduction

Crop sequences in long run represent a systems approach in crop production research, aiming to facilitate and efficiently utilize the available natural resources. The analysis of crop rotation data is complicated due to yearly replications, cycles and crop order, correlation errors and changes in cropping technology (Berzsenyi et al., 2000). Moreover, years are shown to be significantly different and with the inconsistency of treatment enter into year-by-treatment interaction. With such changes over time it is difficult to properly evaluate cropping systems due to the complexity of the factors influencing the yield. Several authors used regression analyses to accesses yield stability to interpreted stability analysis in crop production (Raun et al., 1993). The concept of stability implies that there is a random, unpredictable element in the performance of a cropping system. The larger this random component is, the smaller is stability of a system. A common approach to stability analysis is to correlate the performance of the system onto an environmental mean computed as the mean of all treatments in an environment. Regression techniques used to develop stability parameters are based on linear slope and deviation from that slope. Systems where the regression has a relatively large slope show an above-average response to improved environmental conditions. Mead et al. (1996) elucidate that yield stability over time involves at least three distinct component i) relationship of yield with local environment (ii) average yield level and (iii) variability of yield. With projected rapid changes in the soil-plant-atmosphere system, mainly due to CO_2 increase, yield variability will expand in the future (Birkas, 2009). Therefore maize production must be based on a stable system that changes least in response to changes in environment. The objectives of this work were to evaluate the long-term effects of different cropping system on yield and yield stability of maize.

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Materials and methods

The present study was performed on a long-term crop rotation trial carried out at the Rimski Šančevi Experimental Field of the Institute of Field and Vegetable Crops in Novi Sad (N45° 19`, E19° 50`). The trial was established on a chernozem soil. Data on climatic characteristics and soil properties was previously reported (Seremesic et al, 2008). The study treatments were: (a) a monoculture (100% maize)- MO, (b) a two-year crop rotation (50% maize)-D2, (c) a three-year crop rotation (33% maize)-D3; (d) a four-year crop rotation (25% maize)-D4; (e) twelve-year crop rotation (30% maize)-D12; f) the unfertilized two-year (50% maize)-N2 and three year crop rotation (33% maize)-N3. The treatments are fertilized with mineral N fertilizers at 120 kg ha^{-1} rate for maize (60 kg ha^{-1} in autumn and 60 kg ha^{-1} in spring). No fertilizer containing P or K or barnyard manure have been used in the trial since 1986, because the soil has had a high supply of these nutrients ever since. Stability analysis is the linear regression of treatment yield on the year agro-ecological mean (AM) yield. Linear regression analysis was carried out without the use of data transformation. Relative stability was accessed by studying the joint distribution of data pairs (means for treatment A and B in given year) and by comparing slopes and regression line when the average yield of the pair (A+B)/2 is regressed on the yield difference (A-B). Analysis of variance was used to separate treatment means when there was a significant difference at the $P<0.05$ level.

Results and discussion

In the combined analysis of variance over years the effects of crop sequences containing various proportions of maize showed significant F-test ($P<0.01$**) for cropping systems and years, since treatments means and year for the period 1991-2010 were different (Lente and Pepo, 2009). The design structure employed does not differentiate year-by-treatment interaction since this source of variation is represented with error (*Table 1.*). Cropping system is accounted for 50.84% variation of yield, year contribution is 37.08%, whereas remaining 12.06% variation of yield derives from residual influences.

Table 1. Two-way analysis of variance for maize grain yield (1991-2010)

Source of variation	d.f.	s.s.	s.s.%	m.s.	F	P
Cropping system	6	421300322.	50.84	70216720.	80.05**	<0.01
Year	19	307393366.	37.08	16178598.	18.44**	<0.01
Error	114	100001010.	12.06	877202.		
Total	139	828694698.	100	5961832.		

**-significant at P=0.01 level

The analysis of the 20-year data showed that unfertilized rotation was significantly lower in yield (*Figure 1.*). Among fertilized rotation MO demonstrated significant yield reduction, and higher yields (7095 kg ha^{-1}) were obtained in D3, however with no statistical difference compared to D2, D4 and D12. Lower yields in a MO are mainly observed after a dry winter, summer droughts, and in increased weed pressure. The yield-increasing effect of rotation on the maize yield was inversely proportional to the ratio of maize in the sequence (Pepo, 2009). In the fertilized rotations yield variability is relatively large, higher in MO (2021 kg ha^{-1}) and lowest in D12 (1763 kg ha^{-1}).

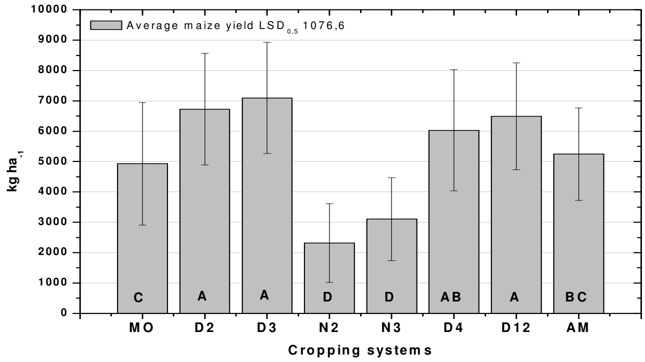

Figure 1. Average yield of maize of different cropping systems of the invetigated long – term experiment and the agroecological mean (AM) (*A-D Data followed by the same letter do not differ at the P ≤ 0.05 level)*

The regression method of stability analysis shows that the stability of various crop sequences differed, and that the observed *r* strongly corresponded with the AM (*Table 2*.). The difference can be attributed to the significant variation between the intercepts, and capacity in utilization of environmental resources. The higher compatibility of coefficient of determination was found with D3. With high response of applied linear regression in all cropping systems, D4 showed higher yield increase with each unit of AM increase (*b* = 1.16), though similar response was find with MO, D2 and D3.

Table 2. Yield stability of different cropping system against agro-ecological mean yield

Cropping systems		Correlation				t-test		
Treatment	% Maize	Equation	SD	R	r^2	SE	t-stat	p
MO	100%	y=-1101,75+1,15x	1041,08	74.9%	0.86**	0.15	7.32**	<0.01
D2	50%	y=724,7+1,14x	604,45	89,8%	0.94**	0.09	12.56**	<0.01
D3	33%	y=1069,72+1,14x	545,97	91,5%	0.96**	0.08	13.95**	<0.01
N2	50%	y=-986.74+0,630x	895,16	54,7%	0.74**	0.13	4.66**	<0.01
N3	33%	y=-440,00+0,675x	923,12	56.2%	0.75**	0.14	4.80**	<0.01
D4	25%	y=-99,05+1,16x	927,10	79.5%	0.89**	0.14	8.36**	<0.01
D12	30%	y=833,13+1,07x	644,08	86.6%	0.93**	0.10	10.77**	<0.01

***-significant at P=0.01 level*

The relative stability had much lower *r* compared with normal stability analyses (*Table 3*.). Significant but weak relative correlation with yield differences was found under MO, D2, D3 and D4. The unfertilized rotation showed no significant correlation indicating a lack of environmental interrelation in favor of an independent system driven by complex interactions. Observed relative stability *r* were nearly half value of stability analyses. The higher yield increase with each unit of yield differences increase showed D3 (*b* = 1.54), and N2 had a decreasing yield trend. The major difference among stability analyses and relative stability is elimination of possible interdependence among regression. Therefore observing slopes significantly different from zero implies that environment specific treatment response did exist. To determine whether the slope

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will not equal zero hypothesis was tested H_0:ß1=0. For the normal stability analyses null hypothesis was rejected since p-value is less than significance level (p<0.01**) and slope will differ from zero. However, within relative stability hypothesis was accepted for N2 ($p<0.32^{ns}$), N3 ($p<0.51^{ns}$) and D12 ($p<0.102^{ns}$) since slope will be equal to zero. Conversely, hypothesis was rejected for MO (p<0.02*), D2 (p=0.02*), D3 (p<0.01*) and D4 (p<0.019*). This combined regression analyses revealed the importance of the year, rotation, fertilization and environment. Generally, MO demonstrated satisfactory level of adaptation to environment although significant yield variation was observed.

Table 3. Relative yield stability of different cropping system against agro-ecological mean yield

Cropping systems		Correlation				t-test		
Treatment	% Maize	Equation	SD	R	r^2	SE	t-stat	p
MO	100%	y=5342+0.822x	1523	24.9	0.5*	0.336	2.44*	<0.02
D2	50%	y=3975+1.35x	1462	26.3	0.51*	0.53	2.53*	0.02
D3	33%	y=3322+1.54x	1435.8	28.7	0.53*	0.57	2.69*	0.01
N2	50%	y=2915-0.295x	1312	5.4	-0.23	0.29	-1.02^{ns}	0.32
N3	33%	y=3736+0.203x	1372.3	0.4	-0.16	0.30	-0.67^{ns}	0.51
D4	25%	y=4272+1.11x	1468	26.9	0.52*	0.36	2.57*	0.019
D12	30%	y=4496+1.15x	1520.6	14.1	0.36	0.53	1.72^{ns}	0.102

**-significant at P=0.01 level, *-significant at P=0.05 level, ^{ns}- not significant

Conclusions

The significantly higher yield was observed at 3-year crop rotation (7095 kg ha^{-1}) compared with other cropping systems. Stability analyses showed good adaptability of all investigated cropping systems. However, when relative stability was applied D3, D4, D2 and MO, respectively, were most successful in utilizing environmental resources. As issue of sustainability become increasingly important stability analyses and relative stability may help in understanding of yield as a function of environment.

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MODELING OF RETURN OF EXCESS INVESTMENT IN PRECISION AGRICULTURE

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Abstract: Precision farming is well known and widely applied technology in Hungary for nearly two decades. In order to apply the technology, the technical conditions (reliable navigation system, sensors, etc.) have to be available. Preliminary research of the technical conditions – in which various types of difficulties appeared – is behind us. The measurements in our study field are dated back to 2001, which provides long enough time horizon to perform Return of Investment (ROI) analysis. In this study, different investment alternatives under two different return intervals (5 and 6 years respectively) are analyzed. A model calculation - based on the measured data - for precision agriculture management technology was carried out. The model has calculated the ROI for each treatment units taking costs of variable rate application (VRA) of applied amount of nutrients, and all other expenses on the input side and yield, as an indicator of the output side into consideration. According to the calculations – in favorable conditions – the excess investment into the technology pays back in a 6 year period in a 33 ha size farm.

Keywords: precision agriculture, ROI, nutrient replenishment, farm size, investment.

Introduction

In recent publications concerning precision farming most papers are written on plant conditionality implementation or technical issues and development of the technology. This approach is very important as precision farming relies on technical and technological development, however most papers does not mention the economical conditions. In the limited number of papers that have been published in Hungary focusing on economical issues, economics of site-specific weed control is discussed.
Precision farming research in Hungary has begun in the late '90s by the Hungarian Academy of Sciences (Győrffy, 2000). Various institutes started to apply the most up-to-date plant production practice, and worked on the development of the technology (Neményi et al., 2003; Milics et al. 2010). The economic aspects of the technology were not investigated until sufficient enough information was not collected. The technical conditions of precision farming in the experimental field were published in many papers (Mesterházi, 2004; Milics, 2007; Milics et al., 2008), however the first paper based on economic approach was published only recently (Smuk et al., 2009). In Hungary only limited reliable data is available on economic issues for the public; at the same time international literature has been dealing with the economic aspects of the older technology, (Lowenberg-DeBoer, 1996, Godwin et al., 2003). The topic appeared in national publications, primarily on weed control efficiency and precision aspects of the return assessed (Takácsné-György et al., 2008, Lencsés – Takácsné-György, 2008). Examining the issues of plant protection in 2003, Takácsné notes that up to 40% savings can be achieved by precision plant protection technology. Kalmár et al. (2004) states that high cost of investment is worth only if the farm size is more than 1,000ha. Reisinger et al. (2008) reports 18% savings in pesticides and €16.3 per hectare extra income in case site-specific pest control is applied.

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The model developed by Takácsné and Lencsés (2008) shows that in a 250 ha size farm the return of additional investments pays back in 10 to 20 years.
Our calculations showed much less time and smaller farm size. For the experiments and calculations a nutrient replenishment model developed by the Research Institute for Soil Science and Agricultural Chemistry, Hungarian Academy of Science was used (Csathó et al., 2007).

Material and methods

The present study is based on a mathematical simulating model, which is analyzing the profit differences between conventional and precision farming systems. The resulting income difference (ΔI) is the result of the calculation of return of investment for each year's positive cash flows. The model enhances the data to the necessary farm size of return of investment. The income differences are the differences between earned incomes by precision farming and conventional farming system during the investigated time period. The income difference is calculated as the follow:

$$\Delta I = (Production\ Value_{prec.} - Total\ Cost_{prec.}) - (Production\ Value_{conv.} - Total\ Cost_{conv.})$$

In the calculations we assumed that the farm already has the necessary farming equipment (tractors, machinery, combine harvester, transport means, etc), and these instruments can be adapted through minor alterations in precision farming.
For the model calculation, the technological details of the whole system (site-specific crop and pest management) the data resulted from our measurements (yield maps, site specific nutrient replenishment) were used. For the extra investment, essential items of site-specific nutrient replenishment was calculated including yield mapping system, positioning system, engine and machinery conversion. The calculations are based on two different configurations. Configuration "A" is the system used by University of West Hungary, Institute of Biosystems Engineering, which is a capital-intensive system due to the fact that investment was made in a research phase /4,587,180 HUF/; configuration "B" is a recently available system on the market /3,247,400 HUF/.
The standard conditions of the model are: exchange rate is 260 HUF $€^{-1}$, calculative interest rate is 8.257% based on the data of the Hungarian Central Bank. The farm size for return of investment is determined for the net present value (NPV) = 0 and the profitability index (PI) = 0.

Results and discussion

Our calculations resulted that the return on investment is highly dependent on projected useful lifetime and significant farm size varieties (*Table 1.*).

Table 1. The return on the necessary scale at standard conditions (ha)

Alternative of investment	Time of return	
	5 years	6 years
Configuration „A"	112	46
Configuration „B"	79	33

It is important to emphasize that if the payback period is reduced by one year, the farm size will be increased to a 2.5-fold for the same ROI. This is important information for

the decision makers as many other factors such as tax issues, depreciation issues, the nature of assets, useful lifetime etc. are depending on the calculations.
The investment needs to be examined in terms of exchange rate changes (*Figure 1.*).

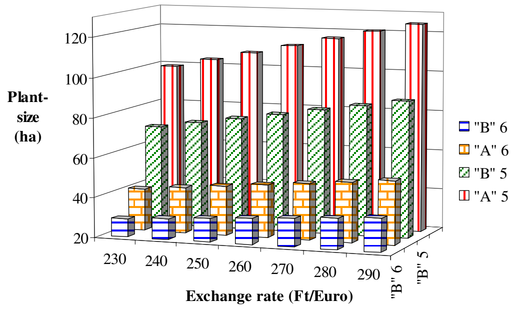

Figure 1. The HUF/€ exchange rate impact on the returns necessary for plant size (ha)

The exchange rate development has undoubtedly serious consequences for the returns and through this the required farm size. The difference between the upper and lower course is 26.09%. The difference between the two endpoints of farm size is the same as the difference between the courses. It is important to point out, that investment deviation is possible in certain versions of the efficient farm size of up to 304%. This fact is important, because the badly chosen conditions for a small farm, can threaten the return on investment. Uncertainty of investments in agriculture will increase due to the unpredictable weather conditions causing yield losses. In the commodity crops irrigation is not widely applied, which could reduce weather risks of yield due to losses. By using model calculation we determined, that the uncertainties inherent in the nature of agriculture is caused by changes how it would affect the return on investment.

Table 2. The effect of yield changes in the returns required plant size (ha)

Alternative of investment	Yield changes (%)				
	-10%	-5%	Standard	+5%	+10%
Configuration „A” 5 years payback period	150	128	112	100	89
Configuration „A” 6 years payback period	56	51	46	43	40
Configuration „B” 5 years payback period	106	91	79	70	63
Configuration „B” 6 years payback period	39	36	33	30	28

The ROI is very sensitive to yield changes. At 5 years payback period an annual 5% decline in yields increases the required farm size by 14.53% for ROI. A further 5% reduction in yields induces 16.99% growth in the necessary plant size for the return. The rate of return responds with increasing to decreasing in crop yields. In the opposite case when yields are increasing 5% the necessary farm size decreases by only 13.04%, while a 5% re-growth of yields, would result only in a further 11.26% reduction.
If we examine the 6 year payback period, than we could not recognize so strong effects at yield changes as compared with the 5 years payback period. A -5% change in yield

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increases the necessary farm size for the return by 8.91%, while a further 5% yield loss is causing another 9.80% increase in the required farm size. In the opposite direction of changes, 8.20% and 7.56% decrease in farm size was the result. If the payback period is longer by one year it is significantly reduces the yield losses caused by the increase of farm size, therefore significantly reduces the investment risk. The two modeled results differ between the end points 67.98% at the five-year return, and 39.17% at the six-year time period on the basis of return (*Table 2.*).

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UTILIZATION OF ARABLE AREAS FLOODED BY RED SLUDGE FOR ENERGY PLANT CULTIVATION

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Abstract: On 4th October 2010 the most serious industrial disaster of the Hungarian history took place: the Veszprém county settlements of Kolontár, Devecser and Somlóvásárhely were flooded by heavily polluting alkaline red sludge. A few days after the disaster members of the Szent István University Faculty for Agriculture and Environmental Studies and of the Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences supported by a number of enterprises arrived in the area to carry out surveys and examinations related to the rehabilitation of non-residential areas. The measurements carried out on-site as well as the laboratory analysis results of soil samples clearly prove earlier assumptions, that is, the heavy metal content of the soil does not reach the pollution limit value of soils and the pH level did not increase significantly in the examined 90 cm deep soil layer. It can be concluded that the damages in non-residential areas are less significant than it had been assumed based on the damage witnessed in residential areas. The area can be made suitable even for food raw material production in a short time (1-2 years). In spite of this it is necessary to alter soil use completely due not so much to habitat damage but to market conditions and psychological impacts. For this, a three-step remediation plan was developed. The present article discusses the main conclusions of the two-month research drawn so far as well as recommendations for arable land rehabilitation.

Keywords: red sludge, heavy metal, energy crop, three-step remediation

Introduction

Red sludge is the by-product of bauxite based aluminium production. Bauxite is a mineral raw material that consists of minerals with aluminium content and other components like iron and silicon compounds. When bauxite is processed with the so-called Bayer technology (this technology is used in Ajka) its aluminium content is separated from the other components with sodium hydroxide in strongly alkaline conditions. The produced main product is called alum earth from which metal aluminium is produced using electrolysis. The by-product of alum earth production is red sludge with high iron content and a characteristic colour. As the name suggests, it is a mud-like material with liquid as well as dry matter content. Its further characteristic feature is that it flows easily in its original form, and its flow features change depending on its moisture content and the pressure it is subjected to. Just like in Ajka, red sludge is stored in reservoirs worldwide. Due to the technology applied, a certain proportion of sodium hydroxide used in the separation process remains in the red sludge and causes it to be strongly alkaline. Its pH is typically between 12 and 14 (MTA KK AKI – Hungarian Academy of Sciences Chemical Research Centre).
According to effective EU regulations (94/904/EC directive) red sludge is not considered to be hazardous waste. When it gets into the environment, however, it becomes a potential source of danger threatening the human population, animals and plants as well as the environment (air, water and soil) that comes into direct contact with it. Red sludge threatens the man-made as well as the natural environment due to its strongly alkaline nature (MTA TAKI 2010).

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A disaster similar to the one that occurred in October 2010 has not yet happened anywhere so there is no previous experience that could be applied for the recultivation of arable land (Gyuricza et al., 2010). In the present study the first soil examination results and the three-step remediation process developed are introduced.

Materials and methods

The region affected by the disaster is situated on the upper watershed area of Marcal in the valley of the Torna stream. Most of the area is covered by loess, muddy, sandy river and slope deposits. The surface soil has a typical light mechanical composition (pebbly sand, sand or loam sand) with occasional muddy, clayey inter layers. On the older and higher areas brown forest soils have formed on the loess deposits while the lower-lying areas have hydromorphic humic gley or river valley soils. The higher territories have pebbly brown soils with thin fertile layers and in smaller patches humic gley chernozem soils. The depth of underground water is generally 2 to 4 meters while in the lower-lying areas 0.5 to 1.0 m with seasonal changes. The groundwater normally has calcium-magnesium hydro-carbonate content.

During the survey soil samples were collected from the upper 90 cm of the soil (0-30, 30-60, and 60-90 cm). Sample taking spots were selected so that areas covered by vegetation (clover and corn) and cultivated are both included. Samples were taken three times based on which an average sample was prepared. Basic and nutrient examinations were conducted and the amounts of the most important toxic elements were measured. The elements of the three-step remediation were elaborated on the basis of site specifics, site surveys and laboratory examinations.

Results and discussion

As a result of the disaster the alkaline red sludge covered about 1000 ha of arable land. On site examinations show that the sludge layer stayed on the surface of the soil. It only flowed into occasional cracks and did not mix with the arable soil. The surface pollution of the soils varied depending on the thickness of plant growth, angle of slope, the distance from the place of burst and the speed of the mud current. On already cultivated land surface free from plants the depth of the sludge left behind was a maximum of 1 to 2 cm. Due to the fast flow and in some areas to the high moisture content of the soil the alkaline fraction reached the deeper layers to a very small extent or not at all. We concluded that the heavy metal content of the soil does not reach the pollution limit value of soils and the pH level did not increase significantly in the examined 90 cm deep soil layer (with the exception of the top 10-20 cm) (*Tables 1-2.*). These areas (about 40 to 45 per cent of the total arable land) can be used again without the removal of the red sludge. The most serious damage occurred in the areas farthest from the site of burst. In these areas the flow of the sludge slowed down and collected in the deeper parts of the surface. It is in these areas that the largest amount of sludge and soil layer had to be removed, and it is also in these areas that the pH level increased.

Table 1. Results of basic pedological and nutrient examinations based on soil samples taken in arable land areas affected by the red sludge disaster (Kolontár, 16 October 2010)

Plant	Depth (cm)	K_A	pH_{KCl}	$CaCO_3$ %	Total salt %	Humus %	NO_2+NO_3-N mg kg^{-1}	P_2O_5 mg kg^{-1}	K_2O mg kg^{-1}
Corn	0-20	60	7.3	12	0.05	3.4	3.92	46.4	83.8
	20-40	43	7.2	11	0.07	3.5	4.93	37	63.3
Clover	0-30	47	7.3	9	0.07	2.0	27.1	93.3	97.1
	30-60	45	7.3	11	0.05	1.6	6.0	45	73.1
	60-90	44	7.2	6	0.07	2.2	3.6	80.8	45.5
Ploughed surface	0-30	36	7.8	7	0.13	2.0	27.7	112	83.8
	30-60	43	7.2	5	0.07	2.0	1.1	33	88
	60-90	38	7.4	9	0.02	1.2	2.9	181	40.9

Table 2. Results of soluble toxic element content based on soil samples taken in arable land areas affected by the red sludge disaster (Kolontár, 16 October 2010)

Plant	Depth (cm)	Arsenic	Cadmium	Chrome	Copper mg	Mercury kg^{-1}	Nickel	Lead	Zink
Corn	0-20	9.8	<0.02	28.9	12.4	<0.05	28.2	7.5	63.1
	20-40	20.2	<0.02	36	14.1	<0.05	36.6	7.2	78
Clover	0-30	8.3	<0.02	25.5	10.5	<0.05	26.3	8.5	59.1
	30-60	8.9	0.087	26.9	10.8	<0.05	27.8	5.4	57.8
	60-90	9.9	<0.02	29	9.9	<0.05	27.8	3.8	55.5
Ploughed surface	0-30	8.8	0.039	25.9	8.5	<0.05	23.9	6.5	50.4
	30-60	12.8	<0.02	41.2	12.3	<0.05	37.7	4.8	77.1
	60-90	6.1	<0.02	14.8	6.5	<0.05	19.2	3.8	39.7
**Pollution limit value*		***15***	***1***	***75***	***75***	***0.5***	***40***	***100***	***200***

*in accordance with 10/2000.(VI.2.) KöM-EüM-FVM-KHVM (Ministry of the Environment, Health Ministry, Ministry of Agriculture and Rural Development, Ministry of Transport, Communication and Water) Common Decree

For the revitalization of the arable land area affected by the disaster it is necessary to elaborate processes that are capable of restoring the cultivation area to its original state. The three-step remediation (3R) was developed for this purpose (*Figure 1.*)

Step 1: The key element of habitat revitalization is the recovery of soil biological activity and the prevention of the dusting out of the red sludge. In order for these to happen, a special soil improving and yield enhancing product (compost-turf mixtures) was used (1st remediation step). This step increased the biological activity of the soils as well as their nutrient storage capacity thanks to the high adsorption capacity, increased the immunity of energy plants (willow and poplar) against germs and pests, established a stable soil structure and improved the water, heat and air management of soils. After spreading the material, it needs to be turned into the soil with a disc (to a depth of max. 10 cm).

Step 2: Right after the compost-turf mixture was spread annual plants were sown on the area (2nd remediation step), which ensures the quick cover of the soil with vegetation and organic matter replacement. For this purpose, undemanding plants with fast growth

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rate (e.g. triticale and rye) were used. In spring the green plant mass will be crushed with stem shredder, which will result in a high volume of mulch cover.
Step 3: Creating a ligneous plantation (3rd remediation step). Planting is possible with 150-200 cm long stick cuttings or 20-22 cm long plain cuttings. A stick cutting is a one-year-old ligneous plain cutting without roots planted 40-50 cm deep. The foliage that falls in the autumn protects the soil surface and provides organic matter. The plants can be first harvested in 2 years and then for the next 10 to 16 years the biomass can be cut with the same cutting cycle.

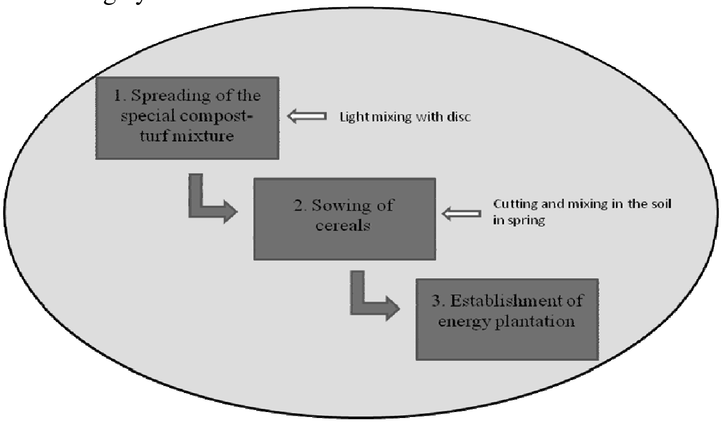

Figure 1. The schematic of the three-step remediation (3R)

Conclusions

In summary, it can be concluded that the disaster caused less damage in non-residential areas then it could have been expected based on the damage caused in residential areas. The area can be made suitable even for food raw material production in a short time (1-2 years). In spite of this it is necessary to alter soil use completely (through growing energy plants with the role of landscape rehabilitation and regeneration) due not so much to habitat damage but to market conditions and psychological impacts. For selecting the most suitable energy crop various aspects need to be considered (ecological, market, social and socio-economic). Based on these, the cultivation of ligneous energy crops with a systemic approach is the most efficient and secure solution. The specifics of the site make the area absolutely suitable for growing willow, poplar, acacia and various other energy crops. The buying up of the biomass can be done by the nearby power plant. At the same time, the heat energy needs of the rebuilt settlement districts could thus be supplied from renewable energy sources.

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NITROGEN FERTILIZER EFFECTS ON GRAIN WEIGHT PER SPIKE IN WINTER BARLEY (*HORDEUM VULGARE* L) LINES

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Abstract: Variability of grain weight spike^{-1} was studied in four barley genotypes: G-3003, G-3020, G-3007-1/02 and G-3019, grown over two years under four nitrogen nutrition treatments: 0, 20, 40 and 60 kg N ha^{-1}. The experiment was set up as a randomised block design in four replications. Differences in average values of grain weight spike^{-1} among tested cultivars were determined in both years and under all nitrogen fertilisation treatments. On average, for all genotypes, grain weight spike^{-1} increased with increasing nitrogen rate. On average, grain weight spike^{-1} in both growing seasons and under N treatment was the highest in barley line G-3019 (1.18g) and the lowest in barley G-3020 (1.08g). Total phenotypic variability of grain weight per spike was mostly affected by mineral nitrogen nutrition, to a much lesser degree by line, and negligibly so by the line × nitrogen interaction, suggesting significant dependence of the trait on the cultural operations used.

Key words: barley, line, grain weight, spike, nitrogen

Introduction

During the first ten years of this century, barley (*Hordeum vulgare* L.) was cultivated on 130,000 ha in the Republic of Serbia. However, barley area has reduced to 90,000 ha over the past two years (Pržulj et al., 2010). The decrease in barley area cannot be compensated for through an increase in grain yield per unit area as barley is also grown on soils of poorer quality and under less favourable semiarid environments.

High grain yield and quality of barley are largely dependent upon choice of cultivar and use of adequate cultural operations, particularly optimal nitrogen fertilisation. Increased nitrogen fertilisation generally results in a linear or quadratic increase in grain yield of barley. However, high N rates can lead to moisture stress due to intensive vegetative growth which involves depletion of moisture reserves for subsequent grain filling. Increased nitrogen levels induce more intensive vegetative growth, higher spike number m^{-2} and reduced grain number per spike, and have variable effects on grain weight (Christensen and Killorn, 1981; Gonzales Ponce et al., 1993; Paunović et al., 2008; Madic et al., 2009). Gonzales Ponce et al. (1993) suggest that the soil moisture × nitrogen level interaction is the major determinant of grain yield in barley.

An optimal strategy used in nitrogen fertilisation of malting barley is aimed at increasing grain yields coupled with maintaining low grain nitrogen levels for malt quality preservation (Baethgen et al., 1995). The same authors stress the importance of supplying small amounts of nitrogen during the sowing stage for initial growth and stem emergence as well as additional amounts, depending on the crop and soil management systems used, at the end of the tillering stage.

The objective of this study was to evaluate the effect of increasing rates of mineral nitrogen applied during the growing season on grain weight per spike as a yield component in four promising lines of two-row winter barley.

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Materials and methods

The trial was conducted at the experimental field of the Small Grains Research Centre in Kragujevac during the growing season of 2006-2007 (2007) and 2007-2008 (2008). The soil used in the trial was pseudogley having poor physical properties, an acid pH (pH_{H2O} = 4,5) and the following content: humus 2,18%, readily available phosphorus 8,0 mg 100^{-1} g soil and potassium 15,0 mg 100^{-1} g soil. This study involved four promising lines of two-row winter barley: G-3003, G-3020, G-3007-1/02 and G-3019, and four mineral nitrogen (N) treatments, including control (0), 20 kg N ha^{-1} (N20), 40 kg N ha^{-1} (N40) and 60 kg N ha^{-1} (N60). Nitrogen in the form of the mineral fertiliser Calcium Ammonium Nitrate (27% N) was applied at the beginning of March during the initial stage of intensive growth (stem elongation). The experiment was set up as a randomised block design in four replications with a plot 5 × 1 m ($5m^2$) in size. Plants were sown using a small mechanical planter during the second ten days in October at a row spacing of 12,5 cm and a within-row spacing of 3 cm. During the full maturity stage, a sample of 30 primary spikes was collected, and grain weight per spike was measured.
The obtained results were subjected to a two-factor (line, nitrogen) analysis of variance using the SPSS software (1995). Individual differences between means were tested by an LSD test.

Results and discussion

Grain weight per spike is a yield component dependent upon productive tillering, spike length, grain number per spike, soil fertility, nitrogen supply and plant density (Pepo and Gyori, 2005; Kovacevic et al., 2006; Lalic et al., 2006; Izsaki et al., 2007; Knezevic et al., 2008). Sinha et al. (1985) suggest that barley selection during early generations should focus on increasing both grain number per spike and spike length and, then, during subsequent cycles, it should aim at increasing grain weight per spike i.e. thousand-kernel weight.

Table 1. Analysis of variance for grain weight per spike in barley lines during 2007 and 2008

		Year					
		2007			2008		
			Variance components			Variance components	
Source of variation	df	F-test	σ^2	%	F-test	σ^2	%
Genotype	3	25.10**	38.92×10^{-4}	27.57	59.36**	20.74×10^{-4}	17.95
Nitrogen	3	88.56**	90.71×10^{-4}	64.28	136.63**	77.40×10^{-4}	66.98
Line x nitrogen	9	1.87ns	0.77×10^{-4}	0.55	1.29	3.11×10^{-4}	2.69
Residual	48		10.72×10^{-4}	7.60		14.29×10^{-4}	12.36
Total	63						

** F –test significant at 0,01, ns F-test non-significant

The analysis of variance reveals significant differences in grain weight per spike among genotypes and N application rates in both years (*Table 1.*). As regards total phenotypic variability of grain weight per spike in both years, the highest effect was exhibited by N, followed by line, and the line × nitrogen interaction. This suggests that the trait is significantly dependent upon the cultural operations used. During the first year, the lines showed significant differences in grain weight per spike: the value of the trait was the highest in G-3019 and G-3007-1/02, followed by G-3020, and the lowest in G-3003 (*Table 2.*). Significant differences among the lines in grain weight per spike were also observed in the second year, with the values measured being as follows in descending order: G-3019, G-3007-1/02, G-3003, G-3020 (*Table 2.*). The increase in N application rates up to 40 kg N ha^{-1} in the first year resulted in a significant increase in grain weight per spike (*Table 2.*) in all barley lines.

Table 2. Grain weight per spike (g) in winter barley lines at different nitrogen application rates (kg N ha^{-1}) in 2007 and 2008

	Years	
	2007	2008
Line (A) G-3003	0.97c	1.23c
G-3020	1.03b	1.16d
G-3007-1/02	1.07a	1.27b
G-3019	1.08a	1.30a
Nitrogen (B) 0	0.92c	1.13d
20	1.02b	1.20c
40	1.10a	1.30b
60	1.04a	1.34a
ANOVA A	**	**
B	**	**
A×B	ns	ns

Mean values for lines and nitrogen rates within columns designated with same small letters do not significantly differ at 95% according to LSD test
** F –test significant at 0,01, ns F –test non-significant

In the second year, grain weight per spike increased in all genotypes with N rate increasing to 60 kg ha^{-1}. A number of authors have indicated that increased N rates lead to a significant increase-decrease in grain weight per spike (Pepó, 2005; Paunović et al., 2007; Knežević et al., 2007; Paunović et al., 2008). Conversely, Baethgen et al. (1995) previously suggested that increased nitrogen rates in malting barley did not have a significant effect on grain weight. A three-year study conducted by Gonzales Ponce et al. (1993) showed that grain yield increase in two-row barley induced by increasing nitrogen rates (0 - 160 kg ha^{-1}) was mostly attributed to the increase in spike number per m^{-2}, with grain weight remaining constant or even increased during years receiving higher rainfall. Analysing the relationship between grain yield and yield components in two-row barley, Barczak and Majcherczak (2009) reported the highest correlation between grain yield and spike number per m^{-2}, as well as between grain yield and grain number per spike, regardless of soil nutrient supply. The same results were previously reported by Dofing and Knight (1994) in their analysis of grain yield and yield components in uniculm lines, where increased grain number per spike led to a slight decline in grain weight.

Conclusions

Grain weight per spike showed significant differences in the tested barley lines in both years notwithstanding the N rate applied. The phenotypic variance components show

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that total variability for the trait was mostly affected by mineral nitrogen nutrition, to a much lesser degree by line, and negligibly so by the line × nitrogen interaction, suggesting significant dependence of the trait on the cultural operations used. The increase in grain weight per spike was induced by increasing nitrogen rates up to 40 kg N ha^{-1} and 60 kg N ha^{-1} in the first and second years, respectively, in all lines.

The significant differences observed among the lines in both years, at different nitrogen application rates, suggest that grain weight per spike is a genotype characteristic and a potential criterion in barley selection for increased grain yield.

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THE CROP SITE – PLANT INTERACTION WITH SPECIAL REGARD TO BIOENERGY PRODUCTION

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Abstract: Biomass is a diverse concept. Primary biomass means the natural vegetation that can be utilised in an energetic way. Both food and energy can be produced from biomass. The interpretation of the production site characteristics and the production features and interactions of crops are especially important from the aspect of energy crop production. The production and yield safety of energy crops determine the safety and quality of bioenergy production, as well as the efficiency and economicalness of the technology used in production. All these can only be systematically realised if the complex correlations between the production site and crops are well interpreted. During the last couple of years, it has been proven that energy plantations and the crops grown for various energetic use can also safely provide yield in weak areas or fields that are prone to high levels of inland water if adequate production technologies are used. Different feedstocks need different technology in order to obtain bioenergy. It would be a significant step forward if a decentralised feedstock supply-utilisation infrastructure could be established in the small regions that would be able to satisfy the local energy demand in local bioreactors, using locally produced feedstock. The logistic costs would also decrease if there was not any need to transport the feedstock at long distances. Biomass-based energy production has important extra effects on rural development.

Keywords: energy crop, crop site, soil type, climate, rural development

Introduction

Land use in Hungary is continuously changing (Kohlheb, 2003). If we do not want to face overproduction or masses who became unemployed because of uncultivated lands, we have to implement a significant change in the agricultural structure (Szendrei, 2005). In Hungary, profitability cannot be easily guaranteed when growing the traditional field crops even on several hundreds of thousand hectares. These areas are often wet and prone to inland waters, but there is a significant area of sandy or sandy adobe soils that have extreme water and nutrient management. Nevertheless, all soils used for agricultural production are suitable for producing rapidly growing tree species (Gyuricza, 2009). At the same time, due to their deep roots, woody crop species are able to utilise their production site endowments better (Gyulai, 2010). Energy production from biomass can be implemented by using both woody and herbaceous crops (Janzing B. 2001). Woody plantations have outstanding economic prospects (Szajkó, 2009). The aim of growing energy plantations is to produce field or forest plants from which energy can be extracted (Energy newsletter, 2010). As regards the energy plantations grown in the field, it is practical to apply the principle of relative sustainability (Ministry of Rural Development, 2007). In Hungary, mainly poplar and acacia are used to perform experiments with the aim of energy production (Orlovic and Klasnja, 2004). Using clones that have improved traits as a result of breeding or selection makes it possible to achieve higher biomass yield at a lower cost in comparison with traditional species (Barótfi, 2000). The utilisation of biomass for energetic purposes gives settlements a chance to ease their considerable dependency and to learn how to exploit their local endowments (Energy Club, 2005).

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Materials and methods

The aim of my research was to examine whether the energy tree species plantations in Hungary were established on production sites that conform to the species' needs. I carried out my research on the basis of the 2008 survey of the Central Agricultural Office (CAO). Before establishing a plantation, the applicants have to prepare a plan that they submit to the CAO for authorisation. Based on the certification by the office, farmers are granted the subsidy that they applied for. The classification was done on the basis of the office's data. After breaking down the established plantations' areas by county and small region to specific tree species, I examined them and compared them to the soil maps of different soil types, as well as climate maps. I drew my conclusions from the obtained results and examined the extent to which the interaction between the production site endowments and crops' needs were realised in practice.

The most determinant factor of a successful plantation is the selection of the right production site. In order to do that, one has to know the crop's ecological needs. High yields can only be expected from adequately prepared plantations.

Results and discussion

Plantations were established in 33 of the 174 small regions (considering the list of regions as of the amendment in 2007). *Figure 1.* shows the significant difference between the planned and implemented plantations. The planned area was 2665.49 ha whereas the area on which plantations were established was 1504.65 ha.

In 2008, no plantations were established in Békés, Csongrád, Nógrád and Szabolcs-Szatmár-Bereg counties. Plantations were established in some of the most unfavoured small regions, such as Barcs, Kadarkút, Sellye, Szigetvár, Tamás, Edelény, Mezőcsát and Ózd. These plantations provide new means of subsistence for these regions' population under the current hopeless conditions.

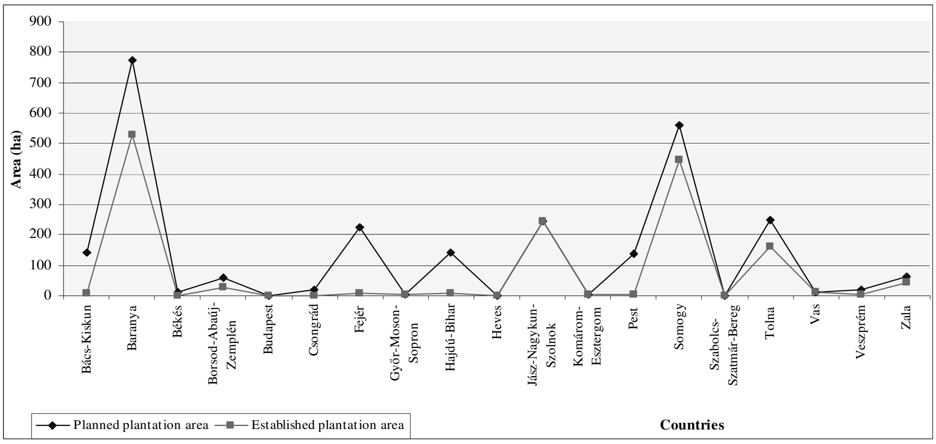

Figure 1. Countrywide report of the planned and established energy plantations broken down by county

Of the examined tree species, willows are rather tolerant to different temperature conditions. As regards their needs, they are able to develop on even unfavourable soils. As a matter of course, similarly to other species, soils that are richer in nutrients are more favourable but they grow adequately also on less favourable soils, due to their deep roots. Willow species have already been planted on various soil types (chernozem, brown forest soil, meaow soil, alluvial soil). They prefer relatively wet production sites and the best soil types for willow production are meadow and alluvial soils that have high groundwater level and that are even covered with water temporarily during the year. Altogether, plantations were established in 16 small regions with warm and moderately warm climate.

Two thirds of the examined areas were used for willow production as it can be seen in *Table 1.* This species prefers mild climate and it is mainly grown in warm and moderately warm areas. Brown forest soil fits the species' needs, as it is rich in humus and it has a good water, air and heat management. Noble poplar species are grown on certain meadow soils, as they prefer it if the ground water level is close to the surface, but they are intolerant to slackwater; therefore, one has to ensure the proper air management of the soil. Altogether, willow species were planted in 29 small regions, including warm and moderately warm areas.

The proportion of areas in which acacia was planted is the lowest, whereas its production site need is rather extended. It was planted on various soils in the four small regions – ranging from dry soils with low nutrient content to wet production areas. It is important that the soil be well aerated. Acacia is characterised by rapid growth and a relatively high wood yield. Its wood can be used in multiple ways.

Table 1. Production site endowments of the grown energy plantation

Species	Area (ha)	Small region (no.)	Soil type	Climate
Osier	161.16	6	brown forest soil, chernozem, meadow soil, alkaline soil, alluvial soil	Moderately warm
EN-001 (willow)	60.41	2	alluvial soil, brown forest soil, chernozem, meadow soil	Warm Moderately warm
Express (willow)	10.2	2	alkaline soil, meadow soil, alluvial soil, chernozem, brown forest soil	Warm
Inger (willow)	116.14	6	alluvial soil, meadow soil, alkaline soil, skeletal soil, chernozem, brown forest soil	Warm
AF2 (poplar)	387.75	16	chernozem, alkaline soil, alluvial soil, skeletal soil, lithomorph soil, brown forest soil, meadow soil	Moderately warm
Monviso (poplar)	619.22	10	chernozem, meadow soil, brown forest soil, alluvial soil, alkaline soil, skeletal soil	Warm
Koltay (poplar)	4.2	1	brown forest soil, alluvial soil, meadow soil	Moderately warm
Pannonia (poplar)	1.295	1	brown forest soil, meadow soil, peat soil	Moderately warm
Kopeczky (poplar)	1.295	1	brown forest soil, meadow soil, peat soil	Moderately warm
False acacia	142.01	4	meadow soil, brown forest soil, chernozem, alluvial soil, alkaline soil, skeletal soil, peat soil	Moderately warm

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Besides poplar, willow and acacia plantations were also established in the examined small regions.

Conclusions

In general, it can be stated that the majority of plantations were established on areas that are favourable for them. It is not even worth deciding about establishing a plantation on the basis of a preliminary examination of the production site. One can only achieve high yields (approx. 30 t ha^{-1} $year^{-1}$) if production site characteristics are adjusted to the needs of tree species, proper nutrient replenishment is ensured and adequate agricultural and harvesting technologies are used. It has to be noted that there is no energy plant that serves all needs. In the future, several species have to be considered, because production site endowments, water management factors and climatic conditions are different in each county and small region in Hungary.

One should establish an energy plantation in production sites on which the profitableness of production is ensured. Profitable yields cannot be achieved by growing cereals or other crops.

If one examines energy plantations from the aspects of environmental protection, favourable effects can be observed. Trees return clear oxygen into the nature during their lives. The long-term effects of plantations on small regions are increasingly obvious. Local feedstock production provides employment for a certain part of the population and the operating or soon to be built bioreactors' needs could also be fulfilled while reducing the high logistic costs.

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AGRICULTURAL UTILIZATION OF YIELD INCREASING ORGANIC WASTE IN CORN PRODUCTION

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Abstract: The elaboration of environmentally-friendly energy raw material technologies is opening new possibilities in Hungary through the utilization of composts produced from biologically degradable waste and mixed mineral fertilizer. With the help of this, two pollution sources, green waste and sewage sludge can be neutralized and utilized in an environmentally friendly way. Our field experiments were set up with maize *Zea mays* L. crop on small plots in Gödöllő. The impact of different forms of nutrients on the quantitative and qualitative characteristics of the yield were examined as well as the impact of organic material based yield enhancing substances on the physical condition of the soil. Extreme weather conditions have unfavourable impacts and bad soil condition makes climate-related economic damage worse. The use of organic materials can be potentially important methods for improving soil condition. As a result of our research it can be concluded the use of organic materials does not have significant impact on the composition of maize grain.

Keywords: compost, waste utilization, maize crop

Introduction

As a result of lack of capital in agriculture in recent decades, the negative impacts of production and cultivation technologies can be detected on about 70% of arable land (Láng et al., 2007). Besides harmful compaction, the majority of Hungarian soils are exposed to risk of erosion or deflation (Barczi, 2005), and the structure of soils and their organic material balance have both become worse. Extreme weather conditions (extra precipitation and drought) also have unfavourable impacts, and, at the same time, bad soil condition makes climate-related economic damage worse (Gyuricza et al., 2006). Apart from the deterioration of the physical and biological condition of soils, an additional reason for production losses can be found in the decrease of their productivity. In certain regions, on soils with inappropriate plantations, these problems are aggravated. Improving the general condition of soils is desirable not only from the economic but also from the environmental aspect. As due to decrease in livestock numbers, there is less manure available, new materials and methods need to be found for the improvement of the raw material balance and through it the physical and biological condition of soils. Recycling the organic by-products generated at the production site as well as transferring the living or dead material of plants grown specifically for this purpose could be potentially important methods for improving soil condition.

Simultaneously to the problem of soil degradation, the other most important environmental issue today is that of waste. For a long time, deposition in landfills appeared to be the cheapest and most appropriate solution for dealing with municipal waste. In contrast to this, in EU countries today legislation regulates the treatment and composting of waste types containing more than a few % of organic matter. (Alexa and Dér, 1999)

At the same time, numerous waste types are generated in agriculture, the food industry and the communal sector that can be utilized in arable crop production for energy raw material production following their biological decomposition. Following a

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microbiological process, the amount of organic material and heavy metals accumulated in sewage sludge can be decreased. In the thermophilic composting stage occurring as a result of the degradation of ligno-cellulose, those microorganisms that are harmful or pose environmental danger are destroyed. Thus, as waste materials are neutralized this way, the compost can be used to provide nutrients for plants. This study aims to examine the effect of different nutrients on crop quality parameters.

Materials and methods

The energy raw material experiment was set up at the Szent István University's Demonstration Farm for Plant Cultivation in October 2006. The area is situated in the Gödöllő Hills micro-region, 323 m above sea level. The climate is continental, thus extremities in weather are typical both in terms of precipitation and temperature. The average precipitation of many years is 550 mm, almost two thirds of which falls in the vegetation period (in a dry period less than half of it). The average temperature of many years is 9.1 °C. The soil of the experimental plot is mostly rusty brown forest soil formed on sand according to the genetic soil classification system used in Hungary. As a result of degradation processes a slightly humic soil with medium surface soil has been formed. The area is in risk of erosion and is susceptible to compaction, a factor that is important from the point of view of cultivation. The nutrient supply of the soil is adequate, in those profiles that are not eroded the nitrogen and phosphorus content is average, potassium provision is good. Prior to the experiment, the land was cultivated using turning and without turning cultivation alternately while producing traditional arable crops. Like the preceding years 7 treatments were repeated 3 times during the experiment. The area of each plot was 40 m^2. 2 different types of composts were used in the treatments. One of them had materials from communal waste (inoculated compost), the other was untreated (non-inoculated) compost. Following the examination of the nutrient content of the soil, the experiment was planted with maize crop. Numerous characteristics were examined in the following treatments:
Treatment 1: (compost (inoculated) + mixed mineral fertilizer): 5 t ha^{-1} compost was transferred to the soil which was supplemented with 0.112 t ha^{-1} mineral fertilizer.
Treatment 2: (compost (non-inoculated) + mixed mineral fertilizer): 5 t ha^{-1} compost was transferred to the soil which was supplemented with 0.115 t ha^{-1} mineral fertilizer.
Treatment 3: (compost (inoculated) + a minimum dose of complex mineral fertilizer): 5 t ha^{-1} compost was transferred to the soil. It was supplemented with 0.1 t ha^{-1} mineral fertilizer.
Treatment 4: (compost (non-inoculated) + mixed mineral fertilizer): 5 t ha^{-1} compost was transferred to the soil. It was supplemented with 0.1 t ha^{-1} mineral fertilizer.
Treatment 5: (compost (inoculated): 10 t ha^{-1} compost was transferred to the soil.
Treatment 6: (mixed artificial fertilizer): 0.38 t ha^{-1} mixed mineral fertilizer was transferred to the soil.
Treatment 7: (minimum dose of complex mineral fertilizer): 0.1 t ha^{-1} mineral fertilizer was transferred to the soil.

Results and discussion

Maize (*Zea mays* L) is one of the major grain crops in the world. Management techniques of corn production are focusing both on economic and ecological factors during its production. Environmentally sound nutrient supply of field crops is a major issue (Sipos, 2009). Long term experiments give an evidence, that deficiency of nutrients from among factors defining the total vegetal performance highly influence crop performance. Plant nutrition is a most effective factor in yield improvement (Bocz, 1976; Jolánkai et al., 2010).

As it is shown in *Figure 1.*, the results of protein content and oil content of maize yield samples from plots treated with compost containing organic matter from the decomposition of municipal waste (treatments 1 and 3) do not differ in a considerably from the other treatments.

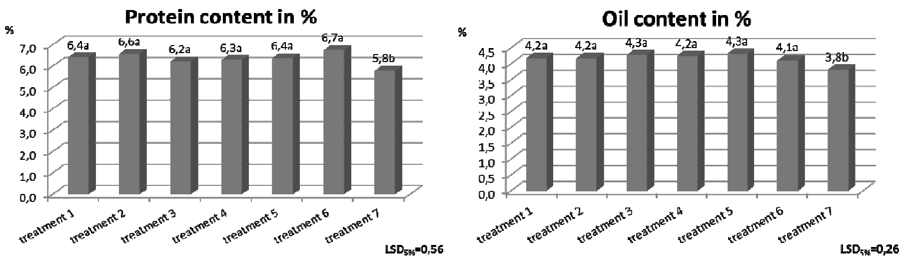

Figure 1. Protein and oil content of maize in different nutrient supply applications, [%]

Treatment 7 is an exception, in which case only a minimum dose of complex mineral fertilizer was added as nutrient supply to the soil. Here, the protein content remained less than 6%, and the oil content did not reach 4%.

The statistical evaluation of starch content and ash content results may lead to similar conclusions (*Figure 2.*). There was no significant difference between the results of the 1st and that of the 3rd treatment, as well as the rest of the treatments.

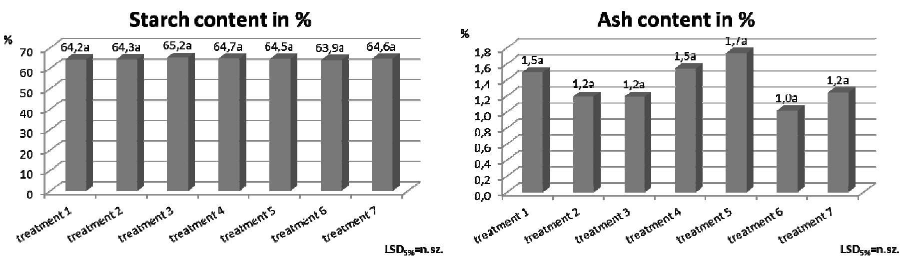

Figure 2. Starch and ash content of of maize in different nutrient supply applications, [%]

Ash content proved to be a most variable value of the experimental samples. Values ranged from 1,0 to 1,7 %. The highest figure was obtained in the highest rate application of inoculated compost (10 t ha^{-1}).

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The average composition of maize grain dry matter is as follows: 77% starch, 2% sugar, 9% protein, 5% oil, 5% pentozan and 2% ash (Kovács, 2008).
The below-average values of the protein-, oil-, starch and ash content of samples of the the recent trials have been influenced by the hybrid selection, and by the poor agronomic characteristics of the experimental site of the SIU Demonstration Farm for Plant Cultivation. Also, the crop year effect of 2008 could contribute to this performance; the total precipitation of the crop year was 688 mm with a rather unfavourable distribution. The amount of precipitation was exceeding 200 mm in the month of July. The average temperature was 11,7 °C in the experimental year.

Conclusions

Utilizing composts in arable crop production is advantageous from the point of view of the environment. It has beneficial impacts on the soil, too. Through the use of the decomposed organic matter from communal waste, it could also be an important step in terms of environmental protection. Based on our experiments, utilizing composts treated with this technology for nutrient supply does not have any significant impacts on the grain composition. Thus, it could be applied together or instead of other nutrient supply methods. Grain samples of the treated plots had an average 6,3% protein, 4,3% oil, 64,6% starch és 1,4% ash content. Since the results obtained were of a single experimental year only, further studies are needed to support these postulates.

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EFFECT OF NITROGEN TO CROP DENSITY OF WINTER BARLEY (*HORDEUM VULGARE* L.)

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Abstract: The variability of tiller number and number of spikes per square meter in winter two-row barley genotypes (G-3003, G-3020, G-3007-1/02 and G-3019) were investigated on experimental field on plots $5m^{-2}$ and four repetitions during two seasons with application of different rate of nitrogen (control N_0=0, N_1=20, N_2=40 and N_3=60 kg ha^{-1}). For analyzed barley lines the average tiller number and number of spikes per square meter are variate in dependance of supplied rate of N fertilizer. In barley genotypes, the values of analyzed trais were highly significant different in two growing season. In generaly, the higher average of tillers m^{-2} and number of spikes m^{-2} were established in second growing season of barley genotypes. Crop density of barley is increased by increasing rate of nitrogen. In average for all variant of supplied N and both growing season, the highest tiller number per square meter (827) and number of spikes per square meter (722) were in barley G-3007-1/02 as well as mainly on each variant of N nutrition.

Keywords: barley, genotype, density, nitrogen

Introduction

Barley (*Hordeum vulgare* L.), the fourth most produced cereal worldwide, which mainly used for animal feed, human food and malting. Traditionally, the main objectives of barley breeding programs are to develop cultivars with high grain yield and malting quality (Knežević et al., 2004; Siahsar et al., 2009). Barley yield is mainly connected with the number of spikes per area unit, which in turn depends considerably on the number of kernels per spike and weight of an individual kernel. Tillering in barley is greater than other spring cereals. Number of spikes per unit of area, apart from genetically determined tillering, is most strongly associated with sowing density (Paunovic et al., 2007b).

Nitrogen is one of the most important mineral nutrients and is being taken up dominantly in inorganic forms by the root system. Plants assimilate nitrogen as a source for growth, biomass production and development. Nitrogen is mainly absorbed as nitrate which is the most common nitrogen source available for higher plants (Krcek et al., 2005). The loss of nitrogen causes environmental pollution as well as economic losses (Muurinen&Peltonen-Sainio, 2004). However, differences in nitrogen uptake have been found between varieties on barley (Gorny, 2001) and on wheat (Le Gouis et al., 2000). These differences have been found between the varieties adapted in variable environments. Besides N rates, the timing of N application has an important effect on grain yield. The response to N fertilizer is maximized with N application just prior to onset of stem elongation when crop N demand is the greatest.

The aim of this study was to investigate nitrogen effect to crop density of four winter barley genotypes.

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Materials and methods

Field experiment was conducted in the 2006/2007 and 2007/2008 growing seasons. The variability of number of tillers and number of spikes per square meter in two-row winter barley genotypes (G-3003, G-3020, G-3007-1/02 and G-3019) were investigated. The experimental treatments involved the application of various rates of nitrogen: control N_0=0, N_1=20, N_2=40 and N_3=60 kg ha^{-1}. The experiment was set up as a randomised block design in four replications with a plot 5 x 1 m ($5m^{-2}$) in size. Nitrogen in the form of the mineral fertiliser KAN (27% N) was applied at the beginning of March during the initial stage of intensive growth (stem elongation). Number of tillers and spikes per square meter was determined in full maturity stage on randomly selected samples.
The analysis of variance was calculated according to randomize complete block design with three factors: A (genotype), B (year) and factor C (N-dose), using ANOVA (MSTAT-C program, 1989). The significant differences among the means were grouped according to least significant difference (LSD).

Results and discussion

The number of spike per unit area is the most important yield component of barley, which is in positive correlation with grain yield. The positive correlations between grain yield and number of spikes per unit area is reported in previous investigation by Bhutta et al. (2005) and Barczak and Majcherczak (2008). Variation in barley yield components resulting from environmental and management factors (Macak et al., 2008). In this investigation, nitrogen application had significant effects on tiller number and number of spikes per unit area. In the investigated barley genotypes, the values of analyzed traits were highly significant different in two growing season. In generaly, the higher average of tillers and number of spikes per square meter were established in second growing season of barley genotypes. Crop density of barley is increased by increasing rate of nitrogen. In average for all variant of supplied N and both growing season, the highest number of tillers per m^{-2} (827) and number of spike per m^{-2} (722) were in barley G-3007-1/02 as well as mainly on each variant of N nutrition.

Table 1. Mean values for number of tillers and number of spikes per square meter in barley

Genotypes	Year	Number of tillers m^{-2} N doses (kg N ha^{-1})				Number of spikes m^{-2} N doses (kg N ha^{-1})			
		N_0	N_1	N_2	N_3	N_0	N_1	N_2	N_3
G-3003	2007	620.5	662.8	681.2	699.2	539.5	555.5	568.5	572.2
	2008	722.5	762.0	836.0	881.5	624.2	659.0	724.5	740.0
	Average	671.5	712.4	758.6	790.4	581.8	607.2	646.5	656.1
G-3020	2007	627.5	638.2	658.2	675.5	549.8	554.2	567.5	576.5
	2008	763.0	830.8	863.8	890.2	669.0	722.0	737.0	759.5
	Average	695.2	734.5	761.0	782.8	609.4	638.1	652.2	668.0
G-3007-1/02	2007	677.0	700.5	723.0	770.0	587.5	610.0	633.0	656.5
	2008	877.8	934.8	954.5	979.0	766.2	818.8	841.8	866.2
	Average	777.4	817.6	838.8	874.5	676.8	714.4	737.4	761.4
G-3019	2007	681.8	702.8	721.5	754.2	602.5	612.2	624.5	645.0
	2008	875.2	881.8	915.5	963.8	765.8	763.5	789.0	815.5
	Average	778.5	792.3	818.5	859.0	684.2	687.8	706.8	730.2

Number of tillers and spikes per unit area increased with N increasing in all investigated genotypes, and was the highest in N_3 variant (*Table 1.*). The highest value of number of tillers was in N_3 variant at line G-3007-1/02 in 2008 (954 tillers m^{-2}). This line had the highest tiller number of all investigated genotypes in average for both years at N_3 variant (874). The increase of nitrogen rate on average is best responded to the genotype G-3003, which had the largest increase in tiller number and number of spikes in N_3 compared with N_0 variant. Increased nitrogen rates induced highly significant differences in general tillering between the nitrogen rates of 60 kg ha^{-1} and the control variant, as noted in previous study (Paunovic et al., 2007b).

In this investigations, tiller number and number of spikets per unit area increased significantly with increasing nitrogen fertilization dose, which agree with previous investigations for these traits and grain yield of barley (Delogu et al., 1998; Spaner et al., 2001; Paunovic et al., 2007a; Malesevic et al., 2010; Sharma and Werma, 2010). Number of tillers linearly increased with increasing level of fertilizer, which is consistent with previous research (Rashid and Khan, 2008). This trait directly influenced spike density and grain yield of barley genotypes.

Table 2. Analysis of variance for number of tillers per m^{-2} in barley

Mean	DF	MS	F	LSD	
				0.05	0.01
Genotype (A)	3	72170.19	686.79**	8.156	14.970
Year (B)	1	1078980.50	10267.92**	-	-
AB	3	10051.06	95.65**	11.530	21.170
N-dose (C)	3	53997.02	513.85**	8.156	14.970
AC	9	783.24	7.45**	11.590	16.660

Analysis of variance showed highly significant differences among genotypes (A) for number of both tiller number and spike number per square meter. Differences between investigated years (B), N levels (C) and all analyzed interactions (A x B, A x C, B x C, A x B x C) were also high significant for this trait. The strongest individual influence for both investigated traits had year, than genotype and N-doses, but less interaction between factors (*Table 2.* and *3.*).

Table 3. Analysis of variance for number of spikes per m^{-2} in barley

Mean	DF	MS	F	LSD	
				0.05	0.01
Genotype (A)	3	72238.99	866.36**	7.265	13.330
Year (B)	1	849719.07	10190.66**	-	-
AB	3	7259.24	87.06**	10.270	18.560
N-dose (C)	3	26275.55	315.12**	7.265	13.330
AC	9	735.08	8.82**	10.330	14.840
BC	3	3340.01	40.06**	10.270	18.860
ABC	9	675.37	8.10**	14.610	20.980

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Conclusions

Nitrogen application had significant effect on plant density and number of spikes per unit area. By analysis of variance, it was established that both of analyzed yield components significantly depended to genotypes and investigated years. Interactions between genotypes, applied nitrogen doses and years were also highly significant, which means that new genotypes are positive reacted on nitrogen applying.

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MAIN FARMING SYSTEMS IN SYRIA

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Abstract: In MENA region there are some farming systems, of which four can be found in Syria, namely: irrigated, highland mixed, dry-land mixed and pastoral farming systems. In MENA regions all of these have different measure areas and population. In Syria the pastoral farming system has mainly the half area of Syria, but this study emphasizes most efficient agricultural areas, as irrigated farming system including Jazire area extending between Euphrates and Tiger rivers.
Main cities of Syria were established on areas closed to irrigated and rain-fed mixed farming systems for example Aleppo, Homs, Hama, Latakia and Tartus. The most important irrigated farming system, of which on these areas there are cotton and sugar-beet, also vegetable, other high-value crops, wheat and fodder, also animal husbandry with cattle, sheep and goats, barley in rain-fed mixed.
The water use is very separated, 89% of used water for agriculture, 6% for municipal, and 5% for industry. In spite that the water use was very considerably in agriculture, but this kind use of water was not successfully. Also the problem that water per capita in MENA decreased sharply from 3400 m^3 / per capita in 1960 to level of 1200 m^3, which is not so higher than the 1000 m^3 scarcity level, per capita.
The study analyses how irrigated and highland mixed farming systems can ensure more successful water-use in order to ensure efficient agricultural production. Analyse and compare influences of irrigated and highland mixed on the agricultural production and food supply. The technological methods, governmental support for farmers, import of machines, and non over irrigation system can solve soil degradation.

Keywords: efficient agricultural areas, irrigated farming system, rain-fed mixed farming system, successful water-use

Introduction

In MENA region there are some farming systems, of which *four* can be found in Syria, namely: *irrigated, highland mixed, dry-land mixed and pastoral farming systems.* In MENA regions all of these have different measure areas and population. In Syria the pastoral farming system has mainly the half areas of Syria, but this study emphasizes most efficient agricultural areas, as *irrigated farming system* including ***Jazire area*** extending between Euphrates and Tiger rivers. The successful water use is needed for efficient agricultural production, when recently the global warming and climatic changes made very considerable difficulties for agricultural sector. This can be experienced in case of Syria including the MENA region.
Additionally to the climatic change problem the growth of population needs much more food production and in consequence of which, water use within unfavourable dry weather conditions based on the global warming process (Ligetvári et al., 2006).
Some expert emphasize that since the publication of the *Brundtland Committee Report* (Our Common Future, 1987), sustainable development has become a major focus of political and economic forums. Recently energy, water management, land use and their complex interaction with climate change became a key research area in sustainable development (see detailed in Farkasné et al., 2010; Khalif et al, 2010.).

Materials and methods

The *water resource data collected* is a basic element for the land-use planning, that is the reason why the data collect methods are important. When we calculate and evaluate

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the water resource conditions, we start from the present water use, which is the first basic issue, namely: river abstraction, tanks, groundwater, also location of abstraction points, sluices, dams, wells, and boreholes with qualified yields and their volume. Also the present storage capacity of tanks and reservoirs contributes to water resource data collection. Reliable yield of water for each river catchment, based on international experiences for example between 75% and 90% probability low flow from hydrograph records or 75% and 90% probability rainfall over seven – or ten-day period correlating with the area of catchment. The safety yield of groundwater is for example test pump data or well records, measure the depth below surface of useful groundwater, location of aquifers, the water quality, location of irrigable land and legal and customary rights.
Finally it can be emphasized that the *water use methods* are based on the water resources and this leads to create *the land – use planning* for farmers (Szabó, 2006)

Results and discussion

Main cities of Syria were established on areas closed to *irrigated and rain-fed mixed farming systems* for example Aleppo, Homs, Hama, Latakia and Tartus. The most important irrigated farming system, of which on these areas there are cotton and sugar-beet, also vegetable, other high-value crops, wheat and fodder, also animal husbandry with cattle, sheep and goats, barley in rain-fed mixed (Szabó, 2005).
The water use is very separated, 89% of used water for agriculture, 6% for municipal, and 5% for industry. In spite that the water use was very considerably in agriculture, but this kind use of water was not successfully. Also the problem that water per capita in MENA decreased sharply from 3400 m^3 / per capita in 1960 to level of 1200 m^3, which is not so higher than the 1000 m^3 scarcity level, per capita.
In Syria, as in general in MENA region, there are two kinds of irrigated farming system, which are as follows: *1- large-scale irrigated sub-system, and 2- small-scale irrigated subsystem*. The large-scale irrigated sub-system, even in Syria, has a traditionally historical development process closed to the main rivers of MENA, for example Nile, Euphrates and Tiger rivers providing water resources for agricultural production.
So in this case the crop production system within the mainly less raining weather conditions, accompanied with setting up irrigating water channel systems and other different irrigating equipment. The different cash crops, (like cotton, sugar-beet) vegetables and fruits with many kinds of high-value crops and fodder are also commonly produced in Syria as well as in MENA region.
The state has significant role to set up irrigation water system, because to build the water channel system is very costly, which cannot be available for singly farmers. Because of the cost for setting irrigation system is very costly, the state should own considerable part of implemented irrigation projects and lands, so the vertical ownership was created by cooperation of the state and private farmers. The state became responsible for implementing and remaining the irrigation projects and also to realize the distribution of irrigating water for farmers by through water channel scheme. The large-scale irrigated farming sub-system was set up based on managing small plots from 0,5 to 5 ha areas in Syria. The economic and institutional background was not enough set up for improving this irrigated farming system in majority of MENA region, for example the lack of financial supports for agricultural production, the unified advisory

system, the information flow of weather and land natural conditions, weakness of monitoring system for controlling the income and tax conditions of farmers.

Some experiences of the large-scale irrigated sub-system can be mentioned, as capacity of the agricultural production was at low efficiency, the rapid depletion of aquifers concerning the global warming conditions, rising groundwater tables, which could result the continuous soil degradation; extending salinity and sodicity wider side on important agricultural areas.

Also the soil degradation continued based on the declining soil organic matter level, which led to low crop yields. The lack of financial supports resulted in low level of mechanization and using fertilizer.

The *small-scale irrigated farming sub-system* became very small farming system based on 0,02 – 1,0 hectare unit laying closed to the areas of *rain-fed mixed farming system*. It means that the small-scale irrigated farming sub-system is mainly according to rain-fed mixed farming system. The small-scale irrigated farming sub-system uses plantation, as fruit trees and intensively grown vegetables. In general this system is in isolated areas providing its production for small local markets, to where large-scale farmers cannot transport their products, for example because of lack of satisfactory unified road network. Also the unfavourable natural conditions are determined by the scarcity water supply for plantation. So such types of crops were developed, which could have also been able to adapt to scarcity water supply for the summer season. This small-scale irrigated farming sub-system was originally adequate for natural geographical conditions of *terraced hillside*. The rain-fed mixed farming system as well as small-scale irrigated farming sub-system was used in terraced hillside. Additionally to Syria the crop production was also extended on terraced hillside in Yemen, where this one was used in ancient historical period.

For the small-scale irrigated farming sub-system the main difficulty was water shortages, which created possibility for declining food production. It means, that the food supply became less than food demands of population, so the food deficit increased sharply stimulating the food import or migration of the local population in some historical periods. The water shortage pressed the farmers and the society:

- to create the water storing system by the continuous improving water management with water channel system and
- to decrease mining of the groundwater.

The water shortage is the most important weakness of the agricultural production in Syria. Consequently the continuous decrease of the water resources led to agricultural yield decline, which decreased the food self sufficiency of the country and majority of the MENA region, emphasizing most of Arab Peninsula. This food deficit made poor family working in agricultural sector poorer. The UN declared that the most renewable water resources have already been harnessed for use, the only viable option left was to improve the management of available water resources by using the adequate technologies and management possibilities (United Nations Task Force, 2000).

Conclusions

The study analysed how *irrigated and rain-fed mixed farming systems* can ensure more successful water-use in order to ensure efficient agricultural production. Analyse and compare influences of irrigated and highland mixed on the agricultural production and

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food supply. The technological methods, governmental support for farmers, import of machines, and non over irrigation system can solve soil degradation. From one side the water resource and water use conditions are important to decide the land – use planning, which also need mechanical and technological background. From the other side the developing farming systems demand governmental support system for farmers.

Even this can be very important, when low rainfall cannot ensure adequate agricultural yield (see in detailed in Dobó et al., 2006).

Also some experts decided that "Keeping partly the function of food production, agriculture may play a significant role in energy production or industrial raw material production. For this, a good example can be the utilization of biological materials (biomass) for heating. They can also be used for making fuels, as well as vegetable oils can be used in plastic industry, or medicine and different chemicals may also be made from them." (Fogarassy et al., 2007). This issue connects with environment-friendly energy use, which can be coming from the agricultural production, not only for food production, but also for renewal energy production.

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HOW THE RESULTS OF WINTER WHEAT VARIETIES TESTING CAN BE USED FOR MORE EFFICIENT CROP MANAGEMENT

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Abstract: Further possibilities of processing and use of results obtained at small-plot field trials have been analyzed for the Recommended Variety List (RVL) of winter wheat, which offers the following information on: (i) manifestation of the crop management practices intensification in individual production areas, (ii) individual varieties with respect to their yield levels and response to increased inputs, (iii) the effect of yield and grain quality on the efficiency of crop management. Based on the obtained results, recommendations have been made as how to modify the assessments and interpretations of RVL results for agricultural practice.

Keywords: winter wheat, variety recommendations, variety response to intensification, grain yield and quality, efficiency of crop management

Introduction

As with the selection of crops in a well designed crop rotation, an appropriate variety selection is an important rationalization measure in plant production which brings significant economic effects without the need of increased costs. Therefore, variety assortment is an important factor of optimization and stabilization in plant production systems (Bøjer et al., 1997; Křen and Kopista, 2007). Selection of suitable varieties enables diminishing the risks of adverse effects of climatic conditions and biotic contaminants in creation of their biological potential at yield formation of the required quality. Assortment of varieties is a challenging task and therefore a responsible managerial decision should not be underestimated (Jensen, 2001). Our contribution demonstrates the possibilities of processing and interpreting the Recommend Variety List (RVL) results of winter wheat which offers broader information about utility value in individual varieties and their response to different intensities of crop management.

Materials and methods

The results of small-plot variety trials for RVL of winter wheat were analyzed. The trials were were carried out (i) in three repetitions in plot size of 10 m^2, (ii) at two input levels:
a) an untreated variant: basic nitrogen dose (is composed of regeneration fertilization of 30-70 kg ha^{-1} and production fertilization of 40-60 kg ha^{-1}, the dose being adjusted according to the location, forecrop, soil Nmin content and current state of the stand),
b) a treated variant: basic nitrogen dose increased by 40 kg ha^{-1} applied at the beginning of heading, growth regulator, two obligatory fungicidal treatments against leave and ear diseases (the first treatment by the end of shooting, the second at the beginning of heading until flowering),
(iii) in 24 locations in five experimental regions, (iv) over the period 2005 – 2008. Yield was assessed in 18 varieties (t ha^{-1}), and the varieties were classified into four quality categories (E – elite wheat, A – high quality wheat, B – bread-quality wheat, C – wheat

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unsuitable for baking) based on the levels of quality parameters obtained in registration trials. Linear regression analysis, correlation analysis and graphical representations of data were used for result processing (Hartman, 205).

Results and discussion

Differences in reactions to increased inputs among individual experimental regions

The parameters of linear regression functions which characterize a 4-year test period (average) are shown in *Table 1.* The obtained results confirmed the use of current zoning of winter wheat growing for interpretation of RLV results. Decrease in the number of the experimental locations and their unification might lead to diminution of the information value of the results. The most stable results with respect to the obtained yield levels were recorded in the Czech sugar-beet growing region (*Figure 1.*), and in the Moravian sugar-beet region with respect to variety responses to increased inputs (*Figure 2.*). The highest risks with regard to increasing inputs were detected in the maize-growing region (*Figure 3.*). A certain similarity can be found in the characteristics of the maize-growing and Moravian sugar-beet growing regions.

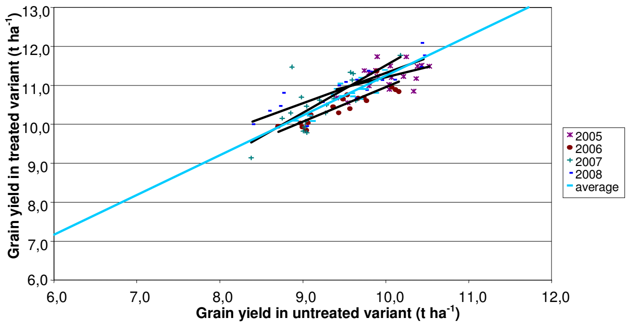

Figure 1. Linear regression relation between grain yields in untreated and treated variants in the Bohemian sugar-beet region

Table 1. Characteristics of linear regression functions in relations between yields obtained in the basic and treated variants over the period 2005-2008 (y = a + bx, x – basic variant, y – treated variant, n =18, ** high statistic significance α = 0.01)

Growing regions	a	b	r	r^2
Maize-growing region	-0.1537	1.1090	0.91**	0.8243
Moravian sugar-beet growing region	4.2141	0.6986	0.76**	0.5844
Bohemian sugar-beet growing region	1.0742	1.0176	0.85**	0.7149
Cereals-growing region	4.2402	0.6611	0.77**	0.5929
Potato- and forage-growing regions	1.2605	0.9710	0.89**	0.7925

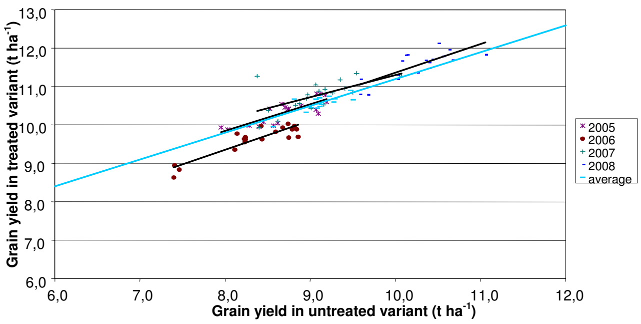

Figure 2. Linear regression relation between grain yields in untreated and treated variants in the Moravian sugar-beet region

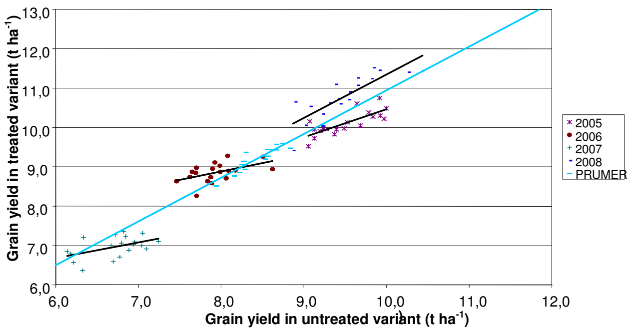

Figure 3. Linear regression relation between grain yields in untreated and treated variants in maize-growing region

Reaction of individual varieties to increased inputs

Variety classification according to their responses to increased inputs offers valuable information for agricultural practice. This is showed in *Figure 4.* as well as information about variety classification into categories based on grain quality. This graphical representation of data allows simple and transparent variety characterization with respect to: (i) yield levels based on the basic input levels, (ii) responses to increased inputs, (iii) grain quality. For example, the variety Akteur can be characterized, according to the position in the graph, as less yielding at the basic input levels and at the same time less reacting to increased inputs. On the other hand, the varieties Biscay and Florett are highly yielding at basic input levels and respond well to more intensive cultivation. The graph shows an average variety response within all the experimental regions. However, with regard to different adaptability of varieties, such differentiation should be made separately for individual growing regions.

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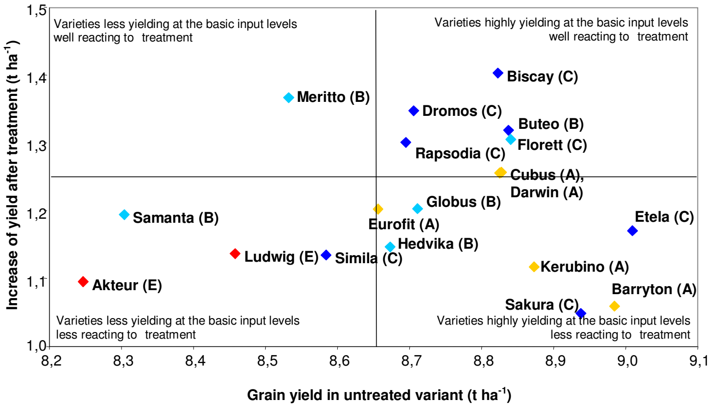

Figure 4. Graphical representation of variety responses to increased inputs

Conclusions

The accomplished analyses demonstrated:

- Significant differences among the growing regions in variety responses to increased inputs and confirmed their current specifications,
- Possibility to make the characterization more efficient as well as variety selection using a combination of three sources of information: (a) yield level at the basis input level, (b) variety response to increased inputs, (c) grain quality,
- The need of variety comparisons with regard to the obtained economic effects, which can be influenced not only by grain yield but also its quality and applied inputs.

This described procedure of RLV experiments assessment and interpretation of results should be used for recommendation of winter wheat varieties.

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ON-SITE AND HYPERSPECTRAL AIRBORNE MEASUREMENTS OF PRECISION CROP PRODUCTION SITE CHARACTERISTICS

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Abstract: Precision crop production is based on the crop site - land use synergism idea on a small scale basis. It requires various measurements in order to receive information on the production site characteristics. Crop plant requirements can be calculated based on the data, collected in the field or by means of airborne imaging. Field measurements - such as soil characteristics - can be time and workforce consuming, if carried out by a point based sampling method, at the same time the reliability of the collected data is limited to the sampling location. On-line measurements on the other hand results well distributed sampling points, covering the whole field, providing more detailed information. Data reliability in this case is depending on the accuracy of the measuring instrument. Airborne imaging with the most up-to-date technology provides a meter scale full coverage of the investigated field. The collected images provide reflectance or radiance values. These values are connected to crop production characteristics, and can help in data collection in the future for the precision crop production technology.

Keywords: precision agriculture, hyperspectral imaging, measurements of production site characteristics

Introduction

Precision crop production uses a variety of technologies in order to manage different parts of a field separately; however some limiting factors always occur (Neményi et al., 2008). Improper cropping pattern and agrotechnics as parts of the irrational land use practices seriously affects the soil formation and processes (Várallyay, 2010). Soil characteristics are the main determining factors for conventional and precision plant production therefore site specific measurements are necessary for the spatial decision making. Data on soil parameters can be collected by various instruments and means furthermore mapped by GIS methods to ensure visualization of within field differences (Balla et al., 2010; Milics et al., 2006; Morschhauser and Milics, 2009). One of the most up-to-date technology for data collection is hyperspectral imaging. Various researchers and experts reported the possible applications of this technology in agriculture (Burai et al., 2009; Deákvári et al., 2009; Tamás and Nagy, 2009; Szalay et al., 2010). In this study various measurement techniques and results are presented based on on-site as well as hyperspectral imaging technologies for site-specific plant production.

Materials and methods

Yield varies even within field along a certain pattern which variation is depending on several interdependent factors. In a relatively small research field (23,52 ha) near Mosonmagyaróvár, Hungary meteorological differences can be neglected. At the same time variations in soil physical and chemical parameters, height above sea level etc. are highly influencing yield. In 2009 soil moisture parameters, electrical conductivity and micro relief were measured by means of on-site methods. Hyperspectral images were

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collected in the vegetation period and after harvest in order to analyze vegetation and soil properties. For soil moisture measurements three different measurement units were applied - all of them based on the time domain reflectometry (TDR) discipline - , however Spectrum TDR-300 moisture analyzer showed the best correlation with the drying chamber laboratory data. Moreover with this instrument sampling can be carried out quickly. The number of sampling points per day can be over thousand. For electrical conductivity Veris-3100 instrument were used. In this case online measurement were carried out, the sampling points were over 13 thousand. For micro relief mapping high accuracy dGPS unit was applied.

Yield map was created based on the data collected by Agrocom ACT yield mapping system and ArcGIS software. The collected data was filtered and post-calibrated.

Hyperspectral images in 2009 were collected on 14.07 for vegetation analysis and 08.09 for soil properties analysis. In 2010 image collection was carried out on 23rd of September. For the image validation reference spectrum of various materials were collected at the same time as the airplane passed over the research field. Geometric resolution at all cases were 1×1 m, spatial resolution was 2 to 5 nm between 400 and 2450 nm.

Results and discussion

In 2009 yield showed similar pattern to soil moisture, electrical conductivity and micro relief. Accuracy of soil moisture data in spatial comparison is good as control measurements accuracy is reliable. Spatial correlation between soil moisture semi continuous and electrical conductivity on-line measurements are weaker, however it can be still stated as strong (*Figure 1.*).

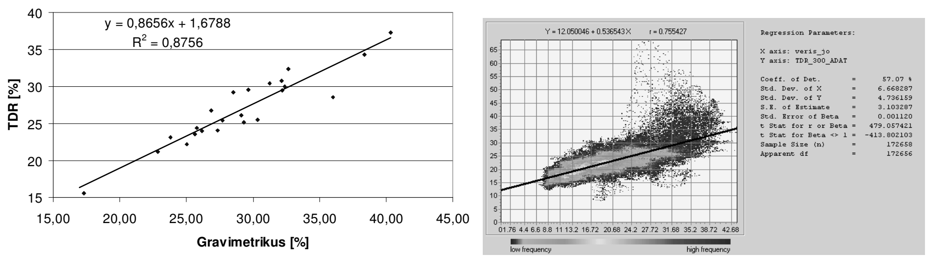

Figure 1. Comparison of soil moisture content measured by Spektrum TDR-300 and gravimetric methods and spatial comparison of soil moisture and electrical conductivity data

Soil moisture and electrical conductivity is interdependent in this research field as total salt content is low in the area. Based on this two layers soil diversity within field can be very well described. (*Figure 2.*).

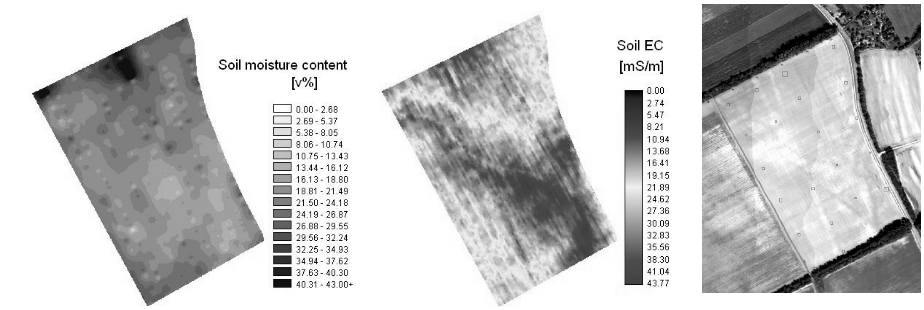

Figure 2. Soil moisture content, electrical conductivity and hyperspectral (VIS) maps

Hyperspectral images in 2009 were compared to yield and soil properties. Due to the fact that hyperspectral image analysis and data comparison was still in research phase spatial correlations were not very strong, however visual comparison always carried out the expected results.

In 2010 hyperspectral image has already helped - prior to harvest - the visualization of the expected yield. In some cases very low yield could be predicted due to missing green materials applying hyperspectral normalized differential vegetation index (hNDVI). (*Figure 3.*).

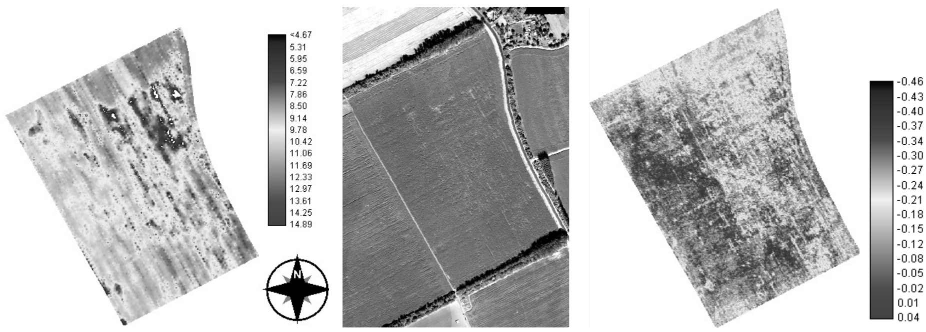

Figure 3. Yield map, hyperspectral image (B:250, @1766 nm) and hNDVI map

Soil properties could not be directly investigated in this year as maize was harvested at the latest possible time due to very high precipitation during the growing season, therefore even at harvest very high moisture content of the grain. Further investigation of the data is necessary as low yield areas were assumed to be the results of wildlife damage. As variable rate fertilizer amounts were applied in the field - especially high differences in the nitrogen amounts - comparison of that data has to be carried out. More detailed investigations of the on-site hyperspectral signatures and the airborne image is needed.

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Conclusions

On-site and hyperspectral airborne measurements of precision crop production site characteristics showed that either by manual data collection or by fully automatized methods within field differences can be mapped. In order to fulfill the requirements of crop and land use synergism various characteristics measurements has to be carried out in order to make the right decisions for sustainable land utilization.

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STUDY ON THE OPTIMAL GROWING TIME AND CLIMATIC FACTORS OF THE CHINESE SILVER GRASS (*MISCANTHUS SINENSIS*) IN HUNGARY

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Abstract: The biomass in a given habitat is the amount of the total live and dead organic matter. Under Hungary's favourable natural conditions, large amounts of biomass can be produced, which have large potential for energy production. For the propagation of energy silver grass young plants or rhizomes are used, but in our country the second one is easier to obtain. Chinese silver grass can be used primarily in areas where it does not compete with food crops. Conditions for the successful cultivation are as follows; appropriate material for propagation, adequate cultivation, effective weed control and harvest method with minimized losses. Bud activity investigations have also been carried out, as it is described in the methodology. The investigations were conducted under controlled circumstances in a climatic chamber (20±1°C) and it was determined that rhizomes have the highest activity in April, June and August. The exact knowledge of rhizome activity contributes to the determination of the possible time of planting, irrigation, fertilization and recultivation.
The aim of the research:

- The examination of *Miscanthus* successful propagation: rhizome, soil management, optimal propagation depth and time, in small and large plot experiment.
- The biological activity of rhizomes: the observation of active and dormant periods that can be used for timing of fertilization.

Keywords: biomass energy, rhizome, Chinese silver grass

Introduction

In the last few years the cultivating researches focused of the agricultural main- and by-products retrieving energy for exploitation (bioethanol, straw) and for the green plant energy germane researches. The countries of the world were already recognized in 1972 on the Roman conference the reduction of the gases causing the greenhouse effect, and in 1997 they quantified in Kyoto (Clifton-Brown et al., 2004). The EU target for renewable energy sources to increase 12% from the current 4%, in this site Hungary, should be increased to 3,6% from the current 0,6% (Mikó, 2007). The perennial gramineae species energy use has examined from the middle 1980s in Europe and in the U.S. The most promising gramineae species are the perennial switchgrass, which are native in America, while in Europe the miscanthus species (*Miscanthus spp.*) were appropriate (Lewandowski and Heinz, 2003; Heaton et al., 2004).
The *Miscanthus* species are native in Southeast Asia. It can be found up to 3000 metres altitude above sea level. The most promising biomass species for the production are stem from *Miscanthus sinensis* (Beale et al., 1997). It lives in warm tropical and subtropical climate in its homeland, but to adopt to temperate climate mainly the selected species water- and temperature require became lower (Jones and Walsh, 2001; Fogarassy, 2001). The basis of the growing with big mass is the development of growing technology which is successful and adaptable to different sites (Percze et al., 2009). This task provides the examination of the biological activity and its regeneration for the Chinese silver grass (*Miscanthus*) rhizomes. The cognition of the rhizomes regeneration is important for calculating planting and nutrient supply in optimal time,

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and for producing reproductive material and for recultivation of the plantation (Pósa et al., 2009).

Materials and methods

Large-plot experiments were set in Felsőpetény and Tát (in Hungary) between 2008 and 2010. The soil in Felsőpetény is a brown forest soil with clay and with medium water management (K_A: 43), including humus between 1,5 and 1,9%. The soil in Tát is good cultivated sandy loam.
Monthly bud activity and regeneration-dynamic tests were done at the Department of Herbology and Pesticide Chemistry, Plant Protection Institute of Pannon University in Keszthely between 25 March 2008 and 12 December 2008. One examination cycle lasted until 22 days and we made the measurements with more occasions which were pertained to bud activity- and shoot length measurement. We examined bud activities in thermostat between controlled circumstances on 20±1°C. The monthly measurement and evaluation of the root number was done after emergence. In case of the first class mother spawn we planted the proposed 10000 pieces per hectare in 1x1 metre spacing. To this we were evaluated the root number relative as a percentage.

Results and discussion

In the first two times there were bud activity examinations including terminal buds and from the third time we work with the rhizome segments only, which were not containing terminal buds. In the rhizome pieces which contained terminal bud, the terminal bud had a significant increase (150%), while the axillary buds increase was minimal.

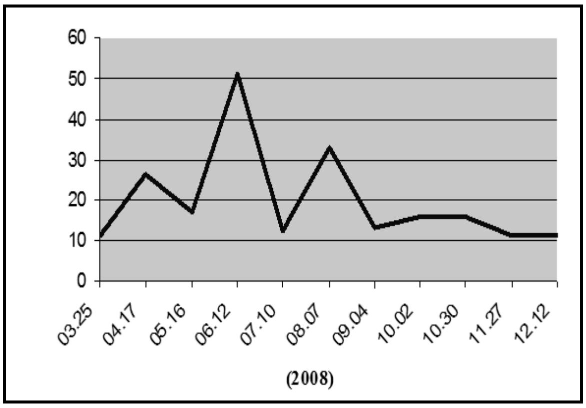

Figure 1. The axillary bud activity (mm) in differents dates

The examinations of the rhizome pieces which contained no terminal bud (apex) were justified by a vigorous increase (58,6-530%). This results -compared with the increment of axillary bud in rhizomes which contain terminal bud- verify the emergence of apical dominance and the correlative inhibition between the terminal- and sideward buds. Correlative inhibition means another organ or bud growth inhibition affected by an organ. The apical dominance is such a correlative inhibition, when the apex (terminal bud) interferes the growth of the axillary bud. With the dismemberment of the organs under the soil surface we disrupt the apical dominance system during the cultivation. When the dormant bud get out from the inhibitory effect, it starts growing.

This growing lasts till re-evolving the dominance system in the remaining rhizome pieces, due to the buds which are placed on apical part become dominant evolving the effect of inhibition to other buds. Due to this system there are always remaining dormant buds in the rhizomes, from which a new shoot can grow, providing regeneration and sustain continuously plant performance.

The *Figure 1.* shows that developing of apex was more dynamic by end of March, beginning of April, because of inhibitory effect of axillary bud was much bigger. The rhizomes have smaller regenerating ability three-times a year: beginning of March, end of April and middle of June. The backflow of nutrients to the rhizome is beginning until September, in this time the growing of juvenile parts stop, the rhizomes start dormancy till next March. The slight growing of shoot in the end of April and middle of June is due to the changes of the plants metabolism. In case of the sample of June the bud activity was decreased, because of flowering.

Table 1. Precipitation data (mm) 2008-2010

	Felsőpetény			Tát	
	2008	2009	2010	2009	2010
January	23	48	51	75	15
February	10	67	63	85	125
March	60	53	26	93	8
April	29	17	78	10	135
May	29	40	180	30	379
June	99	92	165	57	267
July	124	39	98	43	62
August	15	45	63	49	81
September	67	29	143	19	158
October	32	49	56	55	59
November	39	77	90	84	102
December	81	73	-	59	-
Total	*608*	*629*	*1013*	*659*	*1391*

Table 2. Results of plant coverage (%)

Examination times		Time and place of planting		
		2008 Felsőpetény	2009 Tát	2010 Felsőpetény
2008	June	33%	-	-
	July	58%	-	-
	August	63%	-	-
2009	June	60%	1%	-
	July	77%	12%	-
	August	82%	14%	-
2010	June	72%	51%	78%
	July	73%	57%	88%
	August	73%	58%	92%

Planting time has been determined in accordance with various factors. Based on our research the Chinese silver grass may be planted at 8 ^{o}C soil temperature without any risk.

The planting in Felsőpetény was done in the second decade of May in 2008. In spring time there was a few moisture (*Table 1.*), but in the month of June and July there was a high amount of precipitation in the area, due to the initial 33% plant coverage which increase to 63% to end of August (*Table 2.*). In the next year we find 10% of post-emergence so the plant coverage was 75% by the year 2010. In case of precipitation, 2008 was an average year.

The planting in Tát was done in the third decade of April in 2009. After planting there was a very dry season which lasted for 3 weeks, so the cane grew less. The year of 2009

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was very dry in Tát. The plant coverage was only 14% due to the early planting and the later moisture. Due to the post-emergence and the rainy weather, we observed 58% plant coverage to 2010.

In 2010 we found 40% of post-emergence, due to the huge amount of precipitation, in this time the plant coverage was 58%. The stock was covered with water for several weeks, but the cane endured without problems.

The planting was in the second decade of April. In the first month, already 78% was the coverage, which was increased up to 90%, due to the rainy weather.

Conclusions

The results and experience suggest, that one of the fundamental conditions of the growing of successful energy cane is the successful planting and larger coverage in the first two years, which promotes the growth of yield and early return on investment. Based on our investigations the proposed time of planting should be between late March and mid-May, adjusted to the soil temperature and precipitation, with the appropriate mother spawn. It is necessary to prepare for the planting (area preparation, machines, workers, rhizome) in time to begin the plantation. This is a prime example of the last 3 years.

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DEVELOPMENT OF ROOT SYSTEM CAPACITY AND GRAIN YIELD OF SPRING BARLEY DEPENDING ON THE RATIONALIZATION OF PRODUCTION SYSTEMS

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Abstract: In order to determine the development of root system capacity (RSC) and grain yield of spring barley in relation to fertilization, tillage, variety and the year we established polyfactorial field trials in hot maize growing areas of Slovakia in years 2009 and 2010 with four varieties: Bojos, Kangoo, Marthe, Xanadu, at two tillage methods: conventional tillage and minimized tillage, four variants of fertilization (unfertilized, Condit mineral at the dose of 1 t ha^{-1}, 60 kg N as saltpetre nitrate with limestone + Hakofyt extra, 60 kg N as NH_4NO_3 + Hakofyt extra. The root system capacity was measured at four growth stages: BBCH 13-15, BBCH 23-25, BBCH 51 and BBCH 85-89. Year significantly affected values of RSC with a direct impact on grain yield. The differences between varieties was proved in RSC in the growth stages BBCH 23-25 BBCH 51 in favour of variety Bojos (1.458 nF, 0.599 nF respectively), at which variety the highest yield (5.68 $t.ha^{-1}$) was also achieved. Significant difference between tillage methods and fertilization variants was confirmed in BBCH 85-89 in favours of the minimized tillage method (0.211 nF) and application of mineral fertilizer Condit (0.222 nF), and this fertilization variant gave the highest grain yield (5.44 $t.ha^{-1}$) also. A moderate, significantly positive correlation relationship was proved among yield and RSC in each growth stage (r=0.3540 ***, r=0.6047 to ***).

Keywords: spring barley, fertilization, tillage method, root system capacity, yield

Introduction

Nutrient uptake is influenced by available water degree of association between the roots and the soil, other properties of the genotype and conditions of growing (Pruzulja and Momčilovič, 2003; Fazekašová, 2003). Time and expanse are major constraints limiting the detection of genotypic differences in the length, structure and growth rate of root system. A conceptual model is presented that provides a rational basis for using plant root capacitance as an in-situ measurement for assessing plant root development. Capacitance maters may facilitate the non-destructive identification of genotypes with root characteristics that confer adaptation to various environments (Dalton, 1995; van Beem et al., 1998). The electrical capacitance method is based on the polarization of biological membranes in the root system, and is dependent on the geometric and dielectric properties of the root system. The electrical capacitance or LCR meter measures the amount of electric charge stored by the root system for a given electric potential, which is dependent on the active root surface area and root length (McBride et al., 2007).

The aim of the study was to obtain the effect of year, different tillage methods and fertilization treatments on the development of root system capacity (RSC) and grain yield of spring barley.

Materials and methods

The task was solved in conditions of warm corn production area of Slovakia at the research base of FAFR SUA, Dolná Malanta in years 2009 and 2010. The trials were established by split plot method in three repetitions. According to the 50 years climate

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normal, the average annual rainfall is 532.5 mm, the average annual air temperature is 9.8 °C (Špánik et al., 2002). We monitored four spring barley varieties (Bojos, Kangoo, Marthe, Xanadu), two tillage methods (conventional tillage - ploughing to the depth of 0.18 m, minimized tillage - disk harrowing to the depth of 0.10 to 0.12 m), and four variants of fertilization. The first was not fertilized. The second was fertilized with an organic fertilizer Condit mineral at a dose of 1 t ha^{-1} before sowing. On the third variant we applied 60 kg N as saltpetre nitrate with limestone (SNL) + leaf fertilizer (Hakofyt extra), and on the fourth 60 kg N as NH_4NO_3 + leaf fertilizer (Hakofyt extra). The RSC measurements were done using LCR - meter type ELC - 133A at a frequency of 1 kHz. To RSC measurement we used clamp electrode (Rajkai et al., 2005). Measurements have taken place in four growth stages, at leaf development in the stage of four leaves (BBCH 13-15 - RSC1), in full tillering (BBCH 23-25 - RSC2), in the stage of heading (BBCH 51 - RSC3) and at the stage of ripening (BBCH 85-89 - RSC4).
Achievements were statistically evaluated by analysis of variance (ANOVA) in the program package Statistica 8, and the means were tested with Tukey HSD test. The relationship among grain yield and RSC at each growth stage was expressed by correlation coefficient (r).

Results and discussion

Achieved results showed statistically significant effect of year on the development of RSC and grain yield, and significant effect of variety on yield and RSC in growth stages BBCH 25-28 respectively BBCH 85-89. Influence of tillage method and fertilization were significant on RSC2 and RSC4, moreover fertilization had statistically significant effect on grain yield also.
Mean values for grain yield and RSC in various growth stages in the second year were significantly higher than those in the first year. Difference in yield reached 47% and RSC1 was higher by 81%, RSC2 by 21 %, RCS3 by 82%, RCS4 21%. Form the monitored varieties the highest yields were achieved by Bojos (5.68 t ha^{-1}) and Marthe (5.60 t ha^{-1}). Significantly lowest yield was achieved by variety Kangoo (4.80 t ha^{-1}). Significant differences among varieties for RSC were observed in BBCH 25-28 and BBCH 51. Highest values of RSC was achieved by Bojos (RSC2 = 1.458 nF, RSC3 = 0,599nF). We found a significant difference in the early growth stages (RSC2) in favour of conventional tillage (1.588 nF), but for RCS4 it turned in favour of minimized tillage (0.211 nF).
From the monitored fertilization variants significantly highest values of RSC were found at the application of organo-mineral fertilizer Condit in growth stage BBCH 23-25 (1.458 nF) and BBCH 51 (0.599 nF). The greatest yield was also achieved at the variant Condit (5.68 t ha^{-1}). Signifficant difference was found among treatments Condit × NH_4NO_3 and SNL× NH_4NO_3. Macák et al. (2008) reached similar results.
From *Figure 1.* concludes, that variety Bojos achieved the highest yield, showed higher depression of RSC from growth stage of heading to growth stage of maturing. In the year with higher yield (2010) the depression of RSC was decreasing sharply form heading till maturing than in the year 2009 (*Figure 2.*). Higher depression of RSC to the end of vegetation is stated by Chloupek (1977). According to results of Pietola (2005), after grain formation the root numbers decreased toward full ripeness.

Table 1. Mean values grain yield and RSC at the monitored growth stages for different years, spring barley varieties, tillage methods and fertilization levels

	Grain yield ($t\ ha^{-1}$)		RSC1 (nF)		RSC2 (nF)		RSC3 (nF)		RSC4 (nF)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Year										
2009	4.29 a	0.95	0.566 a	0.228	0.985 a	0.284	0.369 a	0.087	0.182 a	0.050
2010	6.33 b	1.57	1.028 b	0.314	1.194 b	0.489	0.673 b	0.222	0.220 b	0.085
Variety										
Xanadu	5.15ab	1.48	0.755 a	0.342	1.410 bc	0.574	0.529 ab	0.219	0.199 a	0.081
Bojos	5.68 a	1.89	0.794 a	0.344	1.458 c	0.564	0.599 b	0.245	0.215 a	0.057
Marthe	5.60 a	1.62	0.806 a	0.332	1.310 ab	0.535	0.486 a	0.259	0.195 a	0.070
Kangoo	4.80 b	1.48	0.833 a	0.415	1.179 a	0.424	0.470 a	0.153	0.194 a	0.077
Tillage method										
Conventional	5.42 a	1.76	0.816 a	0.346	1.588 a	0.554	0.511 a	0.222	0.191 a	0.071
Minimized	5.20 a	1.54	0.778 a	0.371	1.091 b	0.377	0.531 a	0.232	0.211 b	0.072
Fertilization										
Control	5.15ab	1.48	0.755 a	0.342	1.410 bc	0.574	0.529 ab	0.219	0.199 a	0.081
Condit 1 $t.ha^{-1}$	5.68 a	1.89	0.794 a	0.344	1.458 c	0.564	0.599 b	0.245	0.215 a	0.057
SNL+ Hakofyt extra	5.60 a	1.62	0.806 a	0.332	1.310 ab	0.535	0.486 a	0.259	0.195 a	0.070
NH_4NO_3 + Hakofyt extra	4.80 b	1.48	0.833 a	0.415	1.179 a	0.424	0.470 a	0.153	0.194 a	0.077

In each section, mean values followed by the same letter within columns are not significantly different ($p<0.05$) accordong to Tukey test.

Correlation relationship among grain yield and RSC was significant and positive in every monitored growth stage. The highest correlation relationship was between grain yield and RSC3 (0.6047) (*Table 2.*). Cerkal et al. (2008) found a negative correlation relationship between grain yield and RSC.

Table 2. Correlation relationship among grain yield and RSC1, RSC2, RSC3, RSC4

	RSc1	RSC2	RSC3	RSC4
Garin yield	0,4801***	0,5291***	0,6047***	0,3540***

Represents significant level of *0.05-0.01, **0,01-0,001, ***<0,001

Conclusions

The year had a significant effect on yield and root system capacity. Yield was higher in the second year by 47% and significant increase of RSC was achieved in BBCH 25-25 and BBCH 85-89 by 21%, respectively in BBCH 13-15 and BBCH51 by 81-82%. The differences between varieties was proved in RSC in the growth stages BBCH 23-25 BBCH 51 in favour of variety Bojos (1.458 nF, 0.599 nF respectively), at which variety the highest yield (5.68 $t.ha^{-1}$) was also achieved. Significant difference between tillage methods and fertilization variants was confirmed in BBCH 85-89 in favours of the minimized tillage method (0.211 nF) and application of mineral fertilizer Condit (0.222 nF), and this fertilization variant gave the highest grain yield (5.44 $t.ha^{-1}$). The highest correlation relationship was between grain yield and RSC3 (r=6047).

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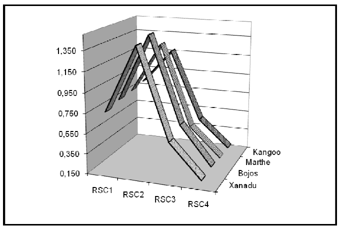

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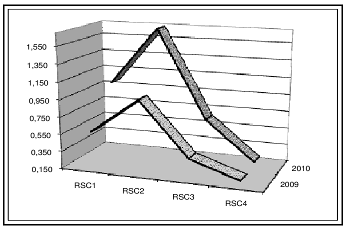

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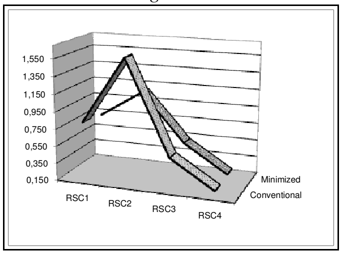

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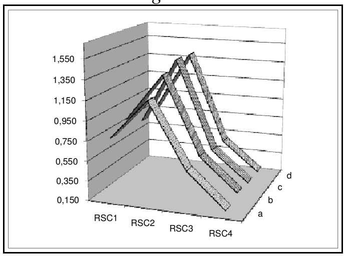

Figure 4.

Figure 1, 2, 3, 4. RSC development depending on variety (1), year (2), tillage method (3) and fertilization (4, a - control, b - Condit, c - SNL + leaf fertilizer, NH_4NO_3 + leaf fertilizer)

Acknowledgements: The paper was supported by VEGA project 1/0551/08.

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INFLUENCE OF ABIOTIC STRESSES AND APPLICATION OF 24-EPIBRASSINOLIDE ON YIELD AND CHEMICAL STRUCTURE OF WHEAT'S GRAIN

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Abstract: The aims of trial was acknowledge of influence 24-epibrassinolide on chemical structure and yield of wheat's grains under abiotic stress (high temperature with drought) and applications of 24-epibrassinolide. A pot experiment with three winter wheat varieties - *Ebi*, *Estica*, *Samanta* and three spring wheat cultivars - *AC Helena*, *Mollera*, *Lucia* was set up in standardised greenhouse conditions - control (70 % of field water capacity, 23 °C/15 °C), stress - (37 % of field water capacity, 33 °C/20 °C) and combination stress with 24-epibrassinolide. The phytohormone 24-epibrassinolide was applied in the form of a spray at the start of flowering (61.DC) in a concentration of 10^{-9} M (4,52624 x 10^{-7} g in 1 l watter). The watering was regulated on the basis of measurement using the AT Theta Kit device. The abiotic stress – combination of drought and high temperatures - significantly affect decrease of measured traits of the grain and yield of grain. The application of 24–epibrassinolide at stress conditions has positive effect on the monitiored parameters (content of lipids, proteins, starch and damage starch) and yield of grain. The cultivars AC Helena, Samanta are tolerant to the drought and high temperature in comparison with Estica a Lucia which have low level of tolerance. The best reaction of cultivar to the application of phytohormone has at cv. Mollera and on the other hand without any influence was obtained at cultivar Samanta (stress tolerant cultivar).

Keywords: wheat, stress, 24-epibrassinolide, grains, chemical structure

Introduction

The current changes in weather bring with them a evident fluctuation in temperatures and also a relatively irregular and random distribution of precipitation during the vegetation period of field crops (Bárek et al., 2010). Therefore a study of plants' adaptation to a water deficit is ever more topical, as the water deficit leads to a fall in the amount and quality of the yield (Hnilička et al., 2007). The negative effect of a water deficit can be alleviated by the application of certain natural and synthetic compounds. Of the natural compounds, the brassinosteroids have such effect (Khripach et al., 2000). Seed quality traits are under influence of complex internal and environmental factors. It therefore depends not only on the plant genotype, as well as on the external circumstances of cultivation. The aims of trial was acknowledge of influence 24-epibrassinolide on chemical structure in wheat's grains under drought and high temperature. The next hypotheses were to be defined: exist differences of genotype in chemical structure in wheat's grain under stress. Exist differences of genotype in chemical structure in wheat's grain after application of 24-epibrassinolide.

Materials and methods

In the years 2006 to 2010 was provided the analysis of the influence of abiotic stresses and possibilities of reduction their negative effect by application of 24-epibrassinolide. A pot experiment with three winter wheat varieties - Ebi, Estica, Samanta and three

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spring wheat cultivars - AC Helena, Mollera, Lucia was set up in standardised greenhouse conditions. 20 grains were sown into earth filled Mitscherlich pots. The experimental scheme is given in *Table 1*. The 24-epibrassinolide was applied in the form of a spray at the start of flowering (61.DC) in a concentration of 10^{-9} M. The watering was regulated on the basis of measurement using the AT Theta Kit device.

Table 1. Experimental scheme

Variant	Conditions of experiment			
	Watering	Temperature	Light regime	Stress induced
Control	70% of field water capacity	23 °C/ 15 °C	16/8 h	-
Stress	37% of field water capacity	33 °C/ 20 °C	16/8 h	40.DC
Stress + 24 - epibrassinolide	37% of field water capacity	33 °C/ 20 °C	16/8 h	40.DC

After harvest of the seeds, the analysis of crude protein content, lipids content, total starch content. The nitrogen content was determined by the Kjeldahl procedure, using set of instruments Kjeltec system1002, Swedish firm Tecator. The calculation of the crude protein content used the conversion factor of 5.7 for wheat. Extraction according Soxhlet was performed using Soxtherm 2000 Automatic extraction system German firm Gerhard. Lipids according Soxhlet includes all non-volatile substances extracted from the analysed material by non-polar solvent under the method conditions.Starch content was determined using AACC Method No. 76-13 by means of enzyme kit Megazyme Total Starch Assay Procedure of Megazyme International Ireland Ltd. Starch in sample is hydrolysed in two phases: firstly by means. of thermostable α -amylase and then by amyloglucosidase. Final product of hydrolysis - glucose - is determined by spectrophotometry. A statistical programme Statistica, version 9.0 Cz, statistical methods ANOVA was used for processing of statistical data, at significance level $\alpha = 0.05$.

Results and discussion

The highest protein content has been found in the cv. Mollera (1.62 g kg^{-1}) and the lowest in Estica (1.21 g kg^{-1}), see *Figure 1*. Protein content was distinctly influenced by the experimental treatment, as the stressed variants and variants with 24-epibrassinolide had a fall in protein content of 4.82 %. The largest decrease was at cultivar AC Helena, where decrease was 0.16 g kg^{-1}. The lowest decrease was at cultivar Ebi (0.02 g kg^{-1}). According to the results of Hrstková and Vejražka (2010) drought have a positive effect on protein content. This result was not confirmed, because stress was through the combination drought with high temperature. In case of the analysis of the stressed plants treated with 24-epibrassinolide significantly decreased the protein content compared to the control sample by 3.12 g kg^{-1}. The stressed grains decreased the protein content, compared to the control grains, by 0.20 g kg^{-1}. The obtained results show that the wheat grain protein content in analysed environments is higher than results according to Figuerola et al. (2005).

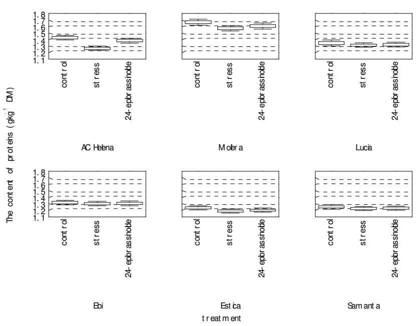

Figure 1. The content of proteins (g kg^{-1} DM)

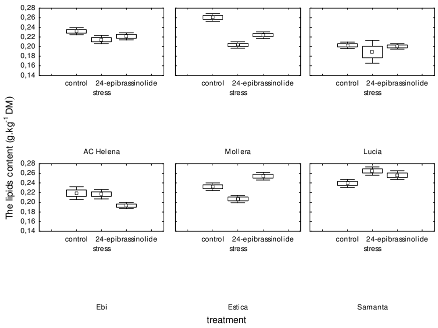

Figure 2. The content of lipids (g kg^{-1} DM)

The changes of the lipids content in the grain were dependent of the treatment, see *Figure 2*. The highest lipid content was at the control (3.1 g kg^{-1}) and the lowest value vas obtained at stress (0.22 g kg^{-1}). The decrease in lipid content subjected to abiotic stress factors, such as high temperatures, is described in the work by for example Williams et al. (1994). Krzymanska and Goebiowska (1987) states that the lipid content in grains lowers under the influence of biotic stress factors. The application of 24 epibrassinolide on the stressed plants has statistically non significant effect on the increase in lipids content in comparison with stresses plants. Only in varieties Estica and Samanta a statistically higher increase in lipids content was found in this treated sample compared to the control grains. From the statistical evaluation in Fig. 2 there were significant cultivars differences, because the highest content of lipids was obtained at cv. Samanta (0.25 g kg^{-1}) and the lowest content was found in the cv. Lucia (0.20 g kg^{-1}). These results were confirmed by the work of Ruibal et al. (2002).

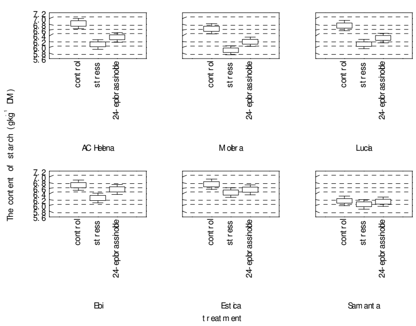

Figure 3. The content of starch (g kg^{-1} DM)

The starch content was monitored in grains of wheat, too. The starch content was not significantly influenced by the wheat cultivars, but the lowest average content of starch was found in the cv. Samanta (6.11 g kg^{-1}) and the highest content were obtained for the cv. Estica (6.58 g kg^{-1}), (*Figure 3*.). These results were confirmed by the work of Orak (2006) for maize. Solomon and Labuschange (2003) also present cultivars differences in

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the reaction to drought. When evaluating the effect of the variants on the starch content it can be stated that the stressed plants showed the lowest content (6.14 g kg^{-1} DM) and the control the highest – 6.64 g kg^{-1}. The application of 24-epibrassinolide increase content of starch of stress experiment to the 6.35 g kg^{-1}.
The most significant decrease in the starch content after treatment with 24-epibrassinolide was recorded at the cultivar AC Helena, where the starch content dropped by 0.70 g kg^{-1} compared to the control grains. The statistically non significant decrease was found in the cv. Samanta when compared to the control (by 0.05 g kg^{-1}).

Conclusions

It follows from the obtained results that the drought with high temperatures significantly affect decrease of measured traits of the grain. There is possibility to conclude that differences among measured parameters (content of lipids, proteins, starch) at cultivars and at different type of environments exists. The cultivars AC Helena, Samanta are tolerant to the drought and high temperature in comparison with Estica a Lucia which have low level of tolerance. In case of analysis of influence of above named phytohormone on the stress tolerant cultivars any effect was obtained. The application of 24-epibrassinolide at stress conditions has positive effect on the monitiored parameters.

Acknowledgements

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EFFECT OF N FERTILISATION ON THE CHLOROPHYLL CONTENT AND GRAIN YIELD OF MAIZE IN DIFFERENT CROP YEARS

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Abstract: The objectives of this study were to evaluate the effect of nitrogen (N) fertilisation, under rain-fed conditions, on the chlorophyll content (Chl) and grain yield of maize and to quantify the relationship between the soil nitrate N and maize Chl over the 2007-2008 crop seasons. On the average of N treatments, in the water-stressed crop year of 2007 significantly higher Chl (SPAD value of 54.4) was measured than in a favourable year of 2008. The lower photosintetically active leaf mass and leaf area in 2007 was compensated by higher Chl. During the examined crop seasons, leaf Chl decreased in 2007, while an increase was measured in 2008. The N uptake was very intensive until the R1 stage in 2008. Conversely, a moderate uptake was received in 2007. Our results showed that Chl measurements at the V12 and R1 stages give a wake yield forecast in a year of drought, while the reliability of the yield prediction was middle at V12 and high at R1 stages under good weather conditions. Regressions between SPAD readings and nitrate N content of the 0-120 cm soil profile were not significant in the early vegetative stages in 2007. However, the relationship between these factors was significant at the stage of 50% silking (r=0.553). In 2008, there was no significant relationship at V6 stage, whereas high correlation was obtained in the V12 and R1 stages (r=0.858 and 0.807).

Keywords: maize, chlorophyll, soil nitrate N content, grain yield

Introduction

The determination of the optimal fertiliser dose is one of the most difficult tasks in intensive crop nourishment. On one hand, one has to consider the nutrient management and nutrient binding ability of the soil and the nutrient utilisation ability and the fertiliser reaction of the grown hybrid and the crop year effects also have to be taken into account on the other (Széll et al., 2005). As a result of the increasing N doses, the photosynthetic activity increases, so does the leaf area (LAI) and the leaf area density (LAD) (Dwyer and Anderson, 1995; Earl and Tollenaar, 1997; Dobos et al., 2010).

The objectives of this study were to evaluate the effect of nitrogen fertilisation, under rain-fed conditions, on the Chl content and grain yield of maize and to quantify the relationship between the soil nitrate N and maize Chl content over the 2007–2008 crop seasons.

Materials and Methods

This study was conducted in 2007–2008 at the Látókép Experimental Station of the Centre for Agricultural and Applied Economic Sciences, University of Debrecen (47° 33’ N, 21° 26’ E, 111 m elevation). The investigations were part of an irrigation x fertilisation long-term field experiment. The soil of the experimental site was a lowland pseudomyceliar chernozem (Mollisol-Calciustoll or Vermustoll, silt loam).

In the 2007 growing season 284 mm rainfall was measured. In the extraordinarily water-stressed April to July period only 120 mm rainfall occurred, which represents 48.8% of the fifty-year average (246 mm). In contrast to the previous year, the weather conditions in 2008 were very favourable for maize with 484 mm precipitation for the growing season.

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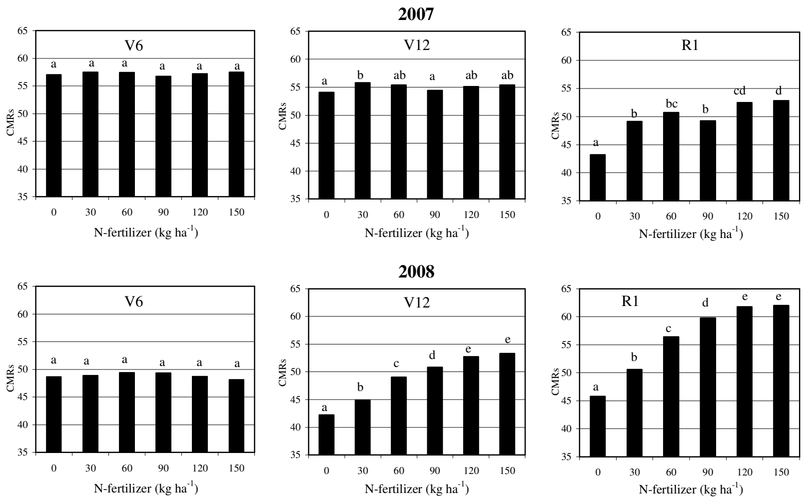
Chlorophyll meter readings (CMRs) were made using Minolta SPAD-502 portable chlorophyll meter. Readings were carried out in the vegetative (V6, V12) and in the reproductive (R1) stages (Ritchie et al., 1997; Shaahan et al., 1999). SPAD readings were taken on fully expanded leaves in the vegetative stages. At the silking stage, the measurement was done at the first leaf below the ear. The examinations were carried out under non-irrigated conditions, in the 0, 30, 60, 90, 120 and 150 kg N ha^{-1} plots, respectively. Twenty plants per plot were measured on each sampling time. Short season corn hybrid Mv 277 SC (FAO 310) was sown at the end of April in both years.
Parallel to the CMRs soil nitrate measurements were taken to a depth of 200 cm in 20 cm increments. Photometric determination (Spectroquant Nova 60 A) was used to determine the nitrate N content. Statistical analysis was performed using SPSS for Windows 13.0 software package.

Results and discussion

Effect of N fertilisation on leaf chlorophyll content

The chlorophyll content of the leaf in the V6 growth stage did not change as a result of the N doses in any of the years. It did not have any positive effect on the chlorophyll content in the V12 stage in 2007 either, but there was a significant ($p<0.001$) effect in 2008 and the highest chlorophyll content was triggered by the 120 kg ha^{-1} N dose. In the R1 stage, the N dose significantly increased the chlorophyll content both in 2007 ($p<0.001$) and in 2008 ($p<0.001$) (*Figure 1.*).



Data in one column indicated by the same letter do not significantly differ from each other on the basis of Duncan test

Figure 1. Effect of different N treatments on the leaf chlorophyll content at 3 phases of growing season (Debrecen, 2007–2008)

The lowest chlorophyll content was measured on the non-fertilised plots at all three measurement dates. The average chlorophyll content on the plots fertilised with nitrogen

was higher in the V6 and V12 stages in 2007 (57.3; 55.2 CMR value) than in 2008 (48.9; 50.1 CMR value). Nevertheless, in the R1 development stage in 2008, a higher CMR value was obtained (58.1 CMR value) than in 2007 (50.9 CMR value). The difference was always significant (p<0.001).
There was a medium correlation between the N treatment and the chlorophyll content in the R1 growth stage in 2007 (0.454), whereas it was closer in the V12 stage in 2008 (0.549) and the it became even closer in the R1 stage (0.689).

Effect of soil nitrate N on the leaf chlorophyll content

In 2007, the nitrate N applied in autumn accumulated in the layers close to the surface at all development stages owing to the very dry weather conditions during winter and early spring. During the vegetation period, the amount of nitrate N did not decrease considerably in the rooting zone and a movement to the deeper layers was also not observed. In contrast to the previous year, the accumulation zone was found at 40-60 cm depth in 2008. Because of the intensive plant N uptake the nitrate N content of these layers were halved until silking period in the 90-150 kg ha^{-1} N treatments (*Figure 2.*).

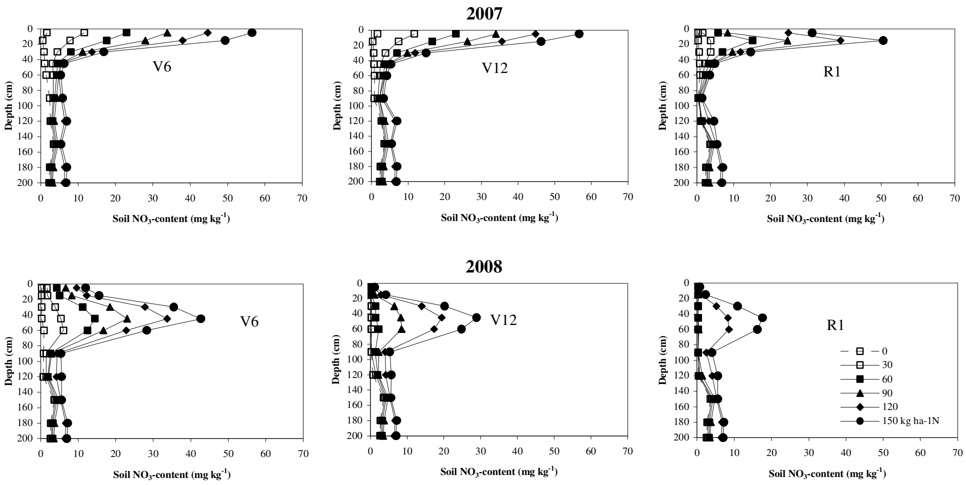


Figure 2. Effect of different N treatments on soil nitrate content in the soil profile at 3 phases of growing season
(Debrecen, 2007–2008)

It was established that regressions between CMR readings and nitrate N content of the 0-120 cm soil profile were not significant in the early vegetative stages (6 to 12 expanded leaves) in 2007. However, the relationship between these factors was significant at the stage of 50% silking (r=0.553). In 2008, there was no significant relationship between these two factors at V6 stage, whereas high correlation was obtained in the V12 and R1 stages (r=0.858 and 0.807).

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The effect of nitrogen fertilisation on yield

The effect of the N treatments on the grain yield was significant both in 2007 ($P<0.01$) and 2008 ($P<0.001$). There was a linear increase in the maize hybrid yield until the application of 60 kg ha^{-1} (5.3 t ha^{-1}) N in 2007 and 90 kg ha^{-1} (11.82 t ha^{-1}) N in 2008, but the further increase of the N dose caused yield depression. The average yield increasing effect of the N fertilisation was 1.34 t ha^{-1} in 2007 and 3.27 t ha^{-1} in 2008.
In the V12 growth stage in 2007, there was a positive weak ($r=0.122$) significant ($P<0.01$) correlation between the chlorophyll content and yield, whereas the correlation between the variables became stronger in the R1 stage ($r=0.384$, $P<0.001$). In the V12 stage in 2008, a medium correlation ($r=0.594$, $P<0.001$) was observed that became even stronger in the R1 stage ($r=0.735$, $P<0.001$).

Conclusions

Our results showed that Chl measurements at the V12 and R1 stages give a wake yield forecast in a year of drought, while the reliability of the yield prediction was middle at V12 and high at R1 stages under good weather conditions. Based on the examination results, it can be established that it is possible to conclude to the available N stock in the soil on the basis of the CMR values in the V12 stage in favourable crop years and in the reproductive phase in dry crop years.

Acknowledgements

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EFFECT OF FOLIAR BORON TREATMENT ON SEED YIELD AND YIELD COMPONENTS OF RED CLOVER (*TRIFOLIUM PRATENSE* L.) GENOTYPES

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Abstract: Adequate micronutrient nutrition can have a positive effect on seed yield and yield components of red clover, particularly on acid soils. The objective of this study was to evaluate the effect of foliar boron treatment on seed yield and yield components (stem number per plant, inflorescence number per stem, inflorescence number per plant, flower number per inflorescence and seed fertility) in ten red clover genotypes grown under low plant density (70 x 40 cm). Foliar boron treatment during intensive growth of red clover had a positive effect on inflorescence number per plant, flower number per inflorescence, fertility and seed yield.

Keywords: red clover, boron, seed yield, seed yield components

Introduction

High variability, adaptability and genetic plasticity of red clover *(Trifolium pratense* L.*)* are the result of the extremely xenogamous character of fertilisation. This has contributed to the development, through natural selection, of a large number of local ecotypes that show superiority under particular growing conditions (Helgadottir, 1996). As seed crops of red clover are frequently established on acid soils where the availability of certain nutrients is reduced, particular attention should be given to adequate mineral nutrition (Dear and Lipsett, 1987). The objective of this study was to evaluate the effect of foliar treatment with boron, a micronutrient whose availability in acid soils is reduced, on seed yield and yield components of selected red clover genotypes.

Materials and methods

The experiment was established in 2009 in Čačak (43°54'39.06" N, 20°19'10.21" E, 246m a.s.l.) on alluvial acid soil (pH_{H2O} 4.8) according to a completely randomised block design in five replications (with 20 plants per plot at a plant spacing of 70x40cm). A total of ten red clover genotypes, including nine diploid (G1, G2, G4, G8, G9 and G10 selected from cvs. Viola, Una, Kolubara, Avala, K-17 and K-39, respectively, and G3, G6 and G7 selected from local populations found in the vicinity of Čačak) and one tetraploid (G5 selected from cv. K-27 Tetra), were used in the study. Two foliar treatments with boron (B) (Bor-feed, Haifa, Izrael, at a concentration of 0.1% and water rate of 1000 L ha^{-1}) were employed: during the stage of intensive growth and prior to the onset of flowering. The second cut in the second year was evaluated under field conditions for the following: stem number per plant (SNP), inflorescence number per stem (INS), and inflorescence number per plant (INP), using a sample of five plants per plot. Laboratory evaluation included determination of: flower number per inflorescence (FNI), (using ten randomly selected inflorescences), fertility (F) (ratio between grain number and total flower number per inflorescence). Seed yield components

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(inflorescence number per plant, grain number per inflorescence, thousand grain weight) were used to determine seed yield pre plant (SY) which was calculated as g plant^{-1}.
The obtained results were subjected to a two-factor analysis of variance (genotype, B) using SPSS software (1995). The significance of differences between mean values was tested by LSD test.

Results and discussion

Stem number per plant ad inflorescence number per stem did not show significant differences among genotypes. Foliar B treatment did not have a significant effect on SNP and INS (*Table 1.*).
Foliar B treatment induced a significant increase in INP in all genotypes as compared to the control, with G2 having a significantly higher INP than G4 and G6. Schon and Blevins (1990) report that foliar treatment of soybean with boron resulted in a significant increase in branch number per plant and pod number per branch. However, a study conducted by Wilczek and Ćwintal (2008) showed no significant effect of foliar treatment with B on INP in red clover during the stage of budding. The reason for the non-compliance between their findings and the present results is most likely the date of B application; in this experiment, the first treatment with boron was conducted earlier (during the stage of intensive growth).

Table 1. Mean values for seed yield and seed yield components: stem number per plant – SNP, inflorescence number per stem – INS, inflorescence number per plant – INP, flower number per inflorescence – FNI, fertility – F (%), and seed yield - SY (g plant^{-1}) in red clover genotypes as affected by foliar treatment with boron (control - 0, boron – +).

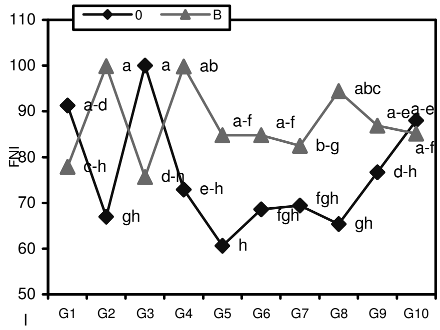
		SNP	INS	INP	FNI	F	SY
Genotype	G1	24.1	4.32	104abc	84.6ab	50.8c	4.75b
	G2	26.5	4.66	118.6a	83.5ab	64.6ab	7.69a
	G3	30.9	3.43	103.3abc	87.8a	52.1c	5.62ab
	G4	28.5	3.66	72.4c	86.4a	56.3bc	5.39ab
	G5	22.9	4.72	104.4abc	72.7b	7.3d	0.9c
	G6	22.8	3.38	76.3bc	76.5ab	60.2abc	4.13b
	G7	23.4	4.65	111.4 ab	76ab	67.9a	6.63ab
	G8	28.0	3.55	93.9 abc	79.9ab	72.5a	6.14ab
	G9	21.2	3.86	80.9 abc	81.1ab	54.3c	5.34ab
	G10	22.3	4.54	85.6 abc	86.5a	70.1a	6.2ab
Boron	0	24.1	3.95	84.7 b	76 b	54.7	5.17
	+	26.1	4.21	105.5 a	87.1 a	56.5	5.39
ANOVA	Genotype (A)	ns	ns	*	*	**	**
	Boron (B)	ns	ns	*	**	Ns	ns
	AB	ns	ns	ns	**	**	**

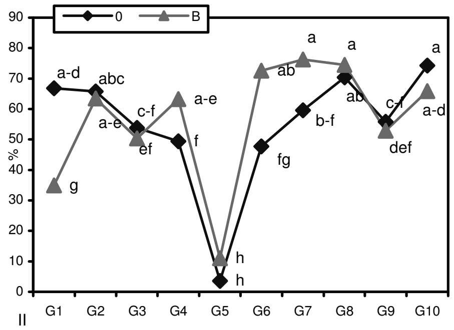
The values denoted with different small letters within columns for genotypes and boron are significantly different (P<0.05) in accordance with the LSD test; **- F test significant at p<0.01; *- F test significant at p<0.05; ns - F test non-significant

Foliar B treatment produced a different effect on FNI (genotype x B interaction). FNI increased significantly as compared to the control in G2, G4, G5 and G8, and decreased significantly in G3 (*Figure 1.* (I)).

Lewis (1980) reports a positive effect of boron on the metabolism of many hormones regulating normal development of generative organs. Dell and Huang (1997) suggest that boron deficiency prevents or retards flower formation in plants developing flowers in compact terminal inflorescences.

The significance of the genotype x B interaction for fertility indicates different responses of genotypes to foliar B treatment. Under B treatments, fertility was significantly higher in G4, G6 and G7 (*Figure 1.* (II)), and significantly lower in G1, as compared to the control. Wilczek and Ćwintal (2008) determined that foliar B application in red clover induced a significant increase in grain number per inflorescence i.e. flower fertility, due to higher pollen vitality and germination intensity, and higher presence of insect pollinators. Lewis (1980), Dordas (2006), and Dell and Huang (1997) also report positive B effects on pollination, fertilisation and growth of both seed and fruit.





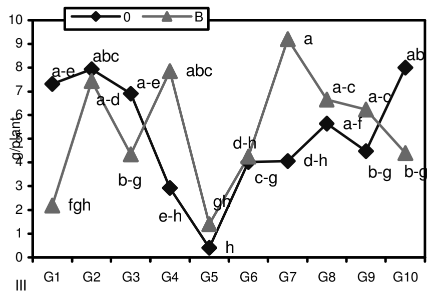


Figure 1. Effect of foliar treatment with B (control-0, boron-B) on: (I) Flower number per inflorescence (FNI), (II) Fertility – F (%), (III) Seed yield - SY (g $plant^{-1}$) in red clover genotypes (G). Values followed by different small letters are significantly different (P<0.05) according to the LSD test

Seed yield of genotypes (genotype x B interaction) was affected differently by foliar B treatment: positively in G4 and G7 (2.8- and 2.3-fold higher, than in the control respectively), negatively in G1, whereas SY in other genotypes did not show significant variation (*Figure 1.* (III)). SY was, as expected, lowest in G5, which was in agreement

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with the results obtained by Vojin (2007) who suggested significantly lower seed yields of tetraploid cultivars as compared to diploid ones. The positive effect of foliar B application on seed yield of red clover was reported by Lewis (1980), Wilczek and Ćwintal (2008), as well as by Dordas (2006) in alfalfa and Schon et Blevins (1990) in soybean.

Conclusions

Notwithstanding foliar boron treatment, the genotypes tested showed differences in inflorescence number per plant, flower number per inflorescence, fertility and seed yield. Foliar treatment with boron induced an increase in flower number per plant in all genotypes. The variable response of genotypes to foliar boron treatment was observed in flower number per inflorescence, fertility and seed yield. Foliar treatment with boron resulted in a significant increase in flower number per inflorescence in G2, G4, G5 and G8, fertility in G4, G6 and G7 and seed yield per plant in G4 and G7. Regardless of stem number per plant, inflorescence number per stem, inflorescence number per plant and flower number per inflorescence, the tetraploid genotype G5 had very low flower fertility, which reflected in grain number per inflorescence and total seed yield per plant.

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EXAMINATION OF DIFFERENT PLANT NUMBER OF SUNFLOWER IN FIELD EXPERIMENTS

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Abstract: Spacing of sunflower hybrids has been studied. The fertilizer usage was the same each year. The plant density varied between 40-50-60-70 thousand plants/ha, in year 2006-2008. It can be stated that the possible density of hybrids is different. Plant number has a considerable effect on yield. Modern hybrids show a flexible behaviour to increasing density range of appilcable spacing is wide. With the increase of plant density the individual production decreases but the yield/unit area, improves. The number of plants/ha can be increased up to a limited degree because above the optimal spacing the number of barren plants increases, the yield decreases and susceptibility to *Sclerotinia spp.* and *Diaporthe helianthi* grows. In the case of modern hybrids the connection between the growing season and plant density is not significant. Increasing of use applicable density is a genetically controlled characteristic of hybrids. It is also influenced by the nature of the site, the seasonal effect and water supply. In case of hybrids, not only the optimal spacing but also the range of optimal plant number should be determined and the lower value should be used to deviate from this value upward is not expedient.

Keywords: sunflower, plant number, density, yield

Introduction

The sunflower is the most important oil crop of Hungary and from the oil crops it is produced on the greatest area. The agroecological circumstances in Hungary are the most favorable for the sunflower from the oil crops, because of it's good adaptability it can adapt to Hungary's fairly extreme continental climatic conditions. Comparing the sunflower's growing area of 100 thousand hectares at the 1970's it extended during the last decade and varied between 400-520 thousand hectares. Improving the agrotechnical factors and biological basics are cardinal elements of increasing crop reliability. The present hybrid assortment is wide both from the viewpoint of the yields and quality of crop. The biggest problem is in the crop stability of hybrids (Pepó, 1999; Szabó et al. 2005). The crop density is a significant factor of agrotechnical elements. The use of optimal crop density makes it possible to exploit the hybrid's productivity. It can be stated that the possible density of hybrids is different (Futó, 2008). The production of sunflower can only be obtained through great farms efficiency. The number, quality and potential productivity of acknowledged sunflower hybrids are definitely good. By improving the agro-technical factors and adjusting them to the climate effects the crop stability and yield quantity can be achieved. The role of crop density in the formation of yields is inevitable. In the rainier and cooler cropyear (2004) the yields were lower because of the higher infection of diseases. In the drier cropyear (2003) the infection values were lower and the yields exceeded the rainier year's results in every crop density. In 2003 the highest yields were at the rate of 45.000 plant/ha (5 hybrids) and 65.000 plant/ha (1 hybrid) (Szabó and Pepó, 2005). Goksoy et al. (1998) analyzed sunflower hybrids and varieties on three density levels (30.000, 47.500 and 95.000 plant/hectare). He stated that the oil content, the oil yield and the crop quantity was the highest with 95.000 plant/hectare.
The sunflower is produced on the greatest area from our oil crops. The crop density affects the oil content of sunflower. In 2004, the oil content of the examined hybrids

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was lower than in 2003, wich was the result of the higher rate of disease infection. The experiments verified that by increasing the number of plants the oil content increased likewise, wich was confirmed also by varience analysis (Szabó, 2006).

Materials and methods

The sunflower experiment at near Törökszentmiklós experimental garden of the Szolnok College, Faculty of Agronomy, Department of Agriculture was adjusted on calciferous chernozem soil between 2006-2008. The plant density experiments were adjusted between 40.000 and 70.000 plant/hectare density interval, with a grade of 10.000 plant/hectare. The small-plot field experiments were randomized and four times replied. In the researches in 2006 were used 12 hybrids, in 2007 were 6 hybrids and in 2008 were also 6 hybrids. The hybrids were applied with single agrotechnology generally used in practice, too. The harvested crops have been standardized by correcting to 8% seed moisture content. The weather of the summer and autumn of 2006 were ordinary, in 2007 the spring and summer-end were characterized by dry and warm climate, while in 2008 there was more than average of thirty years precipitation in all cropyear of sunflower. April was dry and warm in 2006 and 2008, and it was extremely dry in 2007. In May was average precipitation in all three years. In June, 2006, there was high amount of rainfall (92.3 mm), and in 2007, 2008 it was average precipitation. The weather in July and August, 2007, were dry and warm. Said that the weather in 2006 was average, in 2007 was dry and in 2008 was preferably rainy (*Table 1*.).

Table 1. Average precipitation in cropyear of sunflower between 2006-2008

	Apr.	May	Jun.	Jul.	Aug.	Sept.	All
2006.	39.8	49.8	92.3	46.5	74.5	14.9	317.8
2007.	1.8	51.2	50.8	32.8	33.7	55.9	226.2
2008.	37.5	68.3	57.7	60.3	65.7	59.3	348.8
Average	46.0	56.0	59.0	50.0	50.0	40.0	301.0

Results and discussion

Our experimental results different density effect for yield and oil content of sunflower hybrids. In 2006 significant difference could be established. regarding the 40.000 plant/ha density. which indicates the plant density is one of the critical elements of the hybrid-specific production management. In 2006 the highest yields were produced by two hybrids the PR64H41 (3705 $kgha^{-1}$. 50.000 plant/ha) and PR64H61 (3480 $kgha^{-1}$. 40.000 plant/ha). (*Figure 1*.) In 2007 the climatic factors were disadvantage for the development of diseases. owing to this yield was higher than in 2006. In 2007. as opposed to the last year. the highest yields were produced by two hybrids in 70.000 plant/ha. the PR64H32 (3970 $kgha^{-1}$) and PR64H41 (3840 $kgha^{-1}$). (*Figure 2*.) In 2008 was the yields of sunflower hybrids the highest. The climate in 2008 was quite warm and average rainy. In cropyear of sunflower the precipitation from May to September was favourable for productivity and produced. In 2008 the highest yields were for 3 hybrids in the optimal plant densities (50.000 and 60.000 plant/ha). The highest yields were produced by two hybrids. the XF4991 (4803 kgha^{-1}. 60.000 plant/ha) and PR64H61 (4207 kgha^{-1}. 70.000 plant/ha) (*Figure 3.*).

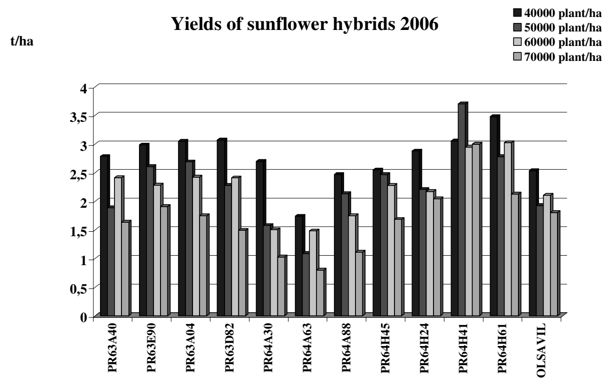

Figure 1. The effect of density on yields of sunflower 2006.

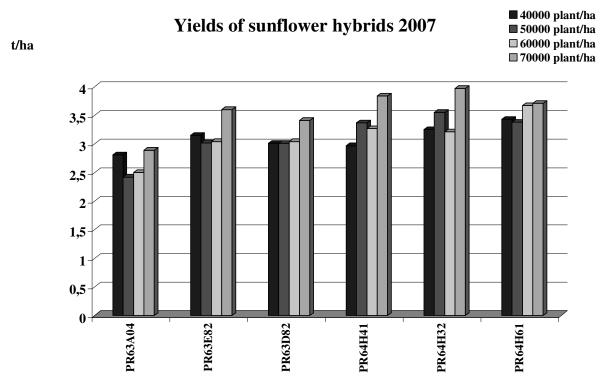

Figure 2. The effect of density on yields of sunflower. 2007.

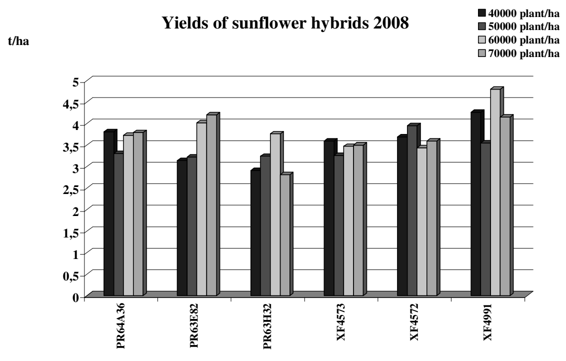

Figure 3. The effect of density on yields of sunflower. 2008.

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During the three examined years (2006-2008) the maximum yields have been reached with different plant density. In 2008 the infection was the lowest in examination. and the yields were the highest in this year.

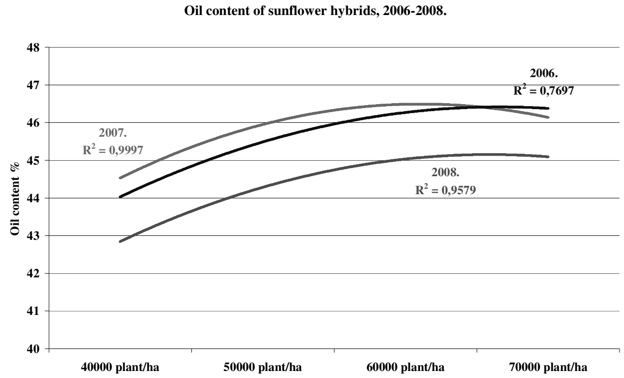

Figure 4. The effect of density on oil content of sunflower. 2006-2008.

In the examined three years the oil content ranged between 42.93% and 46.96% for hybrids. After analyzing the oil content of the hybrids it can be confirmed that the lowest level of oil content resulted from the 40.000 plant/ha. which were grow in 70.000 plant/ha (*Figure 4.*).

Conclusions

The sunflower is produced on the greatest area from our oil crops. The effect of the critical agrotechnical factor. the density on the quantity and quality of the crop are proved by experiments. Our research data proved that during the year with rainer and higher infections in high density plot (2006) the yields were lower. than in low density treatment. In other year (2007) the highest yields were in the high density plots. because the infections were stay low in this year. The oil content of sunflower level was the highest each year in high density (70.000) plots.

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STUDY ON THE EARLY COMPETITION BETWEEN *CIRSIUM ARVENSE* (L.) SCOP. AND MAIZE IN THE FIELD EXPERIMENT

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Abstract: Creeping Thistle belongs to the perennial weed species with G_3 life-form. *C. arvense* is native throughout Europe and northern Asia, and widely introduced elsewhere. It is common at arable fields, plantations and uncultivated areas in Hungary. It is one of the most harmful weeds which can be controlled with difficulties. Its importance was highly increased by the appearance of herbicide resistant ecotypes. In the time of the first national weed survey (1947-1953) it ranked 2nd with 2.0031% cover, it was the 7th in the second survey (1969-1971) with 1.1245% cover, 8th in the third survey (1987-1988) with 0.7090% cover and 6th in the fourth survey (1996-1997) with 1.8070% cover. In the course of the latest 5th national weed survey (2008-09) it ranked 4th with 1.7724% cover (Ujvárosi, 1973; Novák et al., 2009). *C. arvense* may appear in great quantities on humid clay and heavy soils of flooded areas. It grows on all but waterlogged, poorly aerated soils, including clay, clay loam, silt loam, sandy loam, sandy clay, limestone, and chalk, but not peat. It is referred as an allelopathic weed species in the scientific literature therefore its spread is contributed by this feature.

The competition of *C. arvense* and maize was studied in a field experiment in the outskirts of Szombathely (Vas County, Hungary). The effect of the competition on the biomass production and yield was analyzed in details**.**

Keywords: *Cirsium arvense*, maize, early competition, biomass production, shoot length

Introduction

Cirsium arvense (L.) is a perennial weed species, which propagates from rhizomes and belongs to the G_3 life form. Most probably, it is a native plant in South-East Europe and in East Mediterranean countries. Nowadays, it can be found all over Europe, North Africa, East and Middle Asia, Japan and North America. It is an important weed in Hungary on the arable fields, plantations and non cultivated areas (Solymosi et al., 2005). *C. arvense* is one of the most frequent and the most dangerous weeds in Hungary (Ujvárosi, 1957). Its importance increased with the appearance of herbicide resistant biotypes. Creeping thistle propagates in both a generative and a vegetative way. The mass propagation of the Creeping thistle is due to the specific root system. Its roots can be found in the soil at different depth, forming different "root-storey". Lateral roots are also part of the root system where adventitious buds are formed which can produce new individual plants if conditions are suitable (Moore, 1975; Holm et al., 1977). It has been proved for several plants that they have allelopatic properties (Szabó, 1994). There are several publications which describe the allelopatic properties of *C. arvense* (Kovács et al., 1988; Béres and Csorba, 1992; Solymosi and Nagy, 1999). This allelopatic property supports its mass spread. The biggest population of *C. arvense* can be found in the humid, poorly aerated soils like clay, clay loam, silt loam, but not in sandy soils (Ujvárosi, 1957). Creeping thistle heavily consumes the soil humidity and nutrient content (Lehoczky, 2004).

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Materials and methods

This study was established in Vas County in a cultivated area, which was heavily infested by *C. arvense* on loamy clay soil. Rainfall and daily average temperature data of the year 2010 is presented in *Table 1*. Previous crop was spring barley. The crop, maize - hybrid Kladdus, FAO 310, was sowed on April 27, 2010. Hybrid Kladdus belongs to the early maturity group. Recommended plant number is 70-75000 plant·ha^{-1}. It has very good drought tolerance.

Table 1. Rainfall and daily average temperature in Szombathely in 2010

Months	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
precipitation, mm	41.0	31.0	16.0	51.0	46.0	102.0	52.0	137.0	139.0	36.0
daily average temperature, °C	2.3	1.4	6.0	10.7	15.0	18.8	22.1	19.7	14.4	8.3

Corn emergence started about 10 days after sowing. Sampling (2x2m) areas were randomly identified in each plot and its references were recorded with GPS. All plants were removed form the identified sampling areas in order to be able to monitor the competition. Weed survey was made according to the Balázs-Ujvárosi method (Ujvárosi, 1973). Four experimental plots were marked out (0.2 ha each) and the herbicide treatments were carried out on May 20. Applied herbicide was Stellar (50g·L^{-1} topramezon+160g·L^{-1} dicamba) at 1 L·ha^{-1} dose rate with adjuvant: Dash at 1 L·ha^{-1} rate. Plant sampling was made at two timings: 3 weeks after crop sowing at the corn stage of 2-4 leaves and two months after crop sowing when corn was at 6-8 leaves stage. Trial was set up in 4 replicates and plant samples were collected both from the sampling area which was infested with weeds ("weedy plot") and the herbicide treated ("weed free") area. In case of *C. arvense* the number of shoots was counted and this number was used to describe the density. Seven corn plants were collected from both the "weedy" and the "weed free" plots. The shoots' length, fresh and dry weight were measured. Statistical analysis was made with the statistical tool of MS Excel.

Results and discussion

Weed survey was made on the weed infested plots on June 13 and eight weed species were recorded. T_4 weeds had the biggest number of species present.

Table 2. The occurrence of weed species in maize on June 13, 2010

rank	weed species	cover (%)	shoot number·(m^{-2})	life-form
1.	*Cirsium arvense* (L.) Scop.	44.8750	57.0	G_3
2.	*Avena fatua* L.	2.0000	4.3	T_3
3.	*Abutilon theophrasti* MEDIC.	1.6250	2.5	T_4
4.	*Polygonum lapathifolium* L.	0.7500	1.5	T_4
4.	*Chenopodium album* L.	0.7500	0.8	T_4
5.	*Echinocloa crus-galli* (L.) P.B.	0.5000	4.0	T_4
5.	*Ambrosia artemisiifolia* L.	0.5000	0.5	T_4
6.	*Convolvulus arvensis* L.	0.2500	0.3	G_3
	Total	*51.2500*	*70.8*	

47 days after the corn sowing, the total weed coverage was more than 50%, representing a heavy infestation. 87.5% of this was *C. arvense o*f the total weed coverage, ranked 1st with an average coverage of 44.8750%. In terms of the shoot number per m^2, *C. arvense* was the most important weed with 57 shoots·m^{-1}. Data presented in *Table 2.*, shows that the number of weeds per m^2 was 10 times more than the number of crop per m^2. The competition was determined by the presence of the big number of weeds. According to our observation, the development of the *C. arvense* had started before the emergence of corn, thus this weed was already present at the first sampling time, which was made 3 weeks after corn sowing. The number of *C. arvense* shoots was 32 per m^2 (*Figure 1.*).

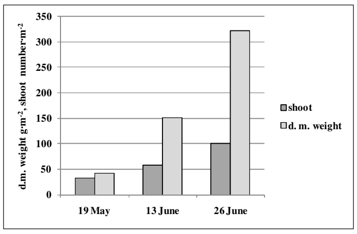

Figure 1. Number of shoots and dry weight of *C. arvense*

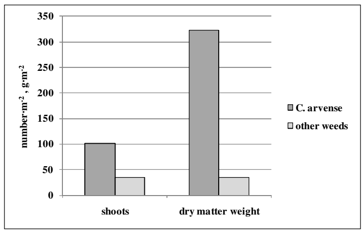

Fig.ure 2. Number of shoots and dry weight of *C. arvense* and other weeds on 26 June

On the contrary, 7 corn plants were counted per m^2 at the stage of 2-4 leaves. Number of *C. arvense* shoots increased by 3 fold between May 19 and June 26. Shoot weight of *C. arvense* increased by 7.7 times its original value during this period. Data presented in *Figure 2.* shows at the time of the second sampling the majority (90%) of the total weed mass came from the average number of *C. arvense* shoots per m^2 was 101, which means a very dense infestation.

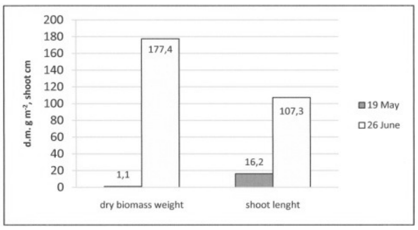

Figure 3. Dry shoot weights of maize (hybrid Kladdus) and growth between 19 May and 26 June

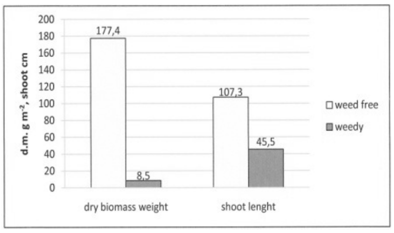

Figure 4. The dry weight and length of the "weedy" and "weed free" maize shoots

The development of the weed free corn was good. The length of maize shoots increased 6.6 fold between 19 May and 26 June. Shoot weight of maize increased by 161 times its original value during this period (*Figure 3.*). The development of the biomass production of the "weedy" and "weed free" corn shoots is presented in *Figure 4*. Trial data shows that the very strong weed - corn competition (especially with *C. arvense*) manifested in a significant reduction of corn shoot. The total biomass weight of weed free corn shoots was 23 times more than the "weedy" corn. The shoot lengths of the "weedy" corn were also reduced and it was less than half the "weed free" corn.

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Conclusions

The majority of the corn weeds belonged to the T_4 life form. There were 2 perennial weeds (G_3 life form) *C. arvense* and *C. arvensis*. The mass infestation of *C. arvense* can be described with the high coverage (44.87%) and with the very high biomass production (322 $g \cdot m^{-2}$) which was equivalent to 3220 kg dry biomass per ha. The other seven weeds gave together only 9.8% of the total weed biomass (35.1 $g \cdot m^{-2}$).
Two months after corn sowing, the biomass of the "weedy" corn was 8.5 $g \cdot m^{-2}$, which was 2.6% than the biomass of the mass emerging *C. arvense*. The total (corn and weed together) biomass per m^2 was 365.5 $g \cdot m^{-2}$, in which only 2.3 % was the biomass of the corn. The development of the weed free corn was good.
The 2 months long competition with the dense *C. arvense*, resulted in a 95% dry weight reduction of corn shoots. Most probably, apart from the competition for the soil nutrients, the allelopatic effect of *C. arvense* played an important role in the reduction of the corn biomass. It is very important to take care of the weed control of crops with wide row distance, especially in the critical period because these crops do not have strong competition ability at the beginning of their cycle.

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ENHANCING PLANT GROWTH WITH *TRICHODERMA VIRIDE* BASED PELLETS

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Abstract: Filamentous fungus *Trichoderma viride* is an opportunistic avirulent plant symbiont as well as mycoparasite of plant pathogenic fungi. There are different mechanisms by which *T. viride* provides beneficial effects to plant growth development and productivity. There are mechanisms for enhancing solubility of soil nutrients, enhancing nutrient uptake by plant and for better routeing what are frequently associated with increase in yield. The subject of this study was to evaluate *T. viride* growth promoting effect on lettuce and to investigate the suitability of alginate pellets as formulation for soil dispersal of fungal inocula. Conducted trial proves alginate pellets as amenable formulation for maintaining and dispersal of *T. viride* inocula into the soil. Obtained results of enhanced lettuce growth associated with treatments involving *T. viride* indigenous strains coded TPS confirmed the hypothesis that *T. viride* has positive influence on plant growth.

Keywords: *Trichoderma viride*, growth promotion, lettuce, alginate pellets.

Introduction

Nutrients in soil undergo a complex dynamic equilibrium of solubilization and insolubilization that is greatly influenced by the soil pH and microflora and that ultimately affects their accessibility to plant roots for absorption. Thus, microbial interactions with plant roots are known to profoundly affect plant nutrient status and to affect plant resistance to pathogens. Numerous microorganisms, especially those associated with roots, have the ability to increase plant growth and productivity *Trichoderma* spp. are among the most prevalent culturable fungi in soils, based upon the frequency of isolation on suitable media. Also, they are among the most commonly studied biocontrol microbes. More than 80 years the scientists are involved in investigation of antifungal ability of genus *Trichoderma*. Today their agricultural importance is good antagonistic abilities against soil born plant pathogenic fungi thanks' to different mechanisms of antagonism; the production of antifungal metabolites (antibiosis), competition for space and nutrients, induction of defence responses in plant and mycoparasitism. Investigations revealed also the ability to promote plant growth which firstly was treated as side effect of suppression of plant pathogen fungi (Harman 2006; Inbar et al., 1994; Ousley et al., 1994). The availability and diffusion of *Trichoderma* based biofertilizers is more widespread then commonly known. Mostly permited for use in organic farming in Europe are: RootShield, Plant Box and Bio Trek (northen Europe,, USA), Binap (Switzerland, Sweeden, UK, USA), Bio fungus (Belgium), Supersivit (Czech Republic), Trichodex (Italy), Trifender (Hungary) and Trianum (Avantagro, Spain) (Robson et al, 2005). Recently, it is speculated that positive effect on plant growth is independent ability and equally remarkable and significant as their antifungal ability because growth enhancement has been observed in the absence of any detectable disease and in sterile soil (Altomare et al., 1999). Plant-

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growth-promoting effect has been suggested to involve solubilization of otherwise unavailable mineral nutrients. Therefore, today is consider that the direct effects of these fungi on plant growth and development are crucially important for agricultural uses and for understanding the roles of *Trichoderma* in natural and managed ecosystems. As our indigenous strain TPS achieved good biocontrol activity some of important phytopathogenic fungi (*Fusarium* spp., *Sclerotinia sclerotiorum*, *Rhizoctonia solani* and *Botrytis cinerea)* it seemed appropriate to investigate whether it would have a direct effect on plant growth when no disease pressure was present. The mode of effective dispersal of fungal inocula became an issue. To accomplish mentioned goal we chose to encapsulate fungal inocula in form of alginate pellets.

Materials and methods

The indigenous *T. viride* strain TPS was used. Cultures were maintained at 25 °C on potato dextrose agar (PDA, Biolife, Italy) slants. The alginate pellets were prepared according to method by Gennari et al (1990). The culture of isolates were grown on Petri dishes 10 cm in diameter containing 20 ml of PDA and incubated in clime chambers at 25 °C for seven days until conidiation occurred. After incubation the substrate altogether with hyphal biomass and conidia from two Petri dishes were upraised with spatula and transferred into glass with 50 ml sterile DI water. These were mixed by common blender at low speed for 3-5 min in order to make a suspension. The final concentration to be used contained 4×10^6 spore ml^{-1}. The suspension was mixed with talcum (Kemig, Croatia) (100 g l^{-1}) and sodium alginate (Fluka, Switzerland) (10 g l^{-1}). The formed matrix was then placed in a separator funnel modified in order to allow suspension to dripping into a 0.1 M suspension of calcium gluconate (Kemig, Croatia) under stirring on magnetic agitator. Drops of alginate matrix dripped into calcium gluconate suspension transformed to gelatinized spherules or pellets. Pellets were removed from suspension within 10 min, rinsed with distilled water and allow to dry on waxed paper under a sterile vertical flow for 12 -24 h. Greenhouse trial was set according to randomised complete block design in five repetitions (8 plants per repetition). Lettuce seeds cv. Sunny (Nickerson-Zuraan, The Netherland, treated with carbendasim-thiram) were sown in April 2010 into pots (9 cm diameter) in two type potting compost mixture: Klasmann-Deilmann P 002 (Germany) and Stender A240 (Germany). Pellets of STP were applied only at sieving (1 pellet per plant). Control plants sown in both composts were also available. The plants were harvested 9 weeks after sowing. The characteristics evaluated were: number of leaves per plant, leaf length (cm), leaf width (cm), fresh weight (g $plant^{-1}$) and dry weight (g $plant^{-1}$). All data obtained were analysed statistically: an analysis of variance was performed, least significant differences between the means were calculated for 5% and 1% and Duncan's multiple-range test was conducted also.

Results and discussion

The goal of this investigation was estimation of indigenous *T. viride* strain TPS only as plant growth stimulator because there was no report concerning the use of *Trichoderma sp.* as plant growth stimulator in Croatia. Therefore, the trial was set to investigate whether it TPS would have a direct effect on plant growth when no disease pressure was present, although TPS showed good antagonisms against soil-borne pathogens in previous investigation (will not be discussed here). In creating the trail we try to respect today's supply and demand on Croatian market so we used most representative materials offered to growers. Therefore, in trial was used lettuce seed cv. Sunny which was originally treated with carbendasim-thiram by producer Nickerson-Zuraan (The Netherland). Two frequently used commercial potting compost mixture were used: Klasmann-Deilmann P 002 (Germany) and Stender A240 (Germany). These substrates are characterized by the use of fine peat with the addition of nutrient specially designed to meet the needs of young plants so they similar in nutrient content (N 150-260 mg l^{-1}, P 180-280 mg l^{-1}, K 200-350 mg l^{-1}, Mg 80-150 mg l^{-1}). *Trichoderma* is able to solubilize nutrients but only the ones present in substrate and as Klasmann and Stender are enriched with the similar nutrients there were no significant differences among them as trial variants. The differences were bespeaking when the TPS pellets were added against control. In conducted trial TPS significantly increased some lettuce quality characteristics except dry weight (*Table 1.*). TPS-pellets enhanced formation of leaves: at Stender difference against control varies for 1 to 2 leaves more, at Klasmann for 1 leaf more. Leaf length was longer for 2 cm at Stender and Klasmann amended with TPS-pellets then at control while leaf width was wider for 3,15 cm at Stender and for 4,27 cm at Klasmann. Fresh weight was greater for 5,36 g at Stender and for 4,68 g at Klasmann against control. Dry weight was only characteristic on which TPS pellets did not have significant influence perhaps due to the similar nutrient content of Stedman and Klasmann substrates (explain earlier). The significant effect of *Trichoderma* to lettuce growth and yield we observed was in line with earlier reports (Bal and Altinatas, 2008; Rabeendran et al., 2000; Lynch et al., 1991).

Table 1. Effects of *Trichoderma viride* TPS on growth of lettuce cv. Sunny grown in pot compost

Treatment	Characteristic				
	Leaves plant^{-1} (no)	Leaf length (cm)	Leaf width (cm)	Fresh wt. (g)	Dry wt (g)
Stender + TPS-pellet	12,33 a	18,3 a	15,23 b	41,17 a	0,1
Klasmann + TPS-pellet	12,5 a	18,78 a	17,3 a	42,67 a	0,1
Stender - control	10,58 b	16,03 b	12,08 c	35,81 b	0,1
Klasman - control	11,03 b	16,78 b	13,03 c	37,99 b	0,8
LSD 5%	0,3	1,13	1,08	3,03	n.s.
LSD 1%	0,4	1,59	1,5	4,25	n.s.

Means followed by the same letters do not significantly differ ($P < 0.01$).; n.s.= non significant.

The encapsulation of *Trichoderma,* mostly *T. harzianum,* in an alginate matrix has been studied and positively evaluated by various authors (Gennari et al., 1990; Leštan and Lamar, 1996; Mafia et al., 2003). Strain TPS was successfully encapsulated into alginate pellets formulation. Pellets allowed effective dispersal of fungal inocula into

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the soil and enable fungal transfer onto the roots of lettuce plants. Colonisation of the roots was confirmed with isolation of strains from root of every plant originated from beds amended with pellets. Obtained results warrant further investigation toward field application for commercialization of this product because of similar products only Trifender (Bioved, Hungary) is legal to sell in Croatia from 2009 (distirbuted by ZKI Sljeme).

Conclusions

The obtained results confirmed two hypothesis:I- the most effective *Trichoderma* strains will colonize roots and provide benefits for at least the life of annual crops; II- even if the *Trichoderma* is present only on roots the enhancement of growth, both on the root and on the foliage can be asses (Harman, 2006). The *Trichoderma* pellets can benefit in eco-farming and greenhouse production of ornamental and vegetable plants as disease control instead of chemical fungicides because it is safer to use for growers, its disease-control effects last longer than those of synthetic chemical pesticides so in long terms it is less costly than chemical fungicides and it can benefit plant growth and yield, eaqualy or better than chemical fertilizers.

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