GENOTYPE SOIL AND YEAR EFFECTS ON YIELD AND NUTRITIONAL STATUS OF MAIZE

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Abstract: Nine maize (*Zea mays* L.) hybrids were grown under field conditions on two soils (eutric cambisol and eugley) for two growing seasons (2004 and 2005). Seven domestic maize hybrids (OsSK444, OsSK554, OsSK644 and OsSK713, Bc66-61 and Bc778) and two foreign (ZPSK633 and ZPSK778 - from Serbia) were used. The field trial was conducted in five replicates (gross of basic plot 56 m^2). Grain yield in 2005 was 13% lower than in 2004 (8.28 and 9.53 t ha^{-1}, respectively). Yields on eutric cambisol were lower than on eugley (6.96 and 10.84 t ha^{-1}, respectively). Also, differences of yields among the hybrids were very significant. The hybrid Bc778 yielded 10.37 t ha^{-1} or 32% more compared to the hybrids Bc592 and ZpSK704. Leaf-N was in 2005 11% higher than in 2004 (means 2.53% N and 2.81% N, respectively), while leaf-P (mean 0.28% P) and –K (mean 1.68% K) differences between two years were non-significant. Leaf-K under eugley conditions was 25% lower than on cambisol (means 1.44% K and 1.92% K, respectively). Differences in leaf composition among the maize hybrids (influences of genotype) were in the ranges from 2.59% N to 2.76% N, from 0.25% P to 0.30% P and from 1.62% K to 1.76% K. In general, low connection was between leaf nutritional status and yields probably because relative favorable soil fertility of both soil types, although the first-ranged hybrid regarding yield (Bc778) was in the group of the hybrids with the highest leaf-N, -P and –K. Also, two low-yielding hybrids (Bc592 and ZpSK704) characterized considerably lower leaf K.
Keywords: maize hybrids, soil influences, yield, leaf-N, leaf-P, leaf-K

Introduction

Yield and nutritional status of the field crops are under environment and heredity influences (Sarić 1981, 1983; Sarić and Kovačević 1980; Kovačević and Vujević, 1993; Kovačević et al., 2006; Barić et al., 2007; Hegyi et al., 2007; Nagy, 2007; Pepo, 2007). Aim of this study was testing yield and plant status of nitrogen (N), phosphorus (P) and potassium (K) in nine of commercial maize hybrids growing on two soil types.

Material and methods

The field experiment, sampling and chemical analysis

Nine maize (*Zea mays* L.) hybrids were grown under field conditions on two soils (Karanac eutric cambisol and Vardarac eugley) of Baranya region (Osijek-Baranya County) for two growing seasons (2004 and 2005). Seven domestic maize hybrids (OsSK444, OsSK554, OsSK644 and OsSK713 – developed in Agricultural Institute Osijek; Bc66-61 and Bc778 – developed in Bc-Institute Zagreb) and two foreign (ZPSK633 and ZPSK778 – developed in Maize Research Institute Zemun Polje, Serbia) were used. The field trial was conducted in five replicates (gross of basic plot 56 m^2). Maize was sown manually by planters (interrow spacing 70 cm and distance in row 26 cm) at end of April. Two seeds were sown in each sowing place. Thin out of young plants (one plant per each sowing place) was made in three-leaf stage (theoretical plant density or TPD = 54945 plants ha^{-1}). Soil and crop management practices were identical

for both locations (fertilization kg ha^{-1}: 170 N + 120 P_2O_5 + 120 K_2O). Harvesting of four internal rows (total area 28 m^2) was made manually at middle of October. Maize yield was calculated on TPD and 14% grain moisture basis.

Soil sampling (0-30 cm of depth) was made before the start of the experiment. The ear-leaf of maize (25 leaves in the mean sample) was collected for chemical analysis at flowering stage (the second half of July).

Soil pH and humus contents were determined according to ISO standards (ISO 1994, 1998). Nitrogen in leaf samples was determined by Kjeldahl procedure. For P and K determination, wet procedure was used: 0,5g of sample + 5ml acid mixture (100ml cc. H_2SO_4+5ml cc. $HClO_4$); +10 ml H_2O_2. After the digestion sample was filtred and filled with deionised water up to 100 ml

Phosphorus was determined spectrophotometrically by molibdat-vanadat method and K by flame photometry.

The soil and weather characteristcs

Two tested soil types have been similar in pH values and humus contents. The eugley was more supplied with N, EUF-extractable Ca and Mg as well., while P and K supplies were lower compared to the eutric cambisol (Table 1).

Precipitation regime for 5-month period of maize growing season was specific in both years because precipitation quantity was 27% lower (2004) and 70% higher (2005) compared to long-term mean (Table 2). In general, high yields of maize are in close connection with water deficit and higher air-temperatures, especially during July and August (Josipović et al., 2005). However, in our study, distribution of moderate quantities of precipitation for the 2004 growing season was favorable and maize yields in both soils were higher (Table 3) compared to wet 2005 growing season.

Table 1. Soil properties (0-30cmdepth) at starting experiment

The soil	pH	%	EUF-extraction (Nemeth, 1982) – mg 100 g of $soil^{-1}$					
	(H_2O)	Humus	$N\text{-}NO_3$	$N\text{-}NH_4$	P	K	Ca	Mg
Karanac eutric cambisol	6.48	2.56	3.84	1.04	1.87	8.83	39.5	3.13
Vardarac eugley	6.44	2.80	4.54	1.22	0.84	5.73	82.4	3.83

* Karanac (cambisol) and Vardarac: air-distance about 12 km

Table 2. Weather and climate characteristics (Brestovac Weather Bureau)

The period		Precipitation (mm) and mean air-temp. (^{0}C) – Brestovac					Total	Mean
		May	June	July	Aug.	Sept.	mm	^{0}C
The growing season 2004	mm	77	18	41	52	43	231	
	^{0}C	14.9	19.5	21.9	21.6	15.9		18.8
The growing season 2005	mm	55	81	168	155	82	541	
	^{0}C	17.0	20.4	22.8	19.7	17.5		19.5
Long-term mean (1965-2003)	mm	59	87	66	51	55	318	
	^{0}C	16.7	19.7	21.2	20.9	16.5		19.0

Results and discussion

In general, considerable influences of the factors: year, soil and genotype on maize yields and leaf-N, -P and -K status were found (Table 3). The yield in 2005 was 13% lower than in 2004. Especially high differences of maize yields between two years were

found on eutric cambisol (40% lower yield in 2005 compared to 2004) and this difference is impossible to explain based on available weather and soil data. The hybrid Bc778 yielded 10.37 t ha^{-1} or 32% more compared to the Bc592 and ZpSK704.
Leaf-N was in 2005 11% higher than in 2004 (means 2.53% N and 2.81% N, respectively), while leaf-P (mean 0.28% P) and –K (mean 1.68% K) differences between two years were non-significant. Leaf-K under eugley conditions was 25% lower than on cambisol (means 1.44% K and 1.92% K, respectively). Leaf-K on eugley was mainly close to inadequate K supplies (less than 1.5% K maize leaves: Bergmann, 1992; Mengel and Kirkby, 2001).

Table 3. Influence of year, soil and genotype on maize properties

Impacts of year (factor A), soil (factor B: B1= cambisol; B2=eugley) and genotype (factor C) on maize status: grain yield (on 14% grain moisture) and leaf (ear-leaf at flowering) composition (on dry matter basis)													
The factors		Year (A)		Soil (B)		Mean	Year (A)		Soil (B)		Mean
C	B	2004	2005	B1	B2		2004	2005	B1	B2	
		Grain yield (t ha^{-1})					**Leaf- nitrogen** (% N)				
		Interaction AC		Interaction BC		C	Interaction AC		Interaction BC		C
OsSK444		9.48	7.81	6.88	10.40	8.64	2.56	2.92	2.68	2.80	2.74
OsSK554		10.99	6.58	5.29	12.28	8.79	2.51	2.78	2.56	2.73	2.64
Bc592		8.46	7.35	5.59	10.21	7.90	2.51	2.87	2.67	2.70	2.69
OsSK644		8.87	8.08	6.30	10.64	8.47	2.57	2.89	2.62	2.84	2.73
Bc66-61		9.84	9.56	7.98	11.40	9.70	2.57	2.73	2.59	2.71	2.65
ZpSK633		8.99	9.72	7.53	11.17	9.35	2.46	2.72	2.53	2.65	2.59
OsSK713		10.40	7.74	7.56	10.58	9.07	2.47	2.86	2.60	2.74	2.67
Bc778		10.81	9.93	8.26	12.47	10.37	2.68	2.84	2.68	2.84	2.76
ZpSK704		8.02	7.74	7.31	8.44	7.89	2.47	2.72	2.52	2.68	2.60
Mean A		9.53	8.28				2.53	2.81			
		Interaction AB				B	Interaction AB				B
	B1	8.66	5.28			6.96	2.49	2.72			2.60
	B2	10.42	11.27			10.84	2.58	2.91			2.74
		A	B	C	AB	AC	BC	A	B	C	AB	AC	BC
LSD 5%		0.16	0.16	0.34	0.23	0.48	0.48	0.03	0.02	0.05	0.04	0.08	ns
LSD 1%		0.21	0.21	0.45	0.30	0.63	0.63	0.04	0.03	0.07	0.05	0.10	
		Leaf- phosphorus (% P)					**Leaf- potassium** (% K)				
		Interaction AC		Interaction BC		C	Interaction AC		Interaction BC		C
OsSK444		0.28	0.29	0.30	0.28	0.29	1.63	1.65	1.95	1.34	1.64
OsSK554		0.26	0.29	0.27	0.27	0.27	1.60	1.80	2.14	1.27	1.70
Bc592		0.30	0.30	0.32	0.29	0.30	1.57	1.67	1.90	1.34	1.62
OsSK644		0.28	0.28	0.28	0.27	0.28	1.61	1.66	1.82	1.45	1.64
Bc66-61		0.28	0.23	0.24	0.27	0.25	1.65	1.64	1.78	1.51	1.65
ZpSK633		0.28	0.27	0.29	0.27	0.28	1.72	1.74	1.99	1.47	1.73
OsSK713		0.25	0.28	0.26	0.27	0.26	1.69	1.65	1.78	1.57	1.67
Bc778		0.31	0.27	0.29	0.29	0.29	1.76	1.76	1.99	1.53	1.76
ZpSK704		0.28	0.25	0.27	0.26	0.26	1.55	1.77	1.89	1.43	1.66
Mean A		0.28	0.27				1.65	1.71			
		Interaction AB				B	Interaction AB				B
	B1	0.28	0.28			0.28	1.86	1.98			1.92
	B2	0.28	0.27			0.27	1.43	1.44			1.44
		A	B	C	AB	AC	BC	A	B	C	AB	AC	BC
LSD 5%		ns	ns	0.02	0.01	0.03	ns	0.06	0.22	ns	ns	ns	0.26
LSD 1%				0.03	0.02	0.04		ns	0.32				0.36

Differences in leaf composition among nine maize hybrids (influences of genotype) were in the ranges from 2.59% N to 2.76% N, from 0.25% P to 0.30% P and from 1.62% K to 1.76% K. Three hybrids (ZpSK633, ZpSK704 and C2 OsSK554) were in the group of lowest leaf N (mean 2.61% N), while three hybrids (OsSK644, OsSK444 and Bc778) in the group of the highest leaf-N (mean 2.74% N).The lower leaf-P was in the hybrids Bc66-61, OsSK713 and ZpSK704 (mean 0.26% P), while in the OsSK444, Bc778 and Bc592 it was the higher (mean 0.29% P).The hybrids Bc778 and ZpSK633 ad the considerably higher leaf-K (mean 1.74% K) than the hybrids Bc592, OsSK444 and OsSK644 (mean 1.63% K).

In general, moderate connection was between leaf nutritional status and yields probably because relative favorable soil fertility of both soil types. However, the first-ranged hybrid regarding yield (Bc778) was in the group of the hybrids with the highest leaf-N, -P and –K. Also, two low-yielding hybrids (Bc592 and ZpSK704) characterized considerably lower leaf K (Table 3).

Conclusions

Genotype and soil properties considerably influenced maize yield and nutritional status. Based on our study, the higher/lower concentrations of N, P and K in maize leaves could be in moderate connections with tendency to the higher/lower yields of the hybrids.

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