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Original scientific paper

IMPACTS OF IRRIGATION AND GENOTYPE ON YIELD, PROTEIN, STARCH AND OIL CONTENTS IN GRAIN OF MAIZE INBRED LINES

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Four inbred lines of maize (Os 438-95 = C1, Os 30-8 = C2, Os 6 = C3 and Os 1-44 =C4) were grown for 4-year period (2006-2009) in the stationary field experiment on Osijek eutric cambisol. Impact of irrigation, nitrogen fertilization and genotype were tested. Soil moisture was maintained by two irrigation rates from 60-100% and 80-100% of the field water capacity). Two steps of N (0, 100 and 200 kg N ha^{-1}) were applied, while P and K fertilization was equal (500 kg/ha NPK 0:30:20). Eight maize genotypes (four inbred lines and four hybrids) were grown on each basic plot of fertilization. The experiment was duplicated for maize – soybean rotation. The experiment was set by split-split plot method according to randomized block design in three replicates. The basic plot areas were 617.2 m^2 (irrigation), 313.6 m^2 (fertilization) and 39.2 m^2 (genotype). Selection of N non-fertilized treatment and four inbred lines were made for this study with aim of testing year (A) irrigation (B) and genotype (C) effects under natural N-soil conditions. Average grain yield in level 1809 kg ha^{-1}without N fertilization is indication of very high fertility of the soil. Differences of yield among the years were from 823 (2007) to 2450 (2006) kg ha^{-1}. Excessive drought and high air-temperature stress is responsible for the low maize yield in 2007. Irrigation considerable affected on maize yields (4-year averages: 1500, 1809 and 2118 kg ha^{-1}, for B1, B2 and B3, respectively). Differences of the 4-year average yields among the genotypes were from 1259 (C3) to 2765 (C1) kg ha^{-1}. Differences of yield among the genotypes in the different years were also considerable because the lowest yield was for 71% (A1), 23% (A2), 63% (A3) and 40% (A4) lower in comparison to the highest yield. The genotype effects under different water supplies were less influencing factor because the high-yielding C1 had for 128%, 129% and 106% the higher yield compared to the low-yielding C3, for

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B1, B2 and B3, respectively. Differences of grain -protein, -starch and -oil among the years was from 9.61 to 11.84%, from 68.51% to 70.93% and from 3.50% to 4.17%, respectively. The C2 separated by the higher grain protein contents (10.93%) from the remaining three genotypes (average 9.96%). The genotype effects on starch and oil contents were from 69.83% (C4) to 70.58% (C1) and from 3.56% (C3) to 4.09% (C1), respectively.

Key words: inbred lines, irrigation, yield, maize, protein, oil, starch

INTRODUCTION

Climate changes, especially precipitation and temperature regimes, have often adverse influence on the quantity of field crop yields. Annual global temperatures have increased by about 0.4 ^{o}C since 1980, with even larger changes observed in several regions (IPCC, 2001). LOBELL and FIELD (2007) estimated that about 30% variations of global average yields for the world's six most widely grown crops (wheat, rice, maize, soybeans, barley and sorghum) are result of growing season precipitation and temperature variations.

Maize is main field crop on arable land of Croatia. In the period 2006-2010 by maize was covered in Croatia 298697 ha or 34 % of used arable land. Average yields of maize in Croatia for the mentioned period were 6.76 t ha^{-1}. Also, in this period were found considerable variations of annual maize yields from 4.9 to 8.0 t ha^{-1}. (SLJ, 2011). Similar observations were found in the countries of the region (MAKLENOVIC *et al.,* 2009; KRESOVIC *et al.,* 2011; KOVACEVIC *et al*., 2013). Weather characteristics, particularly quantity and distribution of precipitation and air-temperatures, are main factors of maize yield variations among years. In general, the lower precipitation and the higher air-temperatures in summer, especially in July and August, usually are in close connection with the lower yields of maize (JOSIPOVIC *et al*., 2012; KOVACEVIC *et al.* 2012; KOVACEVIC and KAUCIC, 2014; MARKOVIC, 2013; MARKULJ *et al.,* 2010; PLAVSIC, 2006, 2013; RASTIJA *et al*., 2012; VIDENOVIC *et al*., 2013). A typical examples of "favorable" and "unfavorable" growing season are 2010 and 2012. Maize yields in 2012 (4.34 t ha^{-1} in Croatia, 3.98 t ha^{-1} in Hungary 2.78 t ha^{-1} in Serbia and 2.74 t ha^{-1} and in B&H were lower than in especially favorable 2010 for 53%, 38%, 38% and 40% respectively (KOVACEVIC *et al*., 2013). MADIC *et al*. (2010) tested eleven maize hybrids under three soil type and two plant densities conditions for two growing seasons differing of weather characteristics. Average grain yields were under normal weather conditions for 31% higher (year effect: 11.08 and 8.46 t ha^{-1}) for 1995 and 1996, respectively), while yield of ZPSC 599 was for 41% higher compared to yield of ZPSC 330M (genotype effects: difference from 7.72 to 10.92 t ha^{-1}). Negative effects of unfavorable weather conditions are possible to alleviate by irrigation in the critical stages of maize growth. Unfavorable weather characteristics have considerable more adverse effects on seed-maize crops compared to mercantile maize.

Building of water accumulations and increases of irrigated arable lands could be priorities, particularly with aim of application to high profitable activities as vegetable growing and seed production of the field crops (KOVACEVIC and JOSIPOVIC, 2013).

Seed-maize growing is particularly exposed to adverse effects of unfavorable weather characteristics. Drought and high air-temperature stress, particularly in flowering and fertilization stages is mainly responsible for the low yields. For example, in the decade-period of 2003-2012, average yield of the seed-maize in Croatia was in range from 881 (2012) to 3127 (2009) kg ha^{-1}. Under drought stress conditions were found either very low or total loss of seed-maize yields (ZDUNIC *et al.,* 2013). Aim of this study to test growing season, irrigation and genotype (parents of maize hybrids in production of F-1 seed generation) effects on maize grain yields and quality under nitrogen non-fertilized conditions.

MATERIALS AND METHODS

The field experiment

The long-term stationary field experiment with irrigation and nitrogen fertilization has been started in spring of 2006 on the experimental field of Agricultural Institute Osijek. The experiment was duplicated for maize – soybean rotation (JOSIPOVIC *et al.*, 2012; PLAVSIC, 2012). The experiment was set by split-split plot method according to randomized block design in three replicates. The basic plot of the tested factors were 617.2 m^2, 313.6 m^2 and 39.2 m^2 (four 14m – long rows), for irrigation, fertilization and genotype, respectively. Soil moisture maintained by two steps of irrigation (from 60-100% and 80-100% of field water capacity, while not irrigated plot was the control. N fertilization treatments were as follows: the control (non-fertilized), 100 kg N ha^{-1} and 200 kg N ha^{-1}. Eight maize genotypes (four inbred lines and four hybrids) were grown on each basic plot of fertilization. Response of four inbred lines in three- year period (2006-2008) according ths model of the experiment was elaborated by PLAVSIC (2012). For this study, year (the factor A: 2006 – 2009), irrigation (the factor B) and four maize inbred lines (the factor C) grown on N-unfertilized plots (0 N/ha for 2006-2009 period) were selected with aim of testing the natural soil N supplies effects on maize status under different irrigation conditions. The inbred lines were as follows: Os 438-95 (C1), Os 30-8 (C2), Os 6 (C3) and Os 1-44 (C4). These lines are either maternal or paternal parent of two maize hybrids (OsSK 596 and OsSK 602) in production of the F-1 seed-generation (PLAVSIC, 2012). The experiment was fertilized every year uniformly with phosphorus and potassium in amounts (kg/ha) 150 P_2O_5 and 100 K_2O (500 kg/ha NPK 0:30:20).

Maize was sown manually at end of April / beginning May by using of the planters adapted for sowing at distance 24.5 cm and 70 cm of inter-row distance. Two seeds were inserted at each sowing place. Thinning of maize crop was made at early stage of growth (theoretical plant density 58333 plants/ha). Maize was harvested at maturity stage. Two internal rows of each basic plot were harvested by special harvesting machine for the field experiments (Wintersteiger, nursery master). Grain yields were calculated on 14% grain moisture basis.

Sampling, chemical and statistical analysis

Average grain samples were taken from each basic plot and dried to storage moisture. About 200 g of average grain sample was taken for chemical analysis. An Infratec 1241 Grain Analyzer Foss Tecator was used for the analysis of protein, oil and starch contents.

Soil water content was measured by Watermark soil moisture instrument in 3-day intervals from two depths (15-18cm and 25-28cm) with aim of determination term of irrigation according the defined parameters.

Irrigation

Irrigation by self-moving sprinkler was performed in term of soil moisture status either of 65% or 80% of the field water capacity (FWC), based on the treatment (B2 and B3, respectively). Quantities of added water and frequency of irrigation were different for tested four growing seasons (Table 1) and they depended on the weather characteristics (Table 2).

Table 1. Irrigation of the experiment

Treatment	Por-tion	Qantities of the irrigated water (mm) and date of the treatments							
		2006		2007		2008		2009	
		mm	Date	mm	Date	mm	Date	mm	Date
B1		the control (non-irrigated maize)							
B2 65-100% FWC	1st	50	June 22-23	50	June 16-17	50	June 26-27	50	May 4-6
	2nd	50	July 14-15	50	July 3-4	50	July 7-8	50	June 3-6
	3rd	50	July 27-28	50	July 22-23	50	July 19-20	50	July 12-14
	4th	-	-	-	-	50	Aug 12-13	50	July 21-23
	5th	-	-	-	-	-	-	50	Aug. 2-4
B3 80-100% FWC	1st	35	June 17-18	35	June 1-2	35	June 1-2	35	May 6-8
	2nd	35	June 29/30	35	June 22-23	35	June 24-25	35	June 7-9
	3rd	35	July 12-13	35	July 10-11	35	July 4-5	35	July 15-16
	4th	35	July 21-22	35	July 18-19	35	July 14-15	35	July 23-24
	5th	35	July 31	35	July 26-27	35	Aug. 3/4	35	Aug. 4-6
	6th	-	-	-	-	35	Aug.14-15	-	-
	7th	-	-	-	-	35	Aug 20-21	-	-
Total	B2	150		150		200		250	
	B3	175		175		245		175	

The soil characteristics

Based on the soil profile visual characteristics and correspondingly physical, chemical analyses, the soil is characterized as eutrical non-calcareous brown soil developed on calcareous loess substrate middle gleyed and silt/clay loam texture (Table 3). The hydromorphic symptoms caused by underground water was found at 1.5 m of depth. Stratigraphy of the soil horizons is as follows: Ap – AC – C – Cgso. On the basis of hydropedological soil properties, soil porosity, field water capacity and air soil capacity have had medium value,in spite the subsoil layer have some lower and unconvinient value (Table 4). Also, volume soil density showed low compaction, while sub soil layer is medium compacted (Soil Survey manuel). Proper time of irrigation made soil very convinient for achieve very good plant potential.

Table 2. Precipitation and air-temperature (Osijek Weather Bureau)

Month	Precipitation and air temperature in Osijek (LTM: long-term means 1961-1990)									
	Precipitation (mm)					Mean air-temperature (^{o}C)				
	2006	2007	2008	2009	LTM	2006	2007	2008	2009	LTM
April	87	3	50	19	54	12.7	13.3	12.5	14.6	11.3
May	78	56	67	39	58	16.2	18.2	18.1	18.3	16.5
June	91	33	76	63	88	20.1	22.3	21.5	19.2	19.4
July	15	27	79	14	65	23.5	23.8	21.8	23.2	21.1
Aug.	134	45	46	61	59	19.3	22.2	21.8	22.9	20.3
Sept.	11	65	86	10	56	17.8	14.5	15.7	19.1	16.6
Total	415	230	405	205	368					
Mean						18.3	19.1	18.6	19.6	17.5

Table 3. The physical and chemical properties of soil

Soil depth (cm)	Soil texture: Sand	Silt	Clay	TD	Soil pH: pH H_2O	pH 1n KCl	Organic matter %	AL-fraction (mg/100g): P_2O_5	K_2O
	Share in percent								
0-40	1	71	28	sl	7.5	6.8	1.56	24.4	27.2
40-95	2	65	33	scl	7.7	7.0	1.32	15.5	22.0

* the size of soil particles (mm): between 2.0 and 0.05 (sand), between 0.05 and 0.002 (silt) and less than 0.002 (clay); texture designation (TD): silt loam (sl), silt clay loam (scl)

Table 4. The hydropedological characteristics of the soil

The soil depth (cm)	Percent of the soil volume: Pores volume	Absolute capacity (c.): Water c.	Air c.	Speciphic density of soil (g/cm^3): Volume soil density	Real soil density
15-20	51	40	11	1.41	2.70
60-65	45	37	8	1.60	2.72
100-105	55	40	15	1.39	2.75

RESULTS AND DISCUSSION

Relative high grain yield of the inbred lines of maize in amount of 1809 kg ha^{-1} under N non-fertilized conditions is an indication of the high level of natural soil fertility. The growing season effect was the most influencing factor of maize yield because differences of annual yields were in range from 823 to 2450 kg ha^{-1}. Maize yield under more favorable weather conditions of the 2006 growing season (Table 2) was about 3-fold higher in comparison of yield achieved under drought and the high air-temperature stress of 2007 (Table 5). Two steps of irrigation has linear effect on maize yields because yields were increased for 21% and 41% as affected by the first and the second level of irrigation (4-year averages: 1500, 1809 and 2118 kg ha^{-1}, for B1, B2 and B3, respectively. Differences of the 4-year average yields among the maize genotypes were in range from 1259 (C3) to 2765 (C1) kg ha^{-1}. Degree of irrigation effects in individual year (AB interaction) was in range from 19% (2006) to 115% (2007) yield increases. The genotype effects under different water supplies conditions (BC interaction) were more similar because the high-yielding C1 had for 128%, 129% and 106% the higher yield compared to the low-yielding C3, for B1, B2 and B3 treatment, respectively. Differences of yield among the genotypes in the different years (AC interaction) were also considerable because the lowest yield was for 71%, 23%, 63% and 40% lower in comparison to the highest yield, for A1, A2, A3 and A4, respectively. Yield stability of the genotypes among the years was somewhat higher in C3 because the lowest yield in 2007 was for 58% lower compared to the highest yield achieved in 2009. Analogical differences for the remaining genotypes were in range from 67% to 71% (Table 5).

Average content og protein in maize grain was 10.21% with range of variation among the years from 9.61 to 11.84% (Table 5). Under drought stress anthe higher air-temperatures conditions (Table 2) of the 2007 and the 2009 growing seasons (averages for April-September period: 218 mm precipitation and 19.3 ^oC temperature) protein contents in grain (Table 5) were the higher (average 10.97%) in comparison with two remaining years (410 mm and 18.5 ^{o}C). Irrigation effects on grain protein contents were in limit of statistical error, both by observation as the main factor and as interaction with year and genotype (AB and BC, respectively). The C2 separated by the higher grain protein contents (10.93%) from the remaining three genotypes (average 9.96 %). Also, year and genotype (AC interaction) was significant. With that regards, the values were in range from 8.70% (A1C4) to 12.11% (A2C4).

Table 5. Impacts of the growing season (the factor A), irrigation (the factor B) and genotype (the factor C) on maize grown on eutric cambisol under without nitrogen fertilization

Year (A1: 2006, A2: 2007, A3: 2008. A4: 2009), irrigation (B1: non-irrigated, B2: 65-100% FWC, B3: 80-100% FWC) and genotype (maize inbred line: C1 = Os 438-95, C2 = Os 30-8, C3 = Os 6-2, C4 = Os 1-44) effects; FWC = field water capacity

Year	Irrigation (B)			Genotipe (C)				Mean
(A)	B1	B2	B3	C1	C2	C3	C4	A
	Grain yield (kg ha^{-1})							
A1	2082	2784	2485	3786	2461	1098	2456	***2450***
A2	564	690	1216	925	818	838	712	***823***
A3	1390	1729	2100	2981	1233	1096	1648	***1740***
A4	1967	2033	2672	3370	2038	2002	1487	***2224***
Mean B	***1500***	***1809***	***2118***					
			Mean C	***2765***	***1637***	***1259***	***1576***	
			B1	2295	1081	1005	1622	
			B2	2839	1656	1240	1500	
			B3	3162	2176	1531	1605	
Statistics	A	B	C		AB	AC	BC	
LSD 5%	71	100	76		224	176	147	
LSD 1%	94	132	100		314	253	206	
	Protein contents in grain (% in dry matter)							
A1	9.29	9.38	9.18	9.06	10.21	9.17	8.70	***9.29***
A2	11.50	12.13	11.88	11.69	11.89	11.66	12.11	***11.84***
A3	9.65	9.54	9.65	8.83	10.42	9.56	9.65	***9.61***
A4	10.31	10.12	9.86	9.62	11.20	9.47	10.09	***10.10***
Mean B	***10.19***	***10.29***	***10.14***					
			Mean C	***9.80***	***10.93***	***9.96***	***10.14***	
			B1	9.83	10.97	10.17	9.79	
			B2	9.93	11.05	9.90	10.29	
			B3	9.64	10.78	9.83	10.33	
Statistics	A	B	C		AB	AC	BC	
LSD 5%	0.19	ns	0.30		ns	0.69	ns	
LSD 1%	0.25	ns	0.39		ns	0.99	ns	

Table 6. Impacts of the growing season (the factor A), irrigation (the factor B) and genotype (the factor C) on maize grown on the eutric cambisol under condition without mineral fertilization

Year (A1: 2006, A2: 2007, A3: 2008. A4: 2009), irrigation (B1: non-irrigated, B2: 65-100% FWC, B3: 80-100% FWC) and genotype (maize inbred line: C1 = Os 438-95, C2 = Os 30-8, C3 = Os 6-2, C4 = Os 1-44) effects; FWC = field water capacity

Year	Irrigation (B)			Genotipe (C)				Mean
(A)	B1	B2	B3	C1	C2	C3	C4	A
	Starch contents in grain (% in dry matter)							
A1	70.24	70.59	70.70	71.03	69.84	70.78	70.39	***70.51***
A2	68.47	68.54	68.51	68.96	68.61	68.57	67.89	***68.51***
A3	70.69	70.99	71.19	71.87	70.25	71.11	70.59	***70.96***
A4	70.47	70.61	70.80	70.47	70.10	71.48	70.44	***70.63***
Mean B	***69.97***	***70.18***	***70.30***					
			Mean C	***70.58***	***69.70***	***70.48***	***69.83***	
			B1	70.40	69.45	70.17	69.84	
			B2	70.52	69.72	70.69	69.80	
			B3	70.82	69.94	70.60	69.85	
Statistics	A	B	C	AB	AC	BC		
LSD 5%	0.21	0.20	0.28	ns	0.65	0.54		
LSD 1%	0.28	ns	0.37	ns	0.93	0.76		
	Oil contents in grain (% in dry matter)							
A1	3.86	3.86	3.77	3.99	3.84	3.49	3.99	***3.83***
A2	3.90	3.59	3.58	3.93	3.75	3.50	3.58	***3.69***
A3	3.51	3.46	3.53	3.74	3.27	3.39	3.58	***3.50***
A4	4.11	4.18	4.23	4.71	4.02	3.85	4.11	***4.17***
Mean B	***3.85***	***3.77***	***3.78***					
			Mean C	***4.09***	***3.72***	***3.56***	***3.82***	
			B1	4.11	3.97	3.53	3.76	
			B2	4.09	3.60	3.54	3.86	
			B3	4.08	3.59	3.61	3.83	
Statistics	A	B	C	AB	AC	BC		
LSD 5%	0.13	ns	0.11	ns	0.26	0.21		
LSD 1%	0.18	ns	0.15	ns	0.37	ns		

Average starch content in maize grain was 70.15% with variation among the years from 68.51% to 70.93% (Table 6). With that regard, the 2007 growing season separated from remaining three by the lower starch contents (averages from 70.51% to 70.96%). The irrigation effects on starch contents were significant but with low differences below 0.34%. Also, combination of year and irrigation (AB interaction) was low with non-significant differences in starch contents. The genotype effects were from 69.83% (C4) to 70.58% (C1) with emphasis that differences between two genotypes (C1 and C3, C2 and C4) were non-significant. The genotypes with the higher starch contents (C1 and C3) had the lower protein contents (Tables 5 and 6). The interaction of genotype with remaining two tested factor were high significant wit differences from 67.89% (A2C4) to 71.87% (A3C1) and from 69.45% (B1C2) to 70.82% (B3C1).

Oil content in grain was 3.80% (4-year average) with very significant differences among the years from 3.50% in 2008 to 4.17% in 2009 (Table 6). Non-significant differences of oil contents among the irrigation treatments and among year and irrigation (AB interaction) were found. Genotype effects were from 3.56% (C3) to 4.09% (C1). Three genotypes (C2, C3 and C4) characterized significant but mutually low differences in oil contents (average 3.70%). Both interactions between genotype and year / irrigation (AC and BC) were significant in the ranges from 3.27% (A3C2) to 4.71% (A4C1) and from 3.53% (B1C3) to 4.11% (B2C1). The values in oil contents of individual genotype under different steps of irrigation were non-significant for three genotypes. Only in the C2 found significant differences between non-irrigated (B1C2: 3.97%) and irrigated treatments (average 3.60%).

Our findings of irrigation, year and genotype effects on grain yield and quality (protein, starch and oil contents) are mainly in accordance with other investigations.

BOSNJAK *et al.* (2008) applied three levels of irrigation (maintenance of soil water in the levels 60%, 70% and 80% of field water capacities and non-irrigated plot) during three growing seasons on the experimental field of Institute of field and vegetable crops in Novi Sad (Serbia). In general, by irrigation grain yields of maize were considerable increased with exception, of the year characterized by excessive precipitation. In 12-year experience with maize irrigation (KOVACEVIC and JOSIPOVIC, 2013) we found the same conclusion.

The considerable effects of irrigation on maize yield were found PEPO *et al.* (2008) in the eastern Hungary, PEJIC *et al*. (2010) in Vojvodina province (Serbia), JOSIPOVIC and KOVACEVIC (2013) in eastern Croatia, and in other studies (ŐKTEM *et al*., 2000; AL-KAISI *et al*., 2003; GWENZI *et al.,* 2008).

SVECNJAK *et al*. (2007) tested four maize hybrids during three growing season under intensive and extensive soil and crop management in the northwestern Croatia. The lower yields of maize under less favorable weather conditions („year effects") an extensive management were associated mainly with the higher protein and oil contents in grain.

By testing 96 maize hybrids at four locations in Hungary under irrigated and non-irrigated conditions for two growing seasons was found that the high-yielding hybrids had the higher starch and the lower protein and oil contents in grain. Also, the higher protein and the lower starch contents in grain were found both under irrigated and under „dry year"conditions (HEGYI *et al*. 2008; HEGYI and BERZY, 2009).

SIPOS *et al*., (2009) tested effects of nutrient supplies and irrigation on yield and starch content in three maize hybrids of different maturity groups on calcareous chernozem of the eastern part of Hungary. Besides nutrient supplies maize yield and starch contents mainly strongly depends on the hybrid and additional environmental factors, such as irrigation. In general, by growing of maize hybrids of the earlier maturity group grain and starch yields are the lower but more stabile compared to those of the longer vegetation period.

SALEEM *et al*. (2008.) found considerable differences of protein, starch and oil contents in maize grain among maize hybrids in Pakistan. In general, low positive correlation was found between grain yield and starch contents and low negative correlation between grain yield and protein contents in grain.

CONCLUSIONS

In our four-year investigation, satisfied grain yields of tested maize inbred lines in amount 1809 kg ha^{-1} under N non-fertilized conditions is an indication of the high level of natural soil fertility. Maize yield under more favorable weather conditions of the 2006 growing season was about 3-fold higher (average 2450 kg ha^{-1}) in comparison of yield achieved under drought and the high air-temperature stress of 2007 (823 kg ha^{-1}). Maize yield under non-irrigated conditions was 1500 kg ha^{-1}. By two steps of irrigation yields of maize were lineary increased for 21% and 41%, respectively. Differences of the 4-year average yields among the maize genotypes were in range from 1259 (C3) to 2765 (C1) kg ha^{-1}.

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UTICAJ NAVODNJAVANJA I GENOTIPA NA PRINOS, SADRŽAJ PROTEINA, SKROBA I ULJA U ZRNU SAMOOPLODNIH LINIJA KUKURUZA

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Izvod

Četiri samooplodne linije kukuruza (Os 438-95 = C1, Os 30-8 = C2, Os 6 = C3 i Os 1-44 =C4) su gajene četiri godine (2006-2009) u stacioniranom poljskom ogledu na eutričnom kambisolu kod Osijeka. Vlažnost zemljišta je održavana navodnjavanjem na nivou 60-100% (B2) i 80-100% (B3) poljskog vodnog kapaciteta. gled je đubren s dve količine azota (0, 100 i 200 kg N ha^{-1}). Osam genotipova (po četiri samooplodne linije i hibrida) su gajene na svakoj parceli đubrenja. Ogled je postavljen u duplikatu za plodored kukuruz – soja i po split-split-plot metodi i slučajnom rasporedu u tri ponavljanja (osnovne parcele 617.2 m^2, 313.6 m^2, i 39.2 m^2 za navodnjavanje, đubrenje i genotip). Parcele neđubrene azotom i četiri samooplodne linije (faktor C) su odabrane za ispitivanje efekata godine (A) i navodnjavanja (B). Prosečan prinos 1809 kg ha^{-1} ostvaren bez đubrenja je indikator veoma plodnog zemljišta. Prinosi zrna (4-god. proseci) ovisno o godini iznosili su od 823 (2007.) do 2450 (2006.) kg ha^{-1}, bez navodnjavanja1500 kg ha^{-1}, a navodnjavanjem su povećani za 21% (B2), odnosno za 41% (B3). Prinosi pojedinih genotipova bile su od 1259 (C3) do 2765 (C1) kg ha^{-1}. Razlike u sadržaju proteina, skroba i ulja u zrnu bile su od 9.61 do 11.84%, od 68.51% do 70.93%, odnosno od 3.50% do 4.17% (uticaj godine). Genotip C2 se izdvajao većim sadržajem proteina (10.93%) od preostala tri genotipa (prosek 9.96%). Uticaj genotipa na sadržaj skroba i ulja u zrnu bio je od 69.83% (C4) do 70.58% (C1), odnosno od 3.56% (C3) do 4.09% (C1).

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