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The Effect of Crop Density on Maize Yield and Grain Traits

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Abstract: During a 2-year study in 1994 and 1995, the effect of crop density on yield and some grain traits in three NS maize hybrids, was studied. The experiment was conducted on the alluvial smonitza type of soil of the Cacak valley.
In all the hybrids, higher crop density led to visibly shorter ears with much smaller grains. The ear length and 1000 kernel weight were the lowest at the highest crop density, and test weight at the lowest one .The highest average biennial yield was obtained at the highest crop density.

Key words: maize, hybrid, crop density, 1000 kernel weight, test weight, ear length, grain yield

Introduction

In order to obtain high and stable maize yields as well as to optimally utilize its yielding potential, an optimal crop density should be provided in the first place. Breeding work on new maize hybrids has been intensified in recent years to a great extent suggesting a permanent need to investigate and determine plant number for better yields. Higher yielding potential of newly-obtained hybrids appears to be an immediate effect of their ability to withstand higher crop density (Russel, 1986).

Among factors of yield, grain traits, particularly 1000 kernel weight seem to be crucial (Nenadić et al., 1989). The same authors also concluded that a higher crop density led to a lower 1000 kernel weight, as confirmed by some previous studies (Bagnara, 1985; Mančev, 1985; Cross et al., 1987; Amoriwa et al., 1987), yet to a higher test weight (Božić, 1992; Bokan, 1996).

The objective of our investigation was to thoroughly study the effect of crop density on some morphological traits of grain, as well as to find out the best plant stand to promote the best yields of the hybrids from the 600 FAO group.

Material and methods

The experiment was conducted at Preljinska Baluga in the vicinity of Cacak on the alluvial smonitza in 1994 and 1995. The experiment was set up according to random split-block design with four replications. The elementary plot was 17.5 m2 in size. All the measurements were made in three in-rows, with border ones used as a protection, thus the entire plot was 10.5 m2. Three hybrids of the Institute of Field and Vegetable Crops in Novi Sad (NSSC-601, NSSC-604 and NSSC-6666) were subjected to the experiment, using three crop densities (50 000, 60 000 and 70 000 plants/ha). Wheat served as a preceding crop in both years. Primary tillage was done in the autumn of the preceding year by means of ploughing at the depth of 30 cm. Seedbed preparation was performed by a disc harrow and a seed conditioner. Sowing was done manually in April, 22 in 1994 and 1995. After sowing, but before emergence, 3 l/ha of herbicide Dual was applied.

Just before primary tillage, 75 kg/ha N,P, K were applied, and before seedbed preparation, 54 kg/ha N were added. Cultural practices included one thinning per planned plant number, two inter-row cultivations and two diggings. Picking was done manually, and grain yield calculated in t/ha with 14% of moisture. 1000 kernel and test weight were determined, using standard methods.

An analysis of variance of the three-factorial design 3 x 3 x 2 was used for data processing, and LSD-test for establishing the individual differences.

Environmental conditions

Meteorological conditions - refer to mean monthly air temperatures and rainfalls, as the key preconditions of smooth plant growth during the vegetation. A high percentage of fields under maize reflects its successful growth under relatively favourable conditions of the Cacak valley.

The data on temeprature and rainfalls were obtained at the Agricultural Station "Ovcar" - Cacak (Tab.1.).

The mean monthly air temperature of the vegetation period in 1994 was higher by 1.0°C compared to 1995. The average temperature of both years was higher than the long-term average, i.e. by 2.1oC and 1.1°C in 1994 and 1995, respectively. Excessive heats in May and September of 1994, and July and August of both years also deviated from the long-term average.

The most abundant rainfalls were recorded in July, 1994 (126.8 mm) and the lowest ones in August (32.9 mm). During 1995, the heaviest rains (102.8 mm) fell in June, and mildest ones (47.0 mm) in May. Although lower by 36,2 mm in 1995 than in 1994, the precipitations of both years proved higher than the long-term average, which, as a factor of vegetation, favoured maize growth.

Tab.1.-The mean monthly air temperatures (°C) and rainfall sums (mm) during maize vegetation in 1994 and 1995

Months	IV	V	VI	VII	VIII	IX	
Year	Temperature						Average
1994	12,2	18,3	20,4	22,7	23,6	20,8	19,7
1995	12,1	16,7	20,6	23,9	22,0	17,1	18,7
1981-1990	12,2	16,3	18,5	21,0	20,3	17,4	17,6
	Rainfalls						Sum
1994	59,5	63,7	122,5	126,8	32,9	40,5	445,9
1995	56,4	47,0	102,8	91,2	53,2	59,1	409,7
1981-1990	36,6	77,1	79,9	51,6	50,1	49,1	344,4

Soil - the experiment was carried out on the alluvial smonitza. Chemical analysis of soil indicated that pH of water and nKCl amounted to 6.65 and 5.85, respectively. The content of humus and total nitrogen amounted to 2.9% and 0.145%, respectively, followed by 15.8 mg P_2O_5 and 19.1 mg K_2O per 100 g of air dried matter. Relatively good availability of nutrients to soil (with intervention of fertilizers), as well as a peculiarly high level of groundwater (about 2 m) will enable it to obtain optimal yields.

Results and discussion

1000 kernel weight - depends not only on the genetic variability, but also on the environmental conditions (Hugger, 1988). In 1994, 1000 kernel weight was shown as much higher, compared to that of the following year. The ears resulting from higher crop densities were shorter, of smaller grains, with remarkable differences found between crop densities. This is supported by some previous studies (Bagnara, 1985; Cross et al., 1987; Bozic, 1993). The hybrid NSSC-601 had a significantly higher 1000 kernel weight, compared to NSSC-6666 (by 8,6 g) and a highly significantly higher one, compared to NSSC-604 (by 11,6 g). The difference of 3 g between the hybrids NSSC-604 and NSSC-6666 was random (Tab.2.).

Tab. 2.The effect of crop density and hybrids on the 1000 kernel weight in maize

Hybrid (A)		NSSC 601			NSSC 604			NSSC 6666		
Density (B)		1994	1995	$\bar{x}$	1994	1995	$\bar{x}$	1994	1995	$\bar{x}$
50 000		383,0	412,7	397,8	399,4	385,8	392,6	406,0	396,1	401,1
60 000		407,9	383,2	395,6	386,3	381,8	384,1	381,3	379,9	380,6
70 000		372,5	376,4	374,5	367,6	345,3	356,5	382,2	338,5	360,4
Average		387,8	390,7	389,3	384,4	371,0	377,7	389,8	371,5	380,7
			A	B	C	AB	AC	BC	ABC	
Lsd	0,05		7,41	7,41	6,05	12,83	10,47	10,47	18,13	
	0,01		9,97	9,97	8,14	17,28	14,10	14,10	24,42	

Test weight - the hybrid NSSC-6666 had the highest (59,40 kg), and NSSC-604 the lowest test weight (58,10 kg). The difference of 1,3 kg between these, and that of 0,8 kg between the other two hybrids, are considered highly significant and significant, respectively. With increase in crop density, test weight also increased, though insignificantly from statistical point of view.

Tab. 3. - The effect of crop density and hybrids on the test weight in maize

Hybrid (A)		NSSC 601			NSSC 604			NSSC 6666		
Density (B)		1994.	1995	$\bar{x}$	1994	1995	$\bar{x}$	1994	1995	$\bar{x}$
50 000		62,48	55,57	59,02	61,12	53,55	57,34	62,55	55,89	59,22
60 000		61,34	54,44	57,89	62,48	54,11	58,29	63,01	56,31	59,66
70 000		63,13	54,63	58,89	63,76	53,61	58,69	63,13	55,51	59,32
Average		62,33	54,88	58,60	62,45	53,76	58,10	62,90	55,91	59,40
			A	B	C	AB	AC	BC	ABC	
Lsd	0,05		0,78	0,78	0,64	1,35	1,10	1,10	1,91	
	0,01		1,05	1,05	0,86	1,82	1,48	1,48	2,57	

Test weight highly varied on a year-basis (62,56 and 54,85 kg), suggesting equally strong impact of both genetic variability and environmental factors on this trait.

Ear length - averaged 22 cm. The hybrids NSSC-601 and NSSC-6666 had equally long ears (22,1 cm), and NSSC-604 significantly shorter ones (21,7 cm) (Tab.4.) Higher ear length by 1,1 cm in 1994 compared to 1995, also suggests the presence of a significantly high difference. With increase in crop density (50, 60 and 70 000 plants/ha) ears got visibly shorter (22,8; 22,2 and 20,9 cm). Similar results were obtained by Nenadic et al., 1989; Obradovic, 1990 and Bozic, 1993.

Tab.4. The effect of crop density and hybrid on ear length

Hybrid (A)		NSSC 601			NSSC 604			NSSC 6666		
Density (B)		1994	1995	$\bar{x}$	1994	1995	$\bar{x}$	1994	1995	$\bar{x}$
50 000		23,4	22,6	23,0	22,7	21,9	22,3	23,7	22,3	23,0
60 000		22,9	21,5	22,2	22,0	21,7	21,9	22,8	22,1	22,4
70 000		21,7	20,3	21,0	21,4	20,1	20,7	21,8	20,3	21,0
Average		22,7	21,4	22,1	22,1	21,2	21,7	22,7	21,6	22,1
			A	B	C	AB	AC	BC	ABC	
Lsd	0,05		0,2	0,2	0,1	0,3	0,3	0,3	0,5	
	0,01		0,3	0,3	0,2	0,5	0,4	0,4	0,6	

Grain yield - depends on crop density to a great extent. As the plant represents a basic production unit, plants should be provided in sufficient number to obtain adequate crop density (Videnovic et al., 1988). In both years of studies and in all hybrids, yield was found to increase with increase in crop density (Tab.5, Fig.1.). Grain yield averaged 15,2 t/ha with 50.000 plants/ha, 16,74 t/ha with 60.000 plants/ha and 17,90 t/ha with 70.000 plants/ha. The

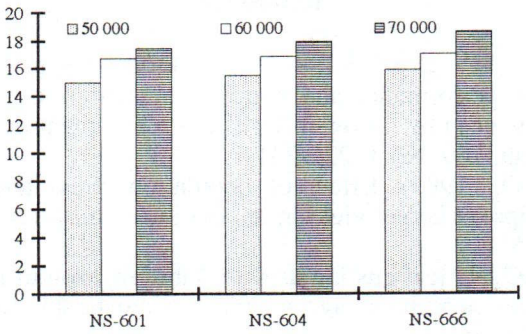
differences of 1,45; 1,16 and 2,61 t/ha were very remarkable. According to Vasic et al., (1985), the increase in crop density per unit area highly influenced yield increase of the studied genotypes. According to more recent studies of genotypic and environmental effects, the crop density of, at least, 60.000 plants/ha should be maintained during the harvest to ensure high yields (Brown, 1986; Videnovic et al., 1987; 1988; Nenadic et al., 1989; Marinkovic et al., 1991; Bokan, 1996).

Tab.5. The effect of crop density and hybrid on maize yield

Hybrid (A)	NSSC 601			NSSC 604			NSSC 6666		
Density (B)	1994	1995	$\bar{x}$	1994	1995	$\bar{x}$	1994	1995	$\bar{x}$
50 000	14,14	15,63	14,88	14,48	15,80	15,14	14,99	16,73	15,86
60 000	15,51	17,49	16,50	16,05	17,30	16,67	16,42	17,69	17,05
70 000	17,12	17,78	17,45	17,66	17,72	17,69	18,05	19,09	18,57
Average	15,59	16,96	16,28	16,06	16,94	16,50	16,49	17,84	17,16

		A	B	C	AB	AC	BC	ABC
Lsd	0,05	0,36	0,36	0,29	0,62	0,50	0,50	0,87
	0,01	0,48	0,48	0,39	0,83	0,68	0,68	1,18

Fig.1. The effect of crop density and hybrid on maize yield



The NSSC-601 hybrid had the lowest yield of 16.28 t/ha, which was lower by 0,32 t/ha compared to NSSC-604, but negligible.

Noticeable difference in yield existed on a year-basis, too. Thus, the average yield for all hybrids and crop densities was 16.05 t/ha in 1994, and 17.25 t/ha in 1995.

Highly significant differences in yields found between crop densities, and benefiting the highest one (70 000 plants/ha), showed that hybrids (in both years) responded best to the vegetation area of 14.28 cm^2 per plant. This contributes to an assumption that new hybrids are able to tolerate higher crop density even under conditons without irrigation. Therefore, a high crop density will be no matter of concern as long as maize field is provided with weather conditions similar to these we have described above. Finally, any lack of humidity during maize vegetation can be supplementd by a more intensive plant

fertilization, for a well-known fact that substantially fertilized plants can easier tolerate water deficit.

Conclusion

The effect of crop density on maize yield and some components of its hybrid yield, suggets the following:

- crop density had a profound effect on studied traits and grain yield;
- in all hybrids, higher crop density led to shorter ears, of much smaller grains. Hence, the lowest values of ear length and mass of 1000 grains occurred at the highest, and those of test weight at the lowest crop density;
- the highest yield was noticed in the highest crop density (70 000 plants/ha) ie. NSSC-601 - 17.45 t/ha; NSSC-604 - 17.69 t/ha and NSSC-666-18.57 t/ha, with an average for both years;
- highly significantly higher yields prevailed in 1995.

The obtained results, primarily those on grain yield, showed that medium late hybrids had a high yielding potential, thus, their production should continue under existing agroecological conditions. Finally, considering merits of a high crop density, producers are strongly advised to optimally adjust maize sowers for protection from pests causing crop thinning.

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PRINOS I NEKE MORFOLOŠKE OSOBINE KUKURUZA U ZAVISNOSTI OD GUSTINE SETVE

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Rezime

Tokom dvogodišnjih proučavanja praćen je uticaj gustine setve na prinos i neke osobine kukuruza.Ogled je izveden na zemljištu tipa aluvijalna smonica u Preljinskoj Baluzi kod Čačka. Za ispitivanja su korišćena tri NS hibrida iz FAO grupe 600 (NSSC 601, NSSC 604 i NSSC 6666) u tri gustine gajenja (50, 60 i 70. 000 biljaka/ha).

Gustina useva je ispoljila veliki uticaj na ispitivane osobine i prinos zrna kukuruza. U gušćem sklopu biljaka kod svih hibrida dolazi do produkcije klipa sa sitnijim zrnom. Tako su dužina klipa i masa 1000 zrna imali najmanje vrednosti u najvećoj gustini, a hektolitarska masa je bila najmanja u najređem usevu.

Najveći prinos je ostvaren u najvećoj gustini gajenja (70 000bilj./ha) i to NSSC-601 - 17,45t/ha; NSSC-604 - 17,69t/ha i NSSC-6666 - 18,57t/ha, u proseku za obe godine .