Scientific Papers. Series A. Agronomy, Vol. LXII, No. 2, 2019
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF PLANTING DENSITY OF DIFFERENT MAIZE HYBRIDS ON CROP GROWTH AND YIELD

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Abstract

Three hybrids of maize of Pioneer Company (P9241, P9900 and P0023) grown at different plant densities (40000, 46000, 56000, 69000 number per ha) were studied in the experimental field of Agricultural University of Plovdiv in 2015 and 2016. The purpose of this study was to trace the influence of sowing density of maize hybrids on growth and yield. The experiments were carried out by split-plots method.
The experimental areas were fertilized with a nitrogen fertilizer rate of 240 kg/ha - ½ $CO(NH_2)_2$, applied in the 5-6 leaf stage of the plant and ½ NH_4NO_3, applied into the 10^{th} leaf stage.
A hybrid P9900 has the highest plants at the end of vegetation. There was no significant difference between variants with plant densities - from 279.4 cm (40000 plants/ha) to 284.4 cm (56000 plants/ha). Height of plants of hybrid P9241 was the smallest - 260.5 cm at a sowing density of 40000 plants/ha.
The highest yield between 3 hybrids was obtained at a sowing density of 69000 plants per ha. Hybrid P9241 showed yield of 13800 kg/ha, while hybrid P9900 - 14257 kg/ha.

Key words*: maize, planting density, growth, yield.*

INTRODUCTION

Maize is one of the most important food and feed crops in the world. Over the last few years, there has been a steady tendency to an increase of the planted areas in Bulgaria, expanding from 328 000 ha in 2010 to 400 000 ha in 2017 (Agricultural Reports 2010-2018, website of the Ministry of Agriculture and Food in the Republic of Bulgaria). Crop density is one of the major factors determining the yield. It depends on the hybrid, the application of innovative approaches in the cultivation technology, a differentiated approach to pest control, etc. **(**Delibaltova et al., 2009; Delibaltova, 2018; Dimitrova et al., 2013; Dimitrova et al., 2018). The aim of the present study was to follow out the effect of maize planting density on crop growth and yield.

MATERIALS AND METHODS

In 2015 and 2016 in the Training-and-Experimental Fields of the Agricultural University in Plovdiv, precise field trials were carried out with 3 maize hybrids - **P9241, P9900** and **P0023**, grown at different planting densities (**40000, 46000, 56000** and **69000** plants per hectare). The experiments were set by the split-plot design method with a perpendicular location of the factors. Drip irrigation was provided in the experimental field during the two years of the study.
The soil in the experimental field of the Agricultural University - Plovdiv has been determined as alluvium, which based on the international classification of FAO belongs to the category of Mollic Fluvisols. It is characterized by average sandy-clay mechanical composition, not high humus content of 1.01-1.32%, a weak alkaline reaction of the soil (pH 7.6-7.9) (Popova et al., 2012).

Plant Material

Seeds of three maize hybrids for forage production of Pioneer Company were used.
According to the length of their vegetation period, the hybrids refer to the following groups, following the classification of FAO:

1. Hybrid P0023 - 450 according to FAO

A new hybrid, its grain releases moisture at the highest rate after reaching physiological maturity compared to the other hybrids in the

group. It is tolerant to high temperatures during flowering and grain filling, which characterizes the hybrid as drought-resistant.

2. Hybrid P9900 - 420 FAO

It is characterized by early flowering and excellent moisture release ability. Tolerant to drought. The hybrid prefers and tolerates high temperatures during flowering.

3. Hybrid P9241 - 370 according to FAO

It resists high temperatures from the intensive growth stage to the end of the grain filling stage. Due to its rapid early start, P9241 is suitable for early sowing. It is characterized by rapid release of moisture during ripening and stress resistance at emergence (www.pioneer.com).

Agro-technical practices

The experimental field was fertilized with a nitrogen fertilizer at the rate of 240 kg/ha ½ CO $(NH_2)_2$, applied at the stage of 5^{th}-6^{th} leaf of the crop and ½ $NH4NO_3$, applied at the stage of 10^{th} leaf.

Weed control was carried out with the herbicide Stomp New 330 EC at a rate of 4000 ml/ha, applied after sowing before the emergence of weeds. During the vegetation, treatment was carried out at the 4^{th}-6^{th} leaf stage of the crop with the herbicide Principal Plus 66.5 WG - 440 g/ha + Trend 0.1%. Selectivity of the herbicide preparations to the crop was reported following EWRS (European Weed Research Society) scale: from score 1 - no damage to the crop plants, to score 9 - the crop is completely destroyed.

Soil and leaf herbicides were applied by a back-sack sprayer, the spray solution being 300 l/ha.

The agrotechnical measures were carried out according to the generally accepted technology for maize growing (soil cultivation, fertilization, sowing, rolling).

RESULTS AND DISCUSSIONS

In both experimental years, the growing season was warm, with temperatures around and above average over a long period of time. A significant difference with respect to the average monthly temperatures was established only in the initial period of crop development, i.e. in April, May and June (Figure 1).

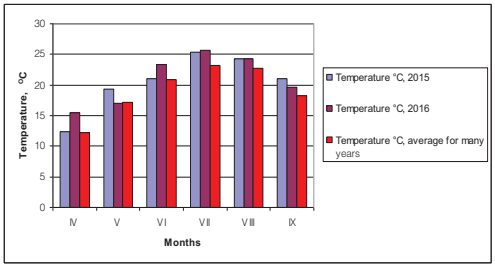

Figure 1. Temperature during the test period, °C

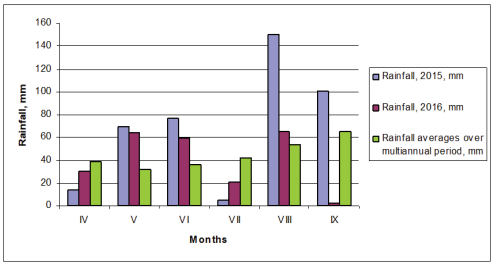

Figure 2. Rainfall during the test period, mm

The amount of rainfall during the experimental period is shown in Figure 2. In April and July 2015, a severe drought was reported, which was compensated by the large amount of rainfall during the rest period of the crop vegetation. Precipitation exceeded the average amount for a long period of time by 143 mm. In 2016, the rainfall was more evenly distributed, with a slight drought in July and September. The amount of rainfall for the vegetation period was 243.3 mm and it was close to the average for a long period of time (268 mm).

In the period 2015-2016, the experimental areas were heavily infested by weeds from the group of the annual late-spring species. Major representatives of that group were: *Amaranthus retroflexus* L., *Solanum nigrum* L., *Chenopodium album* L., *Portulaca oleraceae* L., *Datura stramonium* L., *Setaria* spp., *Echinochloa grus-galli* L. etc. The perennial weed species found are: *Sorghum halepense* Scop. and *Convolvulus arvensis* L. Those weed species are typical for the maize crop in the region (Dimitrova et al., 2013; Zhelyazkov, 2007; Tonev et al., 2007). That combination provided a good control of the weeds found in the experimental site. It was fully selective to

the 3 maize hybrids - **P9241, P9900** and **0023** (score 1, EWRS scale).

Effect of maize crop density on plant height

The height of the maize plants at the end of the vegetation season is presented in Table 1 and Figure 3, on average for the two experimental years. It should be noted that each hybrid showed different development, depending on crop density. According to the length of the vegetation season, each of the 3 hybrids belongs to a different FAO group. The highest plants were reported in hybrid **P9900**, regardless of the crop density, i.e. crop density did not have a significant influence on the studied characteristic. Plant height ranged from 279.4 cm (at 40000 plants per ha) to 284.4 cm (at 56000 plants per ha).

Hybrid **P0023** formed lower plants and the increase of plant density from 46000 to 69000 plants per hectare resulted in 13.3 cm plant height reduction.

Hybrid **P9241** belongs to 370 FAO group. That is one of the leading hybrids in this group and at the same time it does not fall behind the hybrids of the higher group in yields obtained (www.pioneer.com). At a crop density of 40 000 plants/ha, the plant height at the end of vegetation was smaller (260.5 cm) compared to the other two hybrids (Figure 3). The increase of crop density up to 56000 and to 69000 plants per hectare resulted in an increase of plant height by 19.2 cm (7.4%) and 14.2 cm (5.4%), respectively.

Table 1. Height of plants at the end of vegetation, cm

Number of harvested plants per 1 ha	Maize Hybrids		
	P9241	P9900	P0023
40000	260.5	279.9	268.5
46000	269.4	281.4	269.9
56000	279.7^{+}	284.4	259.0
69000	274.7	283.8	255.2

LSDp5%=18.45 LSDp1%=23.90 LSDp0.1%=29.45

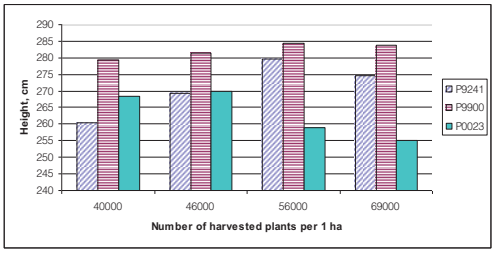

Figure 3. Height of plants at the end of vegetation, cm

Effect of maize crop density on grain yield

The grain yield of maize plants is presented in Table 2 and Figure 4, on average for the two years of the study. The highest yield of all the 3 hybrids was reported at a plant density of 69000 plants per hectare, the grain obtained ranging from 13800 kg/ha (**hybrid P9241**) to 14257 (**hybrid P9900**) kg/ha. The yield was harvested at 12% grain moisture content.

Table 2. Grain yield of maize, kg/ha

Number of harvested plants per 1 ha	Maize Hybrids		
	P9241	P9900	P0023
40000	10786	12071	12557
46000	12143	12757	12950
56000	13200^{+}	13328	13471
69000	13800^{++}	14257^{+}	14072

LSDp5%=2169 LSDp1%=2845 LSDp0.1%=3620

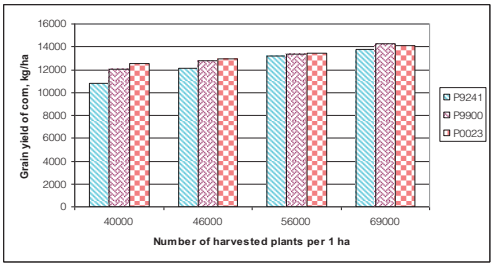

Figure 4. Grain yield of maize, kg/ha

At a planting density of 40000 plants per hectare, the lowest grain yield was established in hybrid **P9241** - 10786 kg/ha and the highest - in hybrid **P0023** - 12557 kg/ha. Similar results were established at a crop density of 46000 and 56000 plants/ha, but the difference of the values between the separate hybrids was less significant.

In hybrid **P9241**, it can be clearly seen that with the increase of the number of harvested plants from 40000 to 69000 plants per hectare, the yield also increased. The largest increase in yield was reported at the increase of the harvested plants per hectare from 40000 to 46000. The yield increase reported with the increase of plant density from 56000 to 69000 plants per hectare was less, but significant compared to the yield obtained from 40000 harvested plants per hectare.

A gradual yield increase with the increase in the number of harvested plants was also established in hybrid **P9900**. The yield

increased from 12071 kg/ha at a density of 40000 plants/ha to 14257 kg/ha at 69000 plants per hectare and the difference was statistically significant.

The highest average yield, irrespective of the planting density, was established in hybrid **P0023** (13262 kg/ha), followed by the yield obtained from hybrid **P9900** (13103 kg/ha).

The yield of hybrid **P0023** gradually increased with the increase in the number of harvested plants per hectare, although in that case the increase was insignificant (Table 2).

CONCLUSIONS

The largest plant height at the end of the vegetation season was reported in hybrid **P9900**, no significant difference being established between the variants of different planting densities. Plant height ranged from 279.4 cm (at 40000 plants/ha) to 284.4 cm (at 56000 plants/ha). Hybrid **P0023** formed lower plants and the increase of planting density from 46000 to 69000 plants/ha resulted in a reduction in plant height by 13.3 cm (5%).

At a planting density of 40000 plants/ha, the plant height in hybrid **P9241** was the smallest - 260.5 cm. The increase of planting density to 56000 and 69000 plants/hectare led to an increase of plant height by 19.2 cm (7.4%) and 14.2 cm (5.4%), respectively, in contrast to hybrids **P9900** and **P0023**.

The highest yield from all the 3 studied hybrids was obtained at a planting density of 69000 plants per hectare, ranging from 13800 kg/ha (hybrid **P9241**) to 14 257 kg/ha (hybrid **P9900**), respectively.

At a planting density of 40000 plants per hectare, the lowest grain yield was obtained from hybrid **P9241** - 10786 kg/ha and the highest - from hybrid **P0023** - 12557 kg/ha. Similar results were established in the variants with a density of 46000 and 56000 plants/ha, but the difference between the hybrids was less significant.

ACKNOWLEDGEMENTS

This study was funded by the Project of Pioneer company, Bulgaria in the period 2015-2016.

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