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The Effects of Plant Density and Row Spacing on the Height of Maize Hybrids of Different Vegetation Time and Genotype

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***Abstract*—**The small plot experiment was set in 2013 at the RISFLátókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen, on lime-coated chernozem soil in four replications. The final heights of the maize hybrids were studied at three plant densities (50, 70, and 90 thousand ha^{-1}) and two row spacing (45 and 76cm). During the experiment, we have investigated the development of the final plant heights of five maize hybrids of different vegetation time and genotype: Sarolta, DKC 4025, P 9175, Reseda/P 37M81, and SY Affinity. In the development of the plant heights, the tiller number and the hybrid were the decisive factors. The increasing stock density resulted in significant difference in the plant height values, while the row spacing did not. With the increase of plant density and the length of vegetation time, the heights of the individual plants increased.

***Keywords*—**Maize, plant density, row spacing, plant height, genotype.

I. Introduction

PLANT height is an important component which helps in the determination of growth. The effect of plant population on plant height was significant, while the effect of hybrids and the interactive effect of plant population density and hybrids were non-significant [16]. The morphological parameters (leaf area, plant height, stalk diameter) of maize well expressed the effects of plant number and the differences between the maize hybrids [2]. The plants become taller as the plant density increased. The lowest plant height was measured at a density of 45,000 plants ha^{-1} and this was significantly different from the values recorded at the other two plant densities. The height of plants grown at densities of 65 and 85 thousand plants per hectare did not differ significantly [7]. Plant height was significantly influenced by the densities. Plant height increased with increase in plant density ant the taller plants were observed in 83,333 plants ha^{-1} density [4]. Plant height was significantly affected by plant densities [10] and corn hybrids. Plant height increased with increasing plant densities. In general, the maximum plant height (200.5cm) was obtained with the highest plant density (13 plant m^{-2}), while the least value (185.2cm) was recorded at the lowest plant density (7 plant m^{-2}) [9]. Higher plant densities produced taller plants. The result showed results showed that there were differences among plant densities in plant height. Plant height inclined with increased plant density up to 120,000 plants ha^{-1} [6]. Plant height significantly affected by plant densities. Plant height increased with increases in plant density and the tallest plants (231.2cm) were observed at 120,000 plants ha^{-1} density and shortest plants (222.8cm) were at 80,000 plants ha^{-1} density [15]. The effect of plant densities on plant height was significant. There was an increasing trend in plant height with the increase in plant densities. The maximum plant height (224.09cm) was recorded where the crop was sown at plant density of 99,900 plants ha^{-1} against the minimum plant height (200.29cm) recorded, where the crop was sown at plant density of 57,100 plants ha^{-1} [12]. Plant population and varieties had a significant effect on plant height. Maximum plant height was recorded from the treatment of 65,000 plants ha^{-1}. Minimum plant height was attained by 45,000 plants ha^{-1} [13]. In contrast with the previous [1] increasing population density decreased the plant height. The maximum plant height of 204.65cm was produced by the lowest plant population of 35,000 plants ha^{-1} and the minimum plant height of 181.24cm was produced by the population of 95,000 plant ha^{-1} respectively.

Effect of row spacing on plant height was nonsignificant [5], [8], [11]. Row spacing and the plant densities did not affect plant height [14], but in contrast with the previous [3] the average effect of row spacing had effect on plant height.

II. Materials and Methods

The small plot experiment was set in 2013 at the RISFLátókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen, on lime-coated chernozem soil in four replications.

The final heights of the maize hybrids were studied at three tiller numbers (50, 70, and 90 thousand ha^{-1}) and two row distances (45 and 76cm). During the experiment, we have investigated the development of the final plant heights of five maize hybrids of different vegetation time and genotype: Sarolta (FAO 290), DKC 4025 (FAO 330), P 9175 (FAO 330), Reseda/P 37M81 (FAO 360), and SY Affinity (FAO 470). During the study, we have selected and measured five plants of average height per plot. The results were evaluated by SPSS 13.0 statistical software and Microsoft Excel.

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Table I lists the precipitation amounts fell in 2013 until the measurements and the monthly average temperatures. The precipitation amounts in April and May as well as the temperature values exceeded the 30-year averages. The precipitation amounts fell in June and July were far below the 30-year averages.

TABLE I
THE VALUES OF MONTHLY AVERAGE TEMPERATURES AND PRECIPITATION AMOUNTS IN 2013 (DEBRECEN, 2013)

	Monthly average temperature (C°)	Temperature (C°) 30-year average	Precipitation (mm)	Precipitation (mm) 30-year average
April	12.0	10.7	48.0	42.4
May	16.6	15.8	68.7	58.8
June	19.6	18.7	30.8	79.5
July	21.2	20.3	15.6	65.7

III. RESULT AND DISCUSSION

A. Plant Density X Row Spacing

In the average of the five studied maize hybrids, the height increased with the increase of the stock density. In the average of the height values, the highest values were measured in the case of the densest stock, which was 286.29 cm at the row distance of 45 cm and 286.69 at the traditional row spacing (Table II and Fig. 1).

TABLE II
THE EFFECTS OF PLANT DENSITY AND ROW SPACING ON THE PLANT HEIGHT OF MAIZE (CM) (DEBRECEN, 2013)

Plant density (plantsha^{-1})	Sarolta	DKC 4025	P 9175	Reseda	SY Affinity	Average
Row spacing			45 cm			
50000	270,45	265,80	271,60	275,25	290,10	274,64
70000	281,05	263,85	288,95	278,90	296,80	281,91
90000	286,35	265,00	286,40	286,65	307,05	286,29
Row spacing			76 cm			
50000	280,15	265,05	281,10	276,35	293,60	279,25
70000	280,10	271,80	285,30	280,10	297,05	282,87
90000	288,20	271,25	286,50	286,85	300,65	286,69

The effects of plant density and row spacing on the development of plant heights of maize hybrids of different genotypes are shown in Table II. The plant height was the highest at 90 thousand plants/ha. In the case of smaller tiller numbers, the heights decreased, while the two row spacing did not cause significant alterations (Fig. 1).

At 90 thousand plants/ha, the largest heights in the average of the hybrids were as follows: at 45cm row spacing (286.29 cm), at 76cm row spacing (286.69cm), while the lowest values at 45cm row spacing (274.64cm), at 76cm row spacing (279.25cm).

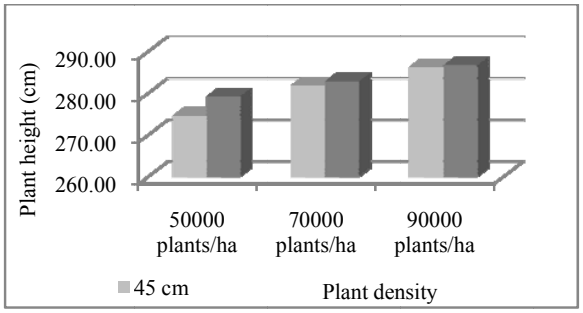

Fig. 1 The effects of plant density and row spacing on the average plant heights of maize hybrids (Debrecen, 2013) (Average of hybrids)

TABLE III
RESULTS OF THE BI-FACTORIAL VARIANCE ANALYSIS IN THE CASE OF PLANT DENSITY*ROW SPACING

	df	Mean Square	F	Sig.
Plant density	2	941,475	6,521	0,002
Row spacing	1	114,075	0,790	0,376
Plant density*Row spacing	2	51,925	0,360	0,699
Error	114	144,381	-	-

Table III shows the results of the bi-factorial variance analysis in the case of plant density*row spacing. According to the table, we can conclude that in the case of the studied hybrids, the plant density caused significant differences, while the row spacing did not ($p<0.05$). The studied factors did not cause significant differences collectively.

B. Variety x Plant Density

The result of the bi-factorial variance analysis in the case of plant density*hybrid is found in Table IV. According to the table, it can be concluded that in the case of the studied hybrids, the plant density and the different hybrid caused significant difference ($p<0.05$). The studied factors cause significant difference individually, while collectively they do not have effect on plant height.

TABLE IV
RESULTS OF THE BI-FACTORIAL VARIANCE ANALYSIS IN THE CASE OF PLANT DENSITY*HYBRID

	df	Mean Square	F	Sig.
Plant density	2	941,475	20,034	0,000
Hybrid	4	2826,904	60,155	0,000
Plant density * Hybrid	8	54,423	1,158	0,332
Error	105	46,994	-	-

In the development of the plant heights of the hybrids, the plant density and the hybrid were the decisive factors. The heights of hybrids increased with the increase of the plant density at both applied row spacing in the case of the hybrid of the longest vegetation time, SY Affinity (307.05cm at 45 cm row spacing, 300.65 cm at 76 cm row spacing) (Fig. 2). In the development of the heights of the hybrids, the effects of different genotypes and vegetation times were observed. With the increase of the length of vegetation time, the plant heights increased as an effect of increasing stock density, except of the hybrid DKC 4025. The increase in the plant height could be experienced the best in the case of the two hybrids of extreme FAO numbers. While in the case of the hybrid, Sarolta (FAO 290), the one with the lowest FAO number, 270.45-288.2 cm heights were measured depending on the plant density and row spacing, the values were between 290.1 and 307.05 cm in the case of SY Affinity, the hybrid of the highest FAO number.

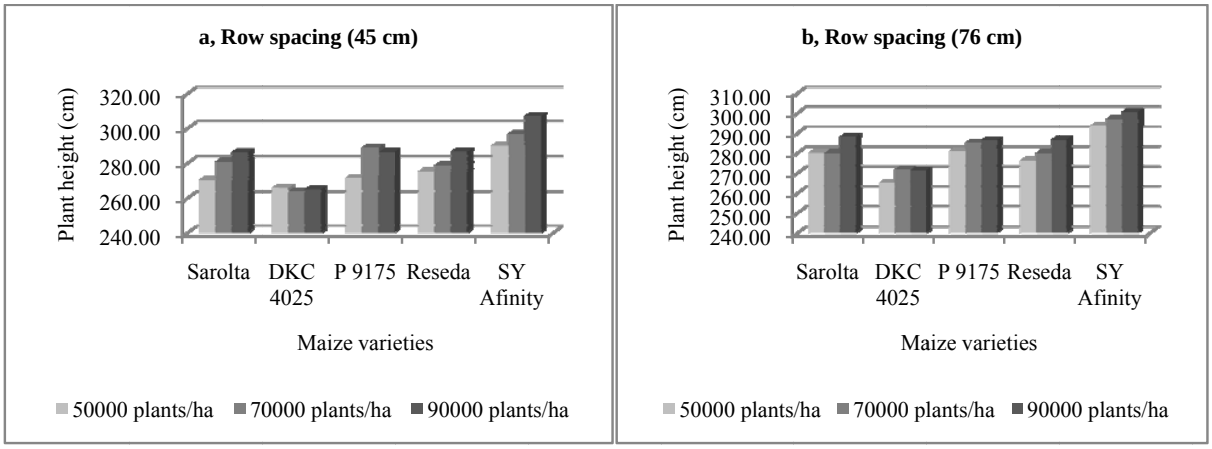

Fig. 2 The effects of tiller number and row distance plant heights of maize hybrids of different genotype (Debrecen, 2013). (a, Row spacing (45 cm), b, Row spacing (76 cm)

IV. Conclusion

According to our results, we can conclude that the size of the plant stock has significant effect on plant height values. With the increase of the plant stock, the heights of the individual plants increase. The cause of the increase of plant height could be the competition for light. At 90 thousand plants/ha, the largest heights in the average of the hybrids were as follows: at 45cm row spacing (286.29cm), at 76cm row spacing (286.69cm), while the lowest values at 45cm row spacing (274.64cm), at 76cm row spacing (279.25cm). During our research, we have studied hybrids of different vegetation time and genotype, which caused significant differences in plant height values. Varieties of longer vegetation times were higher. While in the case of the hybrid, Sarolta (FAO 290), the one with the lowest FAO number, 270.45-288.2 cm heights were measured depending on the plant density and row spacing, the values were between 290.1 and 307.05 cm in the case of SY Affinity, the hybrid of the highest FAO number. The row spacing does not cause significant differences in the plant height values.

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