

Investigation of the plant number reactions of maize hybrids on chernozem soil beside site-specific fertilization

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Abstract: We have investigated the plant number reactions of six maize hybrids of various genotypes in a field experiment; the plant numbers were 50, 70 and 90 thousand ha⁻¹, while the row distances were 45 and 76 cm. The experiment was set on the Látókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen in four replications on chernozem soil. The fertilizer doses applied in favour of the site-specific fertilization were N 108 kg ha⁻¹, P 0 kg ha⁻¹ and K 0 kg ha⁻¹. The hybrids were members of very early (FAO 240-299), early (FAO 300-399) and medium (FAO 400-499) maturation groups. Sarolta was the hybrid of very early, P9578, Reseda, P 37N01 and P 9494 were the ones of the early, while Kenéz was the hybrid of medium maturation.

With the increase of the plant number, the yield amounts increased in the case of both applied row distances in the average of the hybrids, but in the case of the row distance of 45 cm, the yield excess was of greater extent. The highest yield increase was resulted by the increase of the plant number from 50,000 to 70,000 plant ha⁻¹ in the case of both applied row distances. In addition to the plant number reaction, we have determined the plant number optimums and intervals of the studied hybrids under the certain growing area and agrotechnical conditions.

Keywords: maize, hybrid, plant density, narrow row spacing, yield

Introduction

To realize the highest possible yield per unit area besides the greatest possible crop safety is the aim of contemporary crop production; one of its possible methods is the increase of the plant number and the decrease of the row distance. Therefore, the plant number per unit area increases, and the potential individual yield decrease is compensated by the higher plant number.

Shapiro and Wortmann (2006) found that decreasing row spacing from 0.76 to 0.51 m resulted in 4% more grain yield. Widdicombe and Thelen (2002) their results showed that corn grain yield increased 2 and 4 % when row width was narrowed from 76 cm to 56 cm and 38 cm. According to Lutz et al. (1971), Andrade et al. (2002) grain yields were increased as the width between rows decreased. Hunter et al. (1970) found that all hybrids that they examined increased in grain yield with each increase in population and gave small but significant yield increases to narrowing the row width. Gozubenli et al. (2004) found that, grain yield gradually increased with increasing plant densities up to 90000 plants ha⁻¹ (10973 kg ha⁻¹ mean). According to Mohenseni et al. (2013) the highest yield (11.14 t ha⁻¹) was produced in 80000 plants ha⁻¹. The lowest grain yield (9.09 t ha⁻¹) was produced in 60000 plants ha⁻¹. Plant density had not significant difference in 60000 and 70000 densities on grain yield.

According to Sárvári et al. (2002), in addition to the determination of the optimal plant numbers, the plant number optimum intervals of the hybrids have to be also determined, and their lower values have to be applied during production.

Material and methods

We have investigated the plant number reactions of the maize hybrids of various genotypes in a field experiment in 2013, on the Látókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen. The soil of the experiment is calcareous chernozem, its water management traits are very good, and its nutrient management is also good since it is characterized by favourable nitrogen supply, phosphate recovery and potassium providing ability. The fertilizer doses applied in favour of the growing area specific nutrient supply were N 108 kg ha⁻¹, P 0 kg ha⁻¹ and K 0 kg ha⁻¹. In the experiment, we have applied the agrotechnique of the modern maize production. In the experiment, we have studied the plant number reactions of six maize hybrids, in four replications. Three plant numbers (50, 70 and 90 thousand ha⁻¹) and two row distances (45 and 76 cm) were set.

During the vegetation period of maize (1/3–30/9/2013), the precipitation was 379.2 mm, which was practically identical to the 30-year average. In 2013, the high amount of precipitation in March (136.3 mm) was decisive, which refilled the water supply of the soil. The average temperature of the vegetation period was 15.4 °C, which slightly exceeded the multi-year average.

For the statistical analyses of the experiment, we have applied bi-factorial variance analysis (LSD, p=5%) with SPSS software.

Results and discussion

During our research, we have found that the yield increased in the average of the hybrids (Table 1). In the case of the row distance of 45 cm, the increase of the plant number resulted in higher yield excess. The average yields of the hybrids at the narrow row distance were as follows: 13,035 kg ha⁻¹ at the plant number of 50 thousand ha⁻¹, 14,493 kg ha⁻¹ at 70 thousand ha⁻¹, and 15,362 kg ha⁻¹ at 90 thousand ha⁻¹. The increase of the plant number from 50 thousand ha⁻¹ to 70 thousand ha⁻¹ meant 9.93%, while that from 70 thousand ha⁻¹ to 90 thousand ha⁻¹ meant 5.66% yield amount increase. In contrast, at the traditional row distance, the yields of the hybrids were the following: 12,934 kg ha⁻¹ (at the plant number of 50 thousand ha⁻¹), 13,738 kg ha⁻¹ (70 thousand ha⁻¹), and 13,636 kg ha⁻¹ (90 thousand ha⁻¹). The increase of the plant number from 50 thousand ha⁻¹ to 70 thousand ha⁻¹ meant 5.86% yield amount increase, while that from 70 thousand ha⁻¹ to 90 thousand ha⁻¹ meant 0.75% yield amount decrease. To summarize these findings, we can conclude that the highest yield excesses were resulted by the increase of the plant number from 50,000 plant ha⁻¹ to 70,000 plant ha⁻¹ at both applied row distances. In the average of the hybrids, the decrease of the row distance (from 76 to 45 cm), at the stock density of 50 thousand ha⁻¹ resulted in 0.91% (119 kg ha⁻¹), at 70 thousand ha⁻¹ 5.21% (755 kg ha⁻¹), while at 90 thousand ha⁻¹ 11.23% (1726 kg ha⁻¹) yield excess in the cases of the studied hybrids.

The hybrids of various genotypes responded to the changes of the plant number and row distance differently. To the decrease of the row distance, P 9578 and P 9494 responded with yield excess in the case of all applied plant numbers. In the case of the six studied hybrids, the decrease of the row distance caused yield decrease only at the plant number of 50 thousand plant ha⁻¹; the highest decrease was experienced in the case of the hybrid Sarolta: 10.34% (1113 kg ha⁻¹).

Every hybrid responded with yield excess to the increase of the plant number from 50 thousand ha⁻¹ to 70 thousand ha⁻¹ in the at the row distance of 45 cm; at 76 cm, the yield of Reseda decreased, while that of the other studied hybrids increased. The increase of the plant number from 70 thousand ha⁻¹ to 90 thousand ha⁻¹ did not cause yield decrease at the row distance of 45 cm, while at 76 cm, Sarolta, P 9578, and P 9494 responded to the plant number increase with yield decrease.

Table 1: The yields (kg ha⁻¹) of the studied maize hybrids at different row distances and plant numbers (Debrecen 2013)

Hybrids	Grain yield (kg ha ⁻¹)						Average	
	Row spacing						Row spacing	
	45 cm			76 cm			45 cm	76 cm
	Plant density							
50000 plants ha ⁻¹	70000 plants ha ⁻¹	90000 plants ha ⁻¹	50000 plants ha ⁻¹	70000 plants ha ⁻¹	90000 plants ha ⁻¹			
Sarolta	10765	12609	12875	11878	11997	11826	12083	11900
P 9578	13737	15519	16304	12463	15046	13826	15187	13778
Reseda	12499	12883	14354	12991	12483	13182	13245	12885
P 37N01	13293	16061	17077	13765	15421	16296	15477	15161
P 9494	16690	17516	17711	15116	15619	14300	17306	15012
Kenéz	11333	12367	13851	11388	11862	12387	12517	11879
Average	13053	14493	15362	12934	13738	13636	14302	13436
LSD5% (A)	441 kg ha ⁻¹			400 kg ha ⁻¹			528 kg ha ⁻¹	
LSD5% (B)	881 kg ha ⁻¹			800 kg ha ⁻¹			1292 kg ha ⁻¹	
LSD5% (A*B)	1527 kg ha ⁻¹			1385 kg ha ⁻¹			1827 kg ha ⁻¹	

In addition to the increase of the plant number, one has to determine the optimal plant number, which is the most favourable for the applied hybrid under the given conditions. We have determined the optimal plant number corresponding to the yield maximum with regression equations in the range between 50 and 90 plant ha⁻¹ (Table 2).

At the row distance of 45 cm, Reseda obtained its yield maximum at the plant number around 52 thousand plant ha⁻¹; while Sarolta, P 9578, P 37N01, P 9494 and Kenéz between 82 and 90 thousand plant ha⁻¹.

At the row distance of 76 cm, Sarolta, P 9578, Reseda and P 9494 achieved their maximum yields in the plant number interval between 51 and 73 thousand plant ha⁻¹. In summary, we can conclude that in the case of growing area specific nutrient supply, at row distances higher than 45 cm, higher plant numbers can be applied for most of the hybrids, while in the case of the row distance of 76 cm, the case is the opposite, slightly lower plant numbers are more favourable. This can be explained with the positions of the maize plants, since at the row distance of 76 cm, the plant distance is much lower and the assimilation surfaces differ.

On the basis of the width of the interval, hybrids can be classified as ones producible in narrow or broad plant number interval. During our calculations, we have determined the lower and upper values of the plant number interval only in the range of 50 to 90 thousand ha⁻¹. In the case of the row distance of 76 cm, Sarolta and Reseda were the hybrids producible in broad plant number interval, while P 9578 and P 9494 were the ones producible in narrow plant number interval. At the row distance of 45 cm, the

width of the interval was much narrower, the narrowest was in the case of Reseda, the broadest were in the cases of the hybrids P 9494 and Sarolta.

Table 2: Plant number optimums and intervals and yield maximums of the studied maize hybrids in the cases of the applied row distances (45 and 76 cm) (Debrecen, 2013)

Hybrids	45 cm				76 cm			
	Opt. plant density	Max. grain yield	Interval (th ha ⁻¹)	Interval width (th ha ⁻¹)	Opt. plant density	Max. grain yield	Interval (th ha ⁻¹)	Interval width (th ha ⁻¹)
Sarolta	82225	12,77	72-90	18	61875	11,84	50-84	34
P 9578	90000	16,67	-	-	72875	14,86	67-79	12
Reseda	51393	12,60	50-53	3	68833	12,43	66-72	6
P 37N01	90000	17,00	-	-	90000	16,10	-	-
P 9494	84938	17,64	68-90	22	64870	15,57	56-73	17
Kenéz	90000	14,16	-	-	90000	12,36	-	-
Average	81426	15,14	63-78	14	74742	13,86	60-77	17

Conclusions

Similarly to the research results of Shapiro and Wortman (2006), in the year of 2013, under the given weather, agrotechnical and growing area specific nutrient supply conditions, the decrease of the row distance from 76 to 45 cm resulted in increasing yield excess in the average of the hybrids, above the plant number of 50,000 plant ha⁻¹. During their research, Hunter et al. (1970) also found that the yield of every hybrid increased with the increase of the plant number; and the decrease of the row distance significantly increased yield, although, not in a great extent.

Based on the determination of the plant number optimum, at the row distance of 45 cm, higher plant numbers can be applied in the case of most of the hybrids; while at 76 cm, the case is the opposite, lower plant numbers are favourable for the majority of the hybrids. On the basis of the interval width, we can distinguish between hybrids producible in narrow and broad plant number interval.

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