

## EFFECT OF PLANT DENSITY AND ROW SPACING ON MAIZE GRAIN YIELD ON CALCAREOUS CHERNOZEM SOIL

<sup>1</sup>*Eszter MURÁNYI*

<sup>1</sup>Institute of Crop Science, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen E-mail: emuranyi@agr.unideb.hu

**Abstract:** We investigated the yield averages of six hybrids of different genotype in four replications on lime-coated chernozem soil in a small-plot field experiment on the Látókép Experimental Farm of the University of Debrecen in 2013 and 2014. In the experiment, row distances of 45 and 76 cm and plant numbers of 50, 70 and 90 thousand plant ha<sup>-1</sup> were set. During both studied years, there were significant differences between the yield amounts of the studied hybrids, but the effects of plant number on yield were different. In 2013, at the row distance of 45 cm and plant number of 90 thousand plant ha<sup>-1</sup>, the hybrids performed high yields, but in 2014, the yield decrease was high compared to the previous year, due to the weather conditions in April-May and June. We have determined the plant number optimums of the hybrids and the corresponding yields with quadratic equations.

**Key words:** maize, grain yield, plant density, row spacing

### Introduction

According to Pepó and Sárvári (2013), maize is a plant of individual productivity, therefore the plant number determines yield to a great extent. The optimal plant number can be modified by the genetic traits and vegetation time of the hybrid, the conditions of the vegetation area, the cropyear effect and the extent of the water and nutrient supply. Sárvári et al. (2002) found that the plant number densities of the hybrids were different. Plant number is a factor that influences yield to the greatest extent. By the increase of plant number, the individual production decreases but the yield/unit area increases to a certain limit. According to Roekel and Coulter (2011), there is close relationship between maize yield and plant number. The studied hybrid obtained the maximal yield at or above the plant number of 81,700 plant ha<sup>-1</sup>. During their research, Berzsenyi and Lap (2005) found that the optimal plant number varied between 67,483 and 70,161 plant ha<sup>-1</sup> in the average of the hybrids. According to research results, Nagy (1983) concluded that the plant number of 60 thousand plant ha<sup>-1</sup>, which was considered as optimal, could be increased up to 80,000 plant ha<sup>-1</sup> effectively, if the row distance was reduced from 70 centimetres to 50 cm. According to the research results of Shapiro and Wortmann (2006), the decrease of the row distance from 76 cm to 51 cm resulted in the increase of the yield by 4%. According to the research results of Widdicombe and Thelen (2002), the yield increased by 2-4% as a result of the decrease of the row distance from 76 cm to 56 and 38 cm. According to the conclusions of Andrade et al. (2002), Lutz et al. (1971), the decrease of row distance also resulted in yield increase.

### Material and methods

The small-plot field experiment was set on the Látókép Experimental Farm of the University of Debrecen in four replications in the years 2013 and 2014; the soil of the experiment was lime-coated chernozem which has good nutrient management as an effect of the favourable nitrogen supply, phosphate availability and potassium providing ability. The water management of the soil is very good, since its every level has excellent water permeability and water storing ability. The preceding crop was winter wheat in both years; PK fertilization was not performed on the experimental area, while N was applied in the amount of 180 kg ha<sup>-1</sup>. During the research, we studied the effects of different row distances and plant numbers on yield. The studied hybrids were the

following: Sarolta (FAO 290), DKC 4025 (FAO 330), NK Lucius (FAO 330), DKC 4490 (FAO 380), P 9494 (390) and SY Afinity (FAO 470). Considering the water supply, in 2013, the large amount of precipitation in March (136.3 mm) was determining, which filled the water resource of the soil. In 2014, the precipitation amount during the vegetation period (396.7 mm) did not differ significantly from the multi-year average (378.6 mm), but its distribution was not appropriate. The highest water shortage was in June (7.9 mm). For the statistical evaluation of the experiment, we used SPSS 13.0 for Windows and Microsoft Excel 2010 programs. The statistical evaluation, the bifactorial variance analysis and correlation analysis were done according to Sváb (1981), with regression equations. In the correlation analysis, we determined the following types of correlations according to the *r* values:  $r < 0.4$ : loose, 0.4-0.7: medium, 0.7-0.9: tight,  $> 0.9$ : strong.

### Results and discussion

In 2013 and 2014, the effects of the applications of various plant numbers and row distances on yield were studied by using 6 hybrids of different genotypes and vegetation times. In the vegetation year of 2013, at the row distance of 45 cm, the yield varied between 12.8 and 14.3 t ha<sup>-1</sup>, while at 76 cm, between 13.1 and 13.8 t ha<sup>-1</sup>; the highest yields were found at 90 thousand plant ha<sup>-1</sup> in the average of the hybrids at both row distances (*Table 1*). The difference between the yield amounts corresponding to the two row distances was not significant (200 kg ha<sup>-1</sup>).

*Table 1:* The yields (kg ha<sup>-1</sup>) of the studied maize hybrids at different row spacing and plant numbers (Debreceen 2013)

2013	Grain yield (t ha <sup>-1</sup> )							
Row spacing	45 cm			76 cm			Average	
Hybrid/Plant density	50 th ha <sup>-1</sup>	70 th ha <sup>-1</sup>	90 th ha <sup>-1</sup>	50 th ha <sup>-1</sup>	70 th ha <sup>-1</sup>	90 th ha <sup>-1</sup>	45 cm	76 cm
Sarolta	10.8	12.6	12.9	11.9	12.0	11.8	12.1	11.9
DKC 4025	11.9	12.3	11.6	11.9	12.6	13.7	12.0	12.8
NK Lucius	12.1	14.0	13.7	13.4	12.9	13.8	13.3	13.4
DKC 4490	11.7	12.2	12.9	11.9	12.8	13.2	12.3	12.6
P 9494	16.7	17.5	17.7	15.1	15.6	14.3	17.3	15.0
SY Afinity	13.6	14.6	16.9	14.7	15.4	15.9	15.0	15.3
<b>Average</b>	<b>12.8</b>	<b>13.9</b>	<b>14.3</b>	<b>13.1</b>	<b>13.6</b>	<b>13.8</b>	<b>13.7</b>	<b>13.5</b>
LSD 5% A	513 kg ha <sup>-1</sup>			483 kg ha <sup>-1</sup>				
LSD 5% B	917 kg ha <sup>-1</sup>			634 kg ha <sup>-1</sup>				
LSD 5% A*B	1588 kg ha <sup>-1</sup>			1098 kg ha <sup>-1</sup>				

At the row distance of 45 cm, there was significant difference between the yields measured at the plant numbers of 50 and 70 thousand ha<sup>-1</sup>, as well as in the case of both row distances between the plant numbers of 50 and 90 thousand ha<sup>-1</sup>. The studied

hybrids obtained their yield maximums at the plant numbers of 70 and 90 thousand ha<sup>-1</sup>. There were significant differences between the yields of the hybrids. In 2014, at the row distance of 45 cm, the yield varied between 10.3 and 11.6 t ha<sup>-1</sup>, while at 76 cm, between 11.7 and 13.9 t ha<sup>-1</sup> in the average of the hybrids (Table 2.). The difference between the yields corresponding to the two row distances was 14.6% (1900 kg ha<sup>-1</sup>). At the row distance of 76 cm, significant difference was observed between the yields at the plant numbers of 50 and 70 thousand ha<sup>-1</sup>, and also at both row distances between the plant numbers of 50 and 90 thousand ha<sup>-1</sup>. The studied hybrids achieved maximum yields at the plant numbers of 50 and 70 thousand ha<sup>-1</sup> in the case of the row distance of 45 cm; while at 76 cm, at the plant numbers of 70 and 90 thousand ha<sup>-1</sup>. There were significant differences between the yields of the hybrids in this year too. Sarolta, DKC 4025 and DKC 4490 hybrids responded to the increase of the plant number from 50 thousand ha<sup>-1</sup> to 70 thousand ha<sup>-1</sup> with yield decrease; and every studied hybrid responded to the increase of the plant number from 70 thousand ha<sup>-1</sup> to 90 thousand ha<sup>-1</sup> with yield decrease.

Table 2: The yields (kg ha<sup>-1</sup>) of the studied maize hybrids at different row spacing and plant numbers (Debrecen 2014)

2014	Grain yield (t ha <sup>-1</sup> )							
Row spacing	45 cm			76 cm			Average	
Hybrid/Plant density	50 th ha <sup>-1</sup>	70 th ha <sup>-1</sup>	90 th ha <sup>-1</sup>	50 th ha <sup>-1</sup>	70 th ha <sup>-1</sup>	90 th ha <sup>-1</sup>	45 cm	76 cm
Sarolta	10.3	10.1	9.6	9.6	11.0	12.1	10.0	10.9
DKC 4025	11.8	11.5	10.4	11.0	13.1	13.9	11.2	12.7
NK Lucius	10.8	11.2	10.4	11.1	13.3	14.0	10.8	12.8
DKC 4490	11.3	10.7	9.8	11.3	12.7	13.8	10.6	12.6
P 9494	12.4	12.5	12.1	14.3	15.0	14.0	12.3	14.4
SY Afinity	12.5	13.3	9.3	13.2	15.1	15.3	11.7	14.5
Average	11.5	11.6	10.3	11.7	13.4	13.9	11.1	13.0
A	902 kg ha <sup>-1</sup>			539 kg ha <sup>-1</sup>				
B	765 kg ha <sup>-1</sup>			617 kg ha <sup>-1</sup>				
A*B	1325 kg ha <sup>-1</sup>			1068 kg ha <sup>-1</sup>				

Comparing the two years, we can conclude that while in 2013, the hybrids obtained high yields even at the row distance of 45 cm and at the plant number of 90 thousand ha<sup>-1</sup>, in 2014, the yield decrease was considerable compared to the previous year due to the weather conditions in April-May and June. The plant number optimums of the hybrids and the corresponding expected yields can be determined with quadratic equations (Table 3.). The plant number optimums of the hybrids were different in the two years; in 2013, at the row distance of 45 cm, the plant number increase resulted in higher yields, while in 2014, the yield decreased as an effect of plant number increase, the plant number densities of 50 and 65 thousand ha<sup>-1</sup> were more favourable. At the row

distance of 76 cm, the hybrids obtained their yield maximums at 77,103 plant ha<sup>-1</sup> in 2013, while in the vegetation year of 2014, at higher plant number (84,460 plant ha<sup>-1</sup>).

Table 3: Plant number optimums and yield maximums of the studied maize hybrids in the cases of the applied row distances (45 and 76 cm) (Debrecen, 2013, 2014)

	2013				2014			
	45 cm		76 cm		45 cm		76 cm	
	Plant number	Yield	Plant number	Yield	Plant number	Yield	Plant number	Yield
<b>Sarolta</b>	82,225	12.8	61,875	11.8	51,833	10.3	89,500	12.4
<b>DKC 4025</b>	67,214	12.3	90,000	13.9	50,727	11.7	89,353	13.6
<b>NK Lucius</b>	76,712	13.9	65,875	13.0	66,500	11.2	86,575	13.7
<b>DKC 4490</b>	90,000	12.6	90,000	13.5	50,500	11.2	89,500	14.0
<b>P 9494</b>	84,938	17.6	64,870	15.6	64,250	12.5	67,833	14.9
<b>SY Afinity</b>	90,000	16.5	90,000	16.3	63,653	13.7	84,000	15.5
<b>Average</b>	<b>81,848</b>	<b>14.3</b>	<b>77,103</b>	<b>14.0</b>	<b>57,911</b>	<b>11.8</b>	<b>84,460</b>	<b>14.0</b>

There was negative correlation between the yield amount and the row distance in 2013, while in 2014, medium positive correlation was the determinant (Table 4.). Loose correlation was observed between the yield and the plant number in both years.

Table 4: Correlation between the analysed parameters

	Row spacing	Plant density
Grain yield 2013	-0.040	0.219
Grain yield 2014	0.499	0.097

## Conclusions

In the studied years, there were significant differences between the yield amounts of the hybrids, while the plant number made different effects on yield. In 2013, the hybrids achieved high yields even at the row distance of 45 cm and at 90 thousand plant ha<sup>-1</sup>, while in 2014, considerable yield decrease was experienced compared to the previous year and the application of lower plant number was more favourable.

## References

- Andrade H. F. – Calvino P. – Cirilo A. – Barbieria P. (2002) Yield responses to narrow rows depend on increased radiation interception. 94. (5.) 975-980.
- Berzsenyi, Z. – Lap, D. Q. (2005) Responses of maize (*Zea mays* L.) hybrids to sowing date, N fertiliser and plant density in different years. Acta Agronomica Hungarica. 53. (2.) 119-131.
- Lutz A. J. – Camper M. H. – Jones D. G. (1971) Row spacing and population effects on corn yields. 63. (1.) 12-14.
- Nagy M. (1983) A tenyésztés terület alak, sűrítettség, levélterület-index és a termés eredmények alakulása különböző kukorica hibrideknél. Debreceni Agrártudományi Egyetem Tudományos Közleményei. 23. 259-274.
- Pepó P. – Sárvári M. (2013) Agrotechnikai változások. Magyar Mezőgazdaság. 24-31.
- Roedel, R. J. – Coulter, A. J. (2011) Agronomic responses of corn to planting date and plant density. Agronomy Journal. 103. (5.) 1414-1422.
- Sárvári M. – Futó Z. – Zsoldos M. (2002) A vetésidő és a tőszám hatása a kukorica termésére. 51. (3.) 291-307.
- Shapiro A. Ch. – Wortmann S. Ch. (2006) Corn response to nitrogen rate, row spacing, and plant density in Eastern Nebraska. Agronomy Journal. 98. (3.) 529-535.
- Sváb J. (1981) Biometriai módszerek a kutatásban. Mezőgazdasági Kiadó. 171-179.
- Widdicombe D. W. – Thelen D. K. (2002) Row width and plant density effects on corn grain production in the Northern Corn Belt. 94. (5.) 1020-1023.