THE INVESTIGATION OF THE BIOLOGICAL BASIS AND YIELD-FORMING ELEMENTS IN MAIZE IN A COMPARATIV EXPERIMENT ON HYBRIDS

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Abstract

Hybrid selection and the application of hybrid specific production technologies are important in terms of the increase of the yield and crop safety of maize. The main explanation for this is climate change, since weather extremes are going on and seem to accelerate in Hungary too. The spring of 2013 can be characterized as of great amount of precipitation, in the third month, the fivefold of the 30-year average fell. In 2013, in the case of each hybrid, longer ears were observed. We can conclude that during the droughty 2012, lower ears with lesser grains were developed in the case of every hybrid. In 2013, the weather was more favourable during the period of grain-filling and development, therefore the hybrids not only produced longer ears but significantly more grains were developed in one row.

Key words: maize, yield, weather, yield-forming elements.

INTRODUCTION

Currently, the production area of maize is 162 million hectares worldwide; its yield average is 5.2 t, which means a total yield of 840 million tons.

Maize is the second most important crop in our country after wheat. It is produced on 1.2 million hectares, the yield average varies between 3.7 and 7.5 t ha-1, and the total yield is in the range of 4.4-9.2 million tons accordingly. The intensive decrease of crop safety reached 50-60%, although it was only 10-20% in the 1980s. One of the causes of this tendency is the ever-frequent weather extremes in recent years.

In addition to the ecological and agrotechnical conditions, the efficiency of maize production is determined by the biological bases, i.e. the characteristics of the produced varieties and hybrids. The high yields are due to the modern genotypes to a considerable extent.

Currently, the hybrid variety is the strongest link of maize production technology, because the variety supply is one of the richest – nowadays, more than 420 hybrids are cultivated.

The yield of the hybrids is primarily influenced by the weather of the cropyear (Hertel, Rikanova, 1984). Győri and Pásztor (1998) indicated the importance of the production of the varieties of more favourable nutritional value and genetic structure as the main goal of breeding. Productivity is one of the most important factors of hybrid selection (Szieberth, Széll, 1998). Among favourable conditions, the genetic productivity of maize hybrids can reach 15-18 t/ha. Among the decisive elements of maize production, the importance of biological bases, the fertilizer reaction, the connection between the sowing time, the grain wet content at harvest and the increase of plant density have to be emphasized (Sárvári, 2000). Hybrids with high (above 86%) Cold test values can be sown much earlier than the optimal sowing time, which is a very important factor in terms of avoiding the adverse effects of weather extremes due to the climate change (Tóth, 2008). Hungary is close to the Northern border of maize production, thus the length of the vegetation period is a limiting factor. Therefore, mainly the varieties of the early (FAO 300 – 399) and semi-early (FAO 400 – 499) ripening groups are cultivated (Varga et al., 2004).

In favour of the enhancement of the crop safety and the efficiency of production, the following aspects have to be taken into consideration: soil preparation that matches the demands of maize, the appropriate crop rotation, the adequate hybrid selection in accordance with the ecological conditions, the ensuring of plant number that matches the biological and agrotechnical factors, the careful, harmonic NPK fertilization in accordance with preliminary soil studies; and mainly the efficient defence against the corn rootworm and chemical weed control are of special importance (Sárvári et al., 2006). The yield of maize is influenced by the grain number at harvest to a great extent, which depends on the ear number per plant and grain number per ear.

The grain number of maize is the most sensitive to the different stress effects two weeks before and three weeks after female flowering. Sowing time significantly influences the time of female flowering of the hybrids (Tollenaar, Daynard, 1978; Kiniry, Ritchie, 1985). Studying the connections between the individual yield-forming elements, a negative correlation could be observed between the number of rows and grain number per rows (Duncan, 1975).

MATERIAL AND METHOD

We have set both experiments in the experimental farm of the Institute of Crop Sciences of the University of Debrecen CAAES on calcareous chernozem soil, with 24 and 20 hybrids of different vegetation time in 2012 and 2013, respectively.

Only hybrids listed in Table 1 were studied in both experimental years, in favour of comparability. The upper layer of the soil does not contain lime. The soil water is located at the depth of 7-9 m. The humous layer is 50-70 cm thick. The organic material content of the soil is 2.57%.

Due to the lack of lime, the upper layer is susceptible to crackling in dry, droughty cropyears.

Table 1

The examined maize hybrids, both of the two experimental year

Hybrid	FAO number
P9578	FAO 320
P9175	FAO 330
PR37N01	FAO 380
P9528	FAO 380
P9494	FAO 390
P9721	FAO 400
P9915	FAO 410
P0216	FAO 490

Climate change considerably determined the weather in both years. In 2012, the long drought challenged the tolerance of hybrids, the lack of precipitation altogether with the higher-than-average mean temperature in August and September further increased the evaporation. The hybrids grew relatively high stalks, which is the basis of high yield, but to the period of grain-filling, the useful water supply of soils decreased to a great extent, thus they dried to air-dry state. Due to the extremely dry weather, male and female flowerings happened explosively.

The spring of 2013 can be characterized as of great amount of precipitation, in the third month, the fivefold of the 30-year average fell. In the period of months No. 6 to 8, the mean temperatures exceeded the 30-year average by 2-3 °C.

The nutrient supply was N 160, P_2O_5 80, K_2O 110 kg ha^{-1} active substance. Sowing was carried out on 12-13/04/2012 with two different plant number settings: in the case of FAO 200-300s, 72 thousand/ha, while in the case of the FAO 400-500s, 65 thousand/ha stock density was set. In the cropyear of 2013, we began the sowing of hybrids on 15/04. The stock densities was 75 thousand/ha and 70 thousand/ha. The agrotechnical actions were applied in accordance with the agronomic practice in both years.

Chemical weed clearing was applied in 2012: Laudis at the dose of 2.2 L/ha.

For soil disinfection, we used Force 1,5 G at the dose of 12 kg ha^{-1} in both experimental years. The droughtiness of the year 2012 made two irrigations reasonable, at the beginnings of the months 07 and 08, with the application of 10-10 mm water.

Harvest was carried out in the middle of month 09 in both years.

Table 2

Weather of Debrecen, year 2012

Year 2012.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Temperature (°C)	-0,6	-5,7	6,3	11,7	16,4	20,9	23,9	22,5	18,5
30 year average temp (°C)	***-2,6***	***0,2***	***5,0***	***10,7***	***15,8***	***18,7***	***20,3***	***19,6***	***15,8***
Precipitation (mm)	24,5	19,4	1,8	34,4	56,9	79,3	43,9	7,52	1,07
30 year average prec (mm)	***37,0***	***30,2***	***33,5***	***42,4***	***58,8***	***79,5***	***65,7***	***60,7***	***38,0***

Table 3

Weather of Debrecen, year 2013

Year 2013.	*I.*	*II.*	*III.*	*IV.*	*V.*	*VI.*	*VII.*	*VIII.*	*IX.*
Temperature (°C)	-0,7	2,8	3,7	12,6	17,9	21	22,3	22,6	15,2
30 year average temp (°C)	***-2,6***	***0,2***	***5,0***	***10,7***	***15,8***	***18,7***	***20,3***	***19,6***	***15,8***
Precipitation (mm)	49,9	70,4	157	45,7	70,2	46	9,1	24,5	28,8
30 year average prec (mm)	***37,0***	***30,2***	***33,5***	***42,4***	***58,8***	***79,5***	***65,7***	***60,7***	***38,0***

RESULTS AND DISCUSSION

Table 3 shows the yield and grain wet contents at harvest. Both experimental years were abundant in hot days; in contrast, the studied hybrids produced yields far above the country average. In 2012, the highest yield was produced by P0216, the hybrid with the longest vegetation time (11.82 t^{-ha}). The lowest yield was performed by the hybrid P9915 with 10.75 t^{-ha}. The yield results of the studied hybrids were balanced; they did not show high fluctuations.

Table 3

Yield and grain moisture content by of the examined hybrids, year 2012 and 2013.

Hybrid and their FAO number	Moisture content by the time of harvesting %	Yield (t^{-ha})	Moisture content by the time of harvesting %	Yield (t^{-ha})
	Year 2012	**Year 2012**	**Year 2013**	**Year 2013**
P9578 (FAO 320)	8,7	11,59	14,3	8,96
P9175 (FAO 330)	11,6	11,19	14,9	10,03
PR37N01 (FAO 380)	11,9	11,03	15,9	9,15
P9528 (FAO 380)	13,1	11,37	14,8	8,88
P9494 (FAO 390)	11,8	11,26	14,2	9,82
P9721 (FAO 400)	12	11,42	14,4	10,93
P9915 (FAO 410)	11,8	10,75	15,8	9,57
P0216 (FAO 490)	19	11,82	18,1	9,56

Although 2013 was not as droughty as 2012, after all, each hybrid performed lower yields than during the previous year. The highest yield was produced by the hybrid P9721 (10.93 t^{-ha}). The lowest yield was performed by P9528 among the studied hybrids (8.88 t^{-ha}). None of the hybrids reached the yield results of 2012.

In 2012, the lowest grain wet content at harvest was performed by the hybrid P9578 with 8.7%. The highest grain wet content (19%) was experienced in the case of the hybrid P0216, the one of the longest vegetation time (FAO 490). However, in the current cropyear, each hybrid was harvested with higher grain wet contents, the values varied between 14.2 and 18.1%.

During the investigation of the yield-forming elements of the studied hybrids, we have examined ear length, grain number and the number of grains per row, in the average of the repetitions (Fig. 1).

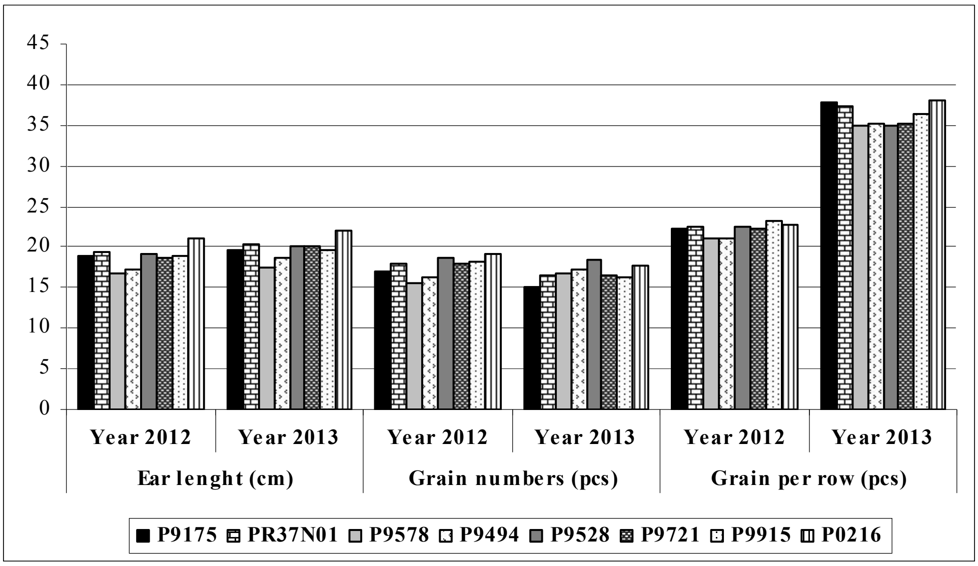

Fig. 1. The yield-forming elements yield of the examined hybrids in the average of the revision, year 2012 and 2013.

In 2012, ear length varied between 16.7 (P9578) and 21 cm (P0216). In contrast, in 2013, in the case of each hybrid, longer ears were observed. The values were within the range of 17.5 cm (P9578) to 22 cm (P0216).

During the studies on the grain numbers, the following values were obtained: in 2012, the lowest number was experienced in the case of the P9578 hybrid in the average of the repetitions (15.62). The most grains were seen on P0216, the number was 19.06. In 2013, the lowest grain number was observed in the case of the P9175 hybrid (15), while the highest one (18.4) was produced by P9528.

In the case of the grains per row, we have observed that in 2013, more grains were produced on one ear than during the previous cropyear. In 2012, we obtained values between 20.97 (P9578) and 23.13 (P9915). In contrast, in 2013, the lowest value was 35 (P9578 and P9528), while the highest one was 38.1 (P0219).

We can conclude that during the droughty 2012, lower ears with lesser grains were developed in the case of every hybrid. In 2013, the weather was more favourable during the period of grain-filling and development, therefore the hybrids not only produced longer ears but significantly more grains were developed in one row.

During the study of thousand grain weight, we concluded that the droughty 2012 negatively influenced the development of grains too. In 2012, the values varied between 296 g (P9494) and 359.3 g (P0216).

As it is seen in the Table, thousand grain weight varied between 268.3 g (P9578) and 349.3 g (P9721). Comparing the two years, one can conclude that in 2013, more grains were developed on the ears (Figure 1), which involved lesser thousand grain weights. During the previous cropyear, lesser grains were developed on one ear, but the grain weights were higher.

Table 3

Thousand grain weight, year 2012 and 2013.

Thousand grain weight (g) in the average of the repetitions		
Hybrid	**Year 2012**	**Year 2013**
P9578	314,0	268,3
P9175	356,3	320,5
PR37N01	349,3	290,8
P9528	296,3	276,5
P9494	296,0	302,3
P9721	331,5	349,3
P9915	317,0	313,3
P0216	359,3	341,5

CONCLUSIONS

The appropriate and proper selection of the biological bases is crucial in favour of successful maize production. Due to the increasing weather extremes, more attention has to be paid to stress bearing hybrids.

During the droughty year, the studied hybrids produced lesser ears with lesser grains but with higher thousand grain weights. In 2013, the weather was favourable at the time of grain-filling, which was reflected during the studies on the crop forming elements; the hybrids produced longer ears and higher thousand grain weights.

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