INFLUENCE OF DIFFERENT SOWING TIME AND NUTRIENT SUPPLY ON THE PRODUCTIVITY OF MAIZE HYBRIDS

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Abstract

Our main aims were to develop the technologies of maize, to increase the effectiveness of maize crop management, to work out and study the different crop models of different maize genotypes. Maize yields are largely dependent upon nutrient supply and sowing date. The effect of these factors is also influenced by the close correlation between ecological and biological factors. In earlier years Hungary was one of the leading countries in the world as regards the yields achieved in maize production, but at present besides unfavourable changes in climatic conditions, the level of NPK fertilization has also decreased.

The experiments were carried out in Debrecen and in Hajdúböszörmény, at the Experimental Station of the University of Debrecen Centre of Agricultural Sciences, Department of Crop Production and Applied Ecology. We tested various hybrids with their own genetic characteristics for three sowing time and five different fertilizer doses, in addition to the parcels without fertilization. In 2004-2005 the favorable results reached were due to the rainy season. There were significant differences between the productivity of maize hybrids. The N 40, P_2O_5 25, K_2O 30 kg/ha treatment caused the highest increase of yield (3-5 t/ha) compared to the control (parcels without fertilization). The reaction of hybrids to the further fertilizer doses was different. The agro-ecological optimum of NPK fertilization was N 120, P 75, K 90 kg of the most hybrids.

In 2004 there was favorable crop year, the yield of every hybrid was the highest at the second and third sowing times. Yields of PR34H31 and PR38B85 hybrids were significant. The seed moisture content at harvest was higher than the previous year, due to the rainy season. In the case of hybrids sown later, this value was higher by 30%. In 2005, we applied three sowing times. Unfortunately, the results of the third sowing time could not be analyzed, due to the low plant density. The yield of the six hybrids varied from 12 to 14 t/ha at the first sowing time. At the second sowing time, the yields fluctuated and each hybrid had the lowest yield, except the PR37D25 hybrid. At the latest sowing time, the yield of the PR34B97 hybrid was the lowest. The crop year had a more dynamic effect on maize than the sowing time. First of all, the quantity and distribution of precipitation played an important role in respect to yield safety.

Key words: maize hybrids, sowing time, nutrient supply, productivity

INTRODUCTION

BERZSENYI and GYŐRFFY (1995) have determined that the different factors of production technology effect maize yield differently: fertilization by 30.7%, hybrid by 30.0%, plant density by 20.3%, crop cultivation by 16.3% and soil cultivation by 2.7%. On the other hand, PEKÁRY (1969) and KOVACEVIC (2004) have concluded from their experiment that climatic factors have an effect on the efficiency of fertilization. SÁRVARI and SZABÓ (1998) claimed that 60-120 kg of N, 45-90 kg of P and 53-106 kg of K ha^{-1} are sufficient for maize hybrids depending on the fore crop and seasonal effects. LAP (1992) emphasizes

that the results of experiments have to be estimated not only in respect of yield but in terms of photosynthetic activity as well. LEMCOFF and LOOMIS (1986), FUTÓ (2003), CSAJBÓK and KUTASSY (2002) experienced that the rising fertilizer rate stimulated the photosynthesis and LAI values.

Some researchers - PETHE (1817), CSERHÁTI (1901) - brought the attention to the importance of sowing time even in the early 19th and 20th century. I'SÓ (1959, 1969) and PÁSZTOR (1966) stated that two main factors affect the initial development of maize: precipitation and temperature. Earlier sowing resulted in slow emergence, however, yield was higher. Yields of hybrids at late sowing time were significantly lower. According to SÁRVÁRI (2005), hybrids with good resistance to cold at germination can be sowed 10-15 days earlier than the classical sowing time (15 April- 5 May). SÁRVÁRI and FUTÓ (2001) found that the seed moisture content at harvest can be significantly lower at the early sowing time, thus the costs of drying can also be reduced.

MATERIALS AND METHODS

The fertilization experiment was carried out on leached chernozem soil in Debrecen. We tested 10 various hybrids for five different fertilizer doses (the lowest was N40, P25, K30 kg ha^{-1} and the highest was the fivefold of this quantity), in addition to parcels without fertilization. In 2004, the experiment of sowing time was carried out with nine hybrids near Hajdúböszörmény on humic gley soil but in 2005 it was started with six hybrids in Debrecen on chernozem soil.

The weather was favorable for maize in both years. In 2004 the amount of precipitation between April and September was 93.2 mm higher than the 30-year average. Moreover, the distribution of precipitation was favorable. The monthly mean temperatures followed the trend of the 30-year average. 2005 was again a very wet year. The amount of precipitation in the vegetation period of maize was 152.2 mm higher than the 30-year average but the distribution was unequal. The mean temperature was similar to the average measured for many years. Summer was somewhat colder, which also had an effect on the yields. In both years we measured the photosynthesis with LI 6400 photosynthesis and LAI with LAI 2000 leaf area index measurement.

In 2004 and 2005 we applied three-three sowing times (2004: 09.04., 24.04., 13.05., 2005: 08.04., 25.04., 02.05.) Due to the draught in June the most seeds could not emerge at the third sowing time in 2005 and the results of the third sowing time could not be evaluated. Nutrient supply was optimal in both years. Experiments were analyzed by analysis of variance.

RESULTS

In 2004, the yield of all hybrids was the highest at the second and third sowing time (Figure 1). The reason behind this fact is that 2004 was a very wet year. There was enough precipitation for the appropriate development of the hybrids. The effect of the wet year was to be seen on the yields, as well. The PR34H31 and the PR38B85 hybrids had the highest yields. Differences in the yields caused by the sowing time were significant in the case of the XO 902 P ($LSD_5\%$=1.31 t ha^{-1}), the PR38B85 ($LSD_5\%$=1.05 t ha^{-1}), the PR37D25 ($LSD_5\%$=0.98 t ha^{-1}), the PR36K20 ($LSD_5\%$=1 t ha^{-1}) and the PR34H31 ($LSD_5\%$=0.92 t ha^{-1}) hybrids. In the wet year, the seed moisture content values at harvest were also higher.

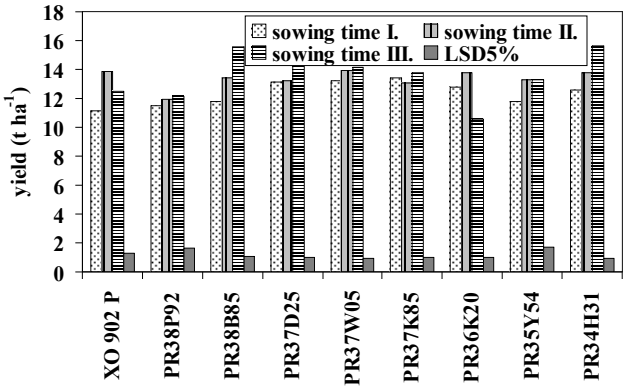

Figure 1. The yield of maize hybrids in different sowing times, 2004

This value was mainly higher than 20% in the case of hybrids sowed at the first sowing time and higher than 30% in the case of hybrids sowed at the late sowing time.

In 2005, the yields of hybrids sowed at the first sowing time varied between 12-14 t ha^{-1}. The chilly summer did not favoured to the development and the production of hybrids sowed at the late sowing time (Figure 2). Unequivocal significant differences were found between the yields of five hybrids: Szegedi 269 ($LSD_5\%$=1.47 t ha^{-1}), the DK 440 ($LSD_5\%$=0.57 t ha^{-1}), the PR37D25 ($LSD_5\%$=2.02 t ha^{-1}), NK Cisko ($LSD_5\%$=0.71 t ha^{-1}) and the Mv Maraton ($LSD_5\%$=0.9 t ha^{-1}) at the first and at the second sowing time. The imago of the western corn rootworm (*Diabrotica virgifera*) caused significant losses in the yield of the PR34B97 hybrid. Being a late hybrid, the stigma of the PR34B97 hybrid remained tender for a long time, which served as a food-source for the imago. Thus, lower yields were due not only to the late sowing time, but to the large extent of imago damage as well.

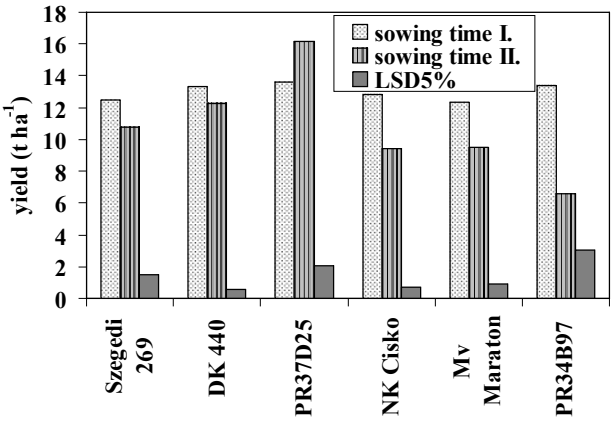

Figure 2. The yield of maize hybrids in different sowing times, 2005

The seed moisture content of the hybrids sowed at the first sowing time varied between 16-24%. These values were higher at the second sowing time. The PR34B97 hybrid had a low yield with high seed moisture content.

In 2005, LAI was also analyzed (Figure 3).

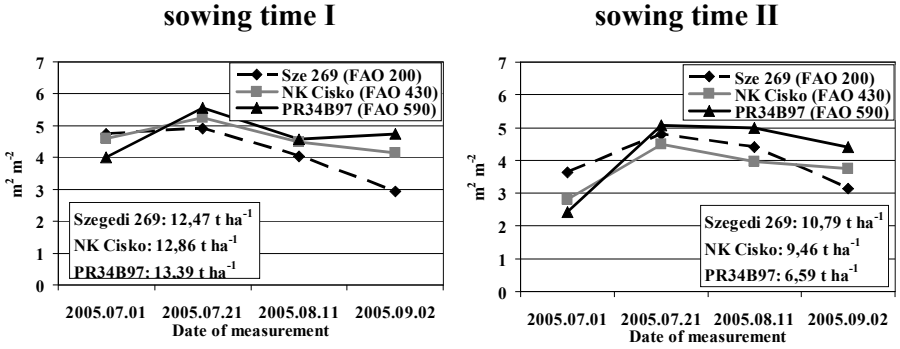

Figure 3. The tendency of leaf area index (LAI) in different sowing times 2005

At the first sowing time, the PR34B97 hybrid -the one with the longest vegetation period- had the largest LAI. The highest yield was obtained by this hybrid as well. At the second sowing time the LAI of the PR34B97 hybrid was the highest. However, the yield of this hybrid was the lowest at this sowing time. The main reason behind this fact is the damage of the corn rootworm western imago. The maximum leaf area value was somewhat lower than at the first sowing time. This can be one of the reasons of the lower yields of the Szegedi 269 and the NK Cisko hybrids.

In 2004 the hybrids with different genotypes had various reactions to fertilizer doses. DK4626, PR38A24, PR36R10 and Mv Vilma had good

fertilizer utilization, because they obtained more than 4 t ha^{-1} yield without fertilization. The maximum yields varied between 9.72-12.54 t ha^{-1}. PR39D81, DK 440, PR37M34, PR38A24 and PR36R10 reached the maximum yield at N200+PK but this quantity was uneconomical and it polluted the environment. Most hybrids reacted to the third fertilizer dose with significant growth of yield, 0.48-2.37 t ha^{-1}, but the next rate did not increase the yield significantly or decreased it. The agro-ecological optimum of NPK fertilization was N120, P75, K90 kg ha^{-1} of the hybrids.

In 2005 we reached similar results as in the former year as a result of the rainy season. The yields varied between 3-4 t ha^{-1} in the parcels without fertilization and the effect of the first fertilizer dose (N40+PK) increased the yield by 4-5 t ha^{-1}. Harmonic nutrition rate was as important as the quantity of fertilizer. The maximum yields of maize hybrids were about 9.7-11.49 t ha^{-1}. Most hybrids–except the PR36R10 and the Mv Maraton–reached their maximum yield at N120, P75, K90 kg ha^{-1} rate and the higher doses decreased the yields. The yields of the other two hybrids were the highest at N160, P100, K120 kg ha^{-1}. All the hybrids reacted to the various fertilizer doses with significant yield growth.

The leaf area index of control treatment was lower than the values of fertilized parcels during the vegetation period; the values hardly reached the value of 2 m^2m^{-2}. After the first measurement LAI increased in the case of every treatment. The leaf area index of PR39D81 hybrid was the highest at N120+PK rate of 3.07 m^2m^{-2} (Figure 4). On 5 July the LAI of control and third treatment was the highest (2.02; 3.07 m^2m^{-2}), while the highest values (2.76; 2.86 m^2m^{-2}) of the first and fifth fertilizer treatments were measured on 26 July.

Photosynthesis was the most intensive at the first measurement in every treatment. The most favourable values were measured at N120+PK parcels (33.8–44.4 μmol CO_2 m^{-2} sec^{-1}), but on 26 July the control value was higher than that of the fertilized parcels. Before 26 July there was little precipitation, the temperatures of leaves were high and plants reacted upon water deficiency with closed stoma. On the whole, there was close and significant correlation between LAI, photosynthetic activity and fertilization.

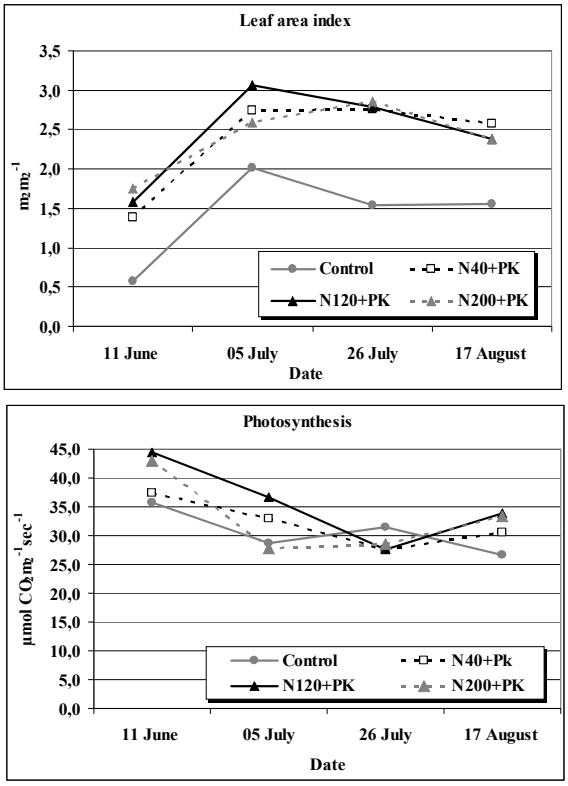

Figure 4. Leaf area index and photosynthesis of PR39D81 hybrids at different fertilizer doses (Debrecen, 2004)

During the experiment we tested the moisture loss of five hybrids. Due to rainy seasons, the seed moisture content at harvest was higher in 2004-2005 than in previous years. The seed moisture content at the harvest of FAO 200-300 hybrids was about 20%. It changed between 21-24% in the case of hybrids with longer vegetation period (FAO 400); the seed moisture content of Mv Vilma (FAO 510) was 24.21-25.04% in average fertilizer treatments. There was important difference between the moisture loss capacities of hybrids, it changed by 0.2-0.6%/day. The moisture loss of hybrids changed depending on the fertilizer treatment; usually it was more favourable at optimal fertilizer doses (N120+PK). On 6 September 2004 the moisture content of DK 440 hybrid seed was 42.6% and it decreased to 18.6% for harvest at the third fertilizer treatment, but at the fifth fertilizer treatment it was more than 19% at harvest. Mv Vilma hybrid with longer vegetation period had high seed harvest moisture content in both years,

24.21% in 2004 and 25.04% in 2005. The moisture loss of Mv Vilma was more unfavourable than that of DK 440, 0.2-0.46% day^{-1} (Figure 5).

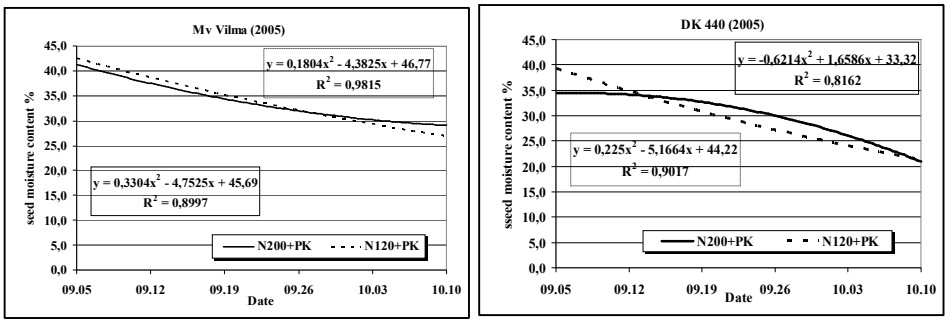

Figure 5. The moisture loss of DK 440 and Mv Vilma hybrids (Debrecen, 2005)

DISCUSSIONS

The importance of the sowing time is well represented by the results of the two-year long experiment. Higher yields were obtained by hybrids at the early sowing time. Moreover, hybrids had lower seed moisture content, as well. Therefore, costs of drying can be significantly reduced. Relationship was found between the sowing time and the LAI. In 2005, hybrids at the early sowing time had higher yields and higher LAI. Furthermore, it is very important to choose hybrids with a good Cold-test value and good moisture loss dynamics, as these traits play a fundamental role in the efficiency of production. However, these relationships are highly influenced by the year effect as well: mainly through the amount and the distribution of the precipitation in the vegetation period.

In the fertilization experiment the favourable results were due to rainy seasons. There were significant differences between the productivity of maize hybrids. N40, P25, K30 kg ha^{-1} treatments caused the highest increase of yield (3-5 t ha^{-1}) compared to the control ones (parcels without fertilization). The reactions of hybrids to further fertilizer doses were different. The agro-ecological optimum of fertilization was N120, P75, K90 kg ha^{-1} for most hybrids. There was important difference between the capacity of moisture loss of hybrids; it changed by 0.2-0.6% day^{-1}. The moisture loss of hybrids changed depending on the fertilizer treatment; usually it was more favourable in the optimal fertilizer dose (N120+PK). In the case of tested hybrids we measured the highest LAI and photosynthetic activity at the optimal treatment, N 120+PK in respect of efficiency and

environmental protection, and the yield was the highest also at this treatment.

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