Annals of the Academy of Romanian Scientists
Series on Agriculture, Silviculture and Veterinary Medicine Sciences
ISSN 2069 – 1149 Volume 6, Number 1/2017

THE EFFECT OF THE CROP YEAR AND THE AGROTECHNICAL FACTORS ON THE YIELD STABILITY OF MAIZE

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Abstract. *In our research we examined the effect of the hybrid, the nutrient supply, the number of plants and the abiotic factors (temperature, amount of precipitation) on the yield, crop quality and yield stability of maize. We devoted special attention to the natural nutrient utilization ability and fertilizer reaction of maize. We tested six hybrids with different genetic characteristics and growing seasons. I analysed the correlation between the nutrient supply and the yield of maize hybrids with control treatment (treatment without fertilisation) and with N 80, P_2O_5 60, K_2O 70 kg ha^{-1} and N 160, P_2O_5 120, K_2O 140 kg ha^{-1} fertilizer treatments. Yield increasing effect of the fertilizer also depended on the number of plants per hectare at a great extent. The number of plants of the six tested hybrids was 60, 70, and 80 thousand plants/ha. The six tested hybrids is 10.65 t ha^{-1} in the average of the stand density of 60, 70 and 80 thousand plants per hectare without fertilisation, while it is 12.24 t ha^{-1} with N80+PK fertilizer treatment. That increase in the yield is 1.6 t ha^{-1}, it is significant. In average, the yield of maize was 6.81 t ha^{-1} in 2015, which was a drought year and 11.86 t ha^{-1} in 2016 that was a favourable year.*

Keywords: maize, nutrient supply, number of plants, hybrid

1. Introduction,

Maize is one of the most important plants of humankind. It is easy to produce, it can be diversely used, it has a high yield potential, it is our most significant export item and main cereal crop. The crop year of 2016 was favourable for stoop crops, thus for maize as well. The distribution of precipitation was especially advantageous. In 2016 the total yield of maize on 947000 ha exceeded 9.2 million tonnes, which is a domestic average yield of more than 8.6 t/ha. This figure highly exceeds the domestic average yield of 5.7 t/ha of 2015, which can be explained by the effect of the crop year. The yield results of the last 2 years excellently demonstrate the extent of the fluctuation in yield, which reached even 50-60% in the past 20 years. The aim of my research is to decrease fluctuation of yields and to reach a higher yield. To achieve that, to choose the proper hybrids and to apply modern, balanced, hybrid-specific agrotechnique are essential.

To increase yield stability the adverse effects of the weather can be reduced by choosing hybrids adjusted to the place of production and with application of the

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right hybrid-specific agrotechnique which meets the needs of the plant [1]. In the production of modern hybrids chosen for the given ecological conditions, the adequate level of inputs and to ensure balanced NPK fertilisation and effective plant protection are important [2].

According to Marton's [3] experiments, in optimum conditions, the yield of new hybrids is not higher than or just hardly exceeds that of the older hybrids. Compared to the older hybrids, their advantageous characteristics are proved mainly in conditions of stress. He examined hybrids in dry and irrigated conditions, and he detected more genetic progress in adverse conditions.

According to Sárvári's [4] experiments, the agroecological fertilizer dosage is 80-120 kg/ha nitrogen with proportionate amount of phosphorous and potassium. In the future, those hybrids can gain more ground which adjust well to an environmentally friendly and cost-effective production technology, thus the ones that have good natural nutrient usage and fertilizer response [5]. Nagy's [6] research results of decades show that the crop year, specifically the precipitation, significantly affects the fertilizer response of maize hybrids.

During the analysis of the results of his experiments conducted over many years Sárvári [7] concluded that with increasing the number of plants with 10000 plants/ha, yield can increase with 1.5-2 t/ha in favourable conditions, while in dry environment it can decrease by the same quantity. Berzsenyi et. al. [8] analysing the results of more than 10 years (1981-1992), found that in the average of rainy years the optimum number of plants was 80000 plants/ha, when the yield reach 8.2 t/ha. In the average of dry years, the optimum number of plants was 50000 plants/ha, which resulted in a yield of 6.6 t/ha. With increasing the number of plants, the ratio of infertile plants exponentially increased, and the number of inclined plants showed a linear decrease. During the examinations of the yield stability, it turned out that with increasing the stand density up to 60000 plants/ha the yield was gradually increasing, while above that number of plants the yield decreased. The yield, in the average of 22 years (taking weather conditions into account), was the most stable with 60000 plants/ha.

According to Sárvári and Bene [9], for the modern hybrid-specific nutrient supply it is essential to find the NPK fertilizer dosages that are optimal for the plants. That can be supported by soil analysis and results of field experiments. In the preparation of the fertilization plan, besides the nutrient content of the soil, the plant species, the nutrient requirements of the variety/hybrid, its yield potential, the aim of production, quality requirements, the cultivation conditions of the soil, the date of spreading and the dosage of livestock manure, the intensity of production technology and the irrigation facilities should also be taken into consideration.

According to the experiments of Zoltán and Jakab [10], we need to have information on the nutrient content of the soil, and have to try to supply nutrients which are in minimum quantity, because with that the efficiency of production can the most easily be increased.

2. Material and method

Our experiment took place in Hajdúszoboszló on on calcareous chernozem soil, on a nearly 8 ha land. The size of one plot was 206 m2. We tested six hybrids with different genetic characteristics and growing seasons. Sowing took place on 23 April 2016, the crop was harvested on 5 November. The correlation between the nutrient supply and the yield of maize hybrids was analysed with control treatment (treatment without fertilization) and with N 80, P2O5 60, K2O 70 kg/ha and N 160, P2O5 120, K2O 140 kg/ha fertilizer treatments. In my experiment, the same fertilizer dosages have been applied for the 2nd year now (it is not a long-term experiment). The yield increasing effect of the NPK fertilizer depended also on the number of plants per hectare at a great extent. The plant number of the six tested hybrids was 60, 70, 80 thousand plants/ha.

In our research, we analysed the effect of the hybrid, the nutrient supply, the number of plants and the abiotic factors (temperature, precipitation) on the yield, yield quality and yield stability. The natural capability of nutrient intake and usage and the fertilizer response of maize were expressed in numbers.

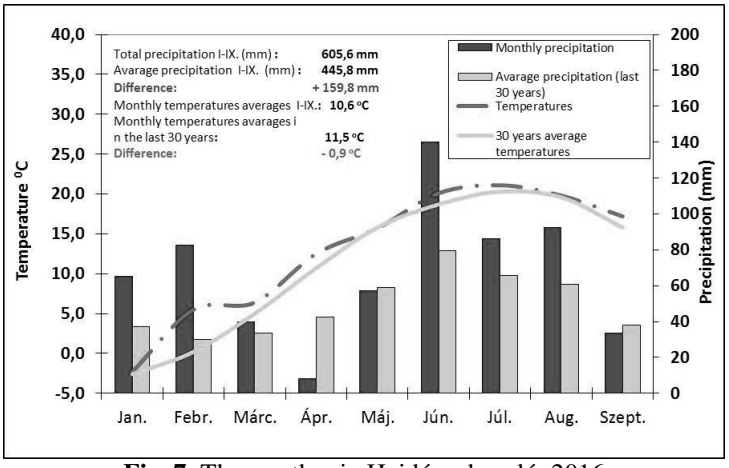

Fig. 7. The weather in Hajdúszoboszló, 2016

In 2016 the crop year was favourable for stoop crops. The distribution of precipitation was especially advantageous. Due to climate changes, mainly in summer months, the amount of rain decreases. But in 2016, in contrast with the previous year, June and July were rainy, whcih increased the yield and yield stability of maize. In Hajdúszoboszló, in 2016, the total amount of rain from

January to October was 605 mm which is more by 160mm than the average of 30 years (see Figure 1). Except for April, in each month, the amount of precipitation was above the average. It was especially ideal that also in the period of flowering, fertilization and grain filling plenty of water was available. It considerably contributed to the outstanding yield results.

3. Results

Figures 2, 3, 4, clearly show the effect of the treatments and the differences in the yield potential of the different hybrids. In the average of the number of plants, without fertilizer treatments the hybrids produced 9.6-11.6 t/ha yield, where the Kamaria and the P9486 hybrids were outstanding: produced a yield of more than 11 t/ha with control treatment and 80000 plants/ha (see Figure 2). The modern hybrids have a very good capability of natural soil nutrient intake and usage, which is a genetically heritable characteristic.

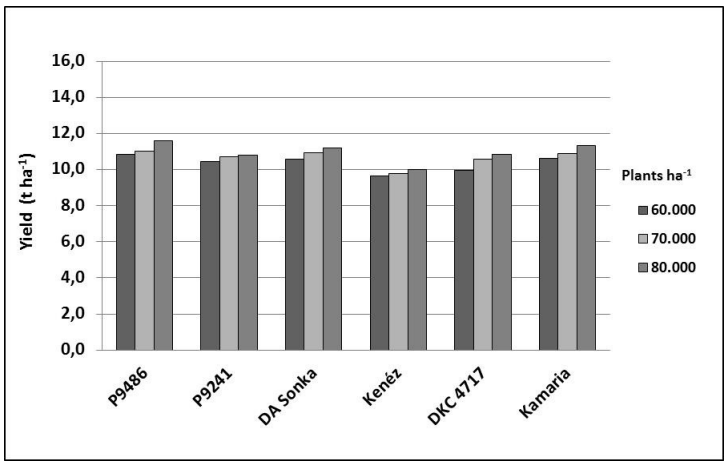

Fig. 8. The effect of the increase of the number of plants on the yield of maize hybrids (control), Hajdúszoboszló, 2016

Note: $LSD_{5\%}$ number of plants: 0.15 t/ha, hybrid: 0.22 t/ha, correlation: 0.38 t/ha

The analysis of the effect of increasing the number of plants revealed the following results: the yield with a stand density of 60000 plants/ha was 11.4 t/ha, with a plant number increase of 10000 it was 11.79 t/ha, and it was 12.38 t/ha with the highest number of plants of 80000 plants/ha. It means that increasing the number of plants from 60000 to 70000 produces a yield increase of 0.4 t/ha, and further increase in the plant number resulted in 0.6 t/ha yield increase. Thus, if we applied a stand density of 80000 plants/ha instead of 60000 plants/ha, I measured 1 t/ha yield increase. Of course, it was caused mainly by the favourable weather conditions.

Based on the results of the examinations it can be considered, that the hybrids produced the highest yield with the N160+PK treatment and with a stand density of 80000 plants/ha (see Figure 3). This confirms that interactions are close also between the agrotechnical factors. Provided that the water supply is adequate, the correlation between the hybrid, the nutrient supply and the number of plants is very strong and positive.

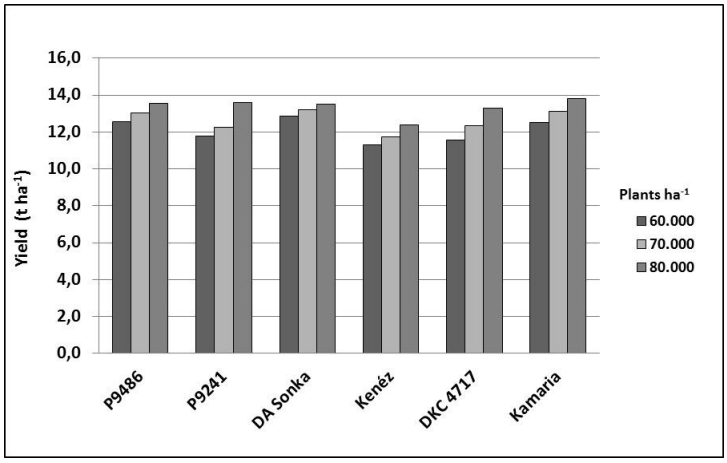

Fig. 9. The effect of the increase of the number of plants on the yield of maize hybrids (N160+PK), Hajdúszoboszló, 2016

Note: $LSD_{5\%}$ number of plants: 0.15 t/ha, hybrid: 0.22 t/ha, correlation: 0.38 t/ha

The effect of fertilizers excellently predominated in 2016. Compared to the N_{80}+PK treatment, the N_{160}+PK kg/ha treatment also significantly increased the yield (see Figure 4). Compared to the control treatment (10.65 t/ha), the N_{80}+PK treatment (12.24 t/ha) increased the yield by 1.6 t/ha, while the N_{160}+PK treatment (12.69 t/ha) increased it by further 0.6 t/ha, in the average of the hybrids and numbers of plants. With N_{160}+PK treatment the highest yield (13.48-13.81 t/ha) was produced by hybrids Kamaria, Da Sonka, P9486 and P924, with 80000 plants/ha. The maximum yield in 2016 was reached by the Kamaria hybrid, which produced 13.81 t/ha yield with N_{160}+PK treatment and with 80000 plants/ha.

It can be concluded that the lowest yield was produced by the Kenéz hybrid with all the treatments. With the adequate nutrient supply, hybrids P9241, DKC 4717 and Kamaria showed the best response to the change in the plant number, which increased their yield. The individual production of those hybrids also developed positively. In 2016 the values of grain moisture content were higher (17-18%). Due to the crop year with above average precipitation, it happened that in some rainy periods not only the daily water release of the grain crop decreased but it became moisty again.

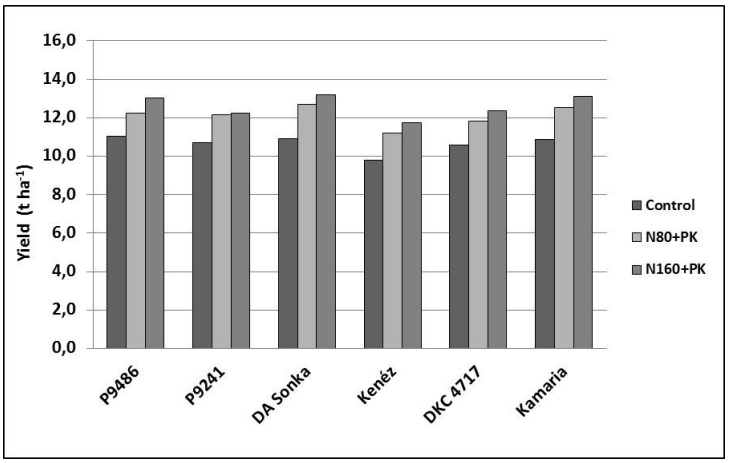

Fig. 10. The effect of NPK fertilizer on the yield of maize hybrids (70000 plants ha^{-1}), Hajdúszoboszló, 2016

Note: $LSD_{5\%}$ fertilizer level: 0.17 t/ha, hybrid: 0.24 t/ha, correlation: 0.41 t/ha

Comparing this year's results with the yield results of 2015, quite large differences can be observed. In 2015, also in Hajdúszoboszló, as in the whole country, the weather conditions were very unfavourable for plant production In the January-October period the amount of precipitation was by 105 mm less than the 30-year average. The most serious problem was that the lower amount of rain fell in the period of flowering and fertilization, the most critical periods for maize.

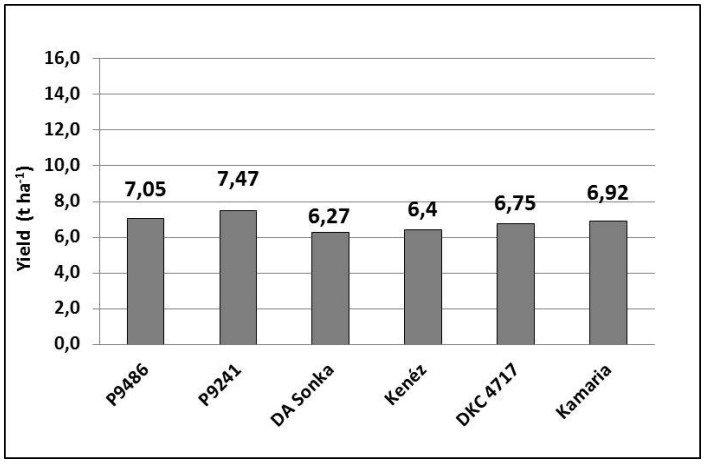

Fig. 11. Effect of maize genotypes in 2015 year (Hajdúszoboszló, in average of plant density of doses of fertilizers)

The monthly average temperature was higher by 2.6-3.7 °C than the average of many years. In a 40-day period from the end of June, only there was only 8 mm, and only 1-2 mm a day. The number of days of extreme heat was 30, the number of hot days was 15 in that period. In that extreme weather all the leaves of maize under the cobs had dried already by the middle of August. The yield changed

between 6.27 and 7.47 t/ha in the average of fertilizer treatments and plant numbers (see Figure 5). Hybrids DA Sonka and Kenéz had the lowest, while hybrids Kamaria and Pioneer had the highest yield.

In 2016, hybrids Kamaria, DA Sonka and P9486 reached the highest, while hybrid Kenéz had the lowest yield (see Figure 6).

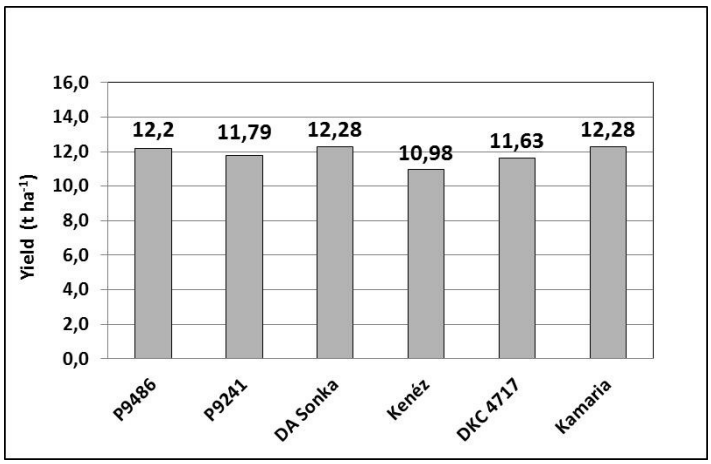

Fig. 12. Effect of maize genotypes in 2016 year (Hajdúszoboszló, in average of plant density of doses of fertilizers)

By comparing those 2 years and ranking the hybrids based on yield results, a number of observations can be made. Hybrid DA Sonka is very sensitive to the weather, compared to draughty years, in favourable conditions it can produce by 6 t/ha more yield, but its stress tolerance is very weak. Hybrids Kamaria and Pioneer had the highest yield stability. In both years, they were among the 3 hybrids that had the best yield results, thus proved that they are able to produce outstanding yield in favourable also in adverse conditions as well.

Conclusions

The crop year has an extremely strong effect on the yield. In the draughty year of 2015, the average yields produced by the hybrids was 6.81 t/ha, while in 2016 it was 11.86 t/ha. The importance of the biological bases is obvious. The performance of hybrid Kamaria and Pioneer hybrids were satisfactory in both years. The adaptability of those hybrids is excellent, they have stronger root system, their anthesis and silking are synchronized, thus flowering takes place at the same time, which results in more secure fertilization.

Based on the results of the 2 years, it can be assessed that the optimum number of plants per hectare is 70 000 plants ha^{-1}. In a favourable year the higher plant number can result in some increase in the yield, but in an unfavourable year it can cause a more considerable loss of production.

Compared to the N80+PK fertilizer dosage, the N160+PK dosage did not bring the expected results. In 2015, as an effect of the higher fertilizer dosage, a depression in yield had occurred, and it decreased by 0.2 t/ha in the average of the hybrids and plant numbers. In 2016 some increase was observed in the yield, but the costs of inputs have not returned. Thus, it can be concluded that the N160+PK fertilizer dosage proved to be too high in my experiment, and to determine the exact optimum fertilizer dosage needs further examinations.

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