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EFFECT OF AGROTECHNICAL ELEMENTS ON THE YIELD OF MAIZE

The article analyses the effect of agrotechnical factors on maize yields. The experiment was carried out on open field soil, for a specific time period. The factors analysed were the relationship between crop rotation-nutrition-time of planting-plant number and the yield of maize.

The crop rotation consists of tri-culture (pea-wheat-maize), bi-culture (wheat-maize) and mono-culture. The nutrition consists of a control (without chemical fertilisation), and chemical fertilizer with a N 40, P_{205} 25, K_{20} 30 kg ha^{-1} base, the largest application being five times this. The planting times were 5^{th}-10^{th} April, 20^{th}-25^{th} April and 13^{th}-15^{th} May; the numbers of plants investigated were 45-, 60-, 75- and 90,000 per ha^{-1}.

For the maize the most favourable crop rotation was autumn wheat (in a tri-culture) with an active ingredient of N 60 120, P_{205} 60-70, K_{20} and 90-110 kg/ha^{-1}, and a density of 75-90,000 plants per ha^{-1}.

Keywords: *Crop rotation, nutrition, planting time, plant number, hybrid*

The cultivation of maize is currently going through significant changes, both in Hungary and in the wider world.

In global terms, the greatest change is that the area under production exceeds 170 million hectares, of which 55 million are devoted to GMO hybrid cultivation. A significant proportion of the maize produced is used for industrial purposes (bio-ethanol) as well as for food and animal feed.

In Hungary change means the use of an increasingly up-to-date biological base (hybrids). 90% of the hybrids produced are single cross hybrids (SC) and 90% FAO 300–400 hybrids, which have good productive capacity and a rapid harvesting period, as well as good drainage properties.

Fundamental changes in the cultivation of maize in Hungary have been underway since the beginning of the 1990s. As a result of the financial and economic difficulties the quantity of inputs and the level of resources invested have decreased. An extremely disadvantageous factor is the reduction in the amount of organic fertiliser used, from 22-24 million tons per $year^{-1}$ to 3-4 million tons per $year^{-1}$ (Sárvári, 2013).

The largely dry, continental climate characteristics of Hungary mean it is important to create an appropriate crop rotation pattern, but the green crop also has an effect on the spread of pathogens and pests, the amount of weeds and the NPK nutritional demands as well (Berzsenyi, 1995, Széll and Makhajda 2003, Sárvári 2004).

The NPK fertiliser and the soil's AL-soluble, P, K content is not only affected by the intensity of the use of fertiliser, but also by the crop rotation and the agro-techniques employed (Blaskó, 1983, Sárvári, 1985, Csathó, 1992).

There is a close relationship between the crop yield and the provision of water to the crop (Szalóki, 1988, Ruzsányi 1989). Over the past decades climate change has increased the extremes in the weather. Between 1860 and 1900 the frequency of dry and wet years was equal (22.5 %), and more than half of the years were characterised as having a typically average pattern (55 %). In the period between 1980 and the 2000s the frequency of dry years increased significantly (52.6 %), at the expense of years with an average pattern (26.3 %) (Szász, Tőkei 1997).

There is a relationship between the time of planting and the yield, but a particularly strong relationship between the time of planting and the moisture content of the grain at harvest time (Sárvári, 1999).

A significant factor in the doubling of average yields was the use of a higher number of plants (Carlone and Russel, 1987). Without appropriate nutrition the number of plants cannot be increased continuously (Nagy J., 1995).

Materials and methods The experiment took place on open field soil. The proportion of the organic material within the segments reduces drastically from 4-5% at the surface to only about 1.5% at a depth of 40-60 cm.

In years of average precipitation the under surface water level is at a depth of about 2.0-2.5 metres. The cultivated levels of the soil are susceptible to silting away when wet, and to severe cracking when dry.

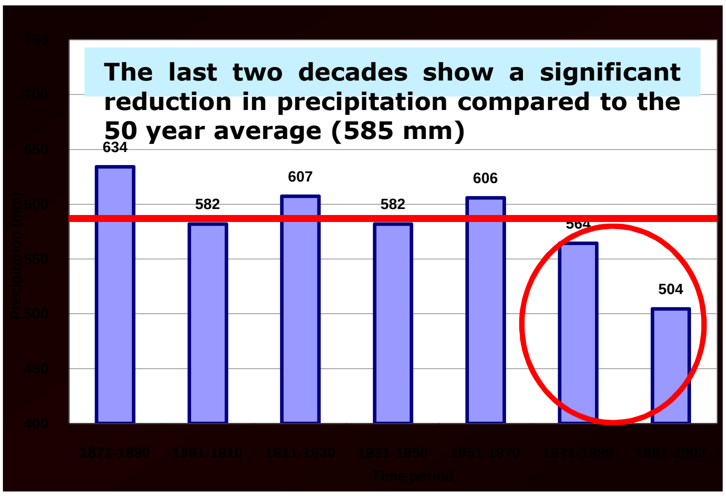


Figure 1. In the past two decades the amount of precipitation has further decreased in comparison with the fifty year average (1871–2002, Debrecen)

The 50 year average for precipitation in Debrecen is 585 mm, and in the maize growing season (the 4th to the 9th months) it is 345.1 mm. The average annual temperature is 10°C.

Climate change can be felt in the fact that over the past 120 years, the amount of precipitation has significantly decreased.

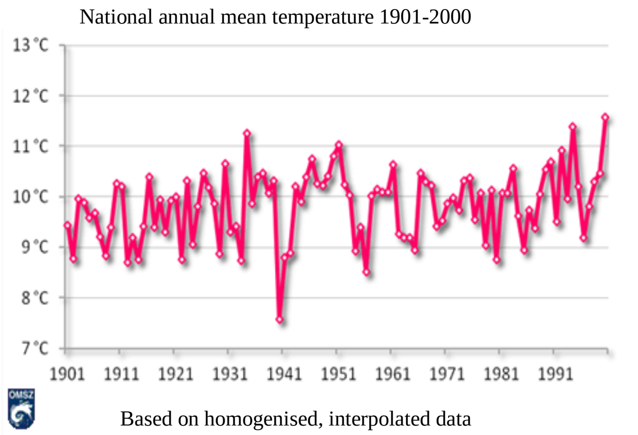
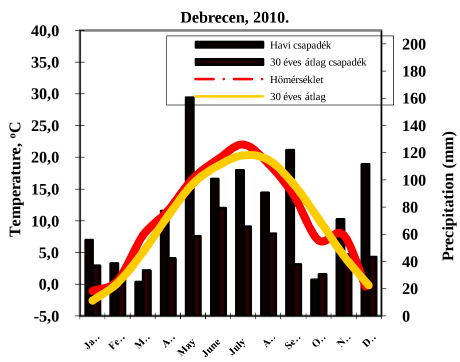
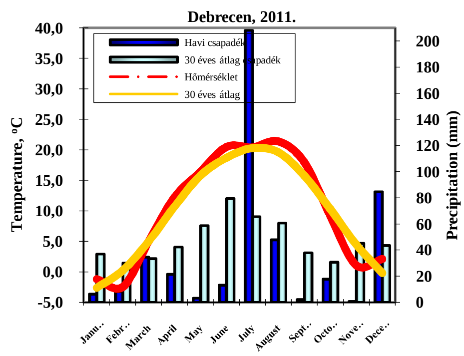


Figure 2. The national mean annual temperature, however, increased by 1°C between 1901 and 2000

The amount of precipitation in the last three years (2010–2012) and the changes in the monthly mean temperature in relation to the multi-year average clearly show the unfavourable changes in climate factors.





Years	Precipi-tation (mm)	Deviation from the 30 year average (mm)	Annual mean temperature (°C)	Deviation from the 30 year average (°C)
2010	987,8	422,5	10,3	0,5
2011	448,9	-116,4	10,2	0,36
2012	271,2	-136,6	10,4	0,7

Figure 3.

In 2010 there was 422.5 mm more precipitation, while in 2009 there was 116.4 mm less, and in 2012 136.6 mm less; in this period the monthly and annual mean temperature exceeded the multi-year average.

The sowing rotation used in the experiment:

- tri-culture (pea-winter wheat-maize)

- bi-culture (winter wheat-maize)
- monoculture maize (1973-1994)

For the nutritional control (without chemical fertilisation) the smallest amount was N 40, P_{205} 25, K_{20} 30 kg/ha^{-1} active ingredient, and the largest amount was five times this figure (N 200, P_{205} 125, K_{20} 150 kg/ha^{-1}).

The numbers of plants were 45-, 60-, 75- and 90,000 per ha^{-1}.

The planting times were 5th-10th April, 20th-25th April and 13th-15th May;

The biological ingredients applied (variably) in the practical cultivation were hybrids which guaranteed the best genetic ingredients.

The evaluation of the experiment was carried out with variance analysis and parabolic regression.

Results and discussion. A rational crop rotation also influences the effectiveness of the cultivation. The green crops are largely decisive in establishing the planned quantity of replacement fertiliser.

In Hungary problems are caused by the fact that the planting structure of the plough land is too simplified, the number of cultivated species has fallen and the proportion of cultivated pulses (e.g. pea, broad bean, lucerne etc.) has fallen particularly sharply. At the same time the proportion of grain crops exceeds 70%.

An appropriate crop rotation is particularly important in maize cultivation, partly because crop rotation is the most effective defence against the larva of the American maize bug, and so the best way to protect against both the bug and its larvae. It is also important because with monoculture the soil's nutritional material can become over-restricted (e.g. zinc) and water use can cause a severe depression in yield (a reduction in yield).

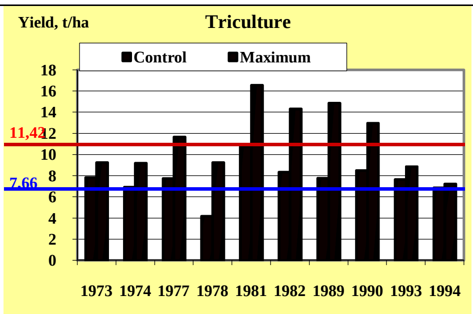
Furthermore, with a higher amount of NPK chemical fertiliser during monoculture cultivation we achieve the same yield as with maize cultivated with crop rotation.

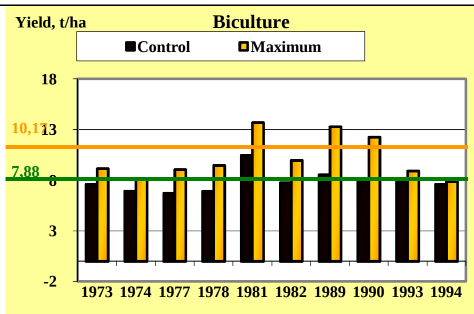
With a tri-culture (pea-wheat-maize), on a more than two-decade average we achieve a 1.31 t/ha greater crop than with a bi-culture (wheat-maize) and a 1.58 t/ha greater crop than with a monoculture.

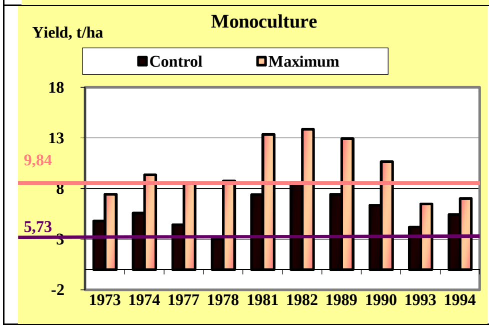
With maize cultivation it is extremely important to have hybrid-specific nutrition. In addition to nitrogen, maize requires a high level of potassium.

We must be aware of the N-P-K nutrition content which can be absorbed in soluble AL in the given soil, and the nutritional demands of the maize hybrid, and these two must be in harmony. It is well-known that it is the minimum level of the nutritional element that will determine the size of the yield.

The yield-increasing effect of a harmonised nutrition which fluctuates with the NPK content is greater than the effect of the amount of chemical fertiliser itself.







SzD5%									
Year	1973	1974	1977	1978	1981	1982	1989	1990	1993
V.idő	0,57	0,44	0,21	0,32	0,52	0,67	0,76	1,52	0,74
M.tr.	0,53	0,44	0,39	0,58	0,84	0,66	0,96	1,09	0,66
K.	0,91	0,70	0,68	1,01	1,45	1,15	1,66	1,88	1,15

*Figure 4.*Crop rotation and the effect of chemical fertiliser on maize yields, OMTK Hajdúböszörmény, 1973–1994

The nutritional requirements for 100 kg of main and secondary production are active ingredients of N 2.5 P_{205} 1.1 K_{20} 2.2 kg/ha. Twice as much potassium is needed as phosphorous, even if 70–75 % of the potassium migrates, not to the grain production, but to the leaves and stalk. The NPK nutritional requirements for maize, depending on the green crops, the season and the hybrid, are for active ingredients of N 60–120, P_{205} 60-70, K_{20} 90–110 kg/ha.

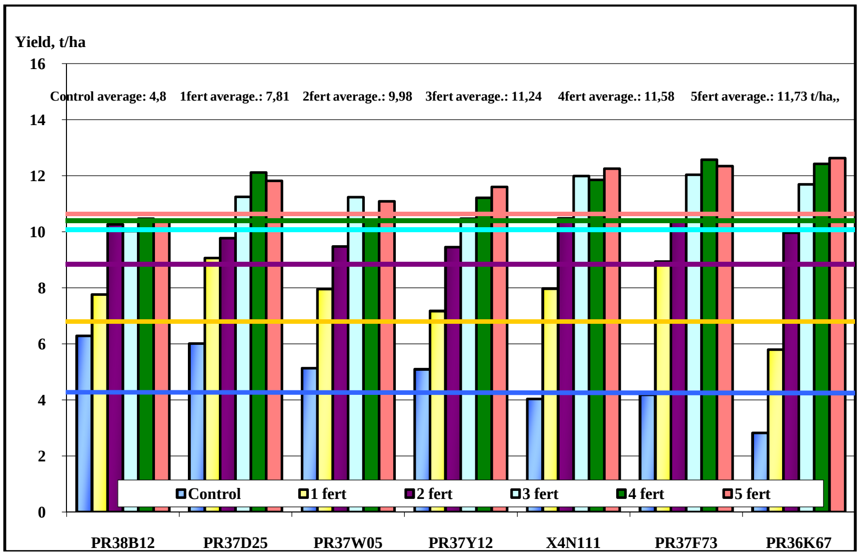


Figure 5. The effect of chemical fertiliser on hybrid maize yields in an average year Hajdúböszörmény, 2006

For the control (without chemical fertiliser) area the average yield was just 3-4 t/ha^{-1}. In comparison with the control, we achieved the highest growth in

yield with active ingredient of N 40, P_{205} 25, K_{20} 30 kg/ha^{-1} (with 1 fertiliser treatment). Although in most cases the yield increased up to an active ingredient level of N 200, P_{205} 125, K_{20} 150 kg/ha^{-1} (5 fertiliser treatments), this did not reach a level of reliability in every case.

The time of planting has a particularly significant effect on the maize yield and on the moisture content of the grains at harvest.

As a result of the global warming caused by climate change the temperature of the soil already reaches 10 °C at the beginning of April. As a result of climate change we must recalculate the concept of the optimal planting time interval.

The advantages of an earlier planting time within the optimal planting time interval:

- The level of weeds will be less, because the maize will shade the ground earlier.
- Male and female flowering and the beginning of the growth of the seed will fall in a more favourable time – at the end of June, not in July when the atmosphere is more prone to dryness. This will produce a growth in both yield and yield security.
- Physiological maturity occurs earlier, and after the formation of the black layer, further absorption of nutrition and water ceases, and the transfer of water to the production of the seed begins. As a result the moisture content of the seed at harvest can be reduced by up to 5–10 %.

In comparison with the previous optimal planting time, a planting time falling 10–14 days earlier increases yields by 1.79–2.06 t/ha^{-1}.

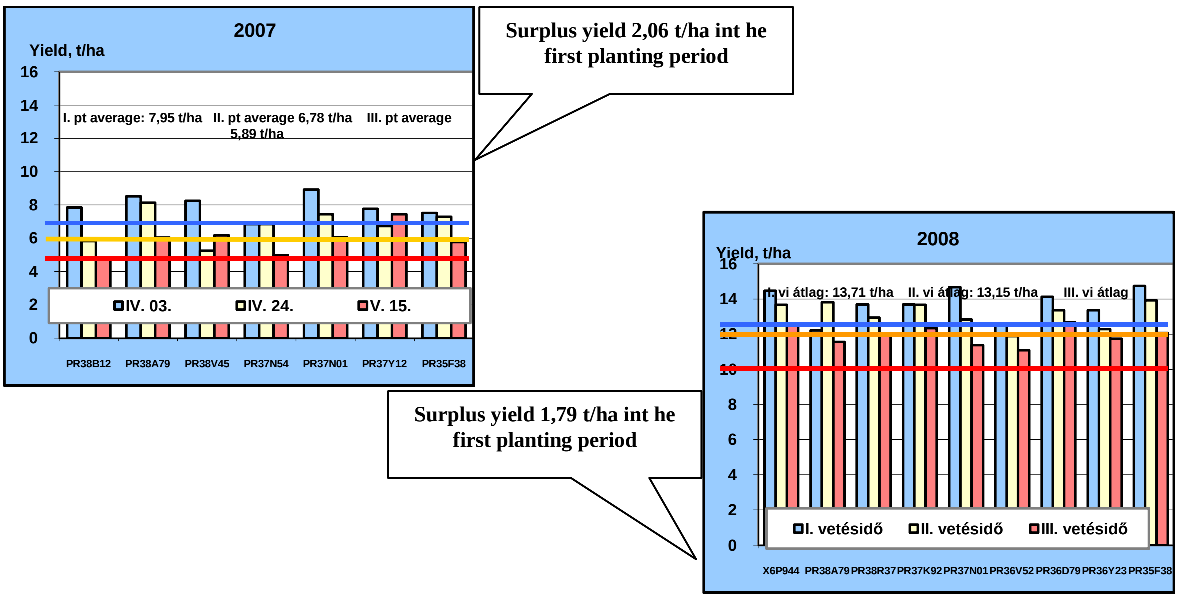
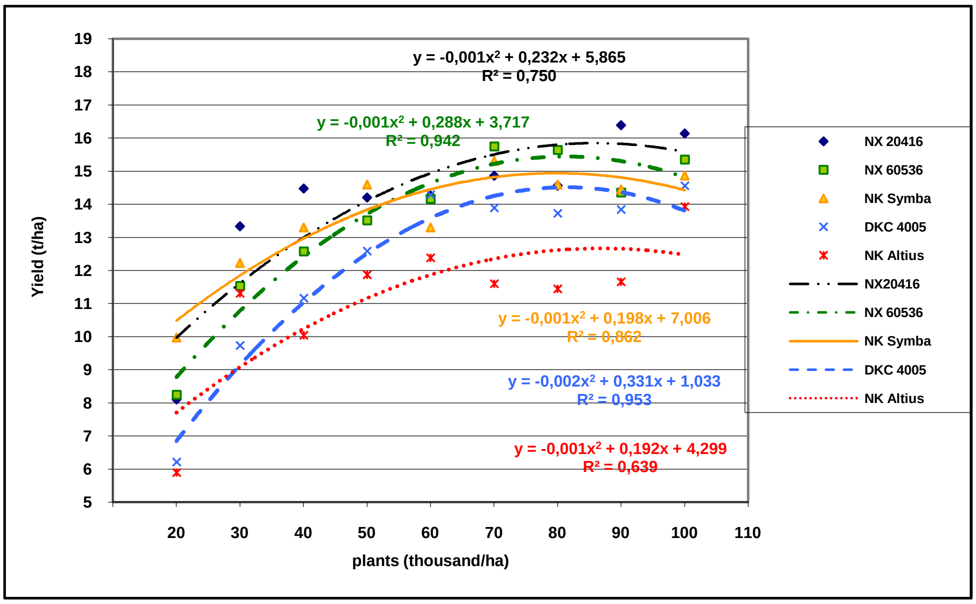


Figure 6. Effect of planting time on maize hybrid yields, Hajdúböszörmény, 2007–2008

The possibility of an earlier planting time is, of course, influenced by the cold-resistance of the maize hybrids at germination. It is clear that, for example, for hybrid no. PR38A79 the 24th April planting time was more favourable. It is advisable to adopt hybrid-specific planting times.

An important agro-technical factor in increasing maize yields is to ensure an optimal number of plants for the size of the area planted.

- The number of plants is a decisive factor in the size of the yield
- To establish the number of plants per hectare, the optimal plant interval for the given hybrid must be known, i.e. the interval which the hybrid can tolerate without a decrease in yield



SD5% Hybrid=0.97 t/ha; Plants=0.26 t/ha; Reciprocal effect=1.26 t/ha

Figure 7. Technological elements of modern maize cultivation

Modification of the optimal number of stalks:

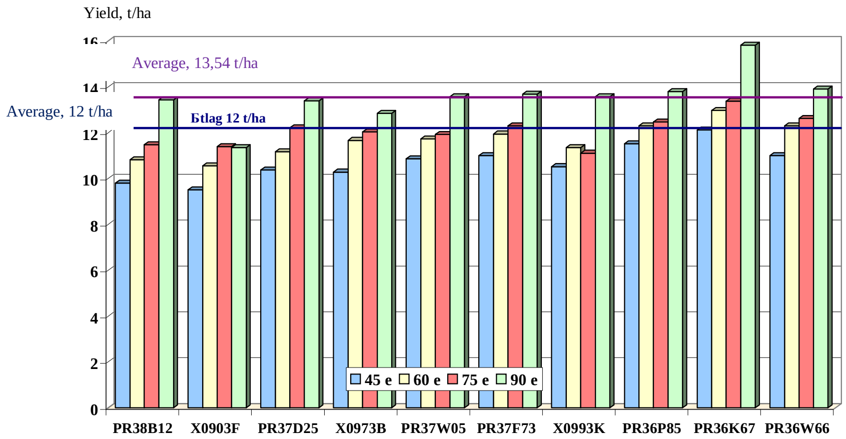
- The hybrid's genetic characteristics
- The hybrid's growing season
- The nature of the planted area
- The annual weather effect
- The level of water and nutrition

If the above factors are at the optimum, then an increase in the density of plant numbers is limited by the light available.

Maize hybrids can be divided into four types in terms of the density of plants:

1. Hybrids with a wide optimum plant density, which can be planted densely
2. Those which do not demand a high plant number, but which give good individual production
3. Flexible stalk types. In good years the stalk extends

4. Hybrids sensitive to an increase in density, with a relatively restricted optimum plant interval



SD5% Hybrid=0.87 t/ha; Plants=0.48 t/ha; Reciprocal effect=1.51 t/ha

Figure 8. Effect of plant density on maize hybrid yields, Hajdúböszörmény, 2005

Conclusions

It can be established that the extremes in the weather caused by climate change have a great influence on the size of the maize yield. There are up-to-date biological base materials (hybrids) in cultivation, but in order to reach a good level of production it is necessary to have the appropriate crop rotation and a harmonised NPK nutrition. Furthermore the planting time and the number of plants per hectare must also be adjusted according to the particular hybrid being planted.

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Сарвари М. Влияние агротехнических элементов на урожайность кукурузы // Корми і кормовиробництво. – 2014. – Вип. 78. – С. 151–159.

Проанализировано влияние агротехнических факторов на урожайность кукурузы. Эксперимент проводился на открытой почве, в течение определенного периода времени. Факторы, которые были проанализированы, включают отношения между севооборотом-удобрением-временем посадки - числом растений и урожайностью кукурузы.

Севооборот включает три культуры (горох-пшеница-кукуруза), две культуры (пшеница-кукуруза) и моно-культуру. Подкормка состоит из контроля (без химического удобрения) и внесения химических удобрений N40, P205 25, K20 30 кг/га-1 базовый. Время посадки – 5–10 апреля, 20–25 апреля и 13–15 мая;

численность растений была 45-, 60-, 75- и 90 тысяч на гектар-1.

Для кукурузы наиболее благоприятным севооборотом была ярая пшеница (три культуры) с активным ингредиентом N 60 120, P205 60-70, K20 и 90-110 кг/га-1, и густотой 75–90000 растений на га-1.

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Sárvári M. Effect of agrotechnical elements on the yield of maize // Feeds and Feed Production. – 2014. – Issue 78. – P. 151–159.

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