The impacts of spring basal and side dressing on maize yield

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SUMMARY

The yield potential of maize is very high. According to Tollenaar (1983), maize yield potential is as high as 25 t ha^{-1} (absolute dry yield) which is the highest among all cereals. In order to fully utilise this high yield potential, proper nutrient replenishment is of chief importance among all agrotechnical factors.

The aim of research was to examine the effect of nitrogen fertiliser applied as basal and side dressing on maize yield.

The measurements were performed at the Látókép experiment site (47° 33' N, 21° 26' E, 111 m asl) of the Centre for Agricultural Sciences of the University of Debrecen on mid-heavy calcareous chernozem soil with deep humus layer in an established experiment in 2011, 2012 and 2013. The trial design was split-split-plot with two replications.

Based on the experiment results, it can be established that the nutrient uptake of maize is greatly dependent on the amount of water store in the soil. From the aspect of the development of the maize plant and water supply, the most determinant factor was the distribution of precipitation over the growing season and not the amount precipitation. This is shown by the fact there was only 276 mm precipitation – which was favourably distributed – in 2012 to increase the availability of nutrients and the main average was the highest in this year (14.394 t ha^{-1}).

Spring basal dressing helped maize development in all three years even on chernozem soil which is well supplied with nutrients. Although the effect of side dressing did not result in any yield increase, it could still contribute to mitigating the stress effects caused by environmental factors. Altogether, nutrient supply adapted to the various development stages of maize can favourably affect the success of maize production.

Keywords: *maize, basal and side dressing, crop year*

ÖSSZEFOGLALÁS

A kukorica terméspotenciálja nagyon magas, Tollenaar (1983) szerint 25 t/ha (abszolút száraz termés), ami a gabonafélék közül a legnagyobb. Annak érdekében, hogy ezt a kiemelkedő terméspotenciált maximálisan ki tudjuk használni számos agrotechnikai tényező közül kiemelt jelentőségű a megfelelő tápanyag-visszapótlás.

A kutatás célja az alap- és fejtrágyázásként kijuttatott nitrogén műtrágya hatásának vizsgálata a termés mennyiségének alakulására.

A méréseket a Debreceni Egyetem Agrártudományi Központ Látóképi Kísérleti Telepén (47° 33' É, 21° 26' K, 111 m), mély humuszos rétegű középkötött alföldi mészlepedékes csernozjom talajon beállított kísérletben 2011, 2012 és 2013-ban végeztük. A kísérlet kétszeresen osztott parcellás (split-split-plot) elrendezésű, kétismétléses.

A kísérleti eredmények alapján megállapítható, hogy a kukorica tápanyag-felhasználása nagymértékben függ a talajban elraktározott víz mennyiségétől. A kukoricanövény fejlődése szempontjából a vízellátottság tekintetében nem annyira a csapadék mennyisége, mint annak tenyészidőszak alatti eloszlása volt a meghatározó. Ezt bizonyítja, hogy a három vizsgált év közül 2012-ben, amikor a tenyészidőszakban lehullott – kedvezőbb eloszlású – mindössze 276 mm csapadék javította a tápanyagok felvehetőségét, ebben az évben volt a főátlag a legnagyobb (14,394 t/ha).

A tavaszi alaptrágyázás mindhárom évben jól segítette a kukorica fejlődését még a tápanyagokkal jól ellátott csernozjom talajon is. A fejtrágyázás hatása ugyan a termésnövekedésben nem mutatkozott meg, de a környezeti tényezők okozta stresszhatásokat azonban általuk mérsékelni lehetett. Összefoglalva, a kukorica különböző fejlődési szakaszaihoz igazodó tápanyagellátás használatával előnyösen befolyásolhatjuk a kukoricatermesztés eredményességét.

Kulcsszavak: *kukorica, alap- és fejtrágyázás, évjárat*

INTRODUCTION

Maize yield is greatly affected by nutrient replenishment, more specifically nitrogen fertilisation. This correlation was examined by several researchers (Cerrato and Blackmer, 1990, Cox et al., 1993; Ványiné et al., 2011; Ványiné et al., 2012a). The dynamics of nutrient uptake is different in each growth phase of maize. At the 4–6 leaf stage, the nutrient and water uptake of the plant increases with the growth of the stem and reaches its peak value at the time of tasseling, which is the most critical period from the aspect of nutrient uptake. The phosphorus and potassium uptake are intensive in the grain-filling period (Debreczeniné, 1965; Debreczeni and Debreczeniné, 1983; Árendás and Csathó, 2002; Jolánkai, 2005). However, weather factors (precipitation, temperature) greatly affect the microbial life of the soil, the growth and nutrient uptake of the plant and yield, resulting in the impact on nutrient conversion ratio (Stefanovits, 1981; Sarkadi, 1991; Kádár, 1992; Berzsenyi and Lap, 2003; Nagy, 2007, Sárvári, 2008, Ványiné and Nagy, 2012, Ványiné et al., 2012b, Pepó and Sárvári, 2013).

The aim of research was to examine the effect of nitrogen fertiliser applied in different amounts and at different dates on yield.

MATERIAL AND METHODS

The measurements were performed at the Látókép experiment site (47° 33' N, 21° 26' E, 111 m asl) of the Centre for Agricultural Sciences of the University of Debrecen on mid-heavy calcareous chernozem soil with deep humus layer in an established experiment in 2011, 2012 and 2013. The trial design was split-split-plot with two replications. The main plots represented the irrigation variants (non-irrigated and irrigated), while the split plots covered the different fertiliser doses and hybrids. In this study, the results of Mv Mikolt on non-irrigated plots were examined.

The average pH_{KCl} of the soil is 6.6 (slightly acidic) which is optimal from the aspect of plants' nutrient uptake. The Arany's plasticity index is 39 in the upper (20 cm) layer of the soil and the total amount of water-soluble salts (anions and cations) is 0.04% which means that the soil is low on salt. The carbonic chalk content of the upper 80 cm of the soil is around 0% (i.e. chalk deficient), but it is 12% from 100 cm down (moderately chalky). The organic matter content is 2.3% in the upper 20 cm layer of the soil and it does not exceed 1.00% even at the 120 cm depth. The soil has favourable potassium supply and average P supply.

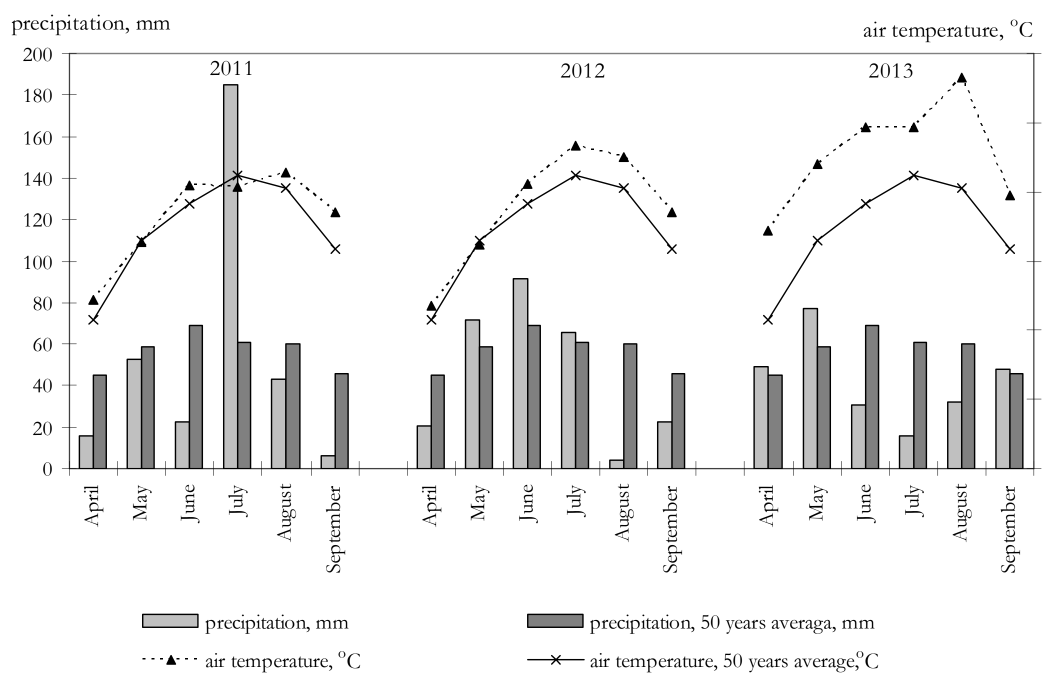
Weather was evaluated on the basis of the data measured and logged by the automatic weather station placed in the experiment area. The following values were measured: air and soil temperature (^{o}C), relative air humidity (%), wind speed ($m\ s^{-1}$), incoming radiation ($W\ m^{-2}$) and amount of precipitation (mm).

There was not enough rainfall in April 2011 and even the temperature was lower than the 50-year-average. In May, the amount of precipitation and temperature were close to the multiple-year-average. In June, the amount of precipitation was 46 mm lower than the 50-year-average and also air temperature was lower. The amount of rainfall in July was three times as much as the multiple-year-average (185 mm) and the temperature was also around average. The precipitation in August (43 mm) and September (6 mm) was lower than the 50-year-average of the respective period. Also, the mean temperature was much lower in these two months than the multiple-year-average. Altogether, there was 324 mm precipitation in the growing season.

April in 2012 ended with 24 mm precipitation shortage and the air temperature was also lower than the 50-year-average. The amount of rainfall was favourable in May (72 mm), June (92 mm) and July (65 mm). However, temperature was lower than the average in June and July. There was only 4 mm rain in August which means 56 mm precipitation shortage when compared to the average value. Also, the amount of rain in September was 23 mm lower than the multiple-year-average. In the last two months of the growing season, air temperature was lower than the average. Altogether, there was only 276 mm rain in the growing season of 2012.

The amount of precipitation in the first two months of the growing season of 2013 was above the multiple-year-average and air temperature was also higher. There was significantly less rain than the 50-year-average in June (31 mm), July (16 mm) and August (32 mm). Temperature during these months was significantly higher than average. The amount of precipitation in September was around the average, while temperature was still greatly above the average in this month. There was only 252 mm rain in the growing season which was accompanied by temperature higher than average *(Figure 1)*.

Figure 1: **Weather of the experiment site (Debrecen, 2011–2013)**



60 and 120 kg N ha^{-1} basic fertiliser doses were used in addition to a non-fertilised control plot. Fertilisers were applied in the spring in the form of ammonium nitrate one month before sowing. Further fertiliser doses (30 kg N ha^{-1}) were applied at the V6 growth phase of maize in addition to the basic fertiliser levels of the 2nd and 3rd treatment with the exception of the control plots. At the V12 phase, a further fertiliser dose (30 kg N ha^{-1}) was applied in the 3rd treatment. The final fertiliser levels were 0, 90 and 150 kg N ha^{-1} in the 2nd treatment and 0, 120 and 180 kg N ha^{-1} in the 3rd treatment *(Table 1)*. Plant number was set to 73 thousand per hectare. The previous crop was maize. The harvested grain yield was determined at 14% grain moisture content.

Table 1.

Applied fertiliser doses and time of fertilisation (Debrecen, 2011–2013)

Treatment	Nitrogen fertiliser dose (kg ha^{-1}) and time of fertilisation								
	Before sowing			At the V6 phase			At the V12 phase		
Technology #1	0	60	120	0	0	0	0	0	0
Technology #2	0	60	120	0	30	30	0	0	0
Technology #3	0	60	120	0	30	30	0	30	30

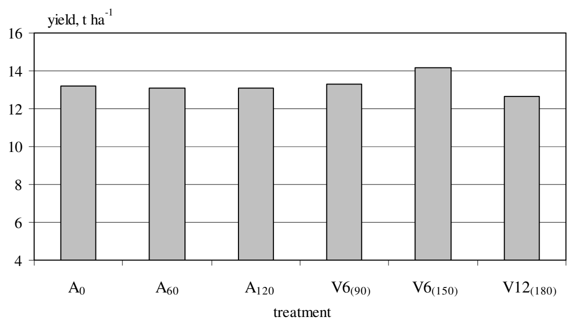
Indications of fertiliser treatments:
A_0=control without fertilisation
A_{60}=60 kg N ha^{-1},
A_{120}=120 kg N ha^{-1},
$V6_{(90)}$=A_{60}+30 kg N ha^{-1} side dressing,
$V6_{(150)}$=A_{120}+30 kg N ha^{-1} side dressing,
$V12_{(180)}$=$V6_{(120)}$+30 kg N ha^{-1} side dressing.

The impact of treatments on yield was examined with a general linear model (GLM) (Huzsvai, 2008). In order to compare the mean values of the treatment, the 5% significant difference (LSD5%) was determined. Duncan's method was used to correct the confidence intervals during multiple comparisons in order to avoid the cumulation of alpha errors. Evaluation was carried out with SPSS for Windows 14.0.

RESULTS

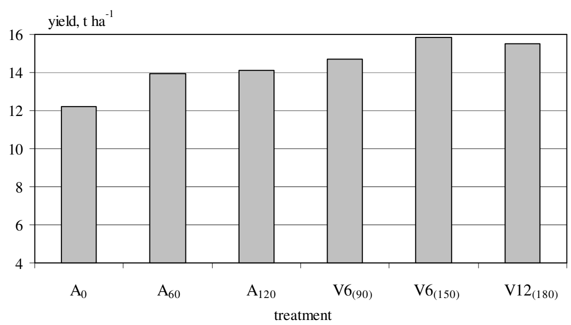
The examination of the amount and application of fertilisers was performed each year. There was no significant difference between the yields of the different N treatments before sowing in 2011 (A_0, A_{60} and A_{120}). The highest yield (14.170 t ha^{-1}) was observed in the case of the 30 kg side dressing applied at the V6 phase – the $V6_{(150)}$ treatment. The further 30 kg side dressing applied at the V12 phenophase caused significant yield reduction (1525 kg ha^{-1}) ($P<0.05$) in comparison with the $V6_{(150)}$ treatment *(Figure 2)*.

Figure 2: **The impact of fertilisation on yield (Debrecen, 2011)**



In 2012, the main average of the experiment was 14.394 t ha^{-1}. The average yield obtained on non-fertilised plots was 12.242 t ha^{-1}. In comparison, the low fertiliser level A_{60} treatment result in 1730 kg ha^{-1} yield surplus which was surpassed by the higher fertiliser level A_{120} and $V6_{(90)}$ treatments, but this growth is not statistically significant. The most successful impact on yield was observed in the case of the $V6_{(150)}$ treatment (15.850 t ha^{-1}) ($P<0.05$). The application of further 30 kg ha^{-1} at the V12 phase ($V12_{(180)}$ treatment) slightly reduced yield, but no significant difference was observed *(Figure 3)*.

Figure 3: **The impact of fertilisation on yield (Debrecen, 2012)**



In 2013, the yield of the non-fertilised treatment significantly decreased by 2323 kg ha^{-1} ($P<0.005$) in comparison with the yield of the lowest N level treatment (A_{60}) applied as basal dressing before sowing. If the N dose was further increased by 60 kg ha^{-1} as basal dressing, a non-significant yield increase of 955 kg ha^{-1} was observed. At the V6 growth stage, when 30 kg N ha^{-1} ($V6_{(90)}$) was applied on top of the 60 kg basal dressing (A_{60}), similar yield was observed as in the case of the A_{60} and A_{120} treatments. The highest yield of the experiment was observed in the case of the $V6_{(150)}$ treatment (13.090 t ha^{-1}) which was significantly higher than the basal dressing treatments and the $V6_{(90)}$ treatment at the significance level of 5%. The 30 kg N ha^{-1} treatment had no significant effect at the V12 phase *(Figure 4)*.

Figure 4: **The impact of fertilisation on yield (Debrecen, 2013)**

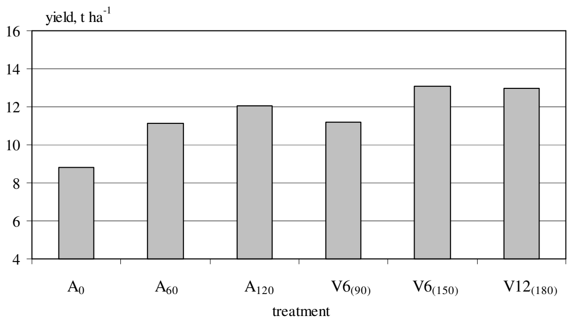
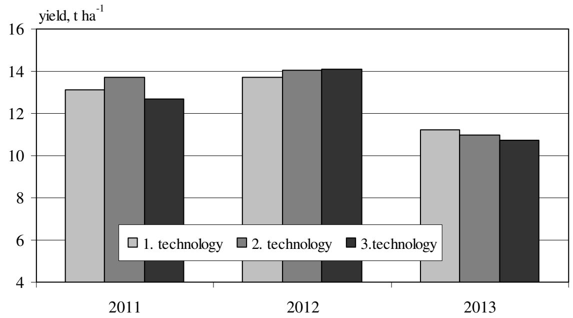


Figure 5: **The impact of fertilisation technology on yield (Debrecen, 2011–2013)**



In the first year, the highest yield (13.702 t ha^{-1}) was observed when using the 2nd technological variant, which was 8% more ($P<0.05$) than that of the 3rd technological variant (12.677 t ha^{-1}) and 581 kg ha^{-1} more than in the case of the 1st technology (13.122 t ha^{-1}) which was not significant. There was no significant difference between each technology in 2012 and 2013. The 1st and 2nd technological variants resulted in similar yields in 2011 and 2012, while the effect of crop year on yield was significant ($P<0.05$) in 2013. The 2nd technological variant was the most effective in 2012, differences were observed in comparison with both examined years –1410 kg ha^{-1} yield surplus in comparison with 2011 and 3360 kg ha^{-1} surplus in comparison with 2013 *(Figure 5)*.

N fertiliser doses applied before sowing had the greatest impact on yield in 2011. Although further side dressing applied at the V6 stage had yield increasing effect, but no significant difference was observed. Further side dressings applied at the V12 growth stage caused significant ($P<0.05$) decrease. The highest main average (14.394 t ha^{-1}) was observed in 2012, yield was not affected by side dressing. Averaged over the different treatments, yield was significantly lower in 2013 (11.536 t ha^{-1}), side dressing had no positive result. The results of the three examined years showed that fertilisers applied before sowing had a positive effect, but side dressing doses did not increase yield.

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