Effects of genotypes, nutrient- and water-supply on the dry matter production and potassium uptake dynamics of maize (*Zea mays L.*) on a chernozem soil of a long-term field experiment in Hungary

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The effects of genotypes, nutrient and water supply on the dry matter production and potassium uptake dynamics of maize (Zea mays L.) were studied on chernozem soil in the Debrecen-Látókép long-term field experiment (Eastern Hungary).

Materials and methods

The experimental site consists of two parts: one half – in most years, if necessary – can be irrigated, the other half is non-irrigated, on which only the water amount from natural precipitation and the stored moisture content of soil are available for plants.

The selection of maize hybrids for the study was based on the length of their vegetation period (FAO-number). Three Hungarian-bread hybrids with varying vegetation periods were used: Mv 251 (FAO 280), Mv Koppány (FAO 420) and Mv 500 (FAO 510).

In the 4-repetition small-plot long-term field experiment the effects of macro-nutrient fertilization are studied – in addition to the control variant – on five nutrient levels with fixed 1.0:0.77:0.90 $N:P_2O_5:K_2O$ rate; the yearly applied N doses being 0, 30, 60, 90, 120 and 150 kg $N\cdot ha^{-1}$ respectively. The total number of investigated treatments (plots) was 2 water supply levels × 3 genotypes × 6 fertilization levels = 36 in both years.

Results and discussion

For the characterization and description of plant growth and nutrient uptake dynamics, several classical types of equations were analysed. According to the results, authors worked out a new combined function that was the most suitable for their purposes, the so-called "S-type" (acceleration – saturation) equation, as follows:

$$y=\frac{A\cdot(1-b\cdot x)}{1+e^{-k\cdot(x-x0)}}$$

where: the variable *y* is the actual value of the measured (dependent) factor ($t\cdot ha^{-1}$ or $kg\cdot ha^{-1}$), *x* is the day after plant shooting (days); the parameter *A* is the maximum value of *y* ($t\cdot ha^{-1}$ or $kg\cdot ha^{-1}$), *x0* is the day of maximum growth rate of *y*, point of inflexion, (days), *b* is the rate of decrease of the dependent value by one unit ($days^{-1}$); *k* is the growth constant ($days^{-1}$). The theory of deriving this function was: this system is the combination of a biological growth (logistic part of function) and a decreasing commensurable to the size of plant (linear decreasing part of function).

Biomass production

The amount of produced biomass of maize (Fig. 1) was mainly determined by the weather conditions, which basically differed in the studied two vegetation periods. In 2008, as the amount of precipitation in the vegetation period of maize was quite high (420 mm), no irrigation was required in any of the treatments. Nevertheless, the differences between the dry matter production of previously irrigated and non-irrigated treatments were significant: the yields of non-irrigated plots (upper curve) were higher than those of the previously irrigated treatments of the long-term field experiment (second curve top-down). Earlier, the produced yields of non-irrigated treatments had regularly been lower than those of the methodically irrigated ones, which lead to the fact that – from the time the long-term experiment was set up in 1984 – plant biomass had extracted smaller amounts of nutrients from the soil of the non-irrigated treatments.

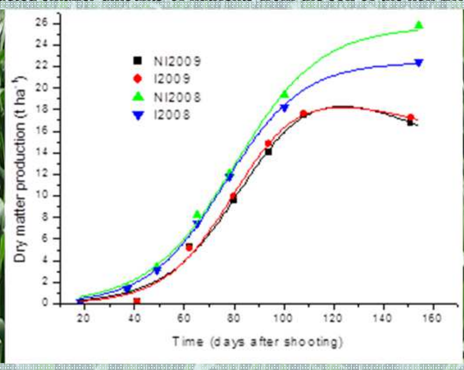

Fig. 1. Dry matter production (t•ha-1) of maize in non-irrigated (NI) and irrigated (I) treatments of the long-term field experiment (Debrecen-Látókép) during its vegetation period in 2008 and 2009, on the average of nutrient supply levels and hybrids

Conclusions

According to the experimental results and calculations it can be concluded that – in addition to the previously used and considered soil and plant nutrient contents – the calculation of the plant-extracted nutrient amount (depending on the applied hybrid, NPK nutrient levels and water supply) is suggested to enable the characterization of the growth and nutrient demand dynamics of maize genotypes. This parameter gives information not only about the available nutrient amount at a given sampling time, but about the supply level of plants up to the sampling time as well. For the proper characterization of the mentioned dynamics of maize plants authors suggest to take the following sampling times into consideration: the intensive vegetative growth period, the switch between the vegetative and generative growth phases (silking), and the grain filling phase..

The curves in Fig. 2 show that the dry matter production of the three hybrids differed significantly. In the first 90–95 days of the 2008 crop year (upper three curves) there was no difference between the hybrids, but at the end of vegetation the difference in the genetic potential of the hybrids manifested, parallel to their increasing FAO-number their dry matter production increased as well. The difference between Mv 251 and Mv 500 hybrids was more than 5 $t\cdot ha^{-1}$ in this year. In the 2009 crop year – due to the dry and warm weather conditions – Mv 500 did not produce the yield expectable of its genetic potential, while the lowest yield loss – in contrast to that of 2008 – was recorded for Mv Koppány (the hybrid with lower demand).

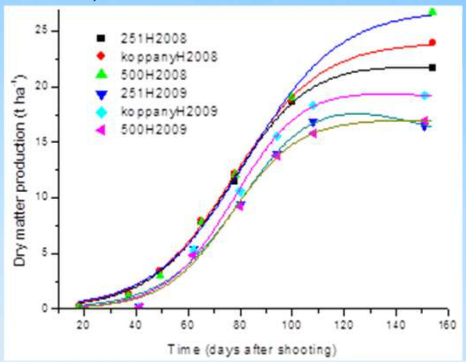

Fig. 2. Dry matter production (t•ha-1) of the Mv 251, Mv-Koppány and Mv500 maize hybrids grown in 2008 and 2009 crop years in the long-term fertilization field experiment in Debrecen-Látókép, on the average of nutrient and water supply

On Figs. 3 and 4 it can be observed that – according to authors' hypothesis – on the average of the genotypes and water supply, the dry matter yield increasing effect of NPK supply could be observed in both crop years.

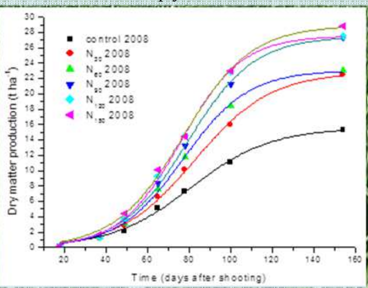

Fig. 3. Dry matter production (t•ha-1) of maize hybrids in 2008.

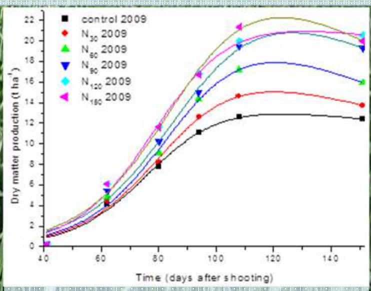

Fig. 4. Dry matter production (t•ha-1) of maize hybrids in 2009.

Nutrient level supplies: control; N30 = 30, 23, 27; N60 = 60, 46, 54; N90 = 90, 69, 81; N120 = 120, 92, 108; N150 = 150, 115, 135 kg•ha-1 N, P_2O_5, K_2O, respectively

Potassium uptake

Increasing nutrient supply levels increased plant potassium uptake (Fig. 5), for on the one hand the increasing NPK supply increased plant dry matter accumulation (Fig. 4), on the other hand plant potassium concentration was higher in treatments with higher potassium supply. The amount of potassium taken up by plants was higher in all treatments than the amount added with fertilization. This was especially spectacular in the control treatment (the lowest curve in Fig. 5 – there was no additional potassium fertilization for 24 years). In this case it can be observed that approx. 100 kg K•ha-1 was mobilized each year from the potassium stock of the chernozem soil. This proves the excellent nutrient mobilization and supplying ability of this soil type.

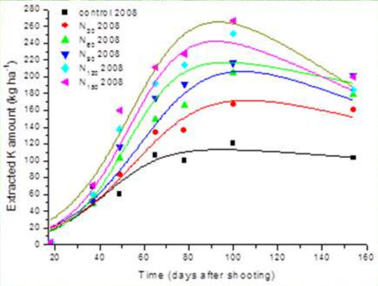

Fig. 5. Potassium uptake dynamics of maize as affected by different nutrient supply levels in crop year 2008 in the long-term fertilization field experiment in Debrecen-Látókép. Nutrient supply levels: 0: control; 1: N30: 30, 23, 27; 2: N60: 60, 46, 54; 3: N90: 90, 69, 81; 4: N120: 120, 92, 108; 5: N150: 150, 115, 135 kg•ha-1 N, P_2O_5, K_2O, respectively