EVALUATION OF THE LEVEL OF N SUPPLY IN MAIZE HYBRIDS ON DIFFERENT NUTRITIONAL LEVELS

A. VÁNYINÉ SZÉLES

UNIVERSITY OF DEBRECEN, CENTRE OF AGRICULTURAL SCIENCES AND ENGINEERING, DEBRECEN

During the research, we wanted to get to know the effect of fertilisation and crop year on the SPAD value and the dynamics of SPAD value in the growing season.

Our research results proved that SPAD values steadily decreased in the dry crop year during the growing season, whereas it increased in a crop year with favourable precipitation supply. Fertilisation increased SPAD values significantly ($P<0.001$). The highest statistically justified SPAD value – both in dry years and those with average precipitation supply – was measured by applying 60 kg N ha^{-1} fertiliser active ingredient at the 6 leaf stage and 120-120 kg N ha^{-1} at the 12 leaf stage and 50% female flowering stage, respectively.

The correlation between fertilisation and SPAD values was greatly affected by crop year. Their correlation was close in 2004 when there was an average precipitation supply, whereas it was the weakest in 2007, the driest year. The correlation between the factors is weak in 6 leaf stage but it gets stronger as the vegetation period passes.

As the growing season was progressing, SPAD values decreased in the dry crop year, whereas they increased in the crop year with average precipitation supply. Nutrient uptake was rather intensive until 12 leaf stage in the crop year with average precipitation supply. In the dry crop year, the decrease of SPAD value was the most intensive in the 50% female flowering stage.

There is no stochastic correlation between the SPAD value measured in 6 leaf stage and yield. Nevertheless, the correlation between the two variables can become stronger during the vegetative period.

Keywords: maize, SPAD values, fertilisation, crop year

Introduction

The importance of maize production in Hungary is indisputable. Its production area has been almost continuously growing since it was introduced and its average yield also increased. After the second World War, the average yield was 2.2 t ha^{-1}, whereas it exceeded 6 t ha^{-1} in the early 1980's (*Nagy* 2008).

Nevertheless, intensive crop nourishment is indispensable for the increase of yields and it is an energy-consuming activity. Within Hungarian conditions, several researchers consider nitrogen to be the most significant yield increasing fertiliser for maize on most soils (*Győrffy et al.*1965).

Excessive, or one-sided N nourishment endangers yield safety. Determining the optimal fertiliser dose is one of the most difficult tasks. On one hand, one has to count with the nutritive management and nutritive incorporation ability of the soil and the nutritive utilisation ability, fertiliser reaction of the grown hybrid and the crop year effect also have to be taken into consideration (*Széll et al.* 2005, *D'Haene et al.* 2007).

Material and methods

The examinations were carried out within a multifactoral long-term field experiment established in 1984 on mid-heavy calcareous chernozem soil at the Látókép experimental site of the University of Debrecen, Centre of Agricultural Sciences and Engineering. The experiment had four replications and strip-plot design. Measurements were conducted in years unfavourable for maize (2003, 2007) and in years with average precipitation (2004, 2006).

Fertiliser active ingredients: The NPK dose experiment had a constant ratio of 1 N:0,75 P_2O_5:0,88 K_2O, the basic N dose was 30 kg ha^{-1} and we used treatments of 1, 2, 3, 4 and 5 times the basic dose, plus a control treatment without fertilisation. In this current study, we evaluated the non-irrigated treatments.

Experiment soil: Based on soil analysis data obtained in 2002, the average pH of the soil is 6.6, soil plasticity in Arany number is 37, total salt content is 0.05% m/m. The humus layer of the soil has been decreasing due to intensive cultivation during the last 25 years; currently it is 2.4 m/m in the upper 0.2 m of soil. The soil nitrogen and potassium supply was good and the phosphorous supply was average.

Weather. The environmental parameters are continuously measured and logged by a data logging station. We calculated the heat sum and the value of potential evapotranspiration (PET) for the entire growing period based on *Szász*' (1973) method. Based on these data, we classified the years into dry, unfavourable (2003, 2007) years for maize and those that had average precipitation supply (2004, 2006) (Figure 1).

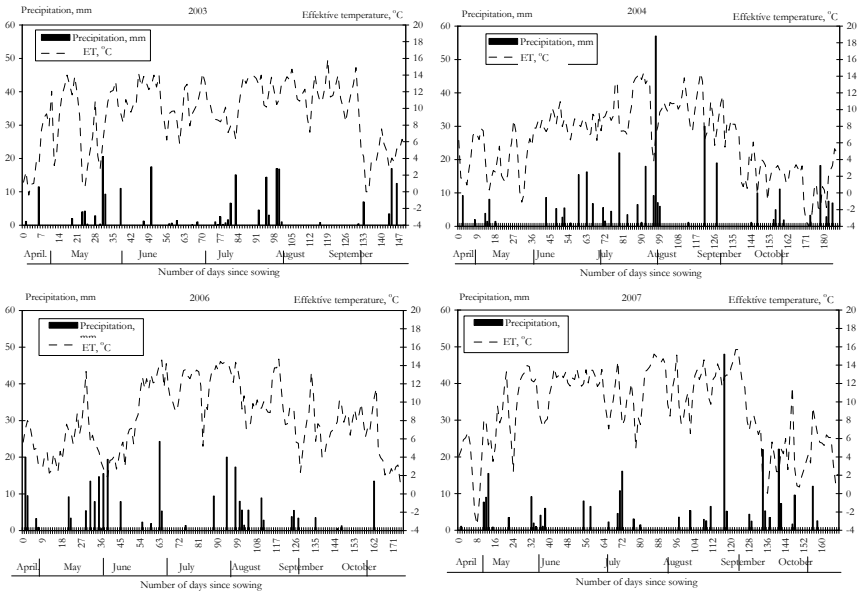

Figure 1. The amount of precipitation and the effective temperature in the growing season (Debrecen, 2003, 2004, 2006 and 2007)

We measured the chlorophyll concentration of maize leaf using the portable chlorophyll meter SPAD-502. Many researchers claim that this tool can be effectively used for the quick and reliable determination of the environmental friendly dose of N fertiliser in maize (*Yadava* 1986,

Berzsenyi and *Lap* 2001). We started the measurements every year in the 6 leaf stage. We performed further measurements in the 12 leaf stage and 50% female flowering. We evaluated the N concentration of the crop during its growing season. Hybrids involved in the study: Debreceni 377, DK 391, Mv 277 and Szegedi SC 352.

Statistical method: We used the *general linear model* (GLM) to evaluate the correlation between the SPAD values of maize and its production factors. The SPAD value was the dependent variable, whereas the amount of fertiliser and years were the independent ones. We used *Duncan's test* to compare the mean values of SPAD. We used a *logarithmic regression analysis* to analyse the correlation between N fertiliser and SPAD values, whereas we examined the relationship between SPAD values and yield using a *linear regression analysis*. We fitted the functions by minimising the sum of squares. The adequacy of fitting was defined by the R value and the Error MS. We used SPSS for Windows 13.0 for evaluation.

Results

The effect of fertilisation on the SPAD value of maize

The results of the variance analysis show that fertilisation significantly ($P<0.001$) increased SPAD values in all crop years at all three measurement dates. The correlation between year x NPK was significant at a level of 0.1%. This correlation shows that the effect of fertilisation depended on the given crop year and that it became more and more significant as the stage of 50% female flowering came closer, that is also shown by the Mean Square (MS) value of the correlation, MS=408.2; MS=1470.4; MS=4916.1. In the years with average precipitation, the effect of crop year increases until the 12 leaf stage, whereas this effect decreases at the flowering stage (MS=366.1; MS=2270.8; MS=1638.3).

We used Duncan's test at a significance level of 5% to analyse the results of fertiliser active ingredient experiments and we found more homogeneous groups in the dry crop years than in the average ones. We showed that 60 kg N ha^{-1} (at the 6 leaf stage) and 120 kg N ha^{-1} (at the 12 leaf stage and at 50% female flowering) are sufficient to obtain the highest SPAD values.

In each year and at all three measurement dates, the lowest SPAD values were recorded on plots that have not been fertilised since 1984. The highest SPAD value (60.3) was measured in 2004. The average SPAD values of fertilised parcels were significantly higher at the six and 12 leaf stages (53.6; 53.4) than in the average crop year (45.1; 51.5). Nevertheless, we measured a lower SPAD value (53.7) at the 50% female flowering stage in the average crop year than in the dry one (49.9). The difference was significant in all cases ($P<0.001$). The highest effect of fertilisation was measured in 2004 at all dates. The average SPAD values of fertilised treatments – in comparison with the non-fertilised ones – were higher by 4.0 at the six leaf stage, 12.1 at the 12 leaf stage and 14.7 at the 50% female flowering stage. Water shortage reduced fertiliser effect the most in 2007. Comparing average to dry crop years, we can state that in the dry crop year, the fertilisation increased SPAD values at six and 12 leaf

stages to a lesser extent, whereas it was more expressed at the 50% female flowering stage.

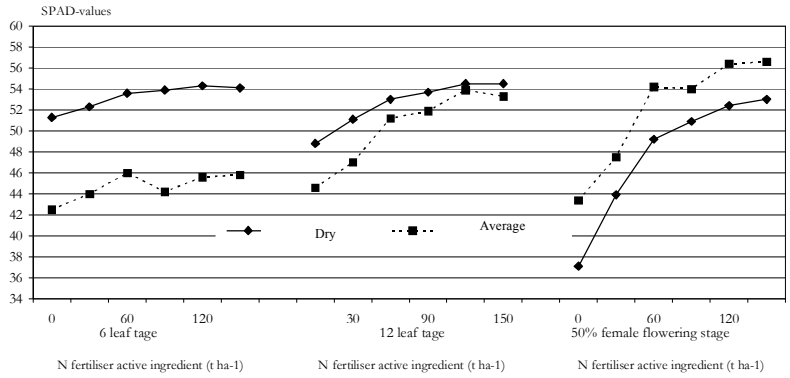

Figure 2. SPAD values against the development stage of maize, crop year effect and the N active ingredient dose
(Debrecen, 2003, 2004, 2006 and 2007)

We examined the correlation between fertilisation and SPAD values using regression analysis. The logarithmic term of fertiliser was the independent variable, whereas SPAD values was the dependent one. Based on a T-test, the parameters of the function are significant at a 0.001% level. There was a close correlation between the two variables in 2004, at 12 leaf stage (0.694) and at the 50% female flowering stage (0.737) (Figure 3). Of the examined years, we measured the weakest correlation in 2007, which was the driest year.
In summary, the correlation between the variables was weak at the six leaf stage but became stronger during the vegetative period.

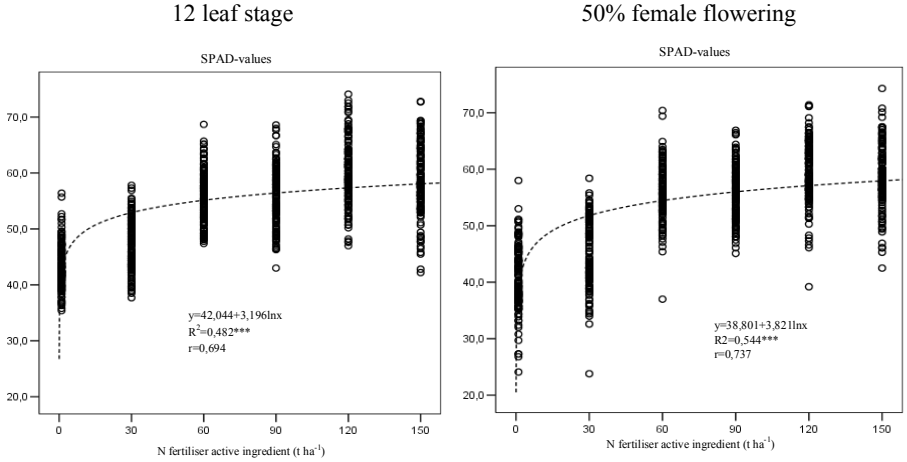

Figure 3. Relationship between fertilisation and SPAD values, the results of logarithmic regression
(Debrecen, 2004)

The dynamics of SPAD values in the vegetative phase

SPAD values were the highest at 6 leaf stage *in non-irrigated treatments* in the dry year – in the average of fertiliser treatments – that decreased during the development (Figure 4). By the time of 50% female flowering, the amount of decrease was 3.7 SPAD units in 77 days. The biggest decrease in SPAD values was measured on the control plot in both dry years. Compared to the 6 leaf stage, the decrease of the leaf's SPAD values was 17.5 in 2003 and 9.8 in 2007.

In crop years of average precipitation supply (2004, 2006) – in the average of fertiliser treatments – the lowest SPAD values (44.7) were measured at 6 leaf stage. As the growing period progressed, SPAD values also increased by 6.3 at 12 leaf stage and a further 2.3 at 50% female flowering stage. The N concentration of the leaf became abundant by the time of 50% female flowering (Figure 4). The highest increase in SPAD values until the time of flowering was shown by the fertiliser active ingredient treatment 120 kg ha^{-1}. When examining the two years separately, we found that in the growing period of 2004, - in the average of fertiliser active ingredient treatments - SPAD values increased by a relatively smaller extent (2.4) than they did in 2006 (5.3). Nevertheless, among fertiliser active ingredient treatments, the increase of SPAD values was smoother in 2006 than in 2004.

We concluded that SPAD values decreased during the growin season in dry crop years, whereas they increased in crop years with average precipitation supply.

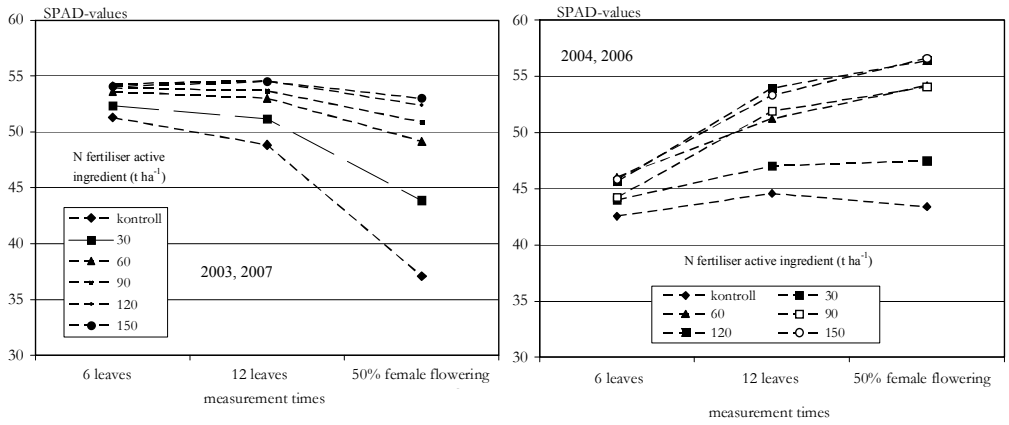

Figure 4. SPAD values of maize during the growing season in the average of dry crop years and crop years with average precipitation supply
(Debrecen, 2003, 2004, 2006 and 2007)

Analysis of the correlation between SPAD values and maize yield

We analysed the correlation between SPAD values and maize yield in the average of four years. We used correlation and linear regression analysis.

During the analysis of SPAD values and the yield data of maize, we observed that there is no stochastic correlation between the SPAD values measured at the 6 leaf stage. As the vegetation period progressed, we found a closer correlation between the two variables. The value of the correlation coefficient is positive, meaning that yield increased with the increase of SPAD value. Based on the statistical evaluation, the correlation between the two variables can be described by a linear function, also proven by the F-test at a significance level of 0.1%. Taking the value of coefficient of determination into consideration – in the average of four years – we concluded that there was an average (r=0.490) correlation between yield and SPAD values measured at the 50% female flowering stage.

Acknowledgement

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