EXAMINATION OF YIELD, LEAF AREA AND RELATIVE CHLOROPHYLL CONTENT, IN MONOCULTURE LONG-TERM EXPERIMENT OF MAIZE IN 2016-2018

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Abstract. *The development of the technology of maize production in Hungary depends largely on the genetic basis and the applied agrotechnology. Among the agrotechnical factors, the most powerful effect is provided by nutrient supply, modern and hybrid-specific plant nutrition. The experiment was carried out for three years in a small parcel set with three repetitions of double split parcels in Szarvas, at the Galambosi experimental site of the Faculty of Agricultural and Economic Sciences of Szent István University. In the experiment we examined the effect of three nutrients N, P and K, where the nutrients were released in three ascending stages. Nutrients, however, were not only tested on their own but in as many combinations as possible, so we can track the effect of each nutrient on each other. We measured the nutrients on a next levels, 4 nitrogens level (0 t/ha, 0,07 t/ha, 0,014 t/ha and 0,021 t/ha), 4 phosphoruses level (0 t/ha, 0,04 t/ha, 0,08 t/ha and 0,012 t/ha) and 4 potassiums level (0 t/ha, 0,06 t/ha, 0,012 t/ha and 0,018 t/ha). The gross, photosynthetically active size of the leaf area has a decisive influence on the size of the resulting crop, therefore, in our experiments, the leaf samples collected from the field experiments are sampled by our Eijkelkamp leaf area measuring device in the lab, and the quantified data are analyzed from several aspects. Samples are taken up to 50% of the leaf drying, so that we can track the rate and dynamics of leaf loss (drying) in stress. To measure the chlorophyll content of corn leaves, we use a portable Minolta SPAD photosynthetic pigment content meter. Using infrared light through the leaves, we can get quantifiable information (SPAD value). SPAD is a dimensionless number that can provide clear data for chlorophyll content in a letter. The result of the study is that there is a moderate positive correlation between the average yield , the relative chlorophyll content,and the leaf area, and the relationship being significant.*

Keywords: *relative chlorophyll content, yield, leaf area, maize, long-term experiment*

INTRODUCTION

The development of the technology of maize production in Hungary depends largely on the genetic basis and the applied agrotechnology. Among the agrotechnical factors, the most powerful effect is provided by nutrient supply, modern and hybrid-specific plant nutrition. Several literary references and scientific research suggest that the chlorophyll content of corn leaves shows a strong positive correlation with N feed. Fertilization is the most influential factor on the soil with adequate P and K supply. In our experiment, we wanted to know which nutrients we can detect in the long-term experiments at different levels of N, P, and K for changes in chlorophyll content, leaf area and yield.

CSAJBÓK et al. (2005) at the beginning of the vegetation period, increasing photosynthesis values were caused by increasing fertilizer doses, and the best results were achieved at the N240 + PK nutrient level. Later, the most favorable results were measured with

N60 + PK treatment. In their opinion, it is likely that the water shortage and stoma dislocation could cause this change.

Corn yields are influenced by a number of factors, such as: insufficient water and nutrient supply. These factors affect the leaf area of corn, where the process of photosynthesis takes place. All factors, including increasing nutrient supply, increase the photosynthetically active leaf area of maize maize (FUTÓ, 2003).

In a decades-long experiment, (BERZSENYI and DANG, 2003) showed that maize grain yield was the highest at 160kg / ha under nitrogen fertilization. According to earlier studies, the yield-increasing effect of phosphorus fertilization was the most justified on soils with poor phosphorus supply. (PEKÁR 1969, KADLICSKÓ and KRISZTIÁN 1977, LÖNHARDNÉ and NÉMETH 1989). Corn is extremely demanding for potassium supply. Several domestic arable land has been shown to have a significant effect on potassium. (KRISZTIÁN et al. 1988, KÁDÁR 1992, DEBRECZENI and DEBRECZENI 1994). IZSÁKI (2015) describes that, based on the results of 15 years, the soil could not show significant yield of potassium fertilization in the AL-K_2O supply range of 200-550 mg / kg. resulting from better K-supply.

El Hallof and Sárvári (2005) achieved the best photosynthesis and yield results for N40 + PK and N120 + PK fertilizers, as well as significant differences between maize yield and photosynthetic activity in control and fertilized plots.

According to BERZSENYI and LAP (2001), the concentration of chlorophyll in maize is positively related to the nitrogen concentration and nitrogen supply of the leaf. SZÉLES (2008), examining the relationship between corn leaf SPAD values and yield, concluded that there was a moderately close positive relationship between the two factors. SZÉLES et al. (2011) significantly higher chlorophyll content measured at average nitrogen fertilizer doses in a droughty year than in a year of favorable water supply. Overall, it can be concluded that the chlorophyll concentration of maize is positively correlated with the nitrogen concentration and nitrogen supply of the leaf (BERZSENYI and LAP, 2001).

JAKAB et al. (2005) examined the effect of nutrient supply on the photosynthetic activities and the yields of the different maize hybrids in Debrecen in 1999 and 2000. They were applied four fertilizer treatments: control (non fertilized), N 40+PK kg ha-1, N 120+PK kg ha-1, N 200+PK kg ha-1. The maximum photosynthetic activity was detected at N 120+PK kg ha-1 and N 200+PK kg ha-1 doses in favourable years, while in unfavourable years the maximum was at N 40+PK kg ha-1 and N 120+PK kg ha-1.

MATERIAL AND METODS

The experiment was carried out for three years in a small parcel set with three repetitions of double split parcels in Szarvas, at the Galambos experimental site of the Faculty of Agricultural and Economic Sciences of Szent István University. The soil of the experiment is carbonate chernozem meadow soil, its physical nature: clay loam, sour or weakly acidic, its water management is characterized by poor water conduction and high water retention. The level A is clogged, its total porosity, and the proportion of gravity pores within it is lower, and it does not contain CaCO3. Lower levels have high clay content, cracking, which explains the high water conductivity values. On the basis of the humus content, the N-supply of the soil is medium, the NO3-N content of the soil in the non-fertilized treatment is 19.8 mg / kg. P-, K-, Mg- and Mn-supply is too high, Zn- and Cu-supply is good.

Table 1.

Characteristics of the soil in the experiment (Szarvas, 0-30 cm soil layer) Source: Author 's own editing

pH (KCl)	K_A	$CaCO_3$	Humus (%)	AL-P_2O_5 $mgkg^{-1}$	AL-K_2O $mgkg^{-1}$	Mg (KCl) $mgkg^{-1}$	EDTA-Zn $mgkg^{-1}$	EDTA-Cu $mgkg^{-1}$	EDTA-Mn $mgkg^{-1}$
4,91	43,6	0,0	2,94	211	255	697	3,16	7,41	437

During the experiment, the following fertilizer compounds were used in as many combinations as possible (Table 2)

Table 2

Fertilizer compounds in the experiment

Levels	Fertilizer compounds kg ha-1	
	Basic fertilizer	Top-dressing Fertilizer
N0	0	0
N1	50	20
N2	100	40
N3	150	60
P0	0	0
P1	40	0
P2	80	0
P3	120	0
K0	0	0
K1	60	0
K2	120	0
K3	180	0

Maize needs between 450-550 mm of water. Although it utilizes very well water, it needs most in the flowering time. Therefore, the weather of the given year is not negligible, especially with regard to the quantity and distribution of fallen precipitation. Table 3 shows the monthly precipitation data in the experimental area with automatic meteorology equipment. The table also includes the deviations for the average of the last 30 years.

Table 3.

Data of rainfall between 2016-2018. Szarvas Source: Author 's own editing.

Month	jan.	febr.	march.	apr.	may.	jun.	jul.	aug.	sept.	sum / average
Mean of rainfall of 30 years (mm)	30,6	31,4	28,9	41,9	62,9	71,4	74,4	56,4	42,8	410,1
Rain 2016 (mm)	61,6	88,5	20	12,3	18,8	**124,4**	**124,4**	50,5	9,8	448,7

Difference to mean (mm)	*31*	*57,1*	*-8,9*	*-29,6*	*-44,1*	*53*	*50*	*-5,9*	*-33*	*38,6*
Rain 2017 (mm)	28,3	30,2	13,4	49,7	40,9	69,3	31,8	33,3	74,2	371,1
Difference to mean (mm)	*-2,3*	*-1,2*	*-15,5*	*7,8*	***-22***	***-2,1***	***-42,6***	***-23,1***	*31,4*	*-39*
Rain 2018 (mm)	18,3	70,3	75,2	11,2	37,4	31	69,8	43,9	14,5	371,6
Difference to mean (mm)	*-12*	*38,9*	*46,3*	*-30,7*	***-25,5***	***-40,4***	***-4,6***	***-12,5***	*-28*	*-38,5*

The data in the table show that the 2016 year was extremely favorable for maize in terms of water supply. Then and so much rainfall fell when the corn was the most important period. However the precipitation distribution of the last two years was extremely unfavorable. Quantities are far below the average of the last 30 years. The gross, photosynthetically active size of the leaf area has a decisive influence on the size of the resulting crop, therefore, in our experiments, the leaf samples collected from the field experiments are sampled by our Eijkelkamp leaf area measuring device in the lab, and the quantified data are analyzed from several aspects. Samples are taken up to 50% of the leaf drying, so that we can track the rate and dynamics of leaf loss (drying) in stress. In addition to the size of the leaf area of the corn, the chlorophyll content of the leaf also determines the production of organic matter and its production. To measure the chlorophyll content of corn leaves, we use a portable Minolta SPAD photosynthetic pigment content meter. Using infrared light through the leaves, we can get quantifiable information (SPAD value). SPAD is a dimensionless number that can provide clear data for chlorophyll content in a letter.

RESULTS AND DISCUSSION

In our monocultural long-term experiment, chlorophyll content, leaf surface and yield were measured in all nutrient combinations during the years studied. In this publication, the results obtained are analyzed in the mean of nutrient levels, and the relationships between the results are searched for. Based on our measurements, the SPAD values measured in our experiment are shown in Table 4. The leaf area index (LAI m^2 / m^2) is illustrated in Figure 1, while the yields can be seen in Figure 2. in the three years examined.

Table 4.

SPAD values on different levels in 2016-2018.

Nutrient levels	**2016**	**2017**	**2018**
1	51,76	55,65	53,08
2	53,61	55,76	54,36
3	55,57	56,75	54,45
4	55,91	56,02	54,89

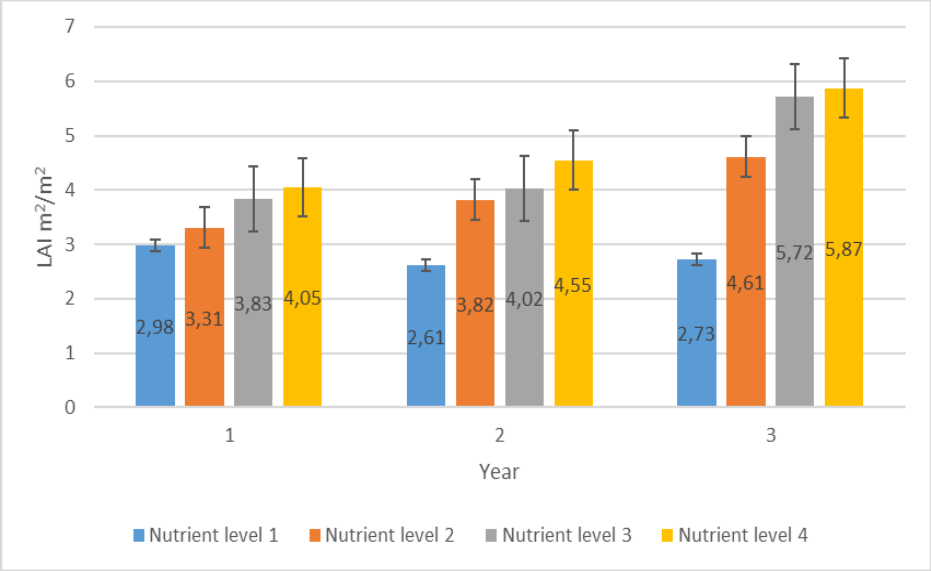

Fig. 1. Leaf area index on different levels in 2016-2018.

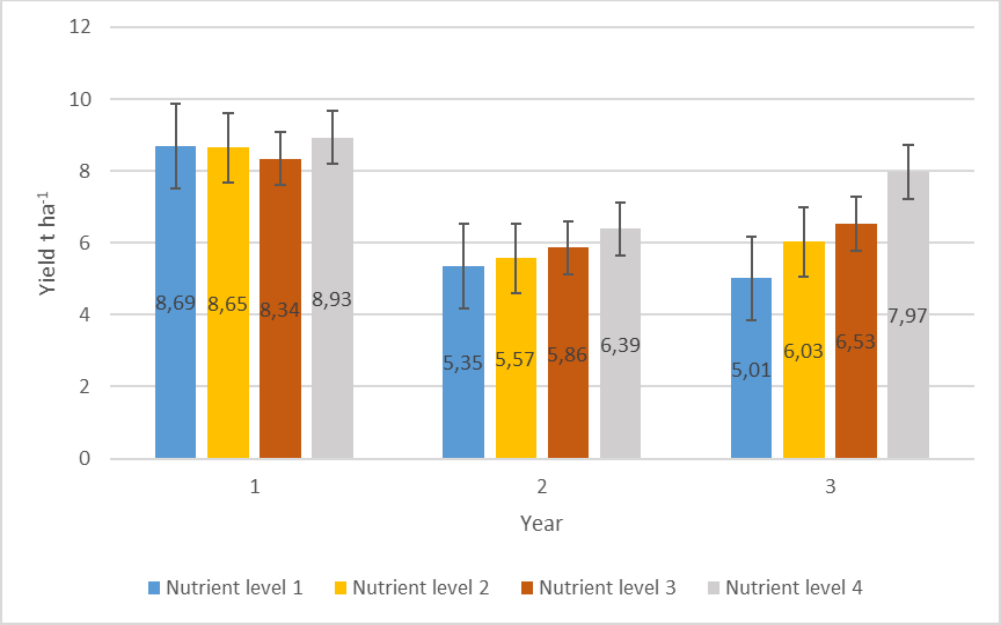

Fig. 2. Yield on different levels in 2016-2018.

The results presented above were subjected to statistical studies to demonstrate the relationship between the individual properties. Of the analyzes, Pearson's correlation analysis was used.

As a first step, we investigated the relationship between SPAD values and yields. The results are shown in Table 5.

Table 5.

Correlation between corn yield and SPAD values in 2016-2018.

Correlations			
		SPAD	**Yield**
SPAD	Pearson Correlation	1	-0,24
	Sig. (2-tailed)		**0,452**
	N	12	12
Yield	Pearson Correlation	-0,24	1
	Sig. (2-tailed)	**0,452**	
	N	12	12

The result of the study is that there is a moderate positive correlation between the average yield and the relative chlorophyll content, the relationship being significant.

The results of the correlation analysis between the average yield and the leaf surface index are shown in Table 6.

Table 6.

Correlation between maize yield and Leaf area in 2016-2018.

Correlations			
		Yield	**LAI**
Yield	Pearson Correlation	1	0,126
	Sig. (2-tailed)		**0,696**
	N	12	12
LAI	Pearson Correlation	0,126	1
	Sig. (2-tailed)	**0,696**	
	N	12	12

The data in the table show that the change of leaf area and the development of crop yields were even closer, the correlation coefficient was 0.696, which shows a close positive correlation.

CONCLUSIONS

Our experiment is a monocultural long-term experiment with a corn test plant in which we searched for correlations between the average yields of different nutrient levels, the relative chlorophyll content and the size of leaf area. The results showed that both SPAD values and changes in LAI values show a positive correlation with average yields. In the former case, we can speak of a medium correlation, while the latter shows a strong positive correlation.

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