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

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Abstract: *In Hungary, maize has the largest field after the winter wheat. Its 26-27% of all cultivated areas. In the World, the yield of maize were 1071 million tonnes in 2016 (FAO). It is estimated that this figure will grow by 12 million annually. Its main field of use is animal feed, which is about 90% of the yield in our country. The world's population is growing steadily, and this is predicting that the use of food is becoming increasingly important. We reveal the plant physiology and technological contexts in our examinations, that the bases of the modern nutrient solutions, and the scientific bases of the efficient development of the maize growing system The experiment was set up at Szarvas in the experimental field of the University of Szent István, Faculty of Agricultural and Economics Studies, in Galambos. During the research, we examined the effect of various nutrients (N, P, K) ratios on maize monoculture in long-term experiments. The contexts between the factors 64 nutrients we measured it on a supply level, 4 nitrogens portion (0 kg ha-1, 70 kg ha-1, 140 kg ha-1 and 210 kg ha-1), 4 phosphoruses portion (0 kg ha-1, 40 kg ha-1, 80 kg ha-1 and 120 kg ha-1) and 4 potassiums portion (0 kg ha-1, 60 kg ha-1, 120 kg ha-1 and 180 kg ha-1) On the parcels all possible combinations get to a setting, which makes the examinations of the interaction of the nutriment elements. The setting of the experiment onto the bases of the old fertiliser experiment of Faculty on a similar manner, on similar principles, modernized to the scientific and practical claims of our days. We examined the nutrient reaction of maize on the chlorophyll content, the establishment of the leaf area and the average yield. The increase of the leaf area yielded a tight positive correlation with the increase of the average yield and the leaf relative chlorophyll content. From among the nutriment elements we measured the most considerable positive effect in the case of the nitrogen in our experiment. The effects of the phosphorus and the potassium were smaller.*

Keywords: *relative chlorophyll content, leaf area, yield, nutrient supply, maize*

INTRODUCTION

In Hungary maize is the largest field crops, 26-27% of all arable land. Its main field of use is animal feed, which is about 90% of the yield in our country. In recent years, maize was the world's second largest field crop after wheat. Its output is based on FAO data on an annual basis of 1071 million tonnes in 2016 and is projected to increase this figure by an average 12 million tonnes per year. With increasing numbers of people in the world, however, the use of the food industry is becoming increasingly important. The development of domestic maize production is largely dependent on the applied agrotechnics. In addition to maintaining the required level of yield, the aim is to minimize crop rotation, with important NPK nutrient supply being also important. The maize leaf, in addition to forming a significant proportion of plant biomass and binding the light energy needed for photosynthesis, is the primary influencing factor of the biomass produced and its yield. The nutrient exploring capacity and nutrient utilizing capacity of the modern hybrids have improved significantly. These hybrids reached maximum yields already at N40-80, P2O5 25-50 és K2O 30-60 kg/ha, like PR37M81, Florencia and DK 557. We can grow these hybrids under extensive conditions as well for their excellent natural nutrient exploring capacity.(FUTÓ 2006.)

In NAGY (1995) opinion order in agricultural factors is the following: fertilization (48%), irrigation (28%), soil cultivation (18%) and density (6%).

The yield of corn may be influenced by many factors such as water- and nutrient deficiency, etc. All these factors have effects on the leaf area of corn, which is the most important scene of photosynthesis. If there are any opportunities to increase the photosynthetically active leaf area, it could have a very favourable effect on the potential yield. One opportunity for increasing the photosynthetically active leaf area is giving the plant an increasing nutrient supply. (FUTÓ 2003.)

BERZSENYI (1993) studied the dynamics of growth and growth characteristics of maize (Zea mays L.) a long-term trial in 1961. The N treatments were as follows: 0, 80, 160, 240 kg ha-1. The dynamics of growth of leaf area reliably reflect the effect of N deficiency and N fertilization, respectively, on growth. The yield(max) and LAI(max) and cumulated values of LAD were highest in N160 and N240 treatments.

MATERIAL AND METHODS

In the experiment we examined the effect of three nutrients N, P and K, where the nutrients were released in three ascending stages. However the nutrients 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.

Levels of nitrogen treatments:
N0 0 kg ha-1 N as basic fertilizer, 0 kg ha-1 N as top-dressing
N1 50 kg ha-1 N as basic fertilizer 20 kg ha-1 N as top-dressing
N2 100 kg ha-1 N as basic fertilizer 40 kg ha-1 N as top-dressing
N3 150 kg ha-1 N as basic fertilizer 60 kg ha-1 N as top-dressing
Levels of phosphorus treatments:
P0 0 kg ha-1 P as basic fertilizer
P1 40 kg ha-1 P as basic fertilizer
P2 80 kg ha-1 P as basic fertilizer
P3 120 kg ha-1 P as basic fertilizer
Levels of potassium treatments:
K0 0 kg ha-1 K as basic fertilizer
K1 60 kg ha-1 P as basic fertilizer
K2 120 kg ha-1 P as basic fertilizer
K3 180 kg ha-1 P as basic fertilizer

According to previous soil surveys, the soil of the experimental area is deeply carbonated chernozem soil. The main characteristics of the soil of the experiment can be summarized as follows from the soil tests performed (*Table 1.*)

Table 1.

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

H (KCl)	K_A	$CaCO_3$	Mould (%)	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

According to the soil tests, the physical surface of the soil is clayey, its staining is acidic, the cultivated layer does not contain CaCO3, the N content of the soil is moderate, the P - supply is excessive, the K - supply is good, the Mg is well Zn - very good, while Cu and Mn are satisfactorily equipped.

In the course of our investigations, the leaf samples collected from the field experiment were collected in the laboratory using the Eijkelkamp leaf area measuring instrument. In addition to the magnitude of the leaf area of the maize, the chlorophyll content of the leaf also determines the production of maize organic matter. To measure the chlorophyll content of maize leaves, a Portable Minolta SPAD photosynthetic pigment measuring instrument was used

To gather and analyze the meteorological data, the automatic meteorological station located near the experimental area is of great help for me. On a daily basis, rainfall and other weather data are obtained. In the year 2016 rainfall between January and September was 38.6 mm above the multi-annual average. The precipitation of the month of September fell by 33 mm below the 30-year average, which contributed water yields of large crops and to ripening.

Table 2.

Data of weather between jan. of 2016. and sept. of 2016. Szarvas, (1) Month, (2) Temperature, (3) Rainfall, (4) Mean of rainfall of 30 years, (5) Difference, Source: Author 's own editing

Month (1)	**jan.**	**febr.**	**march.**	**apr.**	**may.**	**jun.**	**jul.**	**aug.**	**sept.**	**sum / average**
Temperature(°C) (2)	-0,9	6,0	7,3	13,4	16,6	21,3	22,5	21,1	18,3	13,9
Rain (mm) (3)	61,6	88,5	20,0	12,3	18,8	124,4	124,4	50,5	9,8	448,7
Mean of rainfall of 30 years (mm) (4)	30,6	31,4	28,9	41,9	62,9	71,4	74,4	56,4	42,8	410,1
Difference (mm) (5)	**31,0**	**57,1**	**-8,9**	**-29,6**	**-44,1**	**53,0**	**50**	**-5,9**	**-33,0**	**38,6**

RESULTS AND DISCUSSION

After the manually harvest, crushing and processing the experiment the yield averages measured at different nutrient levels were obtained. The relative chlorophyll content of maize leaves was measured for four consecutive times in the same leaflet every time. The SPAD values obtained at the last measurement are given in *Table 3*. The SPAD value is a dimensionless number that can give clear data of the chlorophyll content on the leaf.

Table 3.

SPAD value on different NPK nutrient levels. Source: Author 's own editing

Nitrogen level	SPAD value	Phosphorus level	SPAD value	Potassium level	SPAD value
0	**45,513**	0	**50,796**	0	**49,100**
1	**49,628**	1	**48,049**	1	**51,083**
2	**48,640**	2	**47,330**	2	**48,693**
3	**53,652**	3	**51259**	3	**48,557**

By analyzing the variance of the SPAD values measured at the nutrient levels, we were tracked to see if the change would reach the level of significant difference. The variance values are shown in *Table 4.*

Table 4.

Table of variance analysis of SPAD value in 2016 Source: Author 's own editing

Dependent Variable: SPAD

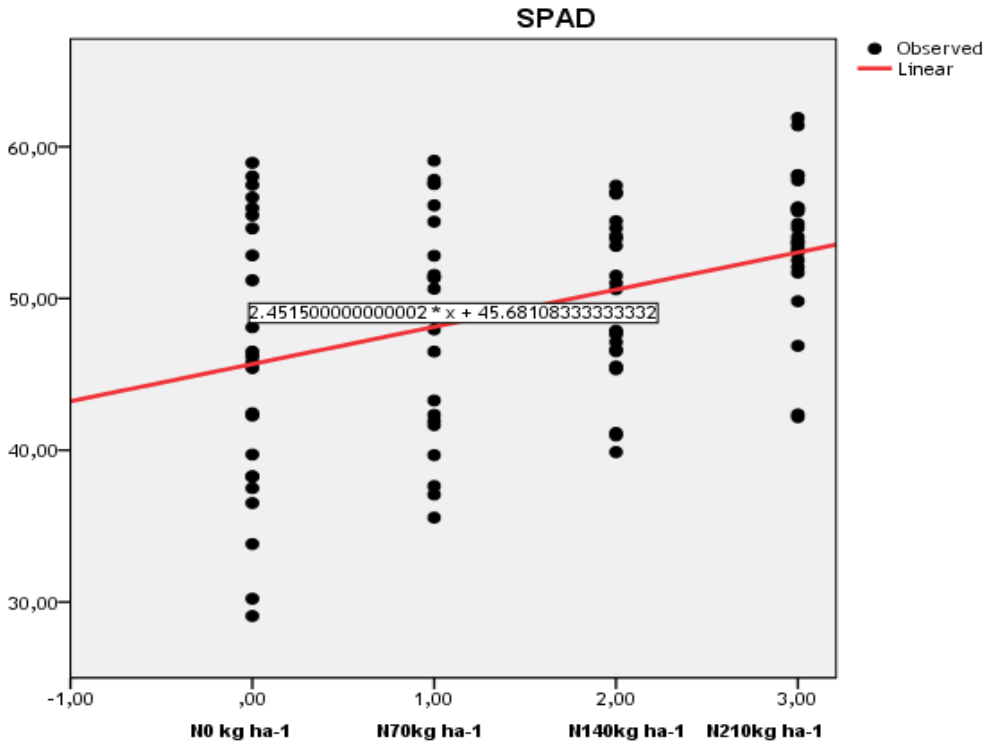
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1085,725[a]	9	120,636	2,642	,009
Intercept	233879,527	1	233879,527	5122,728	,000
Nitrogen	733,139	3	244,380	5,353	**,002**
Phosphorus	220,643	3	73,548	1,611	**,193**
Potassium	99,054	3	33,018	,723	**,541**
Error	3926,353	86	45,655		
Total	238891,605	96			
Corrected Total	5012,078	95			

R Squared = ,217 (Adjusted R Squared = ,135)

Based on the variance analysis, it can be stated that the significant difference between the last measurement times was only due to the N levels and the growth of the P and K levels did not cause significant relative increase of chlorophyll in the maize leaf. When analyzing the regression analysis of SPAD values, we found that the values change most linearly. Increasing levels of nitrogen resulted in a clear relative chlorophyll content (SPAD value), proving that the supply of nitrogen and the chlorophyll content of the maize has a positive and not too close correlation.

Figure 1.

Linear regression of maize's SPAD value and N levels. 2016 Source: Author 's own editing



Further, the increase in the SPAD value of nitrogen levels causing significant difference was also supported by Pearson's correlation study. As a result of the correlation test, a correlation coefficient of 0.379 has a positive sign and not close correlation between nitrogen supply and SPAD results. *(Table 5.)*

Table 5.

Correlation betwen Nitrogen levels and SPAD value Source: Author 's own editing

		Nitrogen	SPAD
Nitrogen	Pearson Correlation	1	**,379****
	Sig. (2-tailed)		**,000**
	N	96	96
SPAD	Pearson Correlation	**,379****	1
	Sig. (2-tailed)	**,000**	
	N	96	96

**. Correlation is significant at the 0.01 level (2-tailed).

The yield of maize is largely dependent not only on the chlorophyll content of the leaf but also on the size of the photosynthetic active leaf area. In our experiment, we measured the size of leaf areas measured at different nutrient levels and expressed on leaf area index (LAI m2 / m2) as well as analysis of data regression analysis.

Table 6.

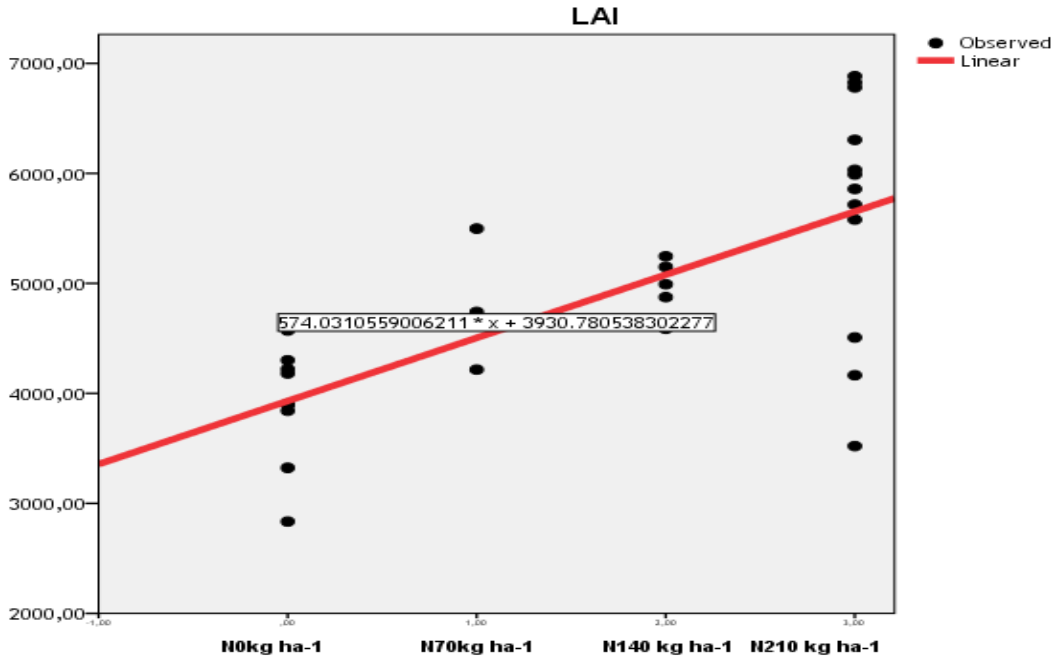
Change of LAI value of maize in different nutriation,

LAI m^2/m^2					
N0	2,81	**P0**	2,99	**K0**	3,15
N1	**3,47**	**P1**	3,05	**K1**	3,42
N2	3,54	**P2**	**3,83**	**K2**	4,14
N3	**4,09**	**P3**	4,41	**K3**	3,67

It is clear from the data that nitrogen and phosphorus have the greatest influence on leaf growth. The effect of potassium is extremely variable, which can be justified by the high potassium content of the experimental area. An exceptionally high LAI increase was observed in the N1 dose (70 kg / ha) nitrogen and N3 (210 kg / ha) nitrogen. (see Table 6) In addition to nitrogen, the phosphorus supply was also highly affected by leaf space change, where the significant LAI increase was ensured by the phosphorus dose of P2 (80 kg / ha). Plants of potassium treatment gave very scattered results, growth was non-linear, differences did not reach the significant limit.

Figure 2.

Linear regression of maize's LAI value and N levels Source: Author 's own editing



From the results of *Table 7*, it can be seen that increasing LAI values have been coupled with increasing yields only in the case of nitrogen treatments. In the case of phosphorus and potassium the effects are different, no clear experimental effect can be demonstrated. It can be stated, therefore, that nitrogen supply had a very favorable effect on the emerging SPAD values and the size of the leaf area, which resulted in a very favorable increase in yields. The role of phosphorus and potassium is smaller in the production of maize, they mostly affect the physiological processes of maize favorably. The effect on yield is smaller because it is based on the interaction of the different nutrients.

Table 7.

Change of yield of maize in different nutriation, Source: Author 's own editing

Yield t ha^{-1}					
N0	7,727	**P0**	9,459	**K0**	8,910
N1	8,809	**P1**	8,446	**K1**	8,718
N2	9,023	**P2**	7,974	**K2**	8,051
N3	9,080	**P3**	8,759	**K3**	8,959

The variance analysis of yield also supported this, and the strongest significant difference was observed with the effect of nitrogen.

Table 8.

Variance analysis of yield of maize in 2016 Source: Author 's own editing

	SQ	**df**	**MS**	**F**	**Sig.**
Corrected Model	138,733[a]	9	15,415	3,475	,001
Intercept	14397,596	1	14397,596	3245,843	,000
Nitrogen	57,656	3	19,219	4,333	**,006**
Phosphorus	55,851	3	18,617	4,197	**,077**
Potassium	25,226	3	8,409	1,896	**,132**
Error	807,298	182	4,436		
Total	15343,628	192			
Corrected Total	946,031	191			

CONCLUSIONS

In our experiment, the nutritional reactions of monocultured maize were studied on the relative chlorophyll content of the plant and its leaf area changes. In addition, we investigated the relationship between leaf area and SPAD values as well as crop yields. We found that the greatest effect of our experiment was shown by nitrogen among the three nutrients studied, with a lower effect on phosphorus and potassium. Significant differences between the examined parameters were found in most cases only in the case of nitrogen treatments, in the case of phosphorus and potassium the effects were most trendy and the significance limit was only very small. We have shown that growing leaf space and increasing relative chlorophyll content result in higher yield averages, and regression analysis supported our baseline hypothesis.

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