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THE EFFECT OF AMINO ACID PREPARATION AND FOLIAR FERTILIZERS ON MAIZE YIELD AND QUALITY

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Abstract: *We made the foliar fertilization experiments in the near of Szarvas in 2022 in cooperation with Hed-Land Hungária Ltd. The soil of the experimental area is deep carbonate chernozem meadow soil. The main characteristics of the soil of the experiment: its physical type is clay loam, its chemistry is acidic or weakly acidic, the cultivated layer does not contain* $CaCO_3$*, based on the humus content, the N-supply of the soil is medium. In the experiment, 5 foliar fertilizer and amino acid treatments were examined, supplemented by an untreated control plot. The treatments had a positive effect on maize yields in the experiment. The achieved average yields increased by 7.80 – 25.61% the average yield of the control, untreated plots (7.56 – 9.37 t/ha). The average yield achieved in the treated plots reached the limit of the statistically difference, so the effect of the treatments was significant. The highest yield average was obtained in the 2x Aminocore 2 l/ha and Ionic Zn 0.2 l/ha treatments (9.37 t/ha). During the experiment, we also examined the changes in the quality of the maize grain. Protein%, starch%, and oil% were measured in the study. We were able to establish that no clear correlation could be established between the treatments and the quality parameters. The values measured in the untreated control plots sometimes improved and increased in the treated plots, while in other cases we could see a slight decrease. Amino acid preparations therefore have a significant effect on the average yield, the quality is more of a genetically determined property.*

Keywords*: maize, yields, foliar fertilizers, amono acid preparation*

INTRODUCTION

Maize (*Zea mays* L.) is one of the world's major cereal crops, ranking third in importance after wheat and rice (LASHKARI et al., 2011; FUTÓ and SÁRVÁRI, 2015). Most of the maize produced worldwide is used for animal feed, although it is also part of the basic diet in human nutrition, as it is a good source of starch, proteins, lipids, polyphenols, carotenoids, vitamins and dietary fibre (NUSS and TANUMIHARDJO, 2010; BLANDINO et al., 2017).

According to FUTÓ and BODNAR (2021) for the uptake and transport of minerals, that is, the mineral nutrition of plants is associated with water uptake. In the case of arable crops, minerals are taken up mostly, but not exclusively by the roots. According to MUHHAMAD et al. (2022) conventional fertilizers have nutrient use efficiency of about 30–35 %, 18–20 percent, and 35–40 % for nitrogen, phosphorus, and for potassium. For foliar application, 5 treatments including control and four concentrations of nanofertilizer (10, 20, 30 and 40 ppm) were applied and the plant growth, photosynthetic pigments and antioxidant activity were increased by 59.28%, 48.19% and 52.91%, respectively.

Foliar fertilization is currently a highly efficient agronomic crop fertilization technique since it favours the assimilation of the nutrients in the plant and consequently, the utilisation of the nutrients applied with the fertilizer, thus increasing crop yields and quality (TEJADA and GONZALEZ, 2004; ABBAS and ALI, 2011). At the higher rate and for both seasons, foliar fertilization significantly increased the leaf concentrations of macro- and micronutrients, while grain protein content and yield increased by 26% and 14%. (TEJADA et al., 2018).

Phosphorus (P), the essential plant nutrient, is the key for numerous metabolic processes in plants, respectively in crops; and its deficit can severely diminish yield quantity and quality. Because soil P availability for crops is often limited, application of foliar P can be an alternative, meaning the P supply for plants during the growth season. Foliar application of

P is increasing significantly the assimilation of CO_2 and SPAD values; and additionally, it enhances the biomass production in all the plant components. Elemental analysis has revealed the increase of P concentrations in tissue following foliar P application in comparison with the plants deficient in P (HENNINGSEN et al. 2022).

Foliar application of nano-zinc oxide (ZnO) is an environmentally safe strategy that alleviates zinc (Zn) malnutrition by improving biochemical attributes and storage proteins of grain. Inoculation of B. subtilis and P. fluorescens with foliar nano-ZnO application is considered a sustainable and environmentally safe strategy for improving the biochemical, metabolic, nutritional, and productivity attributes of maize. (JALAL et al. 2023).

Numerous studies have shown the importance of amino acids in the plant's physiological activities, mainly at the cellular level. Since they are highlywater-soluble, the positive effects of applying amino acids might be due to their internal function within the cell as an osmo-regulator. This increases the concentration of cellular osmotic components (ABDEL-MAWGOUD et al., 2011), stimulating cell growth and consequently increasing the plants' chemical composition, as well as the growth, yield and quality of the harvest (AWAD et al., 2007; ABDEL AZIZ, 2009; THOMAS et al., 2009; ABD EL-AAL et al., 2010). Also and due to the chelating effect of amino acids on micronutrients, when applied together with micronutrients they facilitate the absorption and transport of these micronutrients inside the plant, since they also positively affect cell membrane permeability (IBRAHIM et al., 2010).

MATERIAL AND METHODS

We made the foliage fertilization experiments in the near of Szarvas (Hungary, Békés Country) in 2022 in cooperation with Hed-Land Hungária Ltd. The soil of the experimental area is deep carbonate chernozem meadow soil. The main characteristics of the soil of the experiment: its type is clay loam, its chemistry is acidic or weakly acidic, the cultivated layer does not contain $CaCO_3$, based on the humus content, the soil's N-supply is medium. The NO_3-N content of the soil in the control treatment was 18.7 mg/kg. P-, K-, Mg- and Mn- availability is excessive, and Zn- and Cu- availability is good *(Table 1.)*.

Table 1.

Characteristics of the soil of the experiment (Szarvas, 2022. 0-30 cm soil layer)

Study parameters	Sample			**Átlag**
	1.	2.	3.	
pH (KCl)	5,23	4,99	5,28	**5,03**
K_A (Soil resistance)	41,00	46,00	44,00	**43,67**
$CaCO_3$ [%]	0,00	0,00	0,01	**0,00**
Humus [%]	3,05	2,79	3,12	**2,99**
AL-P_2O_5 [$mgkg^{-1}$]	231	201	209	**213,67**
AL-K_2O [$mgkg^{-1}$]	252	241	268	**253,67**
Mg(KCl) [$mgkg^{-1}$]	627	689	690	**668,67**
EDTA-Zn [$mgkg^{-1}$]	3,01	2,81	3,39	**3,07**
EDTA-Cu [$mgkg^{-1}$]	7,10	7,23	7,61	**7,31**
EDTA-Mn [$mgkg^{-1}$]	411	427	441	**426,33**

Soil water management is characterized by poor water conductivity and high water holding capacity. The Asz level is clogged, its total porosity, and the proportion of gravity pores within it is smaller. The lower levels have a high clay content and are cracked, which explains the high water conductivity values.

The corn hybrid used in the experiment was PR9903. The hybrid was sown on May 10, 2022. The pre-crop of the experiment was winter wheat, the number of plants used was 76,500 plants/ha.

For maize, in the 2022 growing year, the amount of precipitation in the period from January 2022 to October 31, 2022 was 245.0 mm less than the 30-year average measured in the area. The 2022 growing season was unfavorable for the plants, so due to the extreme spring drought, we were forced to use early irrigation in the experiment in order to ensure the safety of the experimental emergence and the smooth development of the experiment.

In the period before sowing (January, February, March), the plant stands faced a significant water shortage. Although the 45 mm of precipitation in April helped to increase the water content of the soils, the first half of May was extremely dry and hot again, so there was not enough water in the seeding depth for a safe and uniform emergence of the experiment. Yeast irrigation has become inevitable! The amount of precipitation around flowering and saturation is important for corn, which was extremely unfavorable at the end of June in 2022 *(Table 2)*. The amount of precipitation in June was only 22.5 mm, which practically could not be useful for the plants. The extremely dry period continued in the months of July and August, breaking many years of drought records. The crop results were therefore at an extremely weak level in unirrigated conditions in 2022. In several places in the county, we found drying corn stands that had not even reached the crest flowering stage. In the case of irrigated stands, this could not be stated, because their average yield significantly exceeded this, achieving a good-excellent result. The experiment was irrigated with 60 mm in June, 80 mm in July, and 60 mm in August.

Table 2.

Precipitation data 01.01.2022. - until 30.09.2022. (Szarvas)

Data of rainfall 2022. Jan. – 2022. Okt., Szarvas											
Months	**Jan.**	**Febr.**	**Marc.**	**Apr.**	**Maj.**	**Jun.**	**July**	**Aug.**	**Sept.**	**Okt.**	**Sum**
Rainfall (mm)	9,0	6,1	10,4	45,0	12,3	22,5	26,8	37,3	62,5	0,4	232,3
Average of 30 years	30,6	31,4	28,9	41,9	62,9	71,4	74,4	56,4	42,8	36,6	477,3
Different	**-21,6**	**-25,3**	**-18,5**	3,1	**-50,6**	**-48,9**	**-47,6**	**-19,1**	19,7	**-36,2**	**-245,0**

The experiment was carried out in 4 replicate small-plot experiments. The size of the experimental plot was 48 m^2. The preparations were applied with a manual sprayer in the phenological phases of the BBCH scale indicated in the research plan, using a droplet size and pressure similar to field sprayers.

The treatments were:

- Aminocore 3l/ha (with weed control)
- Aminocore 5l/ha (with weed control)
- Aminocore 2l/ha + Ionic Zn 0.5l/ha (with weed control) then Aminocore 2l/ha + Ionic Zn 0.5l/ha (in 50% blooming with drone)
- Aminocore 2l/ha + Zsémix 2l/ha (with weed control)
- Ionic Zn 0.5l/ha (with weed control)
- Control

In the experiment, we continuously carried out pathological reclamation, where we monitored the plant protection resistance of the different plots. We measured the average yield, and in addition to the yield results, the quality of the plant products was also tested. The statistical analysis of the experiment was evaluated with the SPSS for 26.0 program.

RESULTS AND DISCUSSIONS

The treatments also had a positive effect on maize yields during the study. The yield averages achieved increased by 7.80 – 25.61% the average yield of the control, untreated plots. The size of the average yield achieved in the treated plots has already reached the limit of the difference that can be verified statistically, so the effect of the treatments was significant *(Figure 1.)*.

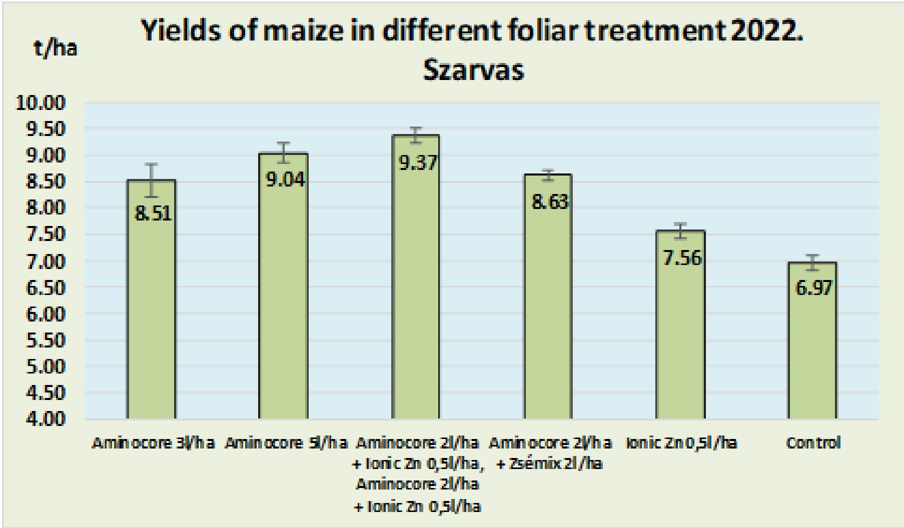

Figure 1. Yields of maize in different foliar treatment

The effect of amino acids was significant in all treatments during the experiment. The highest average yield increase was obtained in the twice applied Aminocore 2 l/ha + Ionic Zn 0.5 l/ha treatment 9.37 ± 0,138 t/ha. Ionic Zn 0.5 l/ha applied alone only increased the average yield by 7.56 ± 0,143 t/ha. The yield increasing effect of Aminocore 3 l/ha used alone was more favorable 8.51 ± 0,311 t/ha), but the combined use of the two foliar fertiliser (Aminocore 2 l/ha + Zsémix 2 l/ha) products was more favorable 8.63 ± 0,095 t/ha. The higher dose of Aminocore, 5 l/ha, increased the yield by 2.07 t/ha (9,04 ± 0,191 t/ha), exceeding the effect of the previous two treatments.

During the study, we measured the weight of the thousand seed mass of maize, which had a significant impact on the yields achieved. We were able to observe changes of a very similar than to the yields in the experiment. The effect of the amino acid treatments on the weight of the thousand seed mass of maize was positive and reached a significant level *(Figure 2.)*! The increased of the thousand seed mass of maize varied between 9.07-16.72%. The largest weight of thousand seed mass of maize 405.5 ± 6.86 g was obtained in the twice-treated Aminocore 2 l/ha + Ionic Zn 0.5 l/ha plots. In control plots (without foliar treatment), the weight of thousand seed mass was only 347.4 ± 2.65 g.

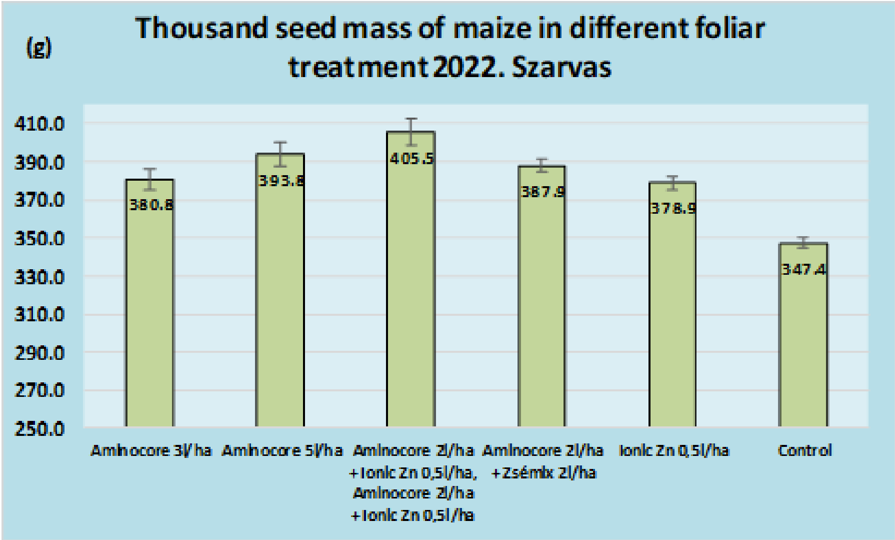

Figure 2. Thousand seed mass of maize in different foliar treatment

In the experiment, we also examined the changes in the quality values of the maize. The protein content was the first parameter measured. We found that for the control (untreated) plots, both a decrease and an increase could be measured visually. The change was not significant in the experiment *(Figure 3)*. The highest protein content 10.1 ± 0.05 % was measured in the Aminocore 2 l/ha + Zsémix 2 l/ha treatment.

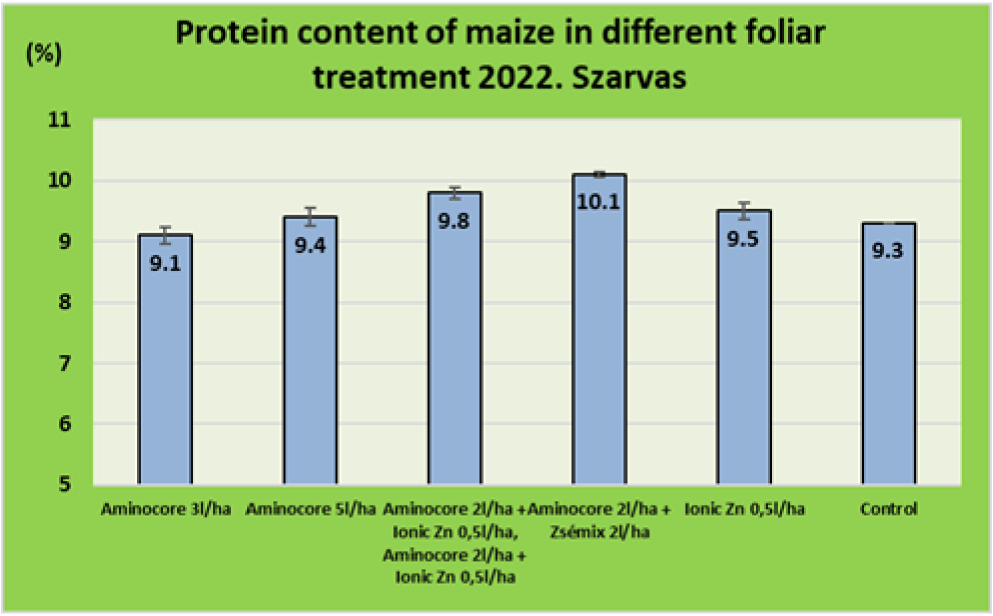

Figure 3. Protein content of maize in different foliar treatment

We also did not find large differences in the change of starch content. Most of the treatments exceeded the starch content of the control plot *(Figure 4.)*. The smallest starch content was measured in the 2x treated Aminocore 2 l/ha + Ionic Zn 0.5 l/ha plot (70.9 ± 0.28 %). The values did not reach the significant difference.

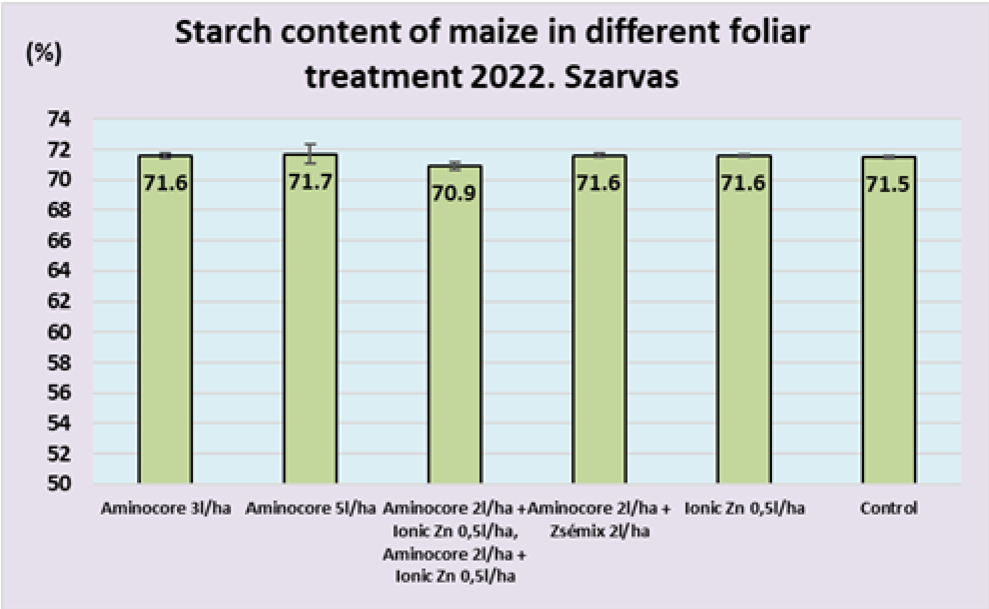

Figure 4. Starch content of maize in different foliar treatment

Finally, we examined the oil content of the maize, as a result of the different amino acid treatments *(Table 3.)*. In this case too, we found that there was no significant difference due to the treatments. The individual amino acid treatments had a higher oil content than the values measured in the control plot (3.6 ± 0.096 %).

Table 3.

Oil content of maize in different foliar treatment 2022. (Szarvas)

	Aminocore 3l/ha	**Aminocore 5l/ha**	**Aminocore 2l/ha + Ionic Zn 0,5l/ha 2x**	**Aminocore 2l/ha + Zsémix 2l/ha**	**Ionic Zn 0,5l/ha**	**Control**
I. replication	3,7	3,6	3,5	3,5	3,6	3,6
II. replication	3,5	3,6	3,6	3,5	3,8	3,5
III. replication	3,5	3,6	3,7	3,2	3,8	3,5
IV. replication	3,6	3,5	3,5	3,3	3,7	3,5
Mean	**3,6** ± 0,096	**3,6** ± 0,05	**3,6** ± 0,096	**3,4** ± 0,150	**3,7** ± 0,096	**3,5** ± 0,05

CONCLUSIONS

The technology of amino acid foliar fertilization had a very good effect on the average yield of maize in the experiment. The increase in the average yield was significant, 7.80 – 25.61%. As several authors write in their papers, Zn and amino acid treatments improve the photosynthetic activity of corn and the amount of photosynthetic pigments (MUHHAMAD et al. 2022). This helps to increase the average yield of maize. The highest average yield increase was obtained in the twice applied Aminocore 2 l/ha + Ionic Zn 0.5 l/ha treatment 9.37 ± 0,138 t/ha.

One of the most important yield parameters in the increase of the average yield is the increase in the weight of thousand seed mass. The mass of thousand seed can only grow significantly with a good water supply. Amino acid foliar fertilizer treatments act as good osmo regulators in the corn cells (ABDEL-MAWGOUD et al., 2011). In our experiment, the mass of thousand seed increased by 9.07-16.72% as a result of amino acid foliar treatments.

We were able to establish that no clear correlation could be established between the treatments and the quality parameters. Amino acid preparations therefore have a significant effect on the average yield, the quality is more of a genetically determined property.

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