THE EFFECT OF WATER DEFICIT AND AMINO ACID TREATMENTS ON THE DEVELOPMENT OF MAIZE

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Abstract. *In the experiment, we examined the effect of water deficit and amino acid foliar treatments on the development of maize in the year 2023. The experiment was carried out under controlled conditions in an experimental climate cabinet. The growing pots had a volume of 0.5 liters, in which 4 water supply levels were examined. We looked at the growth and development of maize at 20, 40, 60 and 80% of the soil water capacity. We examined root length, shoot growth, biomass and leaf surface development. With the improvement of the water supply, the development of the maize improved as expected! The favorable effect of the amino acid treatments was confirmed in the lower water supply level! Amino acid foliar fertilization increased the root mass by 7-19%! The root length also changed positively. Relative chlorophyll content (SPAD) was measured in the shoot. The relative chlorophyll content also developed favorably, slightly increasing as a result of the amino acid foliar treatment. The positive effect was also visible in the case of an increase in the leaf area, the leaf area index (LAI) increased by 6.8 - 20.1 % as a result of the amino acid treatments. During the treatments, we found that amino acid treatments can reduce the stress effects caused by drought! The treated plants were stronger and more developed! These treatments may play an important role in the treatment of drought stress in the future! We would like to continue the experiments in the future in order to develop an efficient technology for the conditions of dry farming.*

***Keywords**: maize, water deficit, foliar fertilizers*

INTRODUCTION

Drought is an enduring abiotic constraint to stable and consistent maize productivity under climate change, especially for low rainfall regions with limited irrigation. One adaptation for severe drought is using drought-tolerant hybrids. They showed that drought-tolerant hybrids had greater yield gain and water savings through improved water productivity under deficit irrigation, highlighting the potential of deficit irrigation for increasing yield for the adoption of DT hybrid. (ZHENG'E et al. 2022).

Given that around one-third of crop yield variability is underpinned by climate variation (RAY et al., 2015), food security under climate change largely depends on the resilience of crop yields to climatic variability. Maize (*Zea mays* L.) plays an essential role in global food security, contributing some 39% of global cereal production in 2020 (FAO, 2021). As the world's largest maize producer, the United States (US) typically supplies ∼40% of global maize production. However, maize is highly sensitive to drought stress (HARRISON et al., 2014, ALI et al., 2016, Tardieu, 2020). Improving crop tolerance to drought has the potential to offset yield losses and sustain maize productivity under climate change in vulnerable regions (TESFAYE et al., 2018). Drought stress is a major cause of yield reduction in maize (*Zea mays* L.), and its effects have far-reaching global socioeconomic implications. In both temperate and tropical regions suitable for commercial maize production globally, the average annual maize yield loss attributable to moderate water deficits is approximately 15% (BARKER et al., 2005). According to Futó and Bencze (2022) the favourable water supply resulting from irrigation in hybrids shows that the decreasing effect of ever-increasing dry periods in climate change is significant, yields decreased in the control plots with bad water supply by 6.72 t/ha (P9903) and 6.07 t/ha (DKC4541). Avoidance of drought, through selecting crop types with lifecycles that enable drought avoidance is one form of adaptation (HARRISON et al. 2014), while breeding of drought-tolerant (DT) maize hybrids is another effective way to maintain the yield with less crop water requirements, particularly in semiarid regions (COOPER et al., 2014).

Drought tolerance is a complicated and multifaceted physiological mechanism (SENAPATI et al., 2018). Compared with conventional hybrids, DT hybrids generally present a yield benefit and/or improved yield stability in water-limited environments (CATTIVELLI et al., 2008; SAMMONS et al., 2014). Drought tolerance in maize is likely to entail the selection of plants with a reduced leaf area (especially in the upper part of the plant), short thick stems, small tassels, erect leaves, delayed senescence, lower root biomass, and deeper root systems with less lateral branching (RIBAUT et al., 2009). KOMLÓSI and FUTÓ (2022) concluded that the hybrids with the best irrigation reaction were clearly GKT 4486 and GK SILOSTAR. These two hybrids were sensitive to drought, but their good irrigation response helped them achieve high biomass and root weight. They could even grow a good cob weight with a good water supply, and they were both able to achieve the highest root mass in the irrigation treatments.

According to KOMLÓSI et al. (2023) the right choice of hybrids is an essential ingredient for economic and sustainable farming, since with a good choice of hybrids we are able to reduce the negative effects of climate change to a certain extent. Another result of our research for us is that irrigation and the conservation of water in our soils can be crucial both in a drought and in a normal year, as it is the most important limiting factor in maize production today.

MATERIAL AND METHODS

In the experiment, we examined the effect of water deficit and amino acid foliar treatments on the development of maize in the year 2023. The experiment was carried out under controlled conditions in an experimental climate cabinet. (Figure 1) The growing pots had a volume of 0.5 liters, in which 4 water supply levels were examined. We looked at the growth and development of maize at 20, 40, 60 and 80% of the soil water capacity. We examined root length, shoot growth, biomass and leaf surface development.

Figure 1. Maize in climate cabinet

The irrigation doses in the experiment were set as follows. We weighed the mass of the soil that had been dried to an unabsorbable water content, then irrigated it up to its water capacity and weighed the mass of the wet soil again.

From this, we calculated the 20, 40, 60 and 80% water capacity masses, which were as follows:

Weight of dry soil: 435 g. Weight of the soil irrigated up to the water capacity (WC): 585 g

Water Capacity 80%: 555g (WC80%)

Water Capacity 60%: 525 g (WC60%)

Water Capacity 40%: 495 g (WC40%)

Water Capacity 20%: 475 g (WC20%).

In the experiment, we examined the early development of 3 maize hybrids. The hybrids were:

1. P9398;
2. P9978;
3. P0023.

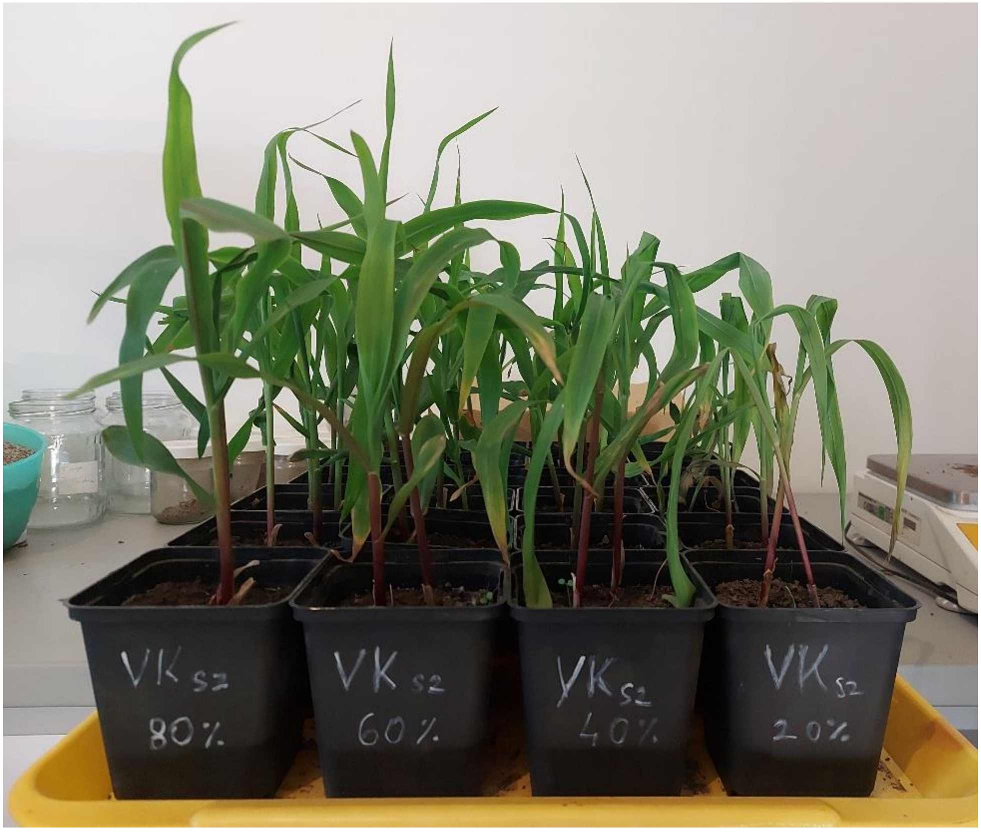

Figure 2. Maize plants in different water supply (WC20%, WC40%, WC60% and WC80%)

In addition to the irrigation doses, an amino acid preparation (Naturamin WSP) was also used in the experiment. The amino acid treatments were carried out in the 4-leaf stage of the plants, using a hand sprayer, according to the dosage indicated on the product. Naturamin supports several physiological processes at the same time. It has an effect on photosynthesis, water and nutrient uptake, and improves plants' resistance to biotic and abiotic stresses. Amino compounds promote enzyme formation and protein synthesis and are essential for the proper physiological functioning and development of the plant. In plant tissues, glycine, alanine and glutamic acid are essential metabolites in the formation of chlorophyll. These substances increase chlorophyll levels by increasing the level of photosynthesis, which guarantees healthier plants and higher yields. Naturamin-WSP contains substances that are precursors of auxins, flowering inducers and growth promoting substances. A unique formula rich in proline and serine protects plants from the harmful effects caused by high concentrations of inorganic ions, high temperatures, salinity and lack of water. In the experiment, we investigated whether amino acid preparations reduce the stress effects caused by water shortage.

Maize plants were measured after 8 weeks and the experiment was terminated. Biomass mass (g), root mass (g), SPAD value, and leaf area (LA) cm^2 were measured.

RESULTS AND DISCUSSIONS

During the biomass test, we first analysed the WC20% treatment. The biomass weight of the hybrids varied from 1.1g to 2.18g per growing pot. At the lowest water dose (drought stress), this is a very low biomass value. In the case of stressed plants, we also investigated the effect of amino acid preparations. We found that in the case of the P0023 corn hybrid, the treatment showed a very significant effect, because the biomass increased by 49.5%! In the case of the P9398 hybrid, the biomass was balanced, but here too we measured an increase of 10.8%! (Figure 3).

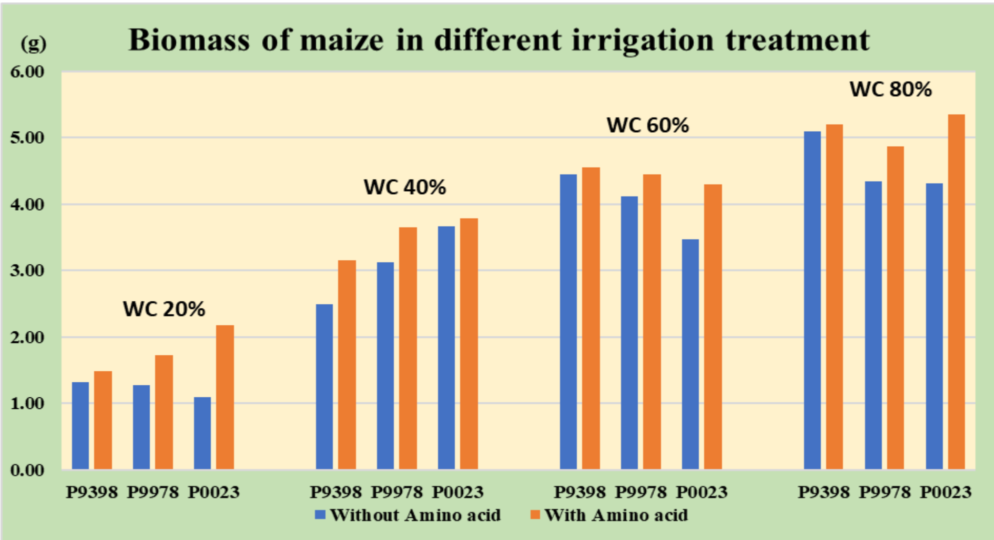

Figure 3. Biomass of different maize hybrids in irrigation and amino acid treatment

Our second treatment was growing pots irrigated up to 40% of the water capacity. The biomass increased significantly; the biomass weight of the corn hybrids changed from 2.49 g to

3.78 g. As a result of irrigation, the corn biomass increased by an average of 42.4-55.9%! At the 20% level of water capacity, there were very drought-stressed plants.

The beneficial effect of amino acid treatments was also seen in this treatment. In the case of the P9978 hybrid, the biomass increased by 14.6%, while the P9398 hybrid increased by 20.9%, reducing the effect of drought stress!

Our third watering source in the experiment was growing pots irrigated up to 60% of the water capacity. The biomass continued to increase; the biomass of the corn hybrids varied from 3.47 g to 4.55 g. As a result of irrigation, the corn biomass increased by an average of 16.9-28.2%! Growth is slower, as the water supply to the plants is constantly improving.

The beneficial effect of the amino acid treatments was also visible in this treatment, a higher biomass was formed in the growing pots treated with amino acids than all hybrids. As a result of the improved water supply, the effect of the amino acid treatments decreased. In the case of the P9398 hybrid, the biomass weight increased by 2.2%, in the P9978 hybrid by 7.4%, and in the P0023 hybrid by 19.1%.

Finally, we examined the optimal water supply treatment (W80%). The biomass continued to increase in this treatment, but the intensity of the increase was moderate, varying from 15.1% to 19.7%. The improved water supply was no longer a limiting factor, so the rate of growth slowed down. In the amino acid treatments, hybrid P0023 again showed the highest biomass increase. As a result of the amino acid treatment, the weight of the hybrid biomass increased by 19.4%.

Overall, it can be concluded that the biomass of all hybrids increased due to the improved water supply and amino acid treatment. Among the hybrids, the P0023 hybrid showed the highest amino acid reaction even at 3 water doses. This may indicate that the hybrid has significant drought stress sensitivity. The biomass-increasing effect of the amino acid treatments is also high 13.25% on average for irrigations and hybrids! The effect of the improved water supply was, of course, high, 68.9% in the average of the hybrids and the treatments.

When examining root masses, we obtained similar results as in the case of biomass. (Figure 4). However, the change in root masses resulted in smaller differences. In the case of all hybrids and at all water supply levels, the measured root weight increased as a result of the amino acid treatment. The improvement of the water supply had a smaller effect on the root mass, the root mass did not increase significantly in the WC80% treatment, but the growth was dynamic until the WC60% treatment! Among the corn hybrids, the root weight of P0023 without amino acid treatment already reached 3.4 g in the WC40% treatment, which did not increase significantly after that.

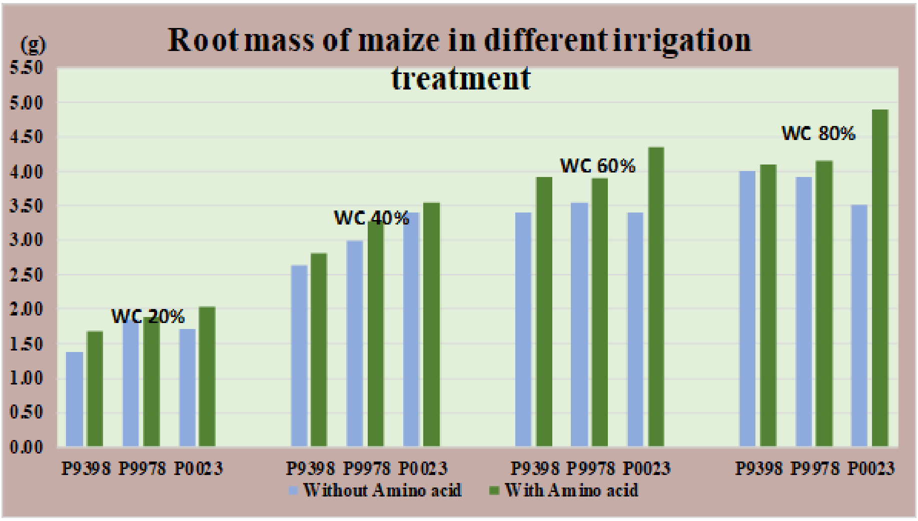

Figure 4. Root mass of different maize hybrids in irrigation and amino acid treatment

Finally, we examined the relative chlorophyll content and the area of the blue leaf, which is the basis of photosynthesis in corn. The two factors together affect the production of organic matter in the case of corn. The higher the relative chlorophyll content (SPAD) of the corn, the more efficient the photosynthesis will be, and the larger the area of the leaf, the larger the surface area of organic matter production! In our experiment, as the water supply improved, the SPAD value of the corn hybrids increased, and the leaf chlorophyll content increased. Albeit to a small extent, the relative chlorophyll content in the leaves of the corn hybrids also increased as a result of the amino acid treatments. (Table 1)

Table 1

SPAD value of different maize hybrids in irrigation and amino acid treatment

WC20%	Without Amino acid	With Amino acid	WC60%	Without Amino acid	With Amino acid
P9398	20,60	27,23	**P9398**	29,20	32,00
P9978	29,17	33,80	**P9978**	34,27	34,70
P0023	31,93	32,90	**P0023**	29,27	29,67
Mean	**27,23**	**31,31**	**Mean**	**30,91**	**32,12**
WC40%	**Without Amino acid**	**With Amino acid**	**WC80%**	**Without Amino acid**	**With Amino acid**
P9398	23,93	33,80	**P9398**	32,73	35,57
P9978	32,80	30,90	**P9978**	32,73	29,80
P0023	29,50	32,10	**P0023**	31,00	32,10
Mean	**28,74**	**32,27**	**Mean**	**32,16**	**32,49**

The change in the leaf area of maize showed the biggest increase! As a result of the improved water supply, the leaf area (LA) increased to a great extent by 75%, and photosynthesis could therefore take place to a greater extent. In all cases, the hybrids increased their leaf area with the improvement of the water supply and also as a result of the amino acid treatments. (Figure 5).

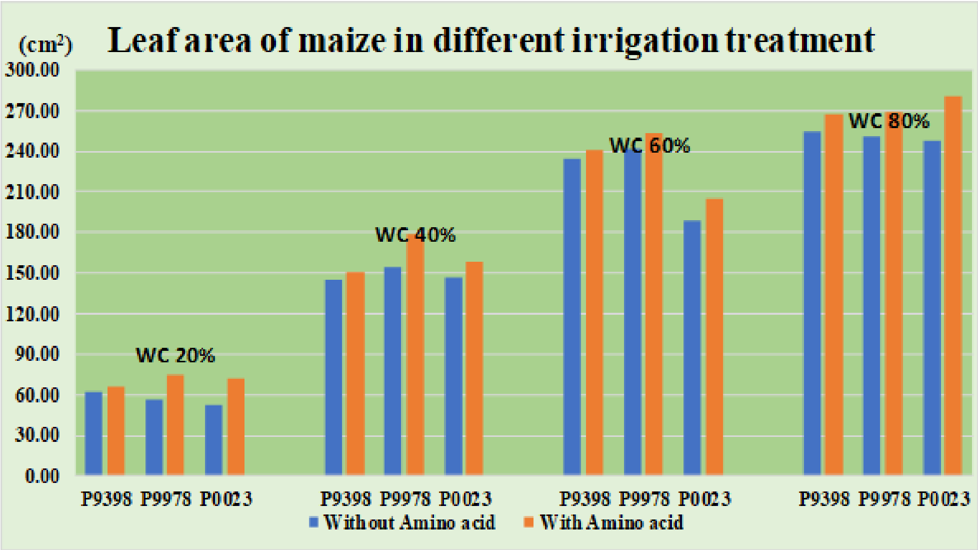

Figure 5. Leaf area of different maize hybrids in irrigation and amino acid treatment

The leaf area values were the lowest in the WC20% treatment with a size of 52.65 - 74.75 cm^2. In the WC40% treatment, the leaf area increased significantly to 144.9 - 178.9 cm^2. This dynamic increase was also maintained in the WC60% treatment, where the leaf area values reached 188.3 - 254.1 cm^2. This growth slowed down in the WC80% treatment, but the growth is still significant, the leaf area of the hybrids varied between 248.1 - 280.2 cm^2. Among the hybrids, the P0023 hybrid increases its leaf area evenly, almost linearly, while the P9398 and P9978 hybrids increased their leaf area dynamically up to the WC60% treatment, from there the improved water supply did not result in a further significant increase. These two hybrids show that they do not need soil with a water capacity of 80%, a slightly drier environment is sufficient, they have better drought tolerance!

CONCLUSIONS

Overall, we can conclude that maize hybrids react differently to the negative effects of drought stress. The biomass, root mass, and leaf area of hybrids with good drought tolerance decrease less than those of sensitive hybrids. During the experiment, it was proven that the amino acid treatments had a positive effect on the development of the corn in all cases! In some cases, the increase was very significant, even 20-40%!

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