DROUGHT STRESS INVESTIGATION OF DIFFERENT MAIZE HYBRIDS

Á. KOMLÓSI*, G. BENCZE, Z. FUTÓ
Hungarian University Agricultural and Life Sciences
Department of Irrigation and Melioration
5540 Szarvas, Petőfi utca 9. Hungary
Corresponding author: adamkomlosi24@gmail.com , bencze.gabor@uni-mate.hu , futo.zoltan@uni-mate.hu

Abstract: *The head of the research is to investigate the effects of mild salt and drought stress on different maize hybrids. The research was set up at 2022 in Szarvas in the area of Hungarian University Agricultural and Life Sciences Department of Irrigation and Melioration. In the research below, we examined the responses of different maize hybrids to mild salt stress and different irrigation treatments. The research was protected from the natural rain, so we took this research under a foil tent. In the experiment, we set up 3 different water doses and a mild salty treatment with the 3 water doses, and these were set up in several repetitions. We measured various phenological parameters on the maize several times during the research, and the final biomass weight at harvest of the experiment. In the research, we examined and analyzed the importance of hybrid selection and irrigation. In the course of the research, we measured the photosynthetic activity and different phenological parameters of different maize hybrids in a pot experiment. During the experiment, drought-sensitive and tolerant hybrids were tested under saline and non-saline conditions. During the experiment, plant height, leaf area (LAI) and relative chlorophyll content (SPAD) were measured every 2 weeks. In today's climate-burdened world, we are increasingly confronted with the negative effects of drought and salt stress, but if we can prepare for and counter them, we can simply have a positive impact on our crop results. The experiment sheds light on how much a simple hybrid choice can affect our yield in a drought or normal year, or even on a saline soil. The novelty of the topic lies in the hybrids and field irrigation / water management results can be further refined for hybrids and soil hybrid and soil-specific irrigation adapted can be use.*

Keywords*: stress, salt, irrigation, maize, drought*

INTRODUCTION

In the case of corn, we distinguish between primary and secondary root systems. The primary or basal root penetrates into the deeper layers of the soil and reaches a depth of up to 2-2.5 meters. From the 2-3-4 nodes close to the soil surface, it can continuously develop additional roots during the growing season, while above the soil surface it produces supporting/dew roots, which they help plant stability and dew utilization (Pepó 2019). During the growth of maize, they are usually exposed to various environmental stresses that limit their growth and productivity (MOUD and MAGSHOUDI, 2008; VUJAKOVIĆ et al., 2011; TUTEJA et al., 2012; KUMARI et al., 2014).

Maize is moderately water-demanding, which can be placed between 450-550 mm. The daily water consumption is 4.5-5.5 mm/ha. Maize's water consumption is highest from the time of earing to grain saturation, while it is lowest at the beginning of development (FUTÓ and SÁRVÁRI 2015, MENYHÉRT 1979).

The generative parts can develop, but as a result of heat stress, even with optimal water supply, the plant may lose its fertility. The concept of water stress includes both salt stress and drought stress (KAUR and ZHAWAR, 2015) and it has been observed that salt stress combined with drought stress can cause even greater yield loss (CONG et al., 2021).

According to PEPÓ (2011), the new directions of plant breeding help and include the maintenance of biodiversity with different methods, since we are only able to carry out appropriate selection with the help of genetically diverse populations. In the today climatic changes world, in Summer we could see the differences of rain at least 5 mm within 200-300 meters (HUDÁK and GOMBOS 2022). Among today's selection goals, increasing resistance to biotic and abiotic stress is the main breeding goal, which proves to be an important value-measuring trait in the 21^{st} century.

MATERIAL AND METHODS

We research the mild salt stress reactions of five different maize hybrids and the drought stress reactions in a pot experiment. In the experiment setting up, 11 kg of arable land was weighed into the culture vessels and the main soil physical and chemical properties of the arable soil were determined. The experiment was set up on May 26 and was harvested on July 27 in 2022.

We set 3 water supply levels in the experiment. We first determined the natural water capacity (SWS) of the soil, which was the amount of water that the soil could retain against gravity. The following treatments were set up in the experiment:

- SWS 40% (40% of the water content of the soil saturated to natural water capacity);
- SWS60% of water content (60% of the water content of soils saturated to natural water capacity);
- SWS80% of water content (80% of the water content of soils saturated to natural water capacity).

In the research the water was applied to the culture vessels every second day and we make a special irrigation system in the foil tent at spring and a different at summer. The amount of water applied per day was recorded regularly, if the temperature and the evaporation of the plant justified it, we changed the amount of water applied per day. The salt tolerance experiments were also based on the setting of treatments with different water supply levels (SWS40%, SWS60% and SWS 80%). The salt tolerance of the different maize hybrids was monitored by the application of Na salts added with irrigation water. The salt mixture contained NaCl, $NaSO_4$ and $NaCO_3$. During the treatments we tried to model the water management properties of a mild quality saline soil.

Our plants stopped photosynthesizing and died as a result of the early high heat totals and the July heat. Due to the early harvesting of the experiment, we could not measure the tube mass results, as they were still very rudimentary.

The following phenological parameters were measured in the experiment:

- Relative chlorophyll content (SPAD) with Konica SPAD 501 instrument;
- Leaf area (based on the Montgomery formula);
- Leaf area index (LAI m^2/m^2);
- Plant height;
- Leaf and stem weight;
- Root mass.

The data were measured several times during the growing season, every two weeks (SPAD, leaf area, plant height), and the final biomass was measured during the harvest (leaf and stem weight, root weight).

The data was processed using the Microsoft Excel program.

Data were measured several times during the growing season, every two weeks (SPAD, leaf area, plant height), and final biomass was measured at harvest (leaf and stem weight, root weight etc.).

RESULTS AND DISCUSSIONS

In Figure 1, the hybrid called P0710 achieved the lowest root weight (93.36g). Looking at the P0710 hybrid and P0023, it is clear that they have different root weight results at different water doses. The hybrid called P9610 and P9363 achieved the highest root mass (149.5g-165.2g) at the medium water level SWS60%, although just ahead of the SWS 80% (134g-152.2g).

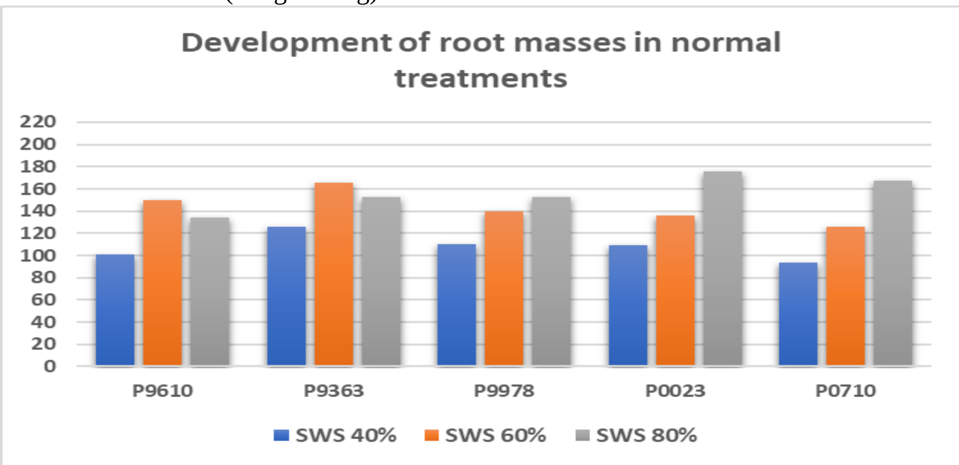

Figure 1. Development of root masses in normal treatment

The hybrid P9978 achieved medium root mass results at all three water doses in the average of the 5 hybrids, which shows us that the drought stress caused by the different water doses did not result in such a change in root mass as, for example, P0710 or P0023. The latest 2 hybrids achieved a small root mass at the SWS 40%, but thanks to their good reaction to irrigation, their root mass increased significantly to the improved water rations.

The P9363 hybrid reached the highest root mass (126g) at a 40% water dose of SWS, which is greater than that of P0710 at a 60% water dose of SWS (125.5g). P9363 responded well to drought conditions and reached the highest root masses at a water dose of SWS 40% and SWS 60%.

Figure 2 shows us how much root mass the plants achieved in the mild saline treatments. The lowest root mass was achieved by the P9610 hybrid at a 40% water dose (103.5g). In all cases, the plants achieved the largest root mass at a water ration of SWS 80% and in this case the P9363 hybrid achieved the largest, which is 213.5g. Looking at the graph, we can see that the hybrids achieved higher root masses on average in the slightly saline treatments than in the non-saline ones. The greatest increase was achieved by the P9363 hybrid at SWS 80%, which shows an increase of +61.3 g as a result of the salt treatments. The P9978 and P0023 hybrids reached almost the same root masses at all three water doses, which shows us that the plant was not really affected by the stress caused by the lack of water, but rather that the salt was a greater stress factor for it. In general, hybrids grew larger root masses in saline treatments than in non-saline treatments. We only exposed the plants to a small amount of salt stress, but this was just enough for the plants to compensate by increasing their root mass, which can be said to be successful considering the other results. With the increased root masses, the plants were able to increase their water absorption and thus balance the disadvantage caused by the salty conditions, thanks to which we could not measure any significant changes in the other results between the salty and non-saline conditions.

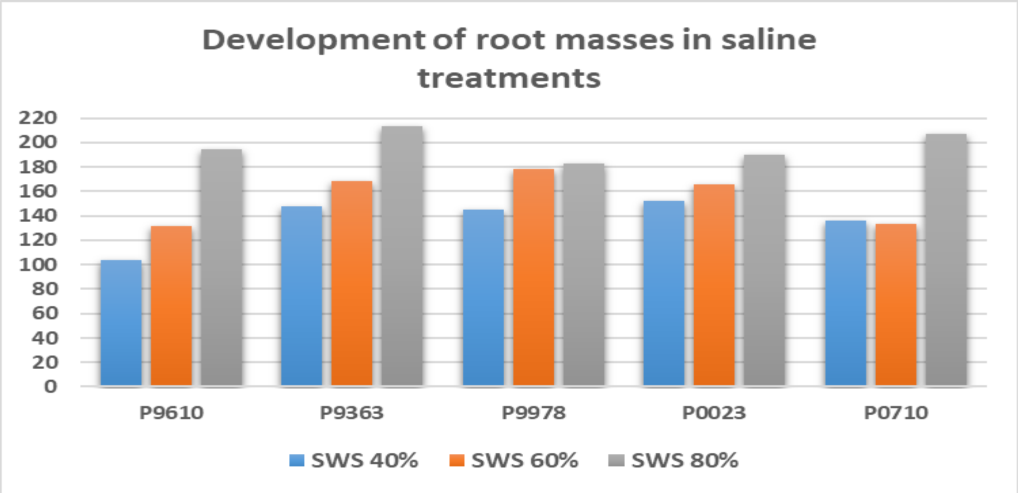

Figure 2. Development of root masses in saline treatments

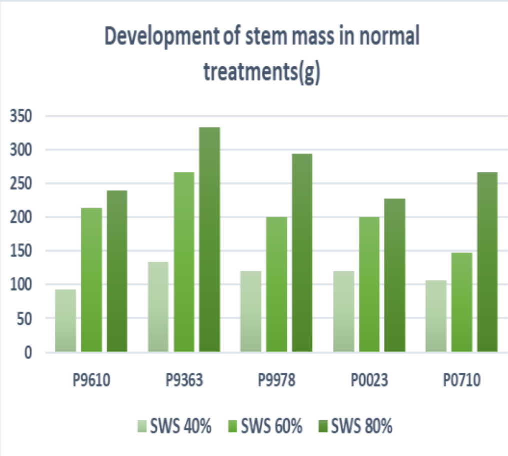

Figure 3. Development of stem weights in normal treatments

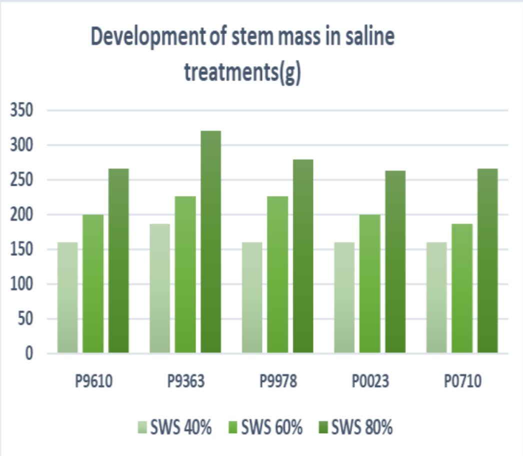

Figure 4. Development of stem weights in saline treatments

The stem weight of the hybrids reflects the different water doses. The lowest stem weights were achieved by our hybrids at the smallest water dose of 40%. The smallest stem mass was achieved by the P9610 hybrid (93.3g). The P9363 hybrid achieved the highest stem weight at harvest with 333g, which is higher than the results of the other hybrids. In the P9978 hybrid, it is also clearly visible how much change in stem mass was caused by the difference between the water doses. The P0023 hybrid did not have a particularly high stem mass at any water dose, despite the fact that it was able to achieve good results in terms of root mass.

The difference between the water doses can be clearly seen in the diagram below. The highest stem mass was achieved at the highest water dose and the lowest at the lowest water dose. The difference in stem weight between the two water doses depended only on the hybrids' stress tolerance and response to irrigation.

In the saline treatments, all hybrids achieved the same stem weight of around 160g at a water dose of 40% SWS, with the exception of P9363, as this hybrid achieved a stem weight of 186.6 g in the saline treatments at the smallest water dose. The highest stem mass was again achieved by P9363 at the highest water dose the SWS 80%, which is 320 g. Hybrid P9363 outperformed its peers in terms of stem weights. The hybrids did not achieve much higher stem weight results at a water ration of SWS 60% than at SWS 40%, as even here there were plenty of stressful conditions. The difference between the water doses is visible. The leaf area and stem weight of the hybrids are related, and the measured LAI and stem weight results reflect the similarity in the results of the hybrids. In saline treatments, we did not discover a decrease in stem weight in hybrids compared to non-saline treatments. It can be concluded that the difference between the hybrids in terms of stem weights is insignificant in the saline treatments, but it is still spectacular for us between the water doses. In the salt treatments, only a small amount of salt was applied to present a slightly saline soil during the experiment, which did not have a negative effect on the stem weights.

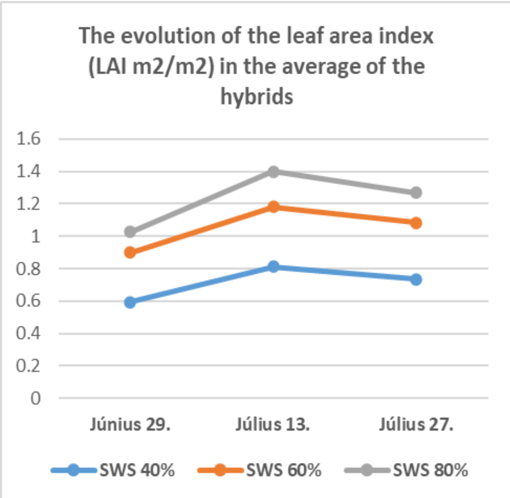

Figure 5. The leaf area index in the average of the hybrids in normal treatments

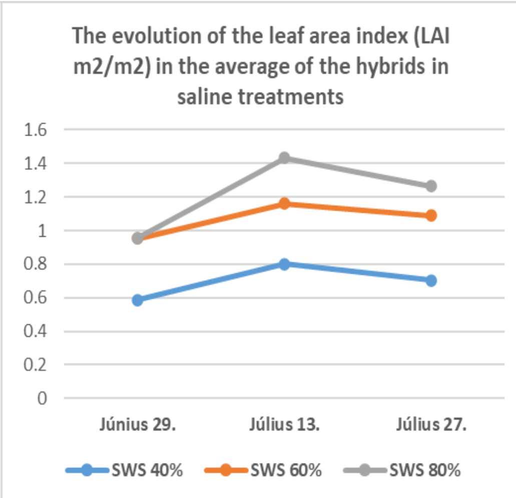

Figure 6. The leaf area index in the average of hybrids in the saline treatments

In the figures below, it is very clear that different amounts of water result in different leaf surfaces. Drought conditions determined the leaf surface of our hybrids not only at the beginning, but throughout the experiment at a water dose of 40% and this is ultimately true for all water doses. If we look at the water dose of SWS60% or SWS80%, it can be established both in saline and non-saline conditions that the negative effects of drought stress will be felt in the leaf surface not only at the beginning, but during the entire growing season. By the third measurement, the plants had already received such heat stress in the film that none of the water doses could help the plants and their water absorption stopped. The difference between the water doses can be clearly seen by looking at the two figures, but not between saline and non-saline conditions. There is a very minimal difference between salty and non-salty treatments, and not always in a negative direction. My previous research proves that salt stress has a negative effect on the leaf surface, however, in those researches we modelled moderately or highly saline soil. The experiment showed us that this level of salt stress has no direct effect on the leaf surface.

CONCLUSIONS

The experiment highlights for us that the water supply of corn plays a huge role in the development of its phenological parameters, and we did not notice any changes in our plants due to the small amount of salt stress.

During the experiment, hybrid P9363 achieved excellent results in terms of root and stem masses, which proves its excellent drought tolerance. It is also important to mention the P0710 hybrid, which belongs to the highest ripening group, but with its growth strength it produced almost the same results as the hybrids belonging to the FAO 300 ripening group in the experiment.

During the experiment, we subjected the plants to a small degree of salt stress, which presented a slightly saline soil or, in the evening, a rudimentary secondary salinization. These hybrids handled this stress factor excellently and were able to overcome the disadvantage caused by salty conditions by increasing their root size. The P9978 hybrid performed well on all water doses in the hybrid average and showed one of the best irrigation responses in the experiment. I think it is also important to mention the P0023 hybrid, which was able to achieve good results in terms of leaf area at a water dose of 40%, so its drought tolerance was confirmed, but it also achieved excellent results in terms of root mass at the unfavourable water supply level, and at the elevated he also gave water rations.

The experiment made it clear to us that the right choice of hybrids is an essential ingredient for economical 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 the 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 plant phenology today.

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