THE NEGATIV EFFECTS OF SALT STRESS ON DIFFERENT MAIZE HYBRIDS

Á. KOMLÓSI, Z. FUTÓ
Hungarian University Agricultural and Life Sciences
Department of Irrigation and Melioration
Corresponding author: adamkomlosi24@gmail.com

Abstract: *The aim of the research is to investigate the effects of salt and drought stress on different maize hybrids. 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. The experiment was set up in a foil housing in an environment closed from external precipitation. During the experiment, plant height, leaf area (LAI) and relative chlorophyll content (SPAD) were measured every 2 weeks after a certain phenological state, and total biomass weight, root weight and tube weight were measured on the plants at harvest. 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*: salt, irrigation, maize, drought*

INTRODUCTION

(SHULL, 1909) established the breeding of inbred hybrid maize. In the U.S., the use of four-line hybrids was introduced in 1920 at the genetic suggestion of D.F. Jones to facilitate seed production.

The size of the root system of maize is also determined by the varieties, but the aeration and water supply of the soil play a significant role. The development of the root of maize is quite influenced by the chemical and physical properties of the soil (SZÁNTOSI, 1981).The size of the stem is also influenced by the water supply, as stems different from the variety may develop from the lack of water (thin stem) or the excess (low stem) (MENYHÉRT ET AL., 1985). The soil is in a saline state, water available to plants determined by the matrix and osmotic potential of the soil. (SHELDON ET AL., 2017).Maize can be said to adapt well to the different properties of soils. As a result, corn is not considered a soil-intensive crop. Deep-layered, humus- and nutrient-rich middle soils, on the other hand, have an advantage in achieving high and safe yields (NAGY and MEGYES 2009). Due to its good adaptability, it can be grown on other soils. It also grows well in nutrient-rich loamy and sandy soils and more compact meadow soils, but in the latter deep loosening is of paramount importance, as maize is particularly sensitive to the air permeability of the soils. Maize cannot be grown economically on quicksand, loamy, damp, airless and shallow soils, these soils already exceed the limits of maize adaptability (RADICS, 2003). According to GYULAI and SEBESTYÉN (2011), the amount of precipitation is not decisive for the development of maize in terms of water supply, but its distribution during the growing season is considered to be decisive. Drip belt irrigation will play a major role in the intensive cultivation technology of maize in the future as it is a cost, energy and water saving technology(FUTÓ and BODNÁR, 2021.).Soils can store up to 500 mm of water (up to 200 cm deep), half of which is disposable water. The water consumption of maize is the lowest at the beginning of the development and during the period of grain saturation, while it is the highest from tassel vomiting to grain saturation (FUTÓ and

SÁRVÁRI 2015, MENYHÉRT 1979). Researchers with Aydinsakir showed that different levels of irrigation (no irrigation, mild, normal and optimal water intake) have a statistically significant effect on different yield components. (AYDINSAKIR ET AL. 2013) At present, maize is most often placed in the wheat-maize-sunflower crop rotation in Hungary, which in turn discourages the cultivation of other crops, thus narrowing our market and national economic opportunities (ANTAL, 2005). An important factor in the high yield level of maize is good quality soil preparation, which consists of autumn tillage and spring seedbed preparation and fertilization. Maize likes air-permeable soils, so we have to take care of a deep summer / autumn deep cultivation (HEGEDŰS , 1984).

Today, at the end of March and the beginning of April, the soil temperature reaches 8-10 oC, which is already suitable for germination, the sowing times established earlier may play a more important role in drier vintages (MARTON, 2013). According to PEPÓ (2011), new directions in plant breeding include the maintenance of biodiversity by different methods, because we can only perform successful selection in genetically diverse populations.

MATERIAL AND METHODS

In the experiment, the salt tolerance reactions of five different maize hybrids and the drought tolerance in a pot experiment were performed in an environment closed from external precipitation. At the time of setting up the experiment, 11 kg of arable land was weighed into the culture vessels and the main soil chemical and physical properties of the arable soil were determined. The size of the culture vessel is 33.7 cm in diameter, giving a soil surface of 891.5 cm^2. Sowing and setting up the experiment: It was April 29, 2020, followed by germination: May 08-09. was between. Starting of different doses of irrigation water treatments (water dose separation): Continuous from 09 June 2020. The experiment was harvested on September 3, 2020.

In the experiment, 3 water supply levels were set. We first determined the natural water capacity (TLC) 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 experiment, water was applied to the culture vessels every 2 days during the cooler climate in the spring and daily during the warmer 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 medium quality saline soil.

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 m2 / m2)
- Plant height
- Leaf and stem weight

- Root mass
- Pipe length, pipe weight

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.).

The data were processed with Microsoft Excel, while their statistical evaluation was performed with SPSS for Windows 25.0.

RESULTS AND DISCUSSIONS

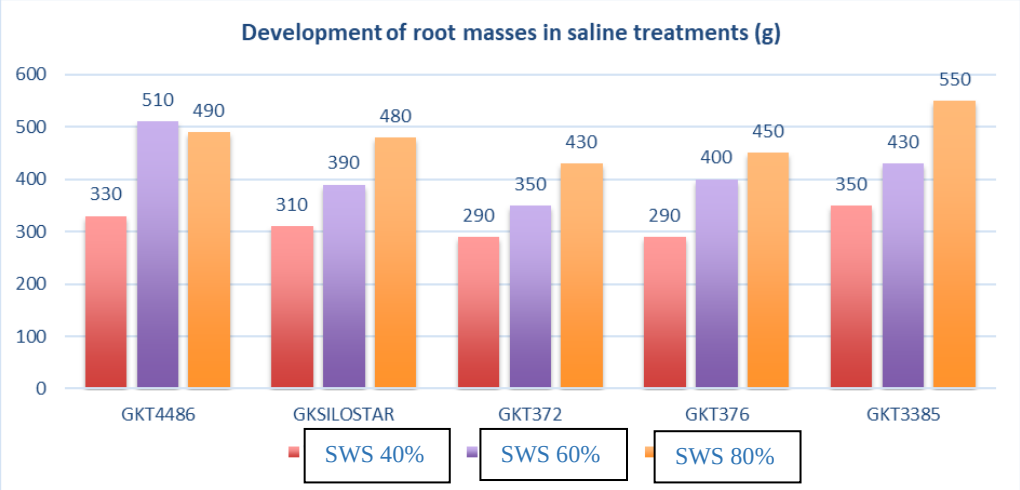

Fig. 1. Development of root masses in saline treatments

Figure 1, it can be concluded that the salt stress did not cause losses in the root mass development of the hybrids only in those hybrids where we have already established that their salt stress tolerance is good.

The hybrid GKT 376 also produced one of the lowest root weights in this measurement and it can be stated that it does not deviate too much from its non-saline results and reacted similarly to water doses, so it can be said that it has a moderate salt stress tolerance. It can also be stated that the highest root weight was reached by the hybrid GKT 3385 (550g), while the second two were reached by the GKT 4486 (510g) and GK SILOSTAR (480g), proving that a good irrigation response to a drought it can be a sensitive hybrid fate in a drier vintage if we can support it with good water retention or irrigation. The hybrids GK SILOSTAR and GKT 4486 also stand out from their peers in this study with their good irrigation response, but their salt tolerance is not sufficient to produce much better results than their peers in the non-saline study.

There were hybrids called GKT 372 and GKT 3385, where they performed better and were where they performed the same in saline treatments as in non-saline ones. These hybrids can also be found to have no outstanding irrigation response, so their irrigation does not involve as much extra rooting, but their response to salt stress is particularly good.

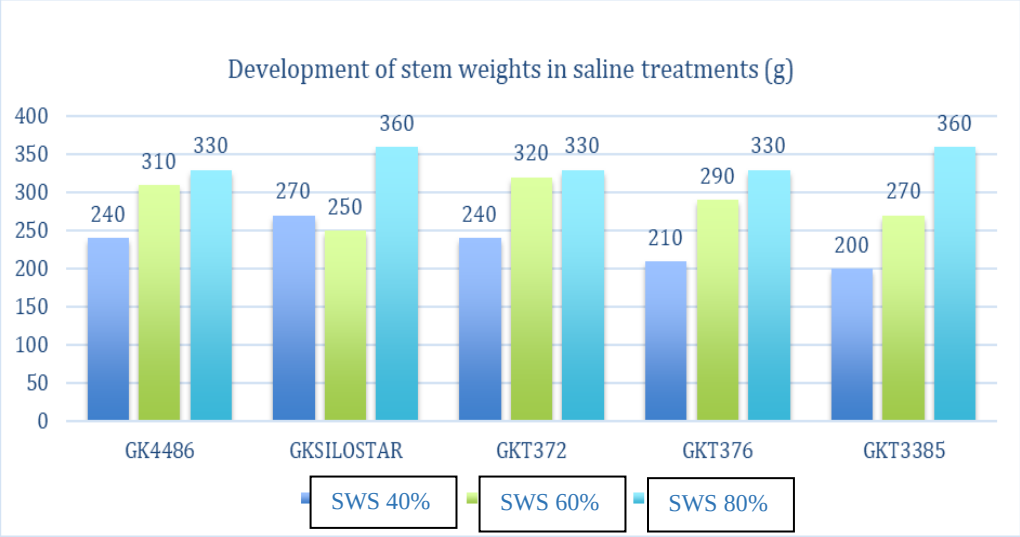

Fig. 2. Development of stem weights in saline treatments

Examining Figure 2, it can be stated that the different water doses do not show an absolutely positive effect on the development of stem weights, with the exception of the SWS water dose of 80%, where all plants were able to reach the highest stem weight during the study. During the study, the hybrid GKT 376 reached the lowest stem weight (210g). A hybrid called GK SILOSTAR produces a significant reduction compared to the non-saline experiment. The water dose of SWS measured at 60% was the lowest (250g) and even lower than the SWS achieved at 40% (270g), which indicates not good salt stress tolerance, however, with its outstanding irrigation reaction it was able to eliminate this at the highest water dose. and the GKT 3385 reached the highest stem weight (360g) in a tie. The difference between the lowest water content of 40% SWS of hybrids and the water dose of 80% of the highest SWS is usually around 100g, except for the GKT 3385 hybrid. There is a difference of 160g between the lowest and highest water dose of the GKT 3385 hybrid, which is almost identical to the results obtained in the non-salt experiment. The GKT 3385 hybrid is thus considered not to be sensitive to salt stress. The hybrid GKT 4486 also suffered losses in stem weight, but the good irrigation reaction in this hybrid was able to compensate for the losses, which can be filtered by the fact that the stems were reduced by 70-80 g, but the difference between the water doses is almost the same. as in non-saline treatment. In the formation and maintenance of high stem masses, salt stress clearly hindered hybrids.

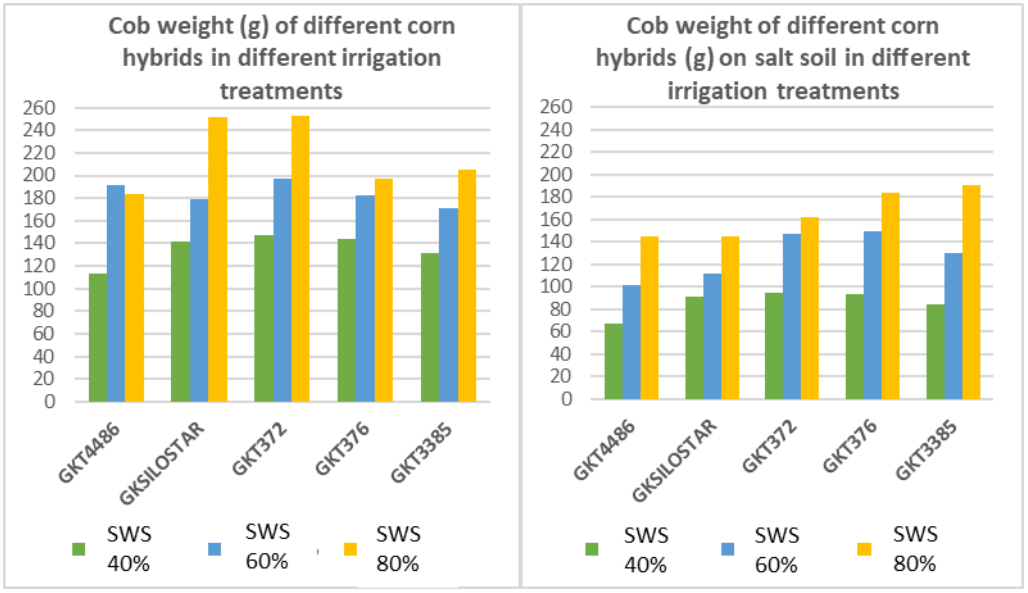

Fig. 3. Cob weight of different corn hybrids in different irrigation treatnents
Fig. 4. Cob weight of different corn hybrids on salt soil in different irrigation treatments

Comparing Figures 3 and 4, it becomes clear that salt stress is reduced in the yield of each hybrid, but this decrease varies from hybrid to hybrid.

Salt stress had the greatest negative effect on the yields of GKT 4486 and GK SILOSTAR, which is not surprising since we are talking about drought-sensitive hybrids. In normal treatments, even their good irrigation reaction helped them keep up with the other hybrids, in saline treatments they were no longer able to keep up with the drought tolerant hybrids (GKT 372, GKT 376, GKT 3385). In Figure 3, GK SILOSTAR was able to achieve the second highest yield at the highest water dose (252g), but was in the penultimate position in salt treatments (145g).

Drought-sensitive hybrids were unable to combat the negative effects of salt stress, and the saline soil completely destroyed these plants. Drought-tolerant hybrids have achieved excellent results despite the negative effects of salt stress. The hybrid called GKT 372 was able to achieve the highest yield in normal treatments (253g) and did not achieve poor results in saline treatment (162g), suggesting that this hybrid is well tolerated, reducing drought and salt stress. effects. In the saline treatments, the hybrid GKT 3385 achieved the highest results (190g), suggesting that this hybrid also has good drought tolerance, with only a loss of yield due to drought (15g).

Salt stress can generally cause large yield losses, but here the figures show that a good hybrid selection can eliminate or reduce these yield losses.

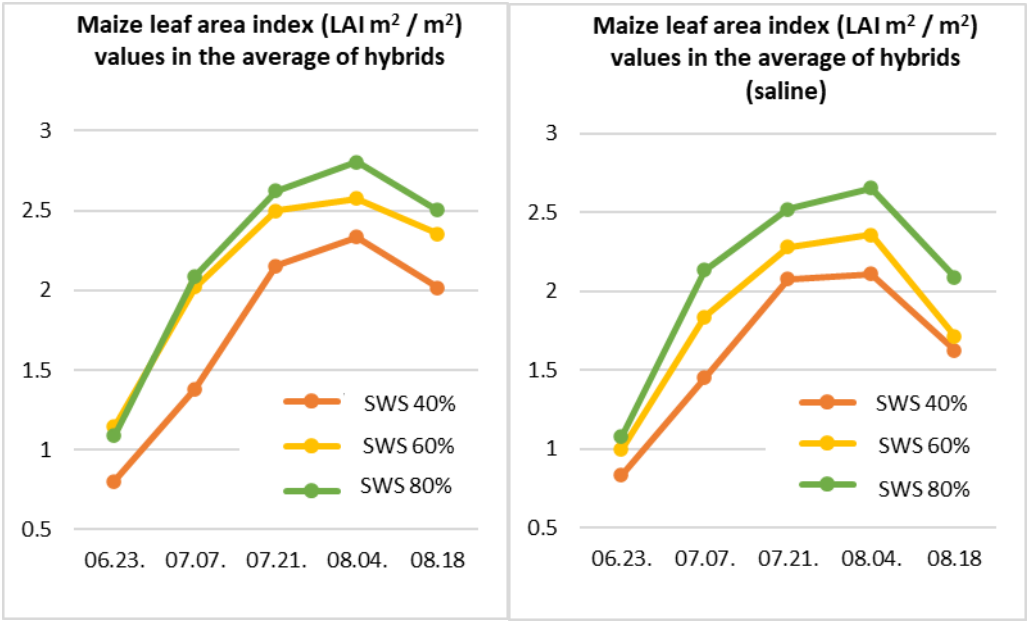

Fig. 5. Maize LAI values in the average of hybrids
Fig. 6. Maize LAI values in the average of hybrids in saline soil

Figures 5 and 6 show the average leaf area index values of the hybrids in the cross-section of water doses. Examining Figure 5, it can be stated that the lowest SWS water dose of 40% deprived the hybrids of significant initial growth, and the hybrids performed worse than the SWS 60% and SWS water doses at 80%. . Examining Figure 5, it can be recognized that the 60% water dose of SWS and the 80% water dose of SWS caused a significant increase in leaf area. The values of SWS 60% and SWS 80% water doses increased the leaf area evenly until the measurement on 07.07. Examining Fig. 6, we can already observe that the other two cannot exceed the 40% water dose of SWS as much as in Fig. 5, which can be explained by the fact that the increase in leaf area by excess water is somewhat suppressed by salt stress. Examining Figure 6, we can observe that here the 80% water dose of SWS already results in a higher leaf area index than the measurement on 07.07. Examining Figures 5 and 6, it can be stated that the largest data of the measurements of saline treatments on 08.18 are only the same as the lowest of the non-saline ones. There may be similar measurement results in the initial phases between the two treatments, but the larger the plants, the better they are able to exert their effects on salt stress and cause drastic leaf area index declines at the end, as the plants are not able to produce as much green mass or the existing ones. maintain for a long time.

CONCLUSIONS

In the course of the experiment, we 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 normal treatments. These two hybrids were at the forefront of the SPAD and LAI results throughout the normal treatments, but were only able to achieve good results in the development of tube mass at the highest water supply level.

In the normal(non-saline) treatments, the GKT 372 maizehybrid was able to achieve a remarkable and best of performance and He had the highest cob weight and the second best results in terms of biomass weights, despite the fact that this hybrid managed to achieve the lowest root weight in normal treatments. In the non-saline treatments, the hybrids GKT 376 and GKT 3385 performed the weakest in the development of stem and root weight, but their tube weight development still preceded the hybrid GKT 4486.

The situation has already changed in the saline treatments, as the two drought-sensitive hybrids were able to reach the lowest tube weight, and their stem and root mass development decreased the most drastically for them. The hybrid GKT 3385 was able to reach the highest cob weight during the salt treatments, but the GKT 376 and GKT 372 hybrids did not lag far behind. The biomass, cob, and root mass evolution of these three hybrids did not change much in the saline treatments, which shows us the confirmation of their drought tolerance.

BIBLIOGRAPHY

ANTAL J. 2005: Növénytermesztéstan 1., A növénytermesztés alapjai. Mezőgazda Kiadó, Budapest, 302-310 p.(In Hungarian)

AYDINSAKIR, K., ERDAL, S., BUYUKTAS, D., BASTUG, R., TOKER, R. (2013): The influence of regular deficit irrigation applications on water use, yield, and quality components of two corn (Zea mays L.) genotypes. – Agricultural Water Management 128: 65-71.

FUTO, Z., BODNAR, K., 2021 - Soil hydrology. In: Gadomski, Adam (szerk.) Water in Biomechanical and Related Systems. Singapore, Szingapúr : Springer International Publishing pp. 277-302.

FUTÓ Z. - SÁRVÁRI M. (2015): A kukoricatermesztés technológiájának fejlesztési lehetőségei, Szarvas 18-19.p (In Hungarian)

GYULAI B.- SEBESTYÉN E. 2011: Adalékok a kukorica trágyázásához. Agrárágazat. 12.4. 40-42. (In Hungarian)

HEGEDŰS I. (1984): Tavaszi talajművelési módok vizsgálata kukorica monokultúrában. Növénytermelés. 33.2:171-177. (In Hungarian)

MARTON L. (2013): Hagyományos- és hidegtűrő kukorica hibridek gyomnövényekkel való versengésének vizsgálata. Doktori értekezés. Keszthely. (In Hungarian)

MENYHÉRT Z. 1979: Kukoricáról a termelőknek. Mezőgazdasági Kiadó, 82 p. (In Hungarian)

MENYHÉRT Z. 1985: A kukoricatermesztés kézikönyve. Mezőgazdasági Kiadó. Budapest. (In Hungarian)

NAGY J.- MEGYES A. (2009): A kukoricatermesztés kritikus agrotechnikai elemei. Agrofórum Extra. 32: 36-40.p. (In Hungarian)

PEPÓ P. 2011: Növénynemesítés. Az agrármérnöki Msc szak tananyagfejlesztése. Debrecen. (In Hungarian)

RADICS L. - ERTSEY A. – GÁL I. – PUSZTAI P. – SZEMÁN B. 2003: Szántóföldi növénytermesztés. Szaktudás Kiadó Ház Rt, Budapest, 110 p. (In Hungarian)

SHELDON, A. R., DALAL, R. C., KIRCHHOF, G., KOPITTKE, P. M., & MENZIES, N. W. (2017). The effect of salinity on plant-available water. Plant and Soil, 418(1–2), 477–491. https://doi.org/10.1007/s11104-017-3309-7

SHULL G. H. 1909: A pure line method of cornbreeding. Amer. Breed. Assoc. RPT. 5. 51-69 p.

SZÁNTOSI A. 1981: Növénytermesztési praktikum (In Hungarian)