THE DROUGHT STRESS EFFECTS IN DIFFERENT CORN HYBRIDS PHOTOSYNTHETIC ACTIVITY AND PHENOLOGICAL PHARAMETERS

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Abstract. *We feel the drought negative effects more time in the last twenty years, because the climatic factors are changed. The farmers must do anything versus the drought, that they can slack this negative effects. The best medicine for the drought the irrigation, however, in years appear a promising line in the hybrid produce. The drought tolerate hybrids produce is a new line, wich like can affect the crop quantity in a droughts year. We look five different hybrids reactions for the drought stress in this research. We made three different water supply and three replay in the study. We set the research in the Szent István University Irrigation and Watermanagement Institute in Szarvas. In the research we look three water supply level (soil water storage capacity (SWS), which were SWS40%, SWS60%, SWS80%) to five different maize hybrids in culture vessel. In the research we look the salt stress reactions in salted soil too. We received the best SPAD value with the SWS 80% water supply level. The relative clorofill contens value was decrease in the end of the vegetation period, but the decrease was the smallest in good water supply. The biomass weight of maize hybrids improvement in all cases with improved water supply. The biomass weight of drought-tolerant hybrids decreased the least under drought stress, whenever the decrease in biomass weight of sensitive hybrids were much more significant. The root weight of corn hybrids decreased significantly under drought stress. The decrease reduced from 280 g to 190 g / plant. The smallest decrease was achieved by the roots of drought-tolerant hybrids. Leaf area index (LAI) of maize hybrids was also examined. The best LAI values were achieved by maize hybrids at the SWS 80% (good water supply) level. LAI values decreased by 19.5–21.7% due to drought stress. As a result of the drought stress, the LAI and root weight values of the hybrids decreased, resulting in low cob weights. A significant mean positive correlation was found between the maize cob weight of the hybrids and the LAI values at r=0.493. In the salted soil the hybrids show bigger drought stress while worsened the yield results. Under saline conditions, the water supply and individual production of maize deteriorated significantly, but significant differences were found between the hybrids. Overall, drought stress significantly reduces the production of corn hybrids. The smallest decrease was shown by drought-tolerant hybrids, that's why so important the proper hybrid selection.*

Keywords: *maize, SPAD, LAI, drought-stress, irrigation*

INTRODUCTION

This research will examine the drought stress reactions and water use reactions in five different corn hybrids. If we choose a good hybrids, we can make storng crop quantity and crop safety and its will be an important quality in this full of climatic change years.

We look the drought and irrigation reactions in hybrids wich patented hybrid or before for the patented. Secondary we will show the salt stress reactions in the research. We examined hybrids, which like sensitive for drought stress and tolerate for draught stress. The agroculture watch more the drougth negative effects. It will be a good answer, if we know the hybrids water supply and drought stress reactions.

The first of all secret of the corn high production level is the soil cultivation in good quality. The good soil prepare have three part: autumn base cultivate, make good seed bed in spring and give enough nutrient to the soil. The maize likes air-permeable soils, so we have to take care of a late summer / autumn deep cultivation (HEGEDŰS 1984, RADICS 2003, BIRKÁS AND SZIEBERTH 1998).

The size of the root system of corn is also determined by the varieties, but the aeration and water supply of the soil play a significant role. The development of corn roots is quite influenced by the chemical and physical properties of the soil (SZÁNTOSI 1981). According to NYIRI (1997), a balanced supply of potassium and phosphorus is very important in the nutrient supply of corn. These are incorporated into the soil in the autumn and a precise supply of nitrogen in the spring is also important. The specific nutrient requirements of maize are 28 kg N / t, 11 kg P_2O_5 / t, 30 kg K_2O / t, from macro nutrients. In contrast to the autumn phosphorus and potassium fertilization of corn, nitrogen has to be incorporated into the soil in the spring (FÜLEKY 1999).

The water requirement of corn is 450-550 mm, which can be said to be medium. Its daily water consumption can be up to 5.5-6.5 mm/day. The water demand and water uptake of maize is characterized by several different factors. Maize can absorb water from a depth of 150-200 cm. Drought during the period of tassel vomiting can reduce yields by 53%, while drought at seed saturation can reduce yields by 30% (FUTÓ AND SÁRVÁRI 2015, MENYHÉRT 1979).

According to GYULAI AND SEBESTYÉN (2011), the amount of precipitation is not necessarily decisive for the development of maize in terms of water supply, but its distribution during the growing season is considered to be the most important.

The water supply of corn consists of three main components. Precipitation stored during autumn and winter, the amount of water kept in the soil by appropriate agrotechnics during the growing season, and water applied by irrigation (PETRASOVITS AND BALOGH 1969). Field experiments and irrigation research prove that the yield surplus of irrigation is 8-9 t/ha compared to the yield of 1-3 t/ha of non-irrigated stock in the highly droughty year periods (CSAJBÓK 2004). Based on the drought index, SZÁSZ ÉS TŐKEI (1997) found that between 1860 and 1900, the incidence of wet and dry years was the same (22.5%), with average years for more than half of the years (55%). were typical, while in the period between 1980 and 2000, the proportion of drought years increased significantly (52.6%) to the detriment of average vintages (26.3%). Drought years are becoming more frequent and drought control is playing an increasingly important role in agriculture.

According to PEPÓ (2011), new directions in plant breeding include the maintenance of biodiversity by different methods, because we can only perform effective selection in genetically diverse populations. According to BASAL (2020), the SPAD results for soybeans will not provide adequate guidance in assessing the resulting drought damage, but the more closely correlated leaf area index (LAI) results will provide reliable data. In corn crops, wich doesn't have water-deficient, the yield increases linearly up to the value of 5-5.5 LAI and to a declining extent then to the value of 6-7 LAI. There is also a correlation between the size of the leaf area of corn and the grain yield (ANTAL 2005, FUTÓ 2003).

MATERIAL AND METHODS

We tested five different corn hibrids reactions for the drought and salt stress in a culture vessel research, under a foil tent and without the natural rainfall.

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.

This five hibrids were in the research: GKT 4486 (sensitive for drought stress), GK SILOSTAR (sensitive for drought stress), GKT 372 (tolerate for drought stress), GKT 376 (tolerate for drought stress) and the GKT 3385 (tolerate for drought stress).

Sowing of the research: was on April 29, 2020, followed by germination: between the May 08-09, 2020. Starting of different doses of water treatments: from 09 June 2020 onwards. The research was harvested on September 3, 2020.

Of the meteorological data, only the changes in temperature values were monitored, as the culture vessels were in an environment closed from external precipitation. The temperature had the greatest effect on the evaporation of the plants and thus on the daily amount of water released. Rising temperature values justified the application of larger doses of water to achieve the same level of water supply.

In the research were set 3 water supply levels. We first determined the natural water storage capacity (SWS) of the soil, which was the amount of water that the soil could retain against gravity. We adjust three soil water storage level in the research: -SWS 40%, -SWS 60%, -SWS 80%. In the research, we measured and calculated the amount of daily evaporation based on the daily temperatures, with which we were able to maintain different water supply levels in the treatments. In the first treatment (SWS 40%), 361.1 mm less water was released during the growing season than would have been justified by plant evaporation. The plants were under significant drought stress. In the highest dose treatment (SWS 80%), the amount of water applied was optimal, covering the amount of evaporation.

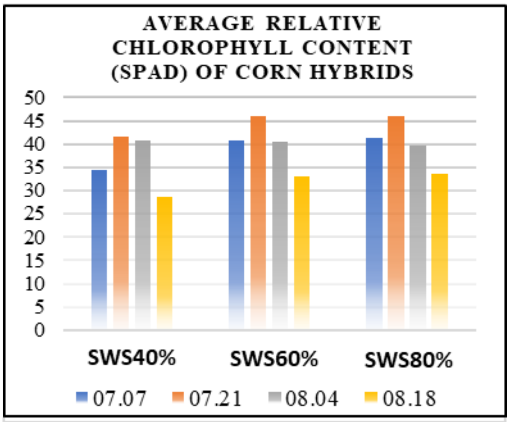
The salt tolerance research were also based on the setting of different water supply level treatments (SWS 40%, SWS 60% and SWS 80%). The salt tolerance of the different corn hybrids was monitored by the application of Na salts added with irrigation water. The salt mixture contained NaCl, $NaSO_4$ and $NaCO_3$. During the treatments we aimed to model the water management properties of a medium quality saline soil.

The following phenological parameters were measured in the research: relative chlorophyll content (SPAD) with Konica SPAD 501 instrument, leaf area (based on Montgomery formula), leaf area index (LAI m^2 / m^2), biomass weight, root weight, cob weight.

Data were measured several times during the growing season, every two weeks (SPAD, leaf area), and final biomass (leaf and stem weight, root weight, etc.) was measured at harvest. The data were processed using Microsoft Excel, while their statistical evaluation was performed with SPSS for Windows 25.0.

RESULTS AND DISCUSSIONS

In the research, corn plants had the highest relative chlorophyll content (SPAD) during the 2nd measurement, and then their chlorophyll content decreased, drying and ripening began (Figure 1). We concluded that the decrease in chlorophyll content by drought stress was significant, but plant aging reduced the relative chlorophyll content to a much greater extent. There were significant differences in SPAD values due to different water doses. Due to the effect of drought stress (SWS 40%), the SPAD value decreased to 41.47, while it was 45.94 for medium water supply (SWS 60%) and 46.05 for good water supply. The decrease in SPAD value during drought stress (SWS 40%) treatment reached the significant limit. At the last measurement time, the lowest relative chlorophyll content values were measured. Under good water supply conditions, the decrease in SPAD value was the smallest, so the corn could continue to photosynthesize with a good water supply, with a higher chlorophyll content. Figure 2 shows that the SPAD values of different maize hybrids are very different for different water doses.



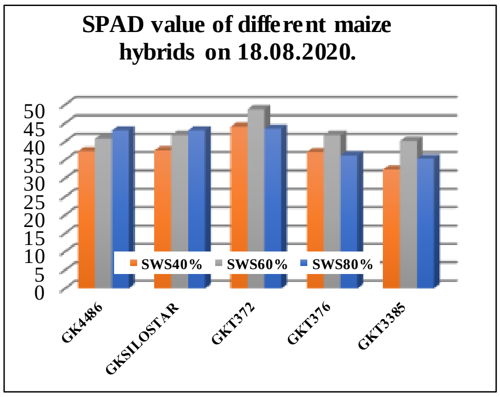


Figure 1. Average relative chlorophyll content at different water doses.
Figure 2. Relative chlorophyll content of different maize hybrids at different water supply levels.

In the experiment, the above-ground biomass (leaf, stem) mass of corn hybrids was measured. The lowest plant weight was achieved by a hybrid called GKT 3385 at all water supply levels. Among the hybrids, the hybrid named GKT 376 has the smallest difference for different water doses, suggesting that this hybrid has the worst irrigation reaction. The hybrid did not reach the highest biomass mass with good water supply but with medium water dose (SWS 60%).

Among the hybrids, GK SILOSTAR achieved the highest stem weight (530g), which is not surprising through silage corn, but the difference between the results of different water dose treatments is also large, from which it can be concluded that this hybrid has a good irrigation response.

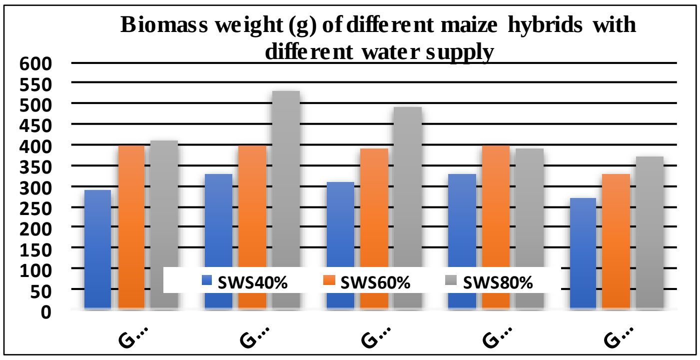


Figure 3. Biomass mass of different corn hybrids at different water supply levels.

The hybrid called GKT 372 can also be said to have a good irrigation reaction and was able to appreciate the higher water dose treatment with higher biomass mass. The weight of the GK 4486 hybrid biomass has already reached a value close to the maximum, in the medium water dose (SWS 60%) treatment. In this hybrid, it can be observed that no further significant increase could be detected between the water doses of 60% of SWS and 80% of SWS, the difference was not significant. This suggests to us that drought does not show a good irrigation response after leaving stress, so keeping it at a higher water dose does not result in extra plant weight.

The development of root weight is one of the most important parameters for us, in addition to the leaf area index and cob weight. Researchs is already underway to demonstrate that hybrids with higher root weight/root area are much better able to tolerate drought. There can also be significant differences between the root weights of hybrids that affect the water and nutrient uptake of a given hybrid. In our research, increasing water doses resulted in increasing root masses for each maize hybrid. A hybrid called GKT 372 achieved the lowest root mass in all water supply treatments. GK SILOSTAR, on the other hand, is also at the forefront of root mass development, with SWS achieving the highest (510g) root mass in a 60% water dose. SWS in 80% treatment with 610g result had only 3g less root mass than GKT4486 maize hybrid (613 g).

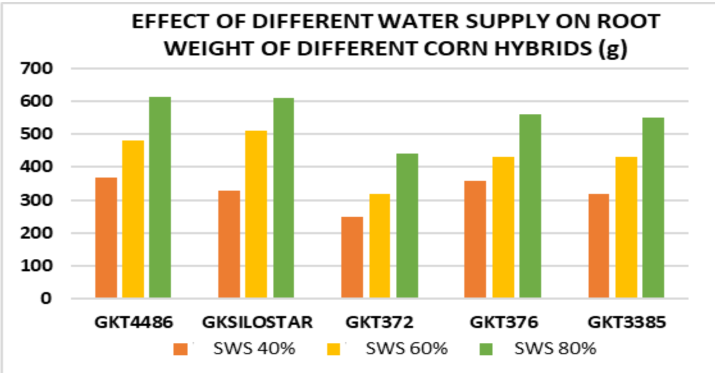


Figure 4. Root mass of different maize hybrids at different water supply levels.

GKT 3385 and GKT 4486 showed similarly strong growth as a result of the increasing water supply. Compared to the 40% results of SWS, GK SILOSTAR showed a jump-like increase due to increasing water doses, but there were also hybrids that did not respond as well to increasing water supply, such as GKT 372 and GKT 376, which are characterized by a worse irrigation reaction.

It can be clearly seen in Figure 4 that the GK 4486 hybrid had the highest root weight (370g) at SWS 40% water dose in dry conditions, which may be an advantageous property in a drier vintage over other hybrids. Under poor water supply conditions (SWS 40%), the GKT376 hybrid also achieved high root mass, despite its poor irrigation reaction. The results of GK SILOSTAR measured at SWS 60% water dose also showed that the hybrid already achieved a very good root weight at medium water supply. In this water supply treatment, GK SILOSTAR achieved the highest root mass.

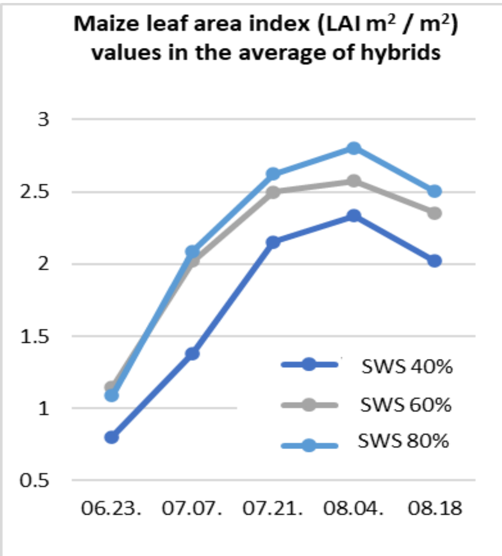
Under good water supply conditions (80% water dose of SWS) the highest root mass was reached by the GKT 4486 hybrid. A favorable feature of the hybrid is that it has reached the highest root weight at both the low water supply level and the good water supply level. Overall, it can be stated that the root mass of the hybrids was greatly influenced by the size of the water doses.

The increase in root weight was significant for all hybrids, increasing between 35.7% and 45.9% in the experiment due to improved water supply.

Figures 5 and 6 show the mean leaf area index (LAI) values of the hybrids in the treatment of different water doses. Figure 5 shows that at the lowest SWS 40% water dose (drought stress state) the leaf area developed significantly smaller in the hybrids, and the leaf area values remained lower than the SWS 60% (medium water supply) throughout the growing season and SWS in 80% (good water supply) treatment.

Both the 60% water dose of SWS and the 80% water dose of SWS caused a significant increase in leaf area. The values of the SWS 60% and SWS 80% water doses increased the leaf area evenly until the measurement on 07.07, but after that the SWS 80% water dose was able to increase the leaf area index of the hybrids to a greater extent.

Figure 6. shows the irrigation results of the salt-treated culture vessels. On saline soils, after the 40% water dose of SWS, the other two treatments (SWS 60% and SWS 80%) could not increase the leaf area of maize hybrids as much as in the treatments without saline treatment, which can be explained by the increase in leaf area by improved water supply due to salt stress, significantly suppresses. Improvement of water supply in saline soils resulted in much weaker leaf area improvement than without saline treatment. Salt in the soil significantly impairs the water management of the medium and inhibits the nutrient and water uptake by maize. Thus, during the measurement on 08.04, even with a medium water supply (SWS 60%), we measured only the same LAI values (2.36 m^2/m^2) as in the experiment without salt treatment under the conditions of drought stress (SWS 40%) (2.33 m^2/m^2).



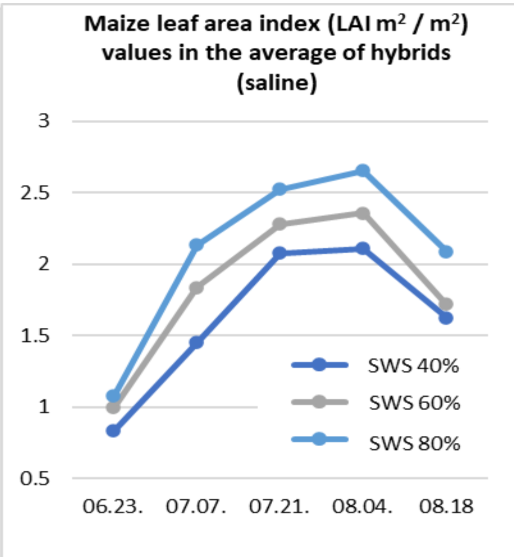
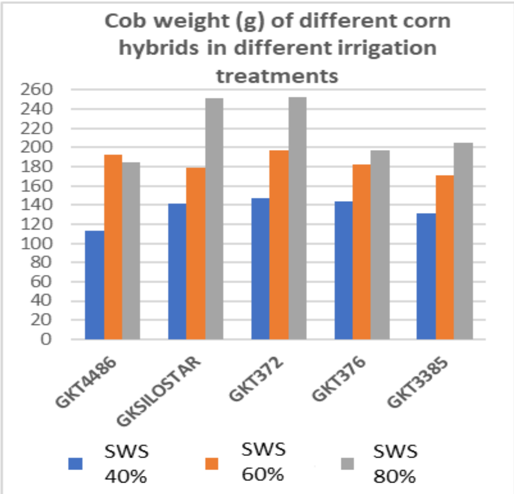


Figure 5. Development of leaf area index (LAI) values in different water supply treatments.
Figure 6. Development of leaf area index (LAI) values on saline soils in different water supply treatments.

There may be similar measurement results in the initial phases between the two treatments, but the larger the plants, the better they can exert their effects on salt stress and cause drastic leaf area index declines at the end (between 14.9% and 26.8%), leading to a faster leaf drying results. Under these conditions, plants can photosynthesize for a shorter time and with a smaller leaf area, which reduces plant organic matter production. Salt stress on saline soils resulted in faster aging, faster water release, and drying of maize plants during the research.

Comparing Figures 7 and 8, it becomes clear that salt stress significantly reduced the cob weight of each hybrid, the only variable being the rate of yield reduction for the different hybrids. Salt stress had the greatest yield-reducing effect on the cob weight of GKT 4486 and GK SILOSTAR. In non-saline treatments, their good water supply reaction kept them in competition with other hybrids, but in saline treatments they were no longer able to compete with drought-tolerant hybrids (GKT 372, GKT 376, GKT 3385). In Figure 7., GK SILOSTAR was able to reach the second largest cob weight (252 g) at the 80% water dose of SWS, but was in the penultimate position in salt treatments (145 g).



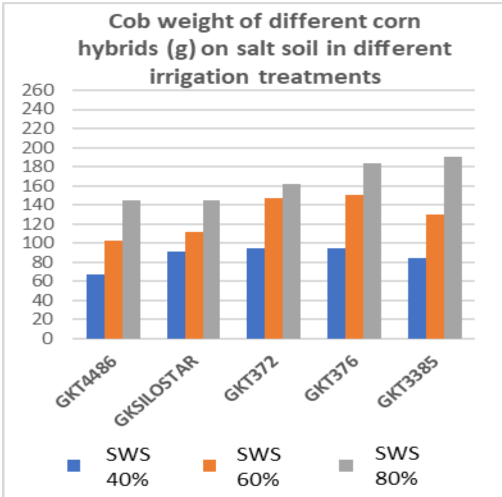


Figure 7. Cob weight of corn hybrids at different water supply levels.
Figure 8. Cob weight of corn hybrids on saline soils at different water supply levels

Drought-sensitive hybrids were not able to tolerate salt stress, and the yield loss of the plants was very significant due to the saline soil. Drought-tolerant hybrids, on the other hand, show little reduction compared to themselves and have achieved excellent results despite salt stress. The hybrid GKT 372 was able to achieve the highest cob weight in non-saline treatments (253 g) and did not perform poorly in saline treatments (162 g), suggesting that this hybrid is well tolerated by drought and salt stress yield effects. In the saline treatments, GKT 3385 hybrid achieved the highest results (190 g), which shows us that this hybrid can also well minimize yield loss due to salt and drought stress (only -15 g).

Salt stress can generally cause large yield losses, but the results of our experiment show that a good hybrid selection can eliminate significant yield losses.

During the statistical evaluation, we examined how closely the relationship between cob weight and leaf area index (LAI) was. We first performed a correlation study. It can be stated that the correlation study showed a reliable, significant correlation, the correlation was positive, medium, and the correlation value was 0.493.

Table 1.

Pearson correlation between LAI and Corn cob weight

		LAI	Cob weight
LAI	**Pearson Correlation**	1	,493**
	Sig. (2-tailed)		,001
Cob weight	**Pearson Correlation**	,493**	1
	Sig. (2-tailed)	,001	

The regression study also confirmed that the increase in leaf area causes an increase in corn cob weight, therefore the decrease in leaf area (LAI) caused by water scarcity is closely related to the decrease in subsequent cob masses.

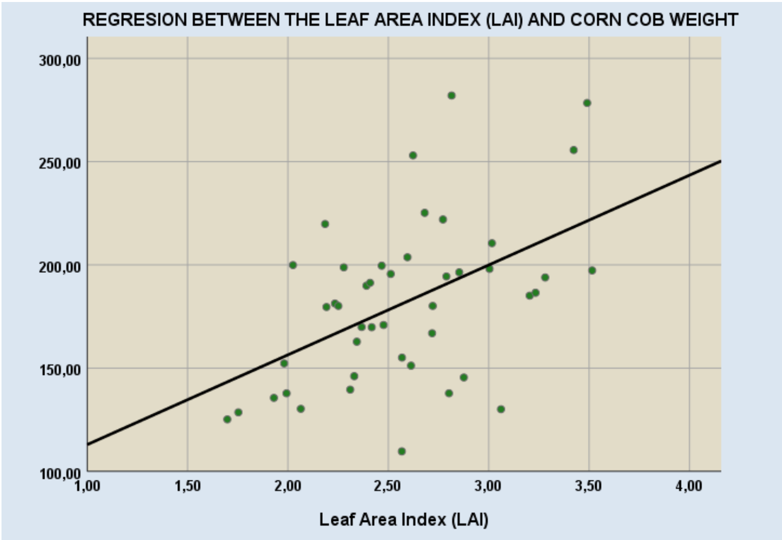


Figure 9. Regression between LAI and maize cob weight

CONCLUSIONS

During the research, we concluded that the hybrids with the best irrigation reaction were clearly GKT 4486 and GK SILOSTAR. These two hybrids are sensitive to drought, but their good water supply has helped them achieve high biomass. With a good water supply, a high cob weight was achieved, and the two hybrids were able to achieve the highest root mass in the salt-free irrigation treatments. These two hybrids were at the forefront of SPAD and LAI results throughout the non-saline treatments, but in the development of the cob weight, only the highest water supply level could achieve good results, the drought stress significantly reduced the cob weight.

In the non-saline treatments, the GKT 372 hybrid was able to achieve a remarkable performance. Its cob weight was the highest for it, and it also achieved the second best result in terms of biomass, despite the fact that this hybrid managed to achieve the lowest root mass in non-saline treatments. During the non-saline treatments, the hybrids GKT 376 and GKT 3385 performed the weakest in the development of stem and root weight, but their cob weight values still preceded the hybrid GKT 4486. In saline treatments, the situation has already changed, as the two drought-sensitive hybrids reached the smallest cob weight, and their biomass and root weight decreases were also the largest. The hybrid GKT 3385 was able to achieve the highest cob weight during the salt treatments, but the GKT 376 and GKT 372 hybrids did not lag far behind.

The stem, cob, and root mass development of these three hybrids did not decrease much in the saline treatments, which shows us the confirmation of their salt tolerance.

In the course of the experiment, we found that in a year with good rainfall, the GKT 372 hybrid could be a good choice. GKT 372 can also produce good results in a droughty vintage or dry growing area, but the other drought-tolerant hybrids GKT 376 and GKT 3385 can also be mentioned here.

GK SILOSTAR has a good irrigation reaction and can achieve a high biomass weight in a normal vintage, which is its number one consideration through silage corn. The GKT 4486 hybrid did not provide outstanding cob weight in the salt-free treatments, but neither in the saline treatments.

This study is a great example of how good crop safety can be achieved with a drought-tolerant hybrid in a drier year. When this trait is combined with a good irrigation reaction, hybrids are placed on the market that can achieve high yields in both a drier and a normal years. Based on our research results, it can be concluded that the hybrids with a good irrigation reaction could not reach the cob weight that a drought-tolerant corn hybrid was able to achieve, even at the highest SWS of 80% water. Even in the salt-free treatments, the highest cob weight was reached by a drought-tolerant hybrid, and, in the saline treatments, each drought-tolerant hybrid pushed the sensitive ones behind. The research also revealed that a good irrigation reaction can be a crucial trait for a drought-sensitive hybrid, but it cannot even catch up with the crop safety provided by drought-tolerant hybrids.

The research clearly shows that with a considered choice of hybrids we can mitigate the effects of both our negative soil properties and climatic factors, which does not necessarily involve additional costs, but can increase our crop safety.

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