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COMPARISON OF STRESS SUSCEPTIBILITY INDEX OF SILAGE CORN AND SORGHUM CROPS

ABSTRACT

Drought is an important factor that causes a decrease in yield and quality in regions where second crop silage plants are grown. One of the biggest problems in animal husbandry is feed. Especially silage feed production tends to decrease in areas with increasing water deficit and where water needs cannot be met. The high water requirement of the corn plant requires irrigation in arid and semi-arid regions. However, in order to continue the production of silage fodder in regions where water resources are insufficient with the increase of drought, it will be necessary to grow forage plants that can be an alternative to corn plant. In previous studies, it has been discussed whether the sorghum plant is an alternative to the corn plant. The aim of this study is to determine the drought sensitivity index based on the yield values of both plants in wet and dry conditions. Thus, it will be determined whether the sorghum plant will be an alternative to the corn plant in terms of drought. The identification and selection of drought-resistant cultivars and species is possible using various indices. In this study, second crop silage maize and sorghum crops were grown in Kahramanmaraş conditions for two years (2018 and 2019), dry and irrigated. Stress sensitivity index (SSI) was used to determine the drought tolerance of silage maize and sorghum crops. 'Colonia' variety was used for silage corn and 'Es Foehn' variety was used for sorghum. When the STI values are examined, the corn and sorghum values for 2018 were 0.55 and 0.53, respectively, while the d values for 2019 were found as 0.33 in corn and 0.54 in sorghum. these values are very close to the YSI values. While the 2018 values in both indices were not determinative in terms of drought resistance, the value of sorghum in 2019 was 64% higher than corn (this value was found to be 61% for YSI). This also showed that there is a direct correlation between YSI and STI indices.

Keywords: *Maize, Sorghum, Yield, Stress Susceptibility Index*

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INTRODUCTION

Lack of water is one of the important problems in crop production. Cultivated plants generally require large amounts of water for their growth. Lack of water often causes significant quality reductions as well as yield losses (Çırak and Esendal, 2006). There should be enough water in the soil in order not to decrease the yield and quality in agricultural production. However, this cannot be achieved in areas with drought. Staniak et al. (2020), drought is an important factor that causes a decrease in yield and quality in areas where second crop silage plants are grown. In order to reduce the negative effects of drought on plant production, it is necessary to irrigate and to cultivate drought-resistant plants/varieties.

Plant production also means the continuity of animal production (Bilal et al., 2021). Feed is one of biggest problems that seen in husbandry. Especially silage feed production tends to decrease in areas with increasing water constraints and where water needs cannot be met. Sarwar et al. (2002), Problems of silage fodder decrease yield of livestock tropic and sub tropic areas. Therefore, in order to prevent animal feed shortages, silage species that need less crop water consumption and resistant to adverse environmental conditions should be grown. After harvesting the plant products containing a certain amount of dry matter, silage feeds are formed as a result of lactic acid fermentation (McDonald et al., 1991). Corn and sorghum crops are the ones with the most silage. Corn and sorghum silage is considered to be the silage plant with the highest nutritional value in the world (Kılıç, 1986).

Corn, which has an important share in production in Turkey, is a cultural plant cultivated in almost every region of our country with its wide adaptation ability and variety of varieties (Geren et al., 2003). Corn is the most widely used material in silage making (Seydoşoğlu, 2017). Corn plant is one of the products with the highest nutritional value in terms of silage feed. Although the richness of the corn plant in terms of yield, quality and nutrient content makes it attractive for silage production, the high water requirement of the plant limits its cultivation in many regions. If irrigation is not done, especially in arid and semi-arid regions, yield cannot be obtained. At the same time, corn cannot be produced in places where water resources are insufficient. Since the corn plant requires agricultural irrigation in Arid and Semi-Arid regions, its cultivation is also limited in places where water supply is insufficient. In such cases, it is necessary to cultivate alternative plants to corn plant in order to meet the silage feed production. In this way, feed production will be provided to some extent even in arid regions where there is no water. Silage sorghum plant is one of the plants that can be an alternative to corn in terms of nutritional value and yield.

Sorghum plant can grow without irrigation in semi-arid tropical regions and can be grown in almost any type of soil (Fageria et al., 1997; Çakmakçı et al., 1999; Çeçen et al., 2005; Arslan et al., 2017). Sorghum is a productive plant that is adapted to grow in arid and salty soils and has multiple mowing possibilities (Almodares ve ark., 2009; Goshadrau ve ark., 2011). Sorghum plant is also used as silage feed. One of its most important features is its tolerance to arid and salty soils. This situation makes it possible to cultivate it in places where water resources are limited. Sorghum is a plant that can be an alternative to corn in regions where water is scarce (Klocke et al, 2014). Therefore, it was thought that it could be an alternative plant to corn in previous studies.

Drought stress indexes consist of different formulations of the results obtained from the yields of the plants grown in both dry and wet conditions. Drought stress indexes consist of different formulations of the results obtained from the yields of the plants grown in both dry and wet conditions. Many methods and models of maths have been applied to determine the varieties suitable for cultivation without irrigation (Reynolds et al., 2005; Yadav and Bhatnagar, 2001; Rosielle and Hamblin, 1981; Singh et al., 2015). Drought indices make a comparison of drought conditions compared to irrigated conditions based on yield loss and are used to identify drought-resistant cultivars and species (Mitra, 2001; Singh et al., 2015). STI (Stress Tolerance Index) identifies high yielding cultivar/species under stressful and non-stressful conditions. According to this index, varieties/crops resistant to water stress and high yielding can be determined. GMP can be classified with high efficiency in both conditions (stressed and unstressed). Therefore, it is the best indicator of stress tolerance. (Fernandez, 1992). According to Rajamani (1994), a high YSI value indicates that that variety or species is more stable against environmental effects, so it would be more appropriate in determining the YSI stability.

In previous studies, comparisons of silage corn and sorghum plants were made in terms of quality and yield. However, drought tolerance status of plants was not determined by drought stress indices. The indexes used in the study are TOL, MP, YSI, HM, Yr, STI. The aim of this study is to determine the drought tolerance of both plants according to the stress indices.

MATERIAL

The land operations of the study were carried out on the lands belonging to Kahramanmaraş Eastern Mediterranean Transitional Zone Agricultural Research Institute.The altitude of the study area is 465 m and it shows the characteristics of typical Mediterranean climate with cold and rainy winters and dry and hot summers. Optimum temperature values for corn plant development are between 24-32ºC. Although corn is a hot climate plant, it is not a plant that requires extreme heat (Cerit et al., 2001). Sorghum, on the other hand, is known as a culture plant that does not withstand too much cold. Therefore, the climate is suitable for growing both plants.

The soils in which the experiment was conducted have properties that do not constitute an obstacle for silage corn and sorghum cultivation. When the soils belonging to both years are examined, it is understood that the electrical conductivity value is at a level that will not cause a salinity problem in the soil. The amount of organic matter was found to be "less" for both years. For irrigated conditions, the plants were irrigated with a drip irrigation system according to the humidity of the soil.

According to the USSL (1954) classification, the irrigation water used was determined to be in the C2S1 class. It can be said that it does not have any negative effect on irrigation of silage corn and sorghum plants. In the research, “Colonia” variety for silage maize (Zea mays L.), which can be used as a second crop adapted to the region, and “Es Foehn” variety for silage sorghum (Sorghum bicolor) were used. In each plot, the area outside the edge effect was cut with a sickle and the wet weights were weighed. Then, the green grass yield was determined by dividing the mown area and converting it to kg da^{-1}.

METHODS

There are seven drought tolerance indices in the study. these indexes were determined as Tolerance Index (TOL), Mean Productivity (MP), Yield Stability Index (YSI), Harmonic Mean (HM), Yield Reduction Ratio (Yr), Geometric Mean Productivity (GMP), Stress Tolerance Index (STI). For these indices, the yield values of the conditions without water stress and under water stress were used. While the conditions without water stress were taken from the yield values of the subject M100-S100 (M: Maize, S: Sorghum), where full irrigation was performed, the conditions with water stress were obtained from the yield values of the subject M20-S20, in which the irrigation water was given as 80% less than the water given in S100.

While calculations are made with formulas, Yp refers to the potential yield, and Ys refers to the yield pertaining to the subject without water. That is, while determining Yp, the efficiency of the subjects M100-S100, while determining the Ys, the efficiency values of the subjects M20-S20 were taken into account.Equations of drought tolerance indices are given in Table 1.

Table 1. Equations of drought tolerance indices

Index	Formula	Referances
Tolerance Index (TOL)	Ys-Yp	Rosielle ve Hamblin (1981)
Mean Productivity (MP)	(Ys+Yp)/2	Rosielle ve Hamblin (1981)
Yield Stability Index (YSI)	Ys/Yp	Bouslema veSchapaugh (1984)
Harmonic Mean (HM)	$2(YpxYs)/Yp + Ys$	Kristin ve ark. (1997)
Yield Reduction Ratio (Yr)	$1 - (Ys/Yp)$	Golestani-Araghi ve Assad (1998)
Geometric Mean Productivity (GMP)	$\sqrt{(YsxYp)}$	Kristin ve ark. (1997)
Stres Tolerance Index (STI)	$(Yp * Ys)/(Yp)^2$	Fernandez (1992)

RESULTS AND DISCUSSION

According to the results of the study, TOL and MP indexes were higher in silage corn plant than sorghum plant in both years. YSI, HM, Yr and GMP indexes showed different values in both years. While the YSI value was very close to each other in maize and sorghum plants in 2018, it was higher in sorghum plants than in maize plants in 2019. The fact that the YSI value was considerably higher in the sorghum plant in 2019 compared to maize showed that the sorghum plant has more drought resistance. When the YSI values are examined, the corn and sorghum values for 2018 were 0.55 and 0.53, respectively, while the d values for 2019 were found as 0.33 in corn and 0.51 in sorghum. While the 2018 values in both indices were not determinative in terms of drought resistance, the value of sorghum in 2019 was 61% higher than corn.

While the HM value was high in the silage corn plant in 2018, it was the same in both plants in 2019. While the Yr value was higher in silage sorghum in 2018, it was higher in silage maize in 2019. While the GMP value was higher in the silage corn plant in 2018, it was higher in the silage sorghum plant in 2019.

When the STI values are examined, the corn and sorghum values for 2018 were 0.55 and 0.53, respectively, while the d values for 2019 were found as 0.33 in corn and 0.54 in sorghum. these values are very close to the YSI values. While the 2018 values in both indices were not determinative in terms of drought resistance, the value of sorghum in 2019 was 64% higher than corn. This also showed that there is a direct correlation between YSI and STI indices.

Based on the findings of the study, it was seen that silage corn was more tolerant according to some indexes and silage sorghum was more tolerant than some indexes. According to TOL and MP values, silage corn plant was more tolerant than sorghum plant in both years. It was thought that the silage sorghum plant could be tolerant compared to the silage maize based on the HM, GMP and Yr indices.

Table 2. Drought stress index results of silage maize and sorghum plants

Index	**Plant**	**Years**	
		2018	**2019**
TOL	Maize	3766	4218
	Sorghum	3309	2309
MP	Maize	6548	4192
	Sorghum	5382	3885
YSI	Maize	0.55	0.33
	Sorghum	0.53	0.51
HM	Maize	39106	13106
	Sorghum	26106	13106
Yr	Maize	0.45	0.67
	Sorghum	0.47	0.46
GMP	Maize	6271	3623
	Sorghum	5121	3710
STI	Maize	0.55	0.33
	Sorghum	0.53	0.54

Some drought indices show silage corn tolerant, while others show silage sorghum tolerant; showed that both plants should be compared with other indices. It would be more accurate to decide on the tolerant plant species according to the results of the comparisons with more indexes. However, even in this case, it has been understood that the sorghum plant can be as tolerant as the corn plant.

According to the results obtained from the study, it is recommended to compare it with other drought indices in order to reach a more precise decision about which plant is more resistant to drought. Since it was understood that the silage sorghum plant is drought tolerant when compared to silage corn in terms of the compared indices, it has been suggested that it would be appropriate to cultivate silage sorghum for silage feed in Arid and Semi-Arid regions or in places where irrigation is not possible.

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