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Araştırma
(Research)

Investigation of Some Turkish Maize Landraces of Water Use Efficiency and Drought Susceptibility Index*

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Abstract

Objective: Due to the increasing drought day by day, local plant populations are the biggest source of breeders focusing on developing drought-resistant varieties. The unit dry matter production of maize, which uses a high amount of water, is also higher than other crops. Accordingly, the importance of varieties with high water use efficiency is increasing against the water shortage that the world is facing today. In the study, in which Turkish maize landraces were examined in terms of water use efficiency (WUE) and drought susceptibility index (DSI).

Materials and Methods: 16 corn populations and 3 corn varieties were used for control purposes. It was conducted for two years (2016-2017) in two application conditions, in which 150% (I 150) and 50% (I 50) of the evaporated water was given, depending on evaporation.

Results: WUE, which varied between 0.32-2.73 kg m^{-3} in the first year of the study, varied between 0.04-1.97 kg m^{-3} in the second year of the study. According to the DSI values varying between 0.83-1.17.

Conclusion: WUE values of cultivars were higher than Turkish maize landraces. According to the results, 5 maize landraces and two varieties were determined as moderately drought resistant.

Keywords: Maize Landrace, Drought, Water Use Efficiency, Irrigation, Stress

Türkiye Yerel Mısırlarından Bazılarının Su Kullanım Etkinliği ve Kuraklığa Dayanıklılık İndekslerinin Araştırılması

Öz

Amaç: Her geçen gün artan kuraklık nedeniyle, yerel bitki popülasyonları, kuraklığa dayanıklı çeşitler geliştirmeye odaklanan ıslahçıların en büyük kaynağıdır. Yüksek miktarda su kullanan mısırın birim kuru madde üretimi de diğer mahsullere göre daha yüksektir. Buna bağlı olarak, bugün dünyanın karşı karşıya kaldığı su kıtlığına karşı yüksek su kullanım etkinliğine sahip çeşitlerin önemi artmaktadır. Çalışmada, Türkiye'deki yerel mısır çeşitleri su kullanım etkinliği (WUE) ve kuraklığa dayanıklılık indeksi (DSI) açısından incelenmiştir. **Materyal ve Yöntem:** Araştırmada, 16 yerel mısır popülasyonu ve Kontrol amaçlı 3 hibrit mısır çeşidi kullanılmıştır. Buharlaşmaya bağlı olarak buharlaşan suyun %150'sinin (I 150) ve %50'sinin (I 50) verildiği iki uygulama koşulunda iki yıl (2016-2017) süre ile yürütülmüştür.

Bulgular: Çalışmanın birinci yılında 0,32-2,73 kg m-3 arasında değişen WUE, çalışmanın ikinci yılında 0,04-1,97 kg m-3 arasında değişmiştir. DSI değerleri ise 0,83-1,17 arasında değişmiştir. **Sonuç:** Araştırma sonucunda, kontrol çeşitlerinin WUE değerleri Türkiye yerel mısır çeşitlerinden daha yüksekti. Sonuçlara göre 5 yerel mısır çeşidi ve iki hibrit çeşidin kuraklığa orta derecede dayanıklı olduğu belirlendi.

Keywords: Yerel mısır, Kuraklık, Su Kullanım Etkinliği, Sulama, Stres

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Introduction

The different stress factors faced by plants cause them to not fully demonstrate their potential. Among the stress factors seen in agricultural areas, drought stress ranks first with a share of 26%. Plants endure many molecular, physiological and biochemical changes due to drought stress. Plants develop resistance systems that will allow them to adapt to different environmental conditions against this situation.

Under drought stress, plants show morphological changes to reduce the amount of transpiration in the leaf, while roots show changes to improve the root structure in order to take water in the soil better. Since photosynthesis will slow down under drought stress, seedling development remains weak, and some plants form dense hairs on their leaves in response to drought.

In order to prevent or minimize existing drought damage, measures such as selecting appropriate soil cultivation methods, enriching the soil with organic matter and fallowing should be taken. In addition, measures should be taken such as the effective fight against weeds, proper fertilization, correct planting time, supplementary irrigation when necessary, and most importantly, choosing the right and resistant variety. In arid and semi-arid regions where precipitation is insufficient or seasonal distribution is irregular, irrigation is the most important factor in revealing the potential of the corn plant (Gencoglan and Yazar, 1999).

Corn farming in Turkey is generally based on irrigation. Corn farming cannot be considered without irrigation, especially in places with high annual precipitation such as the Eastern Black Sea region. Corn plant needs 700-750 mm of water during the production season. Since the increase or decrease in the yield in corn production depends on the variety, rainfall and evaporation amount and the water conductivity of the soil, restricted irrigation in corn production places. Also, water is scarce will not cause a decrease in productivity and will increase water use efficiency (Shaozhong et al. 2000).

The corn plant is most susceptible to drought (water stress), just before the flowering period, during the flowering period and during the grain-filling period. These periods are considered as stress condition stages in drought tolerance improvement studies (Erdal, 2016). Khodarahmpour (2011) stated that drought stress is one of the most important factors affecting the growth, development and production of plants. Majid et al. (2017) emphasized that increasing the moisture content of the root zone during the plant development period will have a large share in increasing the water use efficiency while conserving water.

Corn plant uses carbon dioxide, sunlight and water more effectively than C3 plants, as well as having more water during the growing period and being very sensitive to drought stress (Huang et al., 2006). Increasing water use efficiency (WUE) will play a major role in ensuring efficiency and adaptation in the future periods when global climate change and water shortage will be experienced (Xu and Hsiao, 2004). In order to increase the water use efficiency, it is necessary to develop varieties that can produce a higher amount of dry matter per unit of water. In breeding studies, the potential of the existing genetic material should be known before working on WUE. Debaeke and Aboudrare (2004) reported that water stress is the main factor limiting crop production in rainfed farming systems in arid and semi-arid regions. Doorenbos and Kassam (1979) reported that climate and soil type determine different drought patterns that are more or less damaging to the crop and require special cultivation and farming adaptations. Morris and Garrity (1993) reported that water use efficiency (WUE) in the intermediate crop system generally increases between 4-99% over the WUE of monoculture. However, some investigators have reported that intermediate crop systems sometimes do not clearly increase WUE (Grema and Hess, 1994; Shackel and Hall, 1984) or sometimes do not reduce WUE (Rees, 1986a,b; Singh et al., 1988).

This study, it was aimed to examine some local maize populations in terms of water use efficiency (WUE) and drought resistance index values.

Materials and Methods

The local corn populations examined in terms of water use efficiency and drought resistance index and the areas where they are supplied are given in Table 1. 16 local corn populations and 3 commercial hybrid corn varieties were used in the study. The study was carried out under second crop conditions in 2016 and 2017 in the trial area of Dicle University Faculty of Agriculture located between 37°53' North latitude and 40°16' East longitude in Diyarbakır. The land on which the study was conducted has a slightly alkaline pH between 7.5 and 7.7, without salt stress, moderately calcareous and very low organic matter, poor in phosphorus, and rich in potassium.

Table 1. Local populations and hybrid maize varieties used in the study and where they are supplied

No	CODE	PROVINCE /COMPANY	COUNTY	VILLAGE	NEIGHBORHOOD	Altitude (m)
1	DZ-M-28	ARTVİN	MURGUL	MERKEZ	KÜRE	467
2	DZ-M-47	ARTVİN	HOPA	ÇAMLIKÖY	MADENLİ	147
3	DZ-M-68	ARTVİN	BORÇKA	DÜZKÖY	TEPE	402
4	DZ-M-70	ARTVİN	BORÇKA	DÜZKÖY	ÇAT	316
5	DZ-M-72	ARTVİN	BORÇKA	DÜZKÖY	ÇAT	316
6	DZ-M-161	DÜZCE	MERKEZ	AYNALI		219
7	DZ-M-14	RİZE	FINDIKLI	YENİKÖY	MERKEZ	125
8	DZ-M-25	RİZE	ÇAYELİ	BUZLUPINAR		305
9	DZ-M-41	RİZE	GÜNEYSU	ORTAKÖY	MERKEZ	210
10	DZ-M-45	RİZE	FINDIKLI	SULAK	GÜLTEPE	268
11	DZ-M-172	SAKARYA	HENDEK	KURTBEYLİ		24
12	DZ-M-82	SAMSUN	MERKEZ			128
13	DZ-M-199	ZONGULDAK	EREĞLİ	İZCEPINAR	AYLAR	242
14	DZ-M-205	ZONGULDAK	EREĞLİ	ÇAYLIOĞLU		257
15	DZ-M-206	ZONGULDAK	EREĞLİ	DÜZPELİT	AYVATLAR	303
16	DZM-18	TRABZON	OF		YENİMAHALLE	68
17	EXCELLL	DNA SEED				
18	ELİOSO	DNA SEED				
19	GARİZ	DNA SEED				

Diyarbakır province where the study was conducted is located in the Southeastern Anatolia steppe climate and the annual average rainfall is 450-500 mm, approximately 1% of this precipitation falls in the summer months. The annual average temperature is 15.8°C, especially in July and August, the hottest days are experienced. The average temperature, humidity and precipitation values for the years 2016-2017 and for many years, belonging to the province of Diyarbakır, where the trial was carried out, are given in Figure 1.

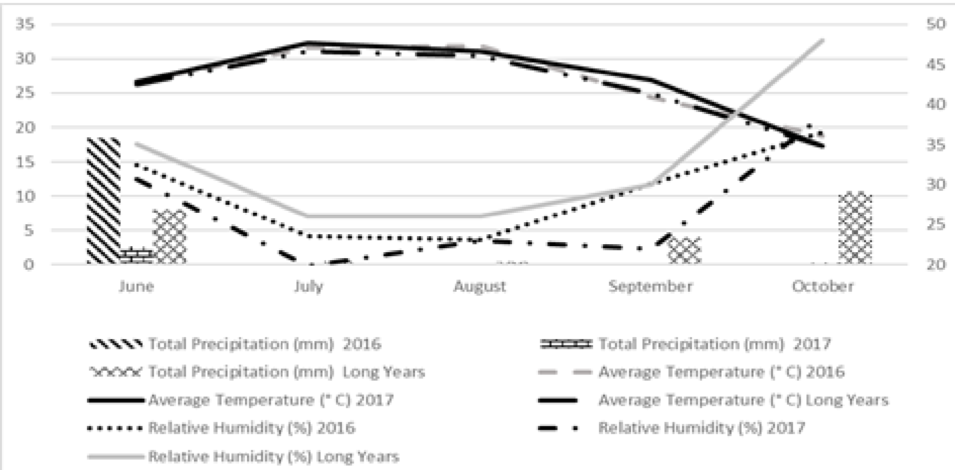

Figure 1. Climate data for 2016-2017 and long years second-crop corn production period of Diyarbakır province where the trial was conducted

During the period in which the study was conducted, the total amount of precipitation was 18.4 mm in 2016 and 2.8 mm in 2017. It is seen in Table 2 that the amount of rainfall for many years in the same period was 23.7 mm. When the average temperature values are examined, it is seen that the values are close to the long-term average in both years of the experiment. The highest average temperature determined as 31.9°C in 2016 is seen to be 32.3°C in 2017. During the trial period, the relative humidity was lower than the long-term averages, and it varied between 23.1% and 36.5% in 2016 and between 19.8% and 38.6% in 2017.

The experiment was carried out with 3 replications according to the divided plots trial pattern in randomized blocks. Irrigation application was established on the main plot and the maize populations on the subplot. After plowing deeply with a plow before planting, the experimental field was made ready for planting by pulling the disc harrow and the worshiper. The trial plots were made up of 2 rows of 6 m long. The sowing norm is set to be 70 cm between rows and 15 cm above rows. The sowing process was carried out on the 1st year on 27.06.2016 and the 2nd year on 16.06.2017 with a test drill. The irrigation system was set up with a lateral position in the middle of both corn rows, depending on separate hours for I 150 and I 50 applications. I 50 applications; It is designed as applications where 50% of the evaporation obtained from A class evaporation boiler is given and I 150 is given 150% of the evaporation.

In the first year, sprinkler irrigation was applied until the plant emergence, and the drip irrigation system was installed after the emergence. In the second year, the drip irrigation system was installed immediately after planting and irrigation operations were carried out. Irrigation was done every 4 days in both years, according to the method specified by Simsek and Gercek (2005).

In determining the amount of irrigation; the amount of evaporation in the irrigation period is taken into account. In the determination of the evaporation amount, an open-top container (Class A Evaporation Pan) made of galvanized sheet, 120 cm in diameter and 25 cm in height, was used near the test area.

The following equation is used in the calculation of irrigation water to be given (Yolcu, 2014).

$$I = A \times Ep \times K \times P$$

In equality; where is I: Irrigation water to be applied to the parcel (L), A: Parcel area (m^2), Ep: The evaporation amount (mm) from the A class evaporation vessel in the irrigation interval, K: Coefficient based on trial, P: Wetting area ratio.

As per the experiment, the wetting area ratio (P) was taken as 0.65, since the entire parcel area was not wetted by drip irrigation.

The coefficient (K) taken as the basis for the experiment was taken as (I 150) 1.50 for full irrigation and 0.50 for restricted irrigation.

In the first year of the study, 128.14 mm of water was given by the sprinkler irrigation system. After the plant's emergence, the drip irrigation system was established and I50 and I150 issues were started to be implemented. In the second year, a drip irrigation system was installed on the trial land right after the planting process, and all irrigation was done with the system. Until the outlet is provided, there is no discrimination in irrigation applications and a total of 100 mm of water was applied to the whole area. After the plant emergence, the irrigation process was continued by making a difference between the applications. The amount of water given in both years and the amount of evaporation are given in Figure 2.

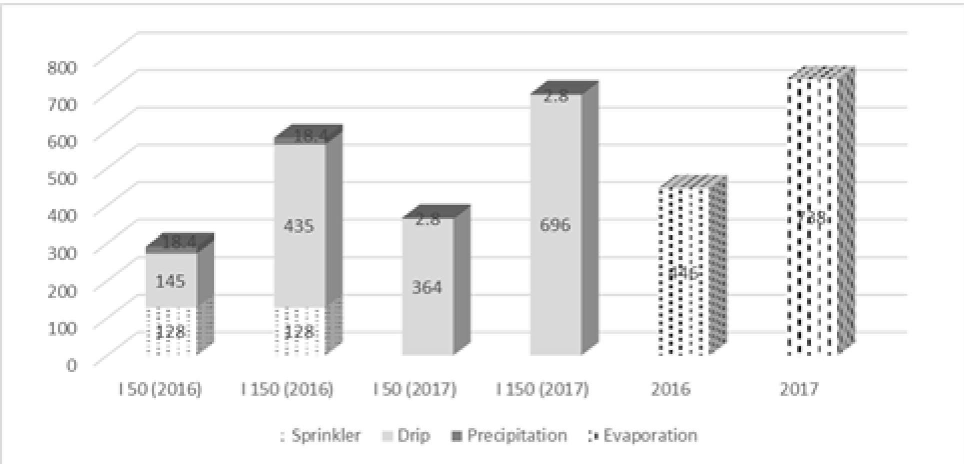

Figure 2. The total amount of water, precipitation and evaporation gave to the trial area in 2016 and 2017

In the study, fertilizers were applied as 240 kg Nitrogen (N) and 100 kg Phosphorus (P_2O_5) per hectare. In both years, before planting, fertilizing was made with 20-20-0 compound commercial fertilizer as 100 kg pure N and 100 kg P_2O_5 per hectare as base fertilizer. After the exit, the remaining N amount was divided into 7 equal parts with drip irrigation and given in the form of urea (46% N).

Water use efficiency is expressed as the ratio of total grain yield to the amount of irrigation water supplied. Irrigation-based water use efficiency (WUE) was calculated by the following formula (Durmus et al., 2015).

WUE=TGY/(IW+R)

Where is TGY: Total grain yield (kg m^{-2}), IW: Total amount of irrigation water (ton m^{-2}), R: Total amount of rain (tons m^{-2})

Drought susceptibility index;

DSI = (1- (Population Yield in Dry Conditions) / (Population Yield in Irrigated Conditions)) / (1- (Yield of All Populations in Dry Conditions) / (Yield of All Populations in Irrigated Conditions))

It has been calculated separately for each genotype with its formula (Ozturk, 1999).

The data obtained from the study were subjected to variance analysis according to the experimental design of divided plots in random blocks for two years separately, and the resulting differences were grouped with TUKEY's multiple comparison test.

RESULTS AND DISCUSSION

It has been determined that different irrigation amounts affected the water use efficiency of some Turkish maize landraces. Accordingly, as a result of the analysis of variance performed separately for the applications, it was determined that the maize landraces different in terms of water use efficiency in both years of the study and in each irrigation dose application (Table 2).

Table 2. Variance analysis results of water use efficiency values of maize genotypes grown in different irrigation applications

	Source of Variation	D.F.	Mean Squares	
			2016	2017
Combined	Replication	2	0.0129	0.029
	Irrigation (I)	1	6.9611**	15.54**
	Error 1	2	0.0073	0.010
	Genotypes (G)	18	1.7015**	0.558**
	I × G Int.	18	0.1110**	0.111**
	Error 2	72	0.0123	0.006
	CV (%)		11.05	11.51
I 50	Replication	2	0.01457	0.0117
	Genotypes	18	0.75742**	0.1151**
	Error	36	0.01205	0.0031
	CV (%)		14.47	18.06
I 150	Replication	2	0.00670	0.0280
	Genotypes	18	1.05515**	0.5557**
	Error	36	0.01259	0.0090
	CV (%)		8.8	9.07

** Significant at 0.01 probability levels.

According to the results of the first year of research, WUE is varied between 0.32-2.20 kg m^{-3} from I 50 application and 0.70-2.73 kg m^{-3} from I 150 application. The highest value of WUE has been obtained Excell genotype from both applications. According to the means of applications, WUE is varied between 0.55-2.46 kg m^{-3} and the highest value was obtained Excel genotype. Also, the highest value among maize landraces was obtained from DZM-161 in the first year of the study (Table 3). WUE value of DZM-161 genotype obtained from I 50 application 1.16 kg m^{-3} and from I 150 application 1.98 kg m^{-3} and the mean of both applications 1.57 kg m^{-3}. As can be seen from Table 3, it was determined that water restriction reduces water use efficiency. Because, while the mean of I 50 application 0.76 kg m^{-3}, the mean of I 150 application is determined as 1.25 kg m^{-3}.

In addition, when the averages of the first year were examined for both applications, it was determined that the DZM-41 genotype was not affected by the difference between the applications and had a higher WUE value in water restriction.

Depending on the results of the first year of the research, the lowest WUE values were obtained from DZM-47, DZM-68, DZM-25, DZM-45, DZM-205 and DZM-172 genotypes in I 50 application, while the lowest value was obtained from DZM-206 genotype in I 150 application. According to the mean of both applications, the lowest value of WUE was obtained from the DZM-68 genotype.

Table 3. *2016 average water use efficiency (WUE) values of maize genotypes grown in different irrigation applications and the groups obtained as a result of multiple comparison tests.*

GENOTYPES	I 50	I 150	Means	Change (%)
DZM-14	0.84±0.107 cd[1]	1.02±0.041 d-g	0.93±0.066 d-g	21.43▲
DZM-18	0.50±0.028 de	1.10±0.038 de	0.80±0.134 e-h	120.00▲
DZM-25	0.38±0.021 e	1.07±0.042 def	0.73±0.155 ghi	181.58▲
DZM-28	0.82±0.060 cd	1.32±0.047 cd	1.07±0.116 d	60.98▲
DZM-41	1.03±0.033 c	1.01±0.027 d-g	1.02±0.019 de	-1.94▼
DZM-45	0.39±0.013 e	0.85±0.017 efg	0.62±0.101 hi	117.95▲
DZM-47	0.32±0.027 e	0.90±0.053 efg	0.61±0.133 hi	181.25▲
DZM-68	0.37±0.022 e	0.73±0.009 fg	0.55±0.082 i	97.30▲
DZM-70	0.59±0.026 de	0.85±0.023 efg	0.72±0.061 ghi	44.07▲
DZM-72	0.51±0.054 de	0.92±0.035 efg	0.71±0.097 ghi	80.39▲
DZM-82	0.52±0.031 de	0.95±0.024 efg	0.73±0.098 ghi	82.69▲
DZM-161	1.16±0.040 c	1.98±0.109 b	1.57±0.191 c	70.69▲
DZM-172	0.42±0.055 e	1.57±0.057 c	0.99±0.259 def	273.81▲
DZM-199	0.55±0.022 de	1.01±0.039 d-g	0.78±0.104 fgh	83.64▲
DZM-205	0.41±0.013 e	0.74±0.057 fg	0.58±0.077 hi	80.49▲
DZM-206	0.56±0.032 de	0.70±0.036 g	0.63±0.038 hi	25.00▲
Elioso	1.08±0.032 c	1.91±0.077 b	1.50±0.189 c	76.85▲
Excell	2.20±0.058 a	2.73±0.181 a	2.46±0.146 a	24.09▲
Gariz	1.74±0.207 b	2.42±0.064 a	2.08±0.179 b	39.08▲
Means	0.76±0.066 b	1.25±0.078 a	1.01±0.056	64.47▲

When the change rates given in Table 3 are examined, it is seen how much the WUE values change in reduced irrigation compared to full irrigation. While DZM-41 genotype gave a higher value in I 50 application in terms of WUE, it was seen that DZM-14 and Excell genotypes were less affected by reduced irrigation application in terms of water use efficiency. These 3 genotypes (DZM-14, DZM-41 and Excell) can be said to be the genotypes that can be used in case of problems in irrigation applications.

According to the result of the second year of study, WUE was changed 0.04-0.79 kg m^{-3} when applied I 50 dose. The highest value of WUE at I 50 application has been obtained Gariz genotype, and the lowest value has been obtained DZM-82 genotype. In addition, DZM-72 among the maize landraces had the highest WUE (0.47 kg m^{-3}) in I 50 application. Based on the 2017 averages of the I 150 implementation, the maximum WUE value has been obtained Excell genotype (1.97 kg m^{-3}), and minimum value has been obtained DZM-45 genotype (0.39 kg m^{-3}).

When the averages of 2017 are examined, it has been determined that water restriction reduces the efficiency of water use, just like the results obtained in 2016. The WUE value, which is 1.05 kg m^{-3} in the I 150 application, is determined as 0.31 kg m^{-3} in the I 50 application (Table 4). According to the results, we can say that the WUE increases with the increase in the amount of irrigation water. Kang et al. (2000) reported that although the water restriction to be applied in the seedling period plays a small role in terms of water saving, the reduction to be implemented in the future periods will have significant effects on the plants.

When the averages of maize genotypes were examined according to the two-year averages, it was determined that the maize varieties used for control in the study had the highest WUE value. Among the maize landraces, the highest WUE value was obtained from the DZM-72 genotype (0.97 kg m^{-3}). When the WUE change rates between treatments were examined in Table 4, it was determined that the genotype most affected by water restriction was DZM-82, and the least affected genotype was DZM-18. Simsek and Gercek (2005), water use efficiency (WUE) value varies between 1.02-1.43 kg m^{-3}, Gencoglan and Yazar (1999a), water use efficiency varies between 1.00-2.43 kg m^{-3}, Durmus et al. (2015) reported that the WUE value was 1.77 kg m^{-3} in the full irrigation water amount and 2.04 kg m^{-3} in the limited irrigation water amount. Kirnak et al. (2003) reported that WUE values increased with the decrease in the amount of irrigation water and the WUE values varied between 1.08-2.37 kg m^{-3}. Erdal (2014) reported that WUE values ranged between 0.41 and 0.78 kg m^{-3}. Adamtey et al. (2010) reported that the WUE value varied between 0.12-0.51 kg m^{-3}.

Mansouri-Far et al. (2010), in their study where they examined the effects of different irrigation periods and nitrogen doses on corn in two different locations, reported that WUE values ranged between 8.57-14.11 kg m^{-3}.

Table 4. 2017 average water use efficiency (WUE) values of maize genotypes grown in different irrigation applications and the groups obtained as a result of multiple comparison tests

GENOTYPES	I 50	I 150	Means	Change (%)
DZM-14	0.26±0.016 e-h[1]	0.75±0.022 fg	0.50±0.112 g-j	188.46▲
DZM-18	0.31±0.032 d-g	0.68±0.026 g	0.50±0.086 g-j	119.35▲
DZM-25	0.38±0.032 c-f	1.03±0.049 ef	0.71±0.148 cde	171.05▲
DZM-28	0.32±0.031 d-g	1.36±0.075 cd	0.84±0.236 bc	325.00▲
DZM-41	0.35±0.041 d-g	0.96±0.060 efg	0.65±0.141 d-g	174.29▲
DZM-45	0.04±0.001 jk	0.39±0.033 h	0.21±0.078 k	875.00▲
DZM-47	0.08±0.008 ijk	0.67±0.026 gh	0.37±0.133 ijk	737.50▲
DZM-68	0.20±0.028 g-k	0.72±0.034 g	0.46±0.118 hij	260.00▲
DZM-70	0.27±0.061 e-h	0.86±0.042 efg	0.56±0.135 e-h	218.52▲
DZM-72	0.47±0.023 bcd	1.48±0.119 bc	0.97±0.233 b	214.89▲
DZM-82	0.04±0.008 k	0.67±0.036 gh	0.35±0.141 jk	1575.00▲
DZM-161	0.24±0.022 e-i	1.12±0.058 de	0.68±0.199 c-f	366.67▲
DZM-172	0.11±0.016 h-k	0.84±0.029 efg	0.47±0.163 hij	663.64▲
DZM-199	0.21±0.008 f-j	0.86±0.075 efg	0.54±0.148 f-i	309.52▲
DZM-205	0.40±0.041 cde	1.07±0.044 de	0.74±0.154 cd	167.50▲
DZM-206	0.24±0.017 e-i	0.94±0.054 efg	0.59±0.159 d-h	291.67▲
Elioso	0.54±0.042 bc	1.77±0.048 ab	1.16±0.278 a	227.78▲
Excell	0.62±0.072 ab	1.97±0.096 a	1.29±0.306 a	217.74▲
Gariz	0.79±0.056 a	1.74±0.064 ab	1.27±0.216 a	120.25▲
Means	0.31±0.026 b	1.05±0.057 a	0.68±0.047	238.71▲

A genotype with DSI ≤ 0.5 means it is high stress-tolerant, 1.0≥ DSI > 0.5 is moderately tolerant, and DSI > 1.0 is sensitive. The stress coefficient was calculated over the most stressful environment (Figure 3).

DZM-28, DZM-45, DZM-199, DZM-47, Excell, DZM-14, Gariz and DZM-72 genotypes used in the study were found to be moderately sensitive to drought, with values between 0.5 and 1.0 in terms of DSI values. None of the genotypes in the study was drought tolerant (DSI ≤ 0.5) in terms of DSI value. DZM-25, DZM-161, DZM-82, DZM-206, DZM-68, DZM-172, DZM-41, DZM-18, DZM-205, DZM-70 and Elioso genotypes are in terms of DSI value (DSI > 1.0) was determined as drought sensitive.

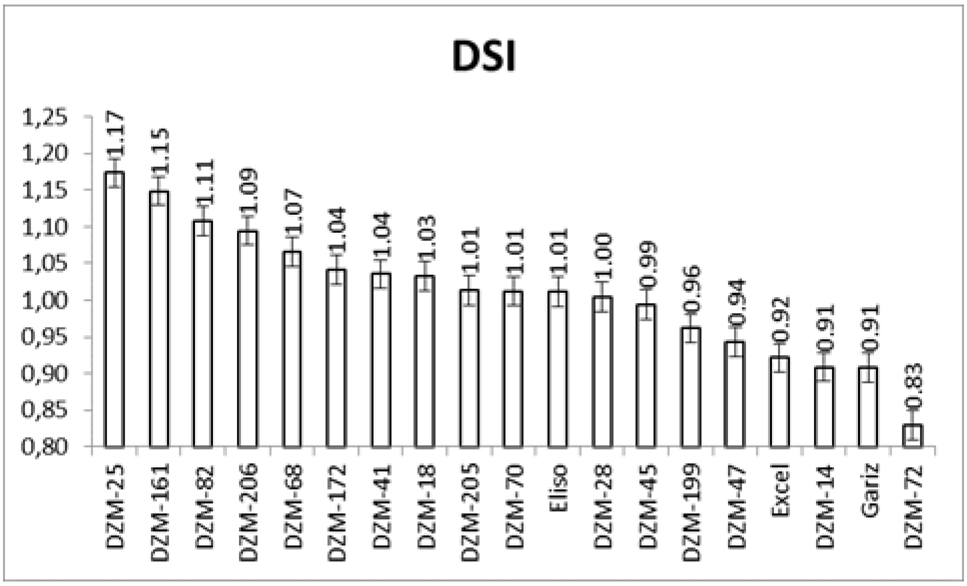

Figure 3. Drought susceptibility index of maize genotypes

Among the genotypes considered, DZM-72 genotype stands out as a promising genotype in drought stress breeding studies in terms of DSI. In addition, DZM-25 and DZM-161 genotypes stand out as promising genotypes in breeding studies to be carried out with the aim of developing new varieties for conditions without drought stress.

Grzesiak et al. (2013) reported that the drought tolerance of a plant species is generally determined by the genes of the plant, as well as its morphological, phonological, physiological and biochemical characteristics, and the responses of plants to drought stress depend on the species, genotype, plant age, level and duration of drought, and physical parameters of the soil.

Conclusion

In order to meet the increasing food, need due to the continuous increase in the world population and to reduce the effect of drought in changing climatic conditions, the need to develop new drought-resistant plant varieties has arisen.

In the process of breeding drought-resistant varieties, since the most important source is local populations, it is necessary to define the population to be studied.

In this study, some of the Turkish maize landraces were discussed in terms of WUE and DSI. According to the results obtained, it was determined that limiting the amount of water supplied reduces WUE, and in cases where the water requirement is not fulfill, there will be a decrease in inefficiency. Although the WUE values of the examined maize landraces were low, it was determined that some of them could be used in the breeding of drought-resistant varieties. DZM-72 genotype was determined to be recommendable in terms of DSI.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contribution Statement

The authors confirm contribution to the paper as follows: study conception and design: OA, CA; data collection: OA, CA; analysis and interpretation of results: OA, CA; draft manuscript preparation: OA, CA. All authors reviewed the results and approved the final version of the manuscript.

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