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ROLE OF SELECTION AND IRRIGATION PERIODS IN IMPROVING SOME SUNFLOWER CHARACTERISTICS RELATED WITH DROUGHT TOLERANCE

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ABSTRACT

A field experiment was carried out at University of Baghdad – College of Agricultural Engineering Sciences in order to improve the drought tolerance characteristics of Sunflower using the two varieties, Shamos and Local, according to selection criteria; early flowering, low plant height and disk diameter under 10% selection intensity and three irrigation periods (5days, 8days, 10days). A split-plot according to Randomized complete block design was used with three replicates during the spring season of 2019 and 2020. Results revealed that the selection has significantly increased the yield characteristics and the drought stress tolerance; the selected genotype (LD) gave the highest peroxidase enzyme activity 20,708, it also gave the highest stability index of yield reached (79.9). Moreover, Drought stress has significantly increased the enzymes activity in the selected genotypes; the genotype (LD) gave the highest value for the POD enzyme under the irrigation of 10 days reached 26.703 mg^{-1}. Protein, and the selected genotype (SHS) gave the highest value of SOD enzyme under the drought stress reached 9,093 ml^{-1}, while the selected genotype (LF) gave the highest value of the CAT enzyme under the 10 day irrigation period reached (25,320) mlg^{-1}. Protein. The genetic, and phenotypic heterogeneity values did not significantly differ in relative water content and POD enzyme reached (11.95), (11.98), (24.33) and (24.66). The plant's yield varied for the selected genotypes; the genotypes (LD) and (SHD) gave the highest values of plant yield reached (8,240) and (7.341), respectively. While the selected genotype (SHF) gave the highest stress tolerance index reached 0.675. Results also revealed that the five-day irrigation treatment gave the most significant values of all the studied traits, which is not significantly differ from the eight-day irrigation treatment, especially in plant yield. Accordingly, the two varieties, Shamos and Local revealed a high response to selection, and that selection has improved most of the traits and increased the crop's stress tolerance.
Keywords: drought tolerance, Sunflower, plant's breeding, POD, SOD, CAT.

Introduction

The sunflower crop is native to North America by origin; Nowadays, it is grown and cultivated widely and adapt to different environmental conditions (Zobiole and others, 2010). Therefore, Sunflower is known to be a drought tolerant crop; on the other hand, it is a sensitive crop to drought stress conditions (Nezami *et al*., 2008 and Nilanthi *et al*., 2015).

Sunflower is considered as the most important oil crop in the world, it contains unsaturated fatty acids and the lack of cholesterol (Razi and Assad, 1998). Sunflower seeds contain 48-25 % of oil and 27-20% protein (Rathor *et al*., 2001); it also contains a soluble vitamins A, E, and K (Hussain *et al*., 2000).

Stress is defined as any physiological change that leads to disruption and imbalance in plant metabolism (Farooq *et al*., 2009). Abiotic stresses cause greater economic losses to field crops than biotic stresses (Slater *et al*., 2003). Drought stress is one of the environmental stresses that occur all over the world, especially in warm and dry regions (Porudad & Beg, 2003). Bosnjak (2004) showed that drought is the predominant condition in summer, which leads to losses of up to 50% of the sunflower crop. Drought stress leads to many changes within the plant, the most important of which are the increase in the concentration of cellular solutions and the shrinkage of the protoplasm in addition to a decrease in the turgor Pressure in the cell walls (Schuize *et al*., 2002). The researchers have developed many techniques to make plants more resistant to drought, among the most important of which is choosing the correct breeding method in addition to genetic modification of the genes. Selection does not create new genes; instead, it changes the genes replication in the population. Therefore, it is necessary to breed for drought tolerance, in fact this depends on the presence of diverse genetic material; accordingly, the genetic resources tolerant to drought can be identified and used to ensure a high yield when drought occurs (Rauf and Sadaqat, 2007).

Therefore, this experiment was aimed to improve the two varieties of sunflower by selection according to three criteria, which are the fewest days to flowering, the shortest plant height and the largest disc diameter with the possibility of determining which criteria is more efficient in order to evaluating the performance of the selected genotypes under three levels of water stress to find out any genetic structure Combines high yield and drought tolerance.

Materials and Methods

A field experiment was carried out at University of Baghdad – College of Agricultural Engineering Sciences in order to improve the drought tolerance characteristics of Sunflower using the two varieties, Shamos and Local, according to selection criteria; early flowering, low plant height and disk diameter under 10% selection intensity and three irrigation periods (5days, 8days, 10days).

Spring season of 2019

The experimental filed was plowed by two perpendicular plows and then the process of smoothing and leveling the ground was carried out and divided into meadows in a distance of 0.75 cm, the seeds were planted at a rate of 3-5 seeds in a distance of 0.25 cm for each of the two varieties.

The experiment filed was planted on March of 2019, and urea fertilizer (N% 46) was applied at a rate of 60 kg. ha^{-1} (Nilanthi *et al.*, 2015) in two portions, the first when four leaves appeared and the second when the flowering buds appeared, the plant discs were wrapped during the flowering phase with cloth bags to ensure self-pollination with mixing pollen grains and distributed for each electoral criterion, the two varieties were harvested on 7/15/2019 and thus the first selection cycle was completed.

No.	Genotype symbol	Details
1	LF	selected for early flowering of the local variety
2	LD	selected for the disc diameter of the local variety
3	LS	selected for short stem for the local variety
4	LC	The origin of the local variety
5	SHF	selected for early flowering for the Shamos variety
6	SHD	selected for the disc diameter of the Shamos variety
7	SHS	selected for short stem for the Shamos variety
8	SHC	The origin of the Shamos variety

Spring season of 2020

A field experiment was carried out at University of Baghdad - College of Agriculture in order to evaluate the genotypes performance under drought stress. The Randomized complete block design (RCBD) under split plot where applied; the main plots were irrigation periods (D1= 5 days D2= 8 days D3 10 days) and the secondary plots where the genetic selection of the parents (8 genotypes).

The plants of the experimental unit were cultivated in 16 lines, two lines for each genotype, in a distance of 0.75 cm between each line, and 0.25 cm between each plant. The plants were regularly irrigated until 6 leaves appeared, and then drought stress treatments were applied, which are different irrigation durations, with the amount of irrigation fixed for each period.

After the completion of disc diameter and random pollination, the plants were covered with perforated bags to preserve the plant seeds from birds. The crop was harvested on 7/1/2020.

The measured parameters were the Stress tolerance Index (STI), Yield stability index (YSI), Plant yield (Tons. Ha^{-1}), POD, SOD, and CAT enzymes.

1. Peroxidase enzyme POD

The efficacy of the peroxidase enzyme was estimated according to the Nezih method (1985). Guaiacol was prepared by placing 1.36 ml of Guaiacol in a beaker and the volume was completed to 250 ml with distilled water.

1 ml of Hydrogen peroxide was mixed with 1 ml of prepared Guaiacol. the data were measured by a Spectrophotometer at wavelength 420 and the change was detected every 30 seconds for 3 minutes.

POD ($u.mg^{-1}$ proten) enzymatic activity = device records / time.

2. The superoxidase dismutase (SOD) enzyme

The enzymatic activity was estimated according to the method (Beyer and Fridoich, 1987) using six solutions, which were

The first solution consists of:

A- Prepare K_2HPO_4 (82.4 mmol) and EDTA-2Na (165 μmol) by dissolving 3.5880 g of K_2HPO_4 and 0.0154 g of EDTA in a volume of distilled water and then complete the volume to 250 ml of distilled water.

B- K_2HPO 82.4 (mmol), EDTA-2Na (165 μM) by dissolving 2.8034 g of K_2HPO and 0.0154 g of EDTA-2Na in an amount of distilled water and the volume was completed to 250 ml of distilled water, and buffer potassium phosphate was prepared by adding solution B to solution A until the PH value became 7.8.

The second solution consists of:

Dissolve 150 mg of L-methionine in 5 ml of distilled water

The third solution consists of:

Prepare by dissolving 0.1 ml of Triton X-100 in 10 ml of distilled water

The fourth solution is prepared through:

Nitro blue titrazolum NBT 14.4 mg is dissolved in 10 ml of distilled water and kept in an opaque vial.

Fifth solution: - a mixture of the four previous solutions, with a volume of 18.35 ml of the first solution, 1.50 ml of the second solution, 0.75 ml of the third solution, and 1.00 ml of the fourth solution, so that the total volume becomes 21.60 ml

The sixth solution is a tincture of riboflavin

Prepare by dissolving 0.0018 grams of riboflavin in a small amount of distilled water and supplement the volume to 100 milliliters of distilled water.

Procedure: - 1.5 ml of the mixture was added to the test tubes and 500 microliters and filled with distilled water. Then, 40 microliters of the sample were added to the tubes and the blank treatment was prepared in the same way with the difference that the tube contains distilled water instead of the sample, and 40 A microliter of riboflavin dye prepared in the sixth solution, then the absorbance was read with a spectrophotometer at the wavelength of 560nm, then the tubes were exposed to light for seven minutes and the absorbance was read again at the same wavelength and the highest inhibition percentage of the sample was calculated, then the enzyme activity was calculated according to the following equations:

SOD (inhibition on%) = (A2B-A1B) - (A2S-A1S) / (A2B-A1B) * 100

A1B = Blank absorbance before illumination

A2B = the absorbance of the Blank after illumination

A1S = Absorbance of the sample before illumination

A2S = Absorbance of the sample after illumination

UML-1 (SOD) efficacy =% sample inhibition /% highest inhibition rate * df / vs (ml)

Df dilution factor (1:10) ml

U unit

Vs sample size

3. CAT enzyme

The effectiveness of the catalase enzyme was estimated according to the method (Aebi, 1974). The following solutions were used:

The first solution

KH_2PO_4 buffer potassium phosphate solution prepared by adding a certain volume of solution A to 50 ml of solution B.

Solution A: - by dissolving 1.7420 g of K_2HPO_4 in a small amount of distilled water and complete the volume to 200 ml of distilled water

Solution B: - by dissolving 1.3608 g of KH_2PO_4 in a small amount of distilled water and complete the volume to 200 ml with distilled water

The second solution

Hydrogen peroxide solution H_2O_2 at a concentration of 30mm by taking 0.34 ml of H_2O_2 (30%) and filling the volume to 100 ml using the buffer solution.

Work: - 0.1 ml of sample was added to 1.9 ml of buffer solution, then 1.0 ml of prepared hydrogen peroxide was added, and the tube was shaken to mix the materials well.

2. CAT enzyme activity (u.mlg^{-1} protein) = device records / time /0.01*0.1* protein concentration (u.mg^{-1} proten)

0.1 = ml sample volume

0.1 = one unit of the enzyme

4. Plant yield ton. Ha^{-1}: - Sun flower heads were harvested in each unit, and then the individual plant yield in the number of plants per hectare was calculated.

Seed yield per experimental unit / experimental unit size * 10,000

5. STI Drought Tolerance Index

6. YSI Yield Stability Index.

Results and Discussions

SOD

The SOD enzyme is related with drought stress by increasing its concentrations during the drought stress to reduce the effects of drought.

The results in Table (3) revealed that there were significant differences among the genotypes in the activity of the SOD enzyme. The genotype (SHS) gave the highest SOD activity reached 5,578 units. ml^{-1}, which is significantly over its origin and similar to all of (SHF), (SHS), (LS), (LF) and (LD) genotypes, while the genotypes (LC) gave the lowest SOD activity reached 3,898 units. ml^{-1}, The selection leads to phenotypic and functional changes that contribute to increase the plant's ability to tolerate drought stress. Therefore, selection increases the activity of SOD enzyme by increasing the action of genes responsible for SOD formation, which thus works to eliminate the free roots ROS.

These results were in agreement with both (Mittler, 2002) and (Elsahookie *et al*., 2009) who emphasized that cultivation of varieties with heterogeneity and high heritability is one of the most important aspects of plant tolerance to drought stress.

Results also revealed a significant difference among the irrigation periods on the activity of the SOD enzyme; the irrigation period of 10 days gave the highest activity of SOD enzyme reached 8.259 units. Ml^{-1}, followed by the period of 8 days, which gave 3.596 units. ml^{-1}, and the period of 5 days, which gave the lowest value reached (2.526) units. ml^{-1}.

The increment in the concentration of SOD enzyme in plants is attributed to the increase in the period between the irrigation times, which means increasing the drought stress, as the most important function of this enzyme is to restore the cells vitality and reduce the speed of their destruction and neutralize free roots. These results were in agreement with Soleimanzadeh (2012), which confirmed that the stress increases the activity of SOD enzyme. All genotypes exhibited similar behavior towards irrigation periods, which means that there is no significant difference among them.

The results revealed that the genetic variations were higher than the environmental variations by a small percentage. Therefore, heritability in had an average value of 68.745. Also, it was found that there were high values for each of the PCV and GCV, which reached (25.06) and (20.78), respectively and this is due to the existence of the responsible genes in the selected genotypes. These results were in agreement with Elbashier *et al*. (2019).

Table 6 : Effect of irrigation periods on the Effectiveness of SOD enzyme for Selected Genotypes and Parents of Sunflower during the spring season of 2020.

Irrigation periods	Genotypes								Average
	LF	LD	LS	LC	SHF	SHD	SHS	SHC	
5day	2.497	1.773	2.920	1.323	2.963	3.000	3.703	2.030	2.526
8day	3.937	3.120	3.703	2.453	4.407	3.743	3.937	3.470	3.596
10day	8.383	8.227	8.307	7.917	8.423	9.090	9.093	6.633	8.259
$Lsd_{0.05}$	N.S								0.682
Genotypes average	4.939	4.373	4.977	3.898	5.264	5.278	5.578	4.044	
$Lsd_{0.05}$	*0.640*								
Genetic variations	σ^2g=0.992			σ^2e=0.451			σ^2p=1.443		
Genetic values	P.C.V%=25.06				G.C.V%=20.78				
Heritability	$h^2_{b.s}$%=68.745								

CAT

The importance of the catalase enzyme when plants are exposed to drought stress lies in removing and eliminating toxins by increasing the concentration of this enzyme and using H_2O_2 as a substrate to be transformed to H_2O and O_2, and thus resisting drought stress (Umar and Siddiqui, 2018).

Results in Table (7) revealed the significant differences among genotypes in the activity of the catalase enzyme; the enzyme activity has been increased and decreased among one genotype to another. The selected genotype (LF) gave the highest activity of the enzyme at 18,680 mlg^{-1} unit protein, compared to all the other genotypes and its origin, which gave the lowest enzyme activity, reached 13,320 mlg^{-1} protein units and did not differ significantly from the genotype (SHS).

The genotype is one of the most important determinants of plant response to environmental conditions, the most important of which is drought stress, as the selected genotypes push themselves to resist drought stress by improving growth and increasing the antioxidant enzymes activity, including the enzyme catalase, which acts as a material that cleans the free roots, thus protecting plants from oxidation of membrane systems and Oxidative damage. This is consisted with (Mafakheri *et al*., 2011) which showed that genotypes differ in their tolerance to drought stress.

A significant difference was observed among irrigation times in the activity of the catalase enzyme, as the activity of this enzyme increased with increasing drought stress, and the irrigation period of 10 days gave the highest value of the enzyme activity reached 22,150 mg^{-1} protein units compared to the 5 day irrigation period, which gave the lowest value of 7.790 mg^{-1} protein. The catalase enzyme is actually present in all organisms that have Aerobic respiration, as it oxidizes alcohol under normal conditions, but the increase in drought stress makes plants adapt to overcome this stress by reducing the damage to the carbonate metabolism process and plant tissues by reducing the toxic levels of H_2O_2 by equation. It involves the presence of two molecules of H_2O_2, one of which has no receptor for the electrons and the other is a donor, thus it will decompose into water and oxygen and supply the tissues with molecular oxygen that is difficult to reach to these tissues due to stress and thus protect them from oxidative stress. These results are in agreement with (Mafakheri *et al*., 2011 and Luxa *et al*., 2019) who confirmed that catalase activity increases with increased drought stress.

Significant differences were found in the interaction between irrigation periods and genotypes in the activity of the catalase enzyme; these differences were due to the difference in the response of the genotypes to the irrigation periods. It differs significantly from the genotypes (SHS) and (LS) in the same irrigation period, while the LC genotype during the 5 day irrigation period gave the lowest value for the trait, which reached 6.280 mlg^{-1} unit of protein.

The results revealed that the genetic variances were higher than the environmental variations, so the heritability in the broad sense was as high as (85.83) and the reason is due to the decrease of environmental variations and the control of the host genes on the trait. Also, the value of PCV and GCV reached (21.46) and (19.88), respectively which means that most of the variance is hereditary.

Table 7: The effect of irrigation periods on catalase enzyme activity for the selected genotypes and their parents of sunflower during the 2020 season.

Irrigation periods	Genotypes								Average
	LF	LD	LS	LC	SHF	SHD	SHS	SHC	
5day	9.610	8.200	7.810	6.280	8.690	8.090	7.050	6.600	7.790
8day	21.110	18.380	19.250	14.350	19.520	17.450	20.820	15.260	18.270
10day	25.320	21.500	23.400	19.320	22.780	21.690	24.800	18.410	22.150
$Lsd_{0.05}$	2.351								1.649
Genotypes average	18.680	16.030	16.820	13.320	17.000	15.740	17.560	13.420	
$Lsd_{0.05}$	1.235								
Genetic variations	σ^2g=10.209			σ^2e=1.685			σ^2p=11.894		
Genetic values	P.C.V%=21.46				G.C.V%=19.88				
Heritability	$h^2_{b.s}$%=85.83								

POD enzyme

The importance of the peroxidase enzyme is represented by its ability to resist biotic and abiotic stress; it is a beneficial method of selecting varieties that are resistant to environmental stresses such as the lack of water (Zoz *et al*., 2013).

The results in Table (8) revealed that there were significant differences between the genotypes in the peroxidase enzyme activity; the selected (LD) gave the highest value for the enzyme activity, reached (20.70) mlg^{-1} protein units, compared to all the genotypes and the parent, while the origin of the two varieties gave lower values for the peroxidase enzyme activity reached (13.14) and (12.48) mlg^{-1} absorption units. Protein, respectively. The reason for the difference in genotypes in the increase or decrease in the activity of the peroxidase enzyme is due to the difference in the ability of plants to resist stress, as the peroxidase enzyme works to eliminate peroxide the hydrogen that causes an imbalance in the cellular oxidative reactions under the drought stress, and the significant values of the (LD) selector in this trait is due to the increased concentration of the drought stress tolerance genes in this genotype due to the selection. These results are in agreement with both Zoz *et al*. (2013) and Mittler (2002) who found that peroxidase activity increased due to water stress and that selection was the best method for determining plant resistance to stress.

It was noticed that there was a significant difference between the irrigation periods in the effectiveness of the peroxidase enzyme; the 10 day irrigation gave the highest value for this characteristic, reached 23.12 mlg^{-1} protein absorption unit, compared with the 5 day irrigation, which gave the lowest value of the characteristic reached 6.38 mg^{-1}

absorption unit. Protein, drought causes oxidative stress by increasing ROS, such as superoxide (-O2), hydrogen peroxide (H2O2) and hydroxyl radicals (-OH) that attack the most sensitive biological molecules such as lipids, proteins, and nucleic acids, which leads to oxidation of these molecules, the most important of which is the oxidation of lipids in the membranes and the weakness of their functions. In contrast, plants stimulate their enzymatic systems to protect them from damage (Geetha *et al.*, 2017).

There was a significant interaction between irrigation periods and genotypes in the peroxidase enzyme activity due to the difference in the genetic nature of the selected structures, as the selected genotype (LD) and the original genotype (LC) gave the highest peroxidase activity (26.703) and (26.543) absorption units. Mg^{-1} protein, respectively, during the 10 days irrigation period, while the non-stressed genotypes (SHS) gave the lowest enzyme activity at (4,870) mlg^{-1} absorption units.

The results also revealed that the genetic variances were higher than the environmental variations, so the heritability in the broad sense was high, reached (97,358); the PCV and GCV were high and not significantly differs, which reached (24.66) and (24.33) respectively, and this indicates that the phenotypic variance is slight in most of the variance. These results were consisted with (Bhutta and Tahira, 2010).

Table 8 : Effect of irrigation periods on the peroxidase enzyme activity on select genotypes and their parents of sunflower during the spring season of 2020.

Irrigation periods	**Genotypes**								**Average**
	LF	**LD**	**LS**	**LC**	**SHF**	**SHD**	**SHS**	**SHC**	
I-1	8.250	8.917	7.427	8.623	6.807	8.380	4.870	3.460	7.092
I-2	24.827	26.503	22.343	17.333	26.227	23.520	20.473	16.427	22.207
I-3	25.047	26.703	23.300	26.543	24.230	24.967	24.070	17.557	24.052
$LSD_{0.05}$	1.182								0.606
Genotypes average	19.374	20.708	17.690	17.500	19.088	18.956	16.471	12.481	
$Lsd_{0.05}$	0.679								
Genetic variations	$\sigma^2 g$=18.723			$\sigma^2 e$=0.508			$\sigma^2 p$=19.231		
Genetic values	P.C.V%=24.66				G.C.V%=24.33				
Heritability	$h^2_{b.s}$%=97.358								

Plant yield

The plant yield is the most important indicator by which it is possible to identify the efficiency of the genetic makeup; and the yield is related to its components that are affected by the external factors.

The results in Table (10) indicated that there are significant differences between the genotypes in the total plant yield, and the selected genotype of the disc diameter (LD) gave the highest plant yield reached 6.247 tons. Ha^{-1}, compared to all the genotypes and surpassing its original. The selected genotype for short stem (LS) had a lower plant yield of (4.514) tons. Ha^{-1} and did not differ significantly from each of the genotypes (SHS) and (SHC).

The genotypes differ in yield and this difference is due to the difference in the components of the yield that contribute to its formation. The reason of the increment in the yield in the selected genotype (LD) is due to the efficiency of selection in increasing the diameter of the disc due to the increase in the process of photosynthesis and the increase in the number of seeds in the disc, which is positively reflected on the yield, these results are consistent with the results (Goksoy *et al.*, 1997).

The results in Table (10) indicated that there were significant differences between the irrigation periods, as the plant yield decreased with the increase in the period between the two irrigation. The irrigation period (5 days) gave the highest plant yield reached 6.640 tons. Ha^{-1} compared to the 10-day irrigation period, which gave the lowest yield of the plant reached (3.992) Tons. Ha^{-1}.

The lack of water in the soil leads to the lack of water absorbed by the plant, which leads to the closing of the stomata, the lack of leaf space and the lack of carbon representation, which results in the lack of minerals represented and the lack of access to the disc, thus leading to a small diameter of the disc and a small number of seeds and thus a decrease in the seed yield of the plant. These results are combined with (Kafi *et al.*, 2000).

There were no significant differences among the irrigation periods and their effect on genotypes, as all genotypes exhibited similar behavior.

The results revealed that the genetic variances were higher than the environmental variations. Therefore, heritability in the broad sense was high and reached (74.826). The PCV and GCV were high and close and reached respectively (23.65) and (20.46). The results were in agreement with (Elsahookie, 2004) which indicated that the selection can succeed.

The results revealed that the genetic variances were higher than the environmental variations. Therefore, heritability in the broad sense was high and reached 74.826. The PCV and GCV were high and close and reached respectively (23.65) and (20.46). These results are in conjunction with the results of (Elsahookie, 2004), which indicated that selection can succeed if it depends on the yield of the plant provided the presence of genetic variances, but selection for the yield components is the most proper method to ensure an increase in the yield by selection.

Table 10 : Effect of irrigation periods on plant yield on selected genotypes and their parents of sunflower during the spring season of 2020.

Irrigation periods	Genotypes								Average
	LF	LD	LS	LC	SHF	SHD	SHS	SHC	
5day	6.282	8.240	5.693	7.669	5.872	7.341	5.698	6.329	6.640
8day	5.847	4.862	4.862	5.947	5.215	6.209	4.532	4.709	5.406
10day	3.967	4.569	2.987	3.909	3.964	4.643	3.647	3.692	3.992
$LSD_{0.05}$	N.S								0.5827
Genotypes average	5.365	6.247	4.514	5.842	5.017	6.064	4.626	4.910	
$Lsd_{0.05}$	0.6014								
Genetic variations	σ^2g=1.186			σ^2e=0.399			σ^2p=1.585		
Genetic values	P.C.V%=23.65				G.C.V%=20.46				
Heritability	$h^2_{b.s}$%=74.826								

Stress tolerance index and quotient stability index

The results in Table (11) indicated that there are significant differences among the selected genotypes of sunflower crop in their stress tolerance; the (SHF) genotype gave the highest drought tolerance reached 0.675 compared to the original genotype of the local variety that gave the lowest stress tolerance reached 0.510. The stability index of the yield for each of the genotypes (LD), (LC) and (SHD) gave the highest stability index of the yield, reached 79.9, 79.9 and 79.3, respectively, due to the convergence of the PCV values and the GCV of these genotypes did not gave a high decrement in all the selected genotypes. This indicates that most of the selected plants were similar and that selection was successful for most of the traits.

Table 11 : Stress tolerance index and yield stability index for sunflower genotypes and parents.

Genotype	LF	LD	LS	LC	SHF	SHD	SHS	SHC
Stress tolerance index	0.631	0.554	0.525	0.510	0.675	0.632	0.640	0.583
yield stability index	76.6	79.9	72.7	79.9	75	79.3	72.9	74.4

Conclusions

The selection has improved most of the traits and increased the crop's tolerance to drought stress.

An increase in the activity of oxidative enzymes which were peroxidase, catalase and subrawoxidase desmiotase was observed upon increasing the period between the irrigation periods, as these enzymes work to preserve the crop from drought stress.

The crop can be irrigated every eight days instead of five days under the spring season conditions, and this will provide an adequate amount of water that allows expansion in the cultivation of the crop or its cultivation even when water is scarce.

New selection cycles can be continued to improve both the suns and the local varieties by adopting the minimum number of days of planting for flowering and low plant height, due to the competence of the teams in all characteristics.

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