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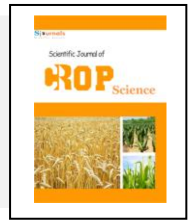

Original article

Evaluation of drought tolerant cultivars and lines of sesame using stress tolerance indices

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ABSTRACT

In order to evaluation drought tolerant of cultivars and lines of sesame, using indicators of "stress tolerance" two separate experiments, was carried out using randomized complete block design in three replications during crop year 2010-2011 at the agricultural research station of Zahak. In the no stress condition, irrigation was performed based on plant growth stages. And in condition of season's end stress, water interruption from flowering stage until end maturity (post–anthesis drought stress). The results showed that in the studied indices, three indices of MP, GMP and STI, with grain yield in stress and no stress conditions had the highest positive and significant correlations. Comparison of the values obtained from indices for each genotype showed that, "Darab-14" and "Sistan local" with having higher sustainability and performance in stress and non-stress conditions had the highest values of indices of STI, GMP and MP, and were determined as most tolerance genotypes with high yield, thus they can be used in breeding programs.

1. Introduction

Deficit of resources water is one of the main factors of production limiting in agricultural systems in arid and semiarid regions, that will also affecting the supply confine of other resources and also their consumption efficiency (kenan, et al., 2007). Sesame (Sesamum indicum L.) As drought tolerant plant and resistant to lack of water has particular importance in arid and semiarid regions (Weiss, 2000, Boureima, et al., 2011). Mensah, et al (2006) showed that, water limitation is leading to reduced growth and yield of Sesame. Fanaei., et al (2012) with studying the response of new cultivars and lines of sesame under drought stress reported that, at total of two years: Dashtestan cultivar, Lines of Sistan local", "Darab-2" and "SG14-9093" was accounted the highest grain yield. Identification proper Index for resistance to drought, always is been case attention researchers because the best Index, facilitates greatly select of genotypes with high yield. Roselle and Hamblin (1981), Introduced the indices of tolerance (TOL) and mean productivity (MP). Fisher and Mayer (1978) proposed index of sensitivity to stress (SSI). Fernandez (1992) has been introduced index of stress tolerance (STI) and geometric mean productivity (GMP) to select the genotypes of tolerant to stress. Index of STI able to identify cultivars with "high potential yield in both conditions of stress and no stress and high levels of its, is indicating more yield stability of genotype in the dry conditions. Many scientists in studies these indices conclude that efficiency of selection indices related to stress sever in goal environment. Golestani and Pakniat (2007) with assess the indices of drought tolerance at Sesame reported that, the highest yield in both conditions of stress and no stress and the MP, GMP, HM and STI is belonging to the genotype number 5. For reason of the high correlation between indices and yield conditions of stress and no stress, each of the four indices are introduced suitable for screening genotypes. Fanaei et al., (2012) reported positive and significantly correlation between STI, GMP and MP indices and grain yield under stress and non-stress conditions and announced that these indices can be used as a selection criterion for selecting high-yield genotypes under stress and non-stress conditions.

2. Materials and methods

This experiment was conducted during 2009, in zahak Agriculture Research Station of Zabol, located at Eastern of Iran with Mean annual precipitation less than 50 mm in year. In order to investigate drought tolerant of cultivars and lines of sesame, using indicators of "stress tolerance" two separate experiments, was carried. In no-stress condition, irrigation was performed based on plant growth stages and in condition of season's end stress, was water interruption from flowering stage until end maturity (post–anthesis drought stress). Each plot consisted of four rows: 5 m length, with distance of 50 cm apart. Fertilizers were applied at A ratio of 250, kg N /ha, 200 kg sulphate dipotash /ha and 150 kg superphosphate,/ha respectively, (according to results of soil analysis). All plots received one-third of N and all sulphate dipotash and super-phosphate prior to sowing. Other two-third of N top dressed at the start of stem elongation, and before flowering, respectively. In each plot, plants of four central rows were harvested to determine seed yield. For assess of genotypes from view drought tolerance and selection indices: stress susceptibility index (SSI, Fischer and Maurer, 1978) stress tolerance index (STI, Fernandez, 1992) tolerance (TOL, Rosielle and Hamblin, 1981) mean productivity (MP, Rosielle and Hamblin, 1981) and geometric mean productivity (GMP, Fernandez, 1992) were calculated based on grain yield under stress and non-stress conditions according to the following formulas:

1. Stress susceptility index (SSI) SSI = (1-(Ysi/Ypi))/SI where SI = 1- (Yms/Ymp)
2. Stress tolerance index (STI) STI = [(Ypi)×(Ysi) /(Ymp)2]
3. Tolerance index (TOL) TOL = Ypi-Ysi
4. Geometric mean productivity (GMP) GMP = (Ypi ×Ysi) 0.5
5. Mean productivity (MP) MP = (Ypi+Ysi)/2

At these formulas Yp, Ys, $\bar{Y}$s and $\bar{Y}$p respectively shows: yield of each genotype under no stress and stress conditions and yield means of genotypes under stress and no stress conditions. To evaluate the yield of genotypes, analysis variance of treatment was performed using the software Mstat-C. For correlations between indices and yields in two environments of stress and no stress analysis correlation was used, and to compare treatment means "least significant difference" test (LSD) was used at 5% probability level.

3. Results and discussion

Sesame genotypes in non-drought stress in drought stress conditions had an average yield of 852.718 and 564.50 kg/ha, respectively. This was showing high severity of drought in Season's end stress condition that result, reduction of biomass and yield (Table 1). In non-stress conditions, the highest grain yield, was belonging to lines of "Ts-3" and "Darab-14", with values of 1141 and 1115 Kg/ha, respectively. In Season's end stress condition, the genotypes of "Drab-14" and "Sistan local", with values of 856 and 826 Kg/ha was showing , the highest grain yield. The results obtained corresponded with the results of Fanaei et al., (2012) and Golestani and Pakniat (2007) that reported under drought stress reduced yield of sesame cultivars.

Based on stress tolerance index of (STI) among genotypes, the genotypes of "Drab-14", "Sistan local" and "Ts-3" had the highest value STI with values of (1.605, 0.94 and 0.78), and were evaluated tolerant than other genotypes to drought conditions (Table 1). But Genotypes of "SG3-86365" , "SG5,86365" and "SG4-82215" by values of (0.328, 0.351, and 0.37) were ranked with the minimum STI , that according to the evaluation by this index, had high sensitivity to stress, , than other genotypes.

Table 1
Compare sesame grain yield based on drought stress tolerance indices under and stress and non-stress conditions.

Genotypes	Yield in non-stress condition (Kg/ha)	Yield in season's end stress (Kg/ha)	Sensitivity to stress (SSI)	Toleranc Index (Tol)	Stress tolerance index (STI)	Geometric mean (GMP)	Arithmetic mean (MP)
Sistan local	1032	826	0.539	206	0.940	923	929
Safiabad	961	644	0.891	317	0.682	787	802.5
TN-238	1034	649	1.006	385	0.740	819	841.5
local Jiroft	1075	651	1.065	424	0.772	837	863
Darab-14	1115	866	0.603	249	1.065	983	990.5
Varamin	969	533	1.216	436	0.569	719	751
Darab	1030	669	0.947	361	0.760	830	849.5
TS-3	1141	620	1.234	521	0.780	841	880.5
Pakistanis Plowhite	1024	676	0.918	348	0.763	832	850
SG5- 4215	992	647	0.939	345	0.708	801	819.5
Haji-Abad	845	546	0.956	299	0.509	679	695.5
TN-240	733	512	0.814	221	0.414	613	622.5
SG5-86365	725	440	1.062	285	0.351	565	582.5
SG1-86365	971	473	1.366	498	0.506	678	722
SG3-86365	793	376	1.421	417	0.328	546	584.5
SG4-82215	787	427	1.236	360	0.370	580	607

Golestani and Pakniat (2007) and Hassanzadeh et al., (2009) and Yavdargahy et al., (2011) found the STI as the better indicator to selection of sesame genotypes under stress and non- stress conditions, that correspond to the results of this experiment.

Lines of SG3-86365, TS-3 and SG1-86365 with the values of (1.422, 1.234 and 1.366) had highest amount of the SSI index and based on index sensitivity to stress is too much in these

Low values of the index is relevant for genotypes of "Sistan local" and "Darab-14" (0.539 and 0.603), respectively (Table 1). It should be noted that this index alone, is not a criterion to identify the drought tolerance cultivars. Guttieri et al., (2001) proposed that: the value of more than 1, SSI showed greater susceptibility to drought. Selection is based on SSI is led to the selection of drought tolerant genotypes but and with low potential grain yield in favorable environments (Clark et al., 1992). Hassanzade, et al., (2009) reported that based on SSI Index, genotypes of "Drab -14 had the highest tolerance to drought stress. The results of this research are corresponded with the results of these experiments.

In stress conditions, the selection should be performed based on the lower values of TOL (Mohammadi et al., 2011). The lines of "Drab-14" and "Sistan local" with values of 206 and 249 had the lowest value of the index, therefore, the relative sensitivity of these lines is low to stress . It seems that TOL was able to highlight genotypes with high yield under stress condition (Fanaei et al., 2012). It should be considered that this index, like SSI is not relative index for recognizing drought tolerant (Mohammadi et al., 2011).

Mean performance productivity index for Sistan-local line was 929. Line of SG5-86365 had the lowest value MP by 582, and maximum value MP (990) was related to the "Darab-14", that show greater tolerance of these lines on stress and "no stress" conditions on basis of definition this index (Table 1). Fernandez (1992) announced that this index in selection cultivars with high-performance in stress conditions is not good, because large differences of yield in environmental because increased this index.

Based on geometric mean performance index (GMP), genotypes are more tolerant that have larger values of this indicator. GMP compared to MP will have ability to separation genotypes that having high yield in both stress and "no stress" conditions (Fernandez, 1992). According to table (1) the lines of "Darab-14" and "Sistan local" had the maximum value of GMP by 983 and 923, respectively, and lines of SG3-86365 with 546 had the lowest value. Hassanzade, et al., (2009) reported that based on tolerance indices of MP, SSI, STI and GMP the highest grain yield obtained in "Darab-14" genotype in both stress and non-stress conditions, that were consistent with the results obtained from this experiment. Results of most research indicate that STI, GMP and MP indices are most suitable indicators for evaluation drought tolerant genotypes (Fanaei et al., 2012, Hassanzade, et al., 2009, and Fernandez, 1992), which with results this experiment are in agreement.

Results of simple correlation coefficients between indicators of drought tolerance and grain yield in non strssed and end season stress conditions in Tables 4 and 5 are presented. The index SSI due to positive and significant correlation with TOL index is n't a criterion for selection, because the high values of this index that indicating the sensitivity to stress , this is associated with high yield in stress condition. Three indices of MP, STI and GMP With grain yield had significant positive correlation in both non-stress and stress conditions. Correlation coefficient of the STI index in stress condition was 0.89 and in no-stress condition was 0.97.

The correlation coefficient of the GMP index in no-stress condition was 0.91 and in stress condition was 0.96, and the correlation coefficient of the MP index in no-stress condition was 0.94 and in stress condition was 0.94. So the selection based on STI, GMP and MP indices is cause the selection of genotypes that their yield is high in stress and no-stress condition. Therefore STI, GMP and MP indices can be as the best indices for drought stress resistance in this experiment (Table 2). In different studies of researchers in different crops: Sunflower (Rezaeizad, 2007), Canola (Fanaei et al., 2012) and sesame (Golestani and Pakniat ,2007: Hassanzadeh et al., (2009) has been reported the high correlation of STI, GMP and MP indices with grain yield in stress and non-stress conditions, and these indices were selected and introduced as appropriate criterion, which were consistent with the results of this experiment.

Table 2
Correlation coefficients between grain yield in non-stress conditions (YP) and stress conditions (YS) and drought tolerance indices.

treatments	Yield under non-stress condition	Yield under stress condition	Arithmetic mean	Geometric mean	Sensitivity to stress	Tolerance Index	Stress tolerance index
YP	1						
YS	**0.771	1					
MP	**0.94	**0.942	1				
GMP	*0.91	**0.966	**0.966	1			
SSI	ns -0.254	** -0.806	*-0.566	**-0.632	1		
TOL	ns 0.311	ns -0.365	ns -0.032	ns -0.113	** 0.832	1	
STI	**0.89	**0.973	**0.991	**0.966	** -0.652	ns -0.151	1

4. Conclusion

The results showed that among the studied indices, the three indices of MP, GMP and STI with the grain yield in stress and non-stress conditions, had the highest positive and significant correlations. And "Darab-14" and "Sistan local" addition to stability and higher performance in stress and non-stress conditions had the highest values of STI, GMP and MP indices, and were determined as most tolerant genotypes with high yield, therefore, These indices and genotypes can be used in breeding programs.

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