International Research Journal of Applied and Basic Sciences
© 2012 Available online at www.irjabs.com
ISSN 2251-838X / Vol, 3 (11): 2327-2332
Science Explorer Publications

Evaluation response of different genotypes of spring canola to water deficit

Hamidreza Fanaei*, Hossein Akbarimoghaddam, Mohammadreza Narouyirad

Agricultural and Natural Resources Research Center of Sistan, Zabol, Iran

****Corresponding author email***: fanay52@yahoo.com

ABSTRACT: In order to evaluation spring canola (Brassica napus) genotypes at three moisture levels, this research was conducted in Zahak Agriculture Research Station of Zabol, in 2007 cropping season. This site located in South Eastern of Iran with precipitation less than 50 mm in year. These genotypes were evaluated in three separate experiments. First experiment was non-stress, (irrigation in roset, budding, flowering, poding and grain filling stages), second experiment was early season of drought stress that from sowing timing until budding stage, approximately 80 day after sowing water interruption (pre-anthesis drought stress) and three experiment was water interruption from flowering stage until end maturity (post–anthesis drought stress). A randomized complete block design was used with three replications. Results analysis of variance grain yield showed significantly difference between genotypes. Mean grain yield of canola genotypes were 4074 kg/ha, 3227 kg/ha, and 2979 kg/ha, under non-stressed, early season drought stress and end season drought stressed conditions, respectively. Among the genotypes, Hyola 401 and Hyola 420 Hybrids were outstanding in non-stress and early season stress conditions, respectively. But Under end season drought stress, highest seed yield belong to Hyola60, Hyola 308, Hyola 401 hybrids and RGS003 cultivar. Five drought tolerance indices were calculated based on relative grain yield under drought and normal conditions. In non-stress and stress conditions, have above genotypes highest amount of stress tolerance index (STI), geometric mean productivity (GMP), and mean productivity (MP). Calculated correlation coefficients revealed positive and significantly correlation between STI, GMP and MP indices and grain yield under stress and non-stress conditions Therefore these indices can be used as a selection criterion for selecting high-yield genotypes under stress and non-stress conditions. Also based on results these study, genotypes Hyola401, RGS003 and Hyola 420, their production was stable when the environment changed than other genotypes, so can be used as a suitable genetic source for improvement drought tolerance in breeding programs.

***Keywords**:* Grain Rapeseed, Water deficit, Stress indices, Grain yield,

INTRODUCTION

Stress drought, among the different environmental stresses has a highly negative impact on crop production. Plants possess a variety of morphological and physiological mechanisms which allow them to adapt to water stress (Karkanis et al., 2011; Aslam-Khan, 2004; Alison, 2005). Drought about 20 percent of produce the crops has limited in around the world (Farooq et al., 2008), (Mcdonald et al., 2003). Oilseed canola plant (Brassica napus L.) is an important agricultural crop grown primarily for its edible oil. The meal that remains after oil extraction has value as a source of protein for the livestock feed industry (Jenson, 1996). In Iran, the production of the canola plant is limited by drought stress. Some scientists in different regions reported that pod formation and flowering stages most susceptibility to drought stress and affect rate depend to severity and duration stress and plant genotype. (Sinaki et al., 2007, Mendham and Salisbury, 1995 and Farooq et al., 2008). Gunasekara et al., (2006) and Jenson (1996), also reported reduction grain yield of Brassica napus, and Brassica juncea under drought stress due to reduction traits relate to yield such as pod in plant, seed in pod and seed thousand weights. The development of cultivars with improved productivity under water stress is important because of severe limitations imposed by drought in specific regions (McWilliam, 1989). There are many ways for developing crop species tolerant to drought. One of those is the screening of crop cultivars based on stable production ability in through warm and dry areas. (Ehdai, 1995). Several selection indices, which provide a measure of drought tolerance based on loss of yield under drought-conditions in comparison with normal conditions, have been suggested for screening drought tolerant genotypes (Clarke et al., 1992, Mitra, 2001).

Rosielle and Hamblin (1981), were introduced productivity mean (MP) and tolerance (TOL) indices. Fisher and Maurer (1978) offered stress susceptibility index (SSI). Fernandez (1992) introduced stress tolerance index (STI) and geometric mean performance (GMP). Fernandez (1992) in assessing comparison of methods drought tolerance in susceptible genotypes stated that the selection based on drought tolerance (TOL) caused that breeding programs directed towards selected genotypes with low yield, however, selection based on average performance (MP) because selected genotypes with high yield. While the stress tolerance index (STI) choice to shift toward selected genotypes with high yield and drought tolerant and any its value higher, indicative greater tolerance to drought stress and result is high performance. Richard (1996) stated that selection in both stress and non-stress conditions caused by accumulation of favorable alleles and genotypes selected with higher performance. According to report Daneshian et al., (2009) and Majidi et al., (2011) both stress and non-stress conditions indicators MP, GMP and STI to select varieties tolerant to drought with high yield for soybeans suitable were detected, but indicators SSI and TOL to choose drought tolerant varieties with low yields were effective. Among stress tolerance indicators, larger values of TOL and SSI represent relatively more sensitivity to stress. Smaller values of TOL and SSI are favored. Sio-Se Mardeh et al., (2006) determined that varieties selected by TOL index caused loss yield in non-stress conditions. Many scientists in studies these indices conclude that efficiency of selection indices related to stress sever in goal environment (Panthuwan et al., 2002 and Blum, 1996). Ramirez and Kelly (1998) reported that selection based on a combination of both SSI and GM indices may provide a more desirable criterion for improving drought resistance in common beans. Guttieri et al., (2001) using SSI criterion in spring wheat, suggested that more than 1 unit of SSI value may indicate above-average susceptibility for drought stress and less than 1 unit has below-average susceptibility. Pourdad (2008) reported that STI was the best index to identify superior cultivated safflower genotypes in conditions both with and without drought stress.

The objectives of this study were estimate the level of drought tolerance of canola and assess the efficiency of different selection indices under stress and non-stress conditions.

MATERIALS AND METHODS

In order to evaluation spring canola (Brassica napus) genotypes at three moisture levels, this research was conducted during 2007, in zahak Agriculture Research Station of Zabol, located at Eastern of Iran with Mean annual precipitation less than 50 mm in year. From between Sixteen genotypes assessment in advanced experiments, nine genotypes selected based on high yield and other suitable traits. These genotypes were evaluated in three separate experiments. First experiment was non-stress, (irrigation in roset, budding, flowering, poding and grain filling stages), second experiment was early season of drought stress that from sowing timing until budding stage, approximately 80 day after sowing water interruption (pre-anthesis drought stress) and three experiment was water interruption from flowering stage until end maturity (post–anthesis drought stress). A randomized complete block design was used with three replications. Seeds were sown on 27 October with using Winterestiger Seeder-plot. Each plot consisted of six rows: 5 m length, with distance of 20 cm apart. Fertilizers were applied at A ratio of 180, kg N /ha, 250 kg sulphate dipotash /ha and 150 kg super-phosphate, /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) $STI = [(Ypi)\times(Ysi) /(Ymp)2]$

3. Tolerance index (TOL) $TOL = Ypi-Ysi$

4. Geometric mean productivity (GMP) $GMP = (Ypi \times Ysi) 0.5$

5. Mean productivity (MP) $MP = (Ypi+Ysi)/2$

Where Ysi is the yield of each genotype in the stress condition, Ypi is the yield of each genotype in normal condition, Yms is the yield means over all genotypes in stress condition, and Ymp is the yield mean over all genotypes in normal condition.

Data were analyzed by using MSTAT-C statistical package (MSTAT-C, Version 1.41, Crop and Sciences Department, Michigan State University, USA). Duncan Multiple Range Test was used to comparing means (P≤0.05).

RESULTS AND DISCUSSION

Results of analysis of variance (ANOVA) over environments (different moisture conditions) showed significantly differences between genotypes for all traits under influence of moisture conditions, (data not shown).The mean grain yield of genotypes under early and end season stress conditions was 3227 and 2979 kg/ha respectively. This indicted a reduction of 21 and 27 % compared with that of non-stress (control) conditions (Table.1).

The highest yields in non-stress condition belonging to genotypes Hyola 401, Hyola 420, RGS003 and Hyola 308, but in drought conditions of early season genotypes Hyola 420, Hyola 401 and RGS003, had the highest grain yield and in drought conditions end season genotypes Hyola 60, Hyola 308, Hyola 401 and RGS003 had high yield. Among all genotypes, Hyola 308, Hyola 401 and RGS003, showed better yield performance in three of early season drought, end season drought and non stress conditions (Table.1). Significant reduction in grain yield in stress conditions can be related to reduce yield components of genotypes such as number of silique in plant and seed in silique and weight seed. Albarak (2006), Sinaki et al., (2007) and Mendham and Salisbury, (1995) reported reduction grain yield due to drought stress that confirmed result of this study. It seems that irrigation interruption in budding stage is main factor for became less silique in plant and irrigation interruption in flowering stage is case of silique abortion and that don't reach to maturity stage and this reduced of silique number and yield.

Table1. Mean yield and yield components of canola genotypes under stress and non stress conditions.

Grain 1000 weight			Grain. silique-1			Silique. Plant-1			Grain yield Kg/ha			Genotypes
Ys_2	Ys_1	Yp	Ys_2	Ys_1	Yp	Ys_2	Ys1	Yp	Ys_2	Ys_1	Yp	
2.53de	3.23bc	2.98c	22a	25a	24bc	228bc	233ab	307ab	3197abc	3502bc	4455a	RGS003
3.36a	3.86a	4.08a	23a	26a	27a	246bc	234ab	284bcd	3245ab	3573b	4457a	Hyola401
2.71bc	3.24bc	3.11c	16b	19a	21d	285a	228ab	318a	3374a	3000e	4248ab	Hyola60
2.5de	3.38bc	3.51b	23a	25a	25ab	234bc	234ab	302abc	2967abc	3238d	4026abc	Hyola330
2.56de	3.04c	3.11c	24a	26a	27ab	252d	207b	308ab	3263ab	2963e	4398a	Hyola308
3.05ab	3.56ab	3.32bc	23a	24a	27a	228dc	239a	277bcd	2892abc	3838d	4508a	Hyola420
2.68cde	3.20bc	3.66b	22a	21a	26ab	234dc	228ab	268cd	2596c	3193d	3650bcd	Option500
2.97bc	3.5ab	3.67b	22a	21a	23cd	217c	223ab	259d	2641bc	2411f	3531cd	PR-401/15E
2.35e	3.28bc	3.61b	22a	24a	24bc	216c	231ab	288bcd	2635bc	3323cd	3390d	PP-308/8
2.75	3.37	3.45	22	24	25	238	229	290	2979	3227	4074	Average

Means followed by the same letters in each column are not significantly different at the 5% level.
Yp= Seed yield in non stress condition, Ys_1= Seed yield in early season stress condition, Ys_2= Seed yield in end season stress condition

Evaluation of tolerance to drought of canola genotypes

Based on STI index, larger value this index represents more tolerance to stress. The highest values of STI were recorded in genotypes, Hyola 420, Hyola 401 and cultivar of RGS003 (Table. 2). Genotypes of PR-401/15E and Hybrid Hyola 308 in non- stress condition belonged to group of high-yielding genotypes, but based on this index were identified as more sensitivity genotypes to stress.

STI a new advanced index which can be used to identify genotypes that produce high yield under both stress and non-stress conditions. Daneshian et al., (2009) in soybean, Mozaffari et al., (1998) in sunflower and Pourdad (2008) in safflower reported that STI was the best index to identify superior cultivated genotypes in conditions both with and without drought stress.

Table2. Average yields of canola genotypes under optimal (YP) and early season stress (Ys1) conditions, and calculated

different drought tolerance indices

STI	SSI	GMP	TOL	MP	Ys_1	Yp	Genotypes
0.94	1.02	3950	953	3978	3502	4455	RGS003
0.96	0.94	3991	884	4015	3573	4457	Hyola401
0.77	1.4	3570	1248	3624	3000	4248	Hyola60
0.78	0.93	3611	788	3432	3238	4026	Hyola330
0.78	1.56	3604	1445	3675	2963	4398	Hyola308
1.042	0.71	4159	670	4173	3838	4508	Hyola420
0.70	0.60	3414	458	3422	3193	3650	opion500
0.51	1.51	2918	112	2971	2411	3531	PR-401/15E
0.68	0.09	3357	68	3357	3323	3390	PP-308/8
0.79	0.99	3626	847	3650	3227	4074	Average

Yp= Seed yield in non stress condition ,Ys_1= Seed yield in early season stress condition, Tol=Stress tolerance, STI=Stress tolerance index, SSI=Stress susceptibility index, MP=Mean productivity , GMP=Geometric mean productivity

Table3. Average yields of canola genotypes under optimal (YP) and end season stress (Ys_2) conditions, and calculated different drought tolerance indices

STI	SSI	GMP	TOL	MP	Ys_2	Yp	Genotypes
0.86	1.04	3774	1258	3826	3197	4455	RGS003
0.87	1.01	3803	1212	3851	3245	4457	Hyola401
0.86	0.76	3786	1003	3811	3374	4248	Hyola60
0.62	0.97	3456	1059	3496	2967	4026	Hyola330
0.86	0.96	3788	1135	3830	3263	4398	Hyola308
0.79	1.33	3611	1616	3700	2892	4508	Hyola420
0.57	1.57	3079	1055	3123	2596	3650	opion500
0.56	0.93	3054	890	3086	2641	3531	PR-401/15E
0.54	0.83	2984	756	3013	2635	3390	PP-308/8
0.73	0.99	3484	1095	3526	2979	4074	Average

Yp= Seed yield in non stress condition , Ys2= Seed yield in end season stress condition, Tol=Stress tolerance, STI=Stress tolerance index,
SSI=Stress susceptibility index, MP=Mean productivity , GMP=Geometric mean productivity

Based on Stress susceptibility index (SSI), larger value this index represents relatively more sensitivity to stress. Genotypes PP-308 /8 and Option 500 under early season stress conditions with have lower values of this index in compared with other genotypes had of less sensitivity and more tolerance to stress (Table.2).

Selection based on these criteria favors genotypes with low yield potential under non-stress conditions and high yield under stress conditions. Naderi et al., (2000) reported that this indicator in identifying genotypes with high-yield in both stress and non-stress environmental not successful.

Tolerance index (TOL) is defined based on difference between the grain yield in stress and non-stress condition. Based on tolerance index (TOL), more tolerance is related to the genotype that has Smaller values of TOL (Rosielle and Hamblin, 1981).The lowest values of TOL were recorded in the genotypes PP-308/8, (TOL=68), PR-401/15E (TOL=112) and Option 500 (TOL=458) under early season stress conditions and lines PP-308/8 (TOL=756) and PR-401/15E (TOL=890) under end season Stress conditions and have higher tolerance in compared with other genotypes (Table. 2, 3). It seems that TOL was able to highlight genotypes with high yield under stress condition.

Mean productivity index (MP) defined average yield in normal and stress conditions. Larger value this index represent more tolerance to stress (Rosielle and Hamblin, 1981). According to this index, Hyola 420, Hyola 401, and RGS003 under early season stress condition and Hyola 401, Hyola 308, and RGS003 under end season stress condition selected as genotypes with the most-tolerant to drought stress (Tables 2, 3). 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. According to this index, two genotypes, PP-308/8 and PR-401/15E with had lowest value this index was identified as most sensitive genotypes under early stress (Table. 2).

Based on geometric mean performance index (GMP), genotypes are more tolerant that have larger values of this indicator (Fernandez, 1992). Based on study with this indicator, genotypes, Hyola 420, Hyola 401, and RGS003 under early season stress conditions and genotypes Hyola 401, Hyola 308, Hyola 60 and cultivar of RGS003, under end season stress conditions were determined as more stress tolerant genotypes.

Genotypes of, PP-308.8 and PR-401/15E were assessed as sensitive genotypes under early season stress (Table 2,). Fernandez (1992) stated that due to less sensitivity GMP index to values yield in stress and non- season stress conditions, this indicator has a superior than indicator MP. Results of most research indicate that STI, GMP and MP indices are most suitable indicators for evaluation drought tolerant genotypes (Mozaffari et al., 2001, Pourdad, 2008, Majidi et al., 2011 and Fernandez, 1992), which with results this experiment are in agreement.

Correlation coefficients of indices with grain yield

Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield (Mohammad et al., 2002). Results of simple correlation coefficients between indicators of drought tolerance and grain yield in early and end season stress conditions in Tables 4 and 5 are presented. In the water-stressed environment, in early season, grain yield was not significantly correlated with non stress conditions while in end season stress condition; seed yield significantly positive correlated with non stress conditions (Table. 4, 5).

Grain yield has been shown a significant positive correlation with indicators, STI, GMP and MP, in early season stress condition. Between indices above the highest correlation coefficient achieved between yield and STI and GMP indices in early season stress but in end season stress condition the highest correlation coefficient achieved between seed yield and GMP, MP indices (Table. 4, 5).

Also grain yield in non-stress conditions has showed positive correlation and significant with the STI, GMP, MP indices. Correlations between YS with GMP, STI, and MP indicated that selection based on these indices may increase yield in stress and non stress conditions. Similar results were reported by Sio-Se Mardeh et al., (2006), Panthuwan et al., (2002) and Majidi et al., (2011). Several researchers introduced index better that with grain yield had correlated in both stress and non-stress and could be determined superior genotypes in both conditions (Mozaffari et al., (2001), and Fernandez, (1992).

In condition this experiment was determined that indicators of STI, GMP and MP, have such property and can be good indicators for this subjection. Daneshian et al., (2009) and Majidi et al., (2011) introduced that indices of STI, GMP and MP as good indicators for selection tolerant genotypes to stress in limited irrigation.

Table 4. Correlation coefficients between YP, YS and drought tolerance indices for early season stress.

	YP	YS	TOL	MP	GMP	SSI	STI
YP	1						
YS	0.524ns	1					
TOL	0.537ns	-0.438ns	1				
MP	0.881**	-0.864**	0.074ns	1			
GMP	0.85**	0.893**	0.014ns	0.998**	1		
SSI	0.374ns	0.589ns	0.978**	-0.106ns	-0.165ns	1	
STI	0.85**	0.891**	0.015ns	0.996**	0.998**	-0.158ns	1

ns and ** : Not significant and significant at 0.01 probability levels, respectively

Yp= Seed yield in non stress condition ,Ys_1= Seed yield in early season stress condition, Tol=Stress tolerance, STI=Stress tolerance index, SSI=Stress susceptibility index, MP=Mean productivity , GMP=Geometric mean productivity

Table 5. Correlation coefficients between YP, YS and drought tolerance indices for end season stress.

	YP	YS	TOL	MP	GMP	SSI	STI
YP	1						
YS	0.818**	1					
TOL	0.80**	0.319ns	1				
MP	0.971**	0.932**	0.636ns	1			
GMP	0.957**	0.949**	0.596ns	0.999**	1		
SSI	0.025ns	-0.441ns	0.494ns	-0.164ns	-0.202ns	1	
STI	0.933**	0.920**	0.592ns	0.97**	0.971**	-0.173ns	1

ns and ** : Not significant and significant at 0.01 probability levels, respectively

Yp= Seed yield in non stress condition, Ys_2= Seed yield in end season stress condition, Tol=Stress tolerance, STI=Stress tolerance index, SSI=Stress susceptibility index, MP=Mean productivity , GMP=Geometric mean productivity

CONCLUSION

From results this experiment can be conclude that under affected shortage water, grain yield reduced due to impressed, morphological traits and yield components. However, genotypes can be shows response differently in different situations. Among genotypes under study in this experiment, hybrids Hyola 401, Hyola 308 and cultivar of RGS003 had highest, STI, GMP and MP. Based on evaluation with these indicators, above genotypes were detected as genotypes with high grain yield in both non-stress and stress conditions. Also, STI, GMP and MP indices due to high correlation coefficient there with seed yield under both conditions (non-stress and early season stress) can be used in selection tolerant cultivars to drought in breeding programs with the aim of improved canola seed yield under arid and semi-arid conditions.

ACKNOWLEDGEMENTS

The authors express their appreciation to Sistan agricultural research center for providing funds for this research and staff members of Zahak agricultural research for their assistance in field works.

REFFRENCES

Albarrak KH. 2006. Irrigation Interval and nitrogen level effects on growth and yield of Canola (Brassica napus L.), Sci. J. King Faisal University 7: 87-99.

Allison E, Jones C. 2005. Plant water relations. Montana State University, Extension paper, 4481-5. P.7.

Aslam-khan M. 2004. Intra specific variation and role of potassium for drought tolerance in oil seed rape (Brassica nupus), Ph. D. Tez. University of arid Agricultural, Pakistan.

Blum A. 1996. Crop response to drought and the interpretation of adaptation. J. Plant. Growth. Regul. 20: 135-148.

Clarke JM, De-Pauw RM, Townley-Smith TM. 1992. Evaluation of methods for quantification of drought tolerance in wheat, Crop Sci. 32: 728–732

Danshian J, Hadi H, Jonobi P.2009. Study of quantitative and quality characteristic of soybean genotypes in deficit irrigation conditions, Iranian J Crop Sci. 44:393-409.

Ehdaie B. 1995. Variation in water-use efficiency and its components in wheat: I. Pot and Field experiments, Crop science. 35:1617-1626.

Farooq M, Wahid A, Kobayashi N, Fujita D, Basra SMA. 2008 Plant drought stress: Effects, mechanisms and management. Agron Sustain Devel, 10: 1051-1059.

Fernandez GCJ. 1992. Effective selection for criteria assessing plant stress tolerance, In: Proceedings of vegetables and other food crops in temperature and water stress,Taiwan. 257-270.

Fischer RA, Maurer R. 1978. Drought resistance in spring wheat cultivars.I: Grain yield responses, Aus. J. Agric. Res. 29: 897-912.

Gunasekera CP, Martin LD, Siddique KHM, Walton GH. 2006. Genotype by environment interactions of Indian mustard (B. Juncea L.) and canola (B. napus L.) in Mediterranean-type environments:II. Oil and protein concentrations in seed, Europn J Agron. 25: 13-21.

Guttieri MJ, Stark JC, Brien K, Souza E. 2001. Relative sensitivity of spring wheat grain yield and quality parameters to moisture deficit, Crop Sci 41: 327-335.

Jensen CR, Mogensen VO, fieldsen JK, Thage JH. 1996. Seed glucosinolate, oil and protein contents of field grown rapeseed (Brassica napus L.) effected by soil drying and evaporative demand. Field Crops Res. 47: 93-105.

Karkanis A, Bilalis D, Efthimiadou A. 2011. Architectural plasticity, photosynthesis and growth responses of velvetleaf (Abutilon theophrasti Medicus) plants to water stress in a semi-arid environment. Aust J Crop Sci 5(4): 369-374

Majidi MM, Tavakoli V, Mirlohi A, Sabzali MR. 2011. Wild safflower species (Carthamus oxyacanthus Bieb.): A possible source of drought tolerance for arid environments. Aust J Crop Since. 5(8):1055-1063.

McDonald AE, Sieger SM, Vanlerberghe GC. 2003. Method and approaches to study plant mitochondrial alternative oxidase. Physiol Plant. 116: 135-143.

McWilliam JR. 1989. The dimensions of drought. In: Baker FWG (eds) Drought Resistance in Cereals, CAB International,Wallingford, Oxon, UK. pp 1–11.

Mendham NJ, Salisbury PA. 1995. Physiology, crop development, growth and yield. P.11-64. in: Kimber, DS McGregor, DI. (Eds.). Brassica Oilseeds: Production and Utilization. CAB International, Landon.

Mitra J. 2001. Genetics and genetic improvement of drought resistance in crop plants. Curr Sci 80: 758-762

Mohammad S, Fida M, Mohammad T. 2002. Path coefficient analysis in wheat. Sarhad J Agric. 18:383-388.

Mozaffari K, Arshi D, Zeynali khaneghah H. 1996. Study of drought stress on some of morpho– physiological traits and yield components of sunflower. Seed and plant.3:24-33 (in Persian).

Naderi A, Majidi Heravan E, Hashemi Desfuli AG. 2000. Assessment to tolerance indices to environmental stresses and introducing of new index. Seed and plant J. 15:390-402 (in Persian).

Panhuman G, Fokai S, Cooper M, Rajatasereekul S, Toole JC. 2002. Yield response of rice genotypes to different types of drought under rain fed lowlands, Grain yield and yield components. Field Crop Res. 41:45-54.

Pourdad SS. 2008. Study of drought resistance indices in spring safflower, Acta Agronomica Hungarica, 56: 203–212

Ramirez P, Kelly JD. 1998. Traits related to drought resistance in common bean. Euphytica 99: 127-136.

Richards RA.1996. Defining selection criteria to improve yield under drought. Plant Growth Regulation.20:157-166.

Rosielle AA, Hamblin J. 1981. Theoretical aspects of selection for yield in stress and non stress environments. Crop Sci. 21:943-946

Sinaki J, Majidi Heravan ME, Shirani Rad AH, Noormohammadi Gh, Zarei Gh. 2007. The effects of water deficit during growth stages of canola (Brassica napus L.). Ameri Eurasian J Agric & Environ Sci. 2:417- 422.

Sio-Se Mardeh A, Ahmadi A, Poustini K, Mohammadi V. 2006. Evaluation of drought resistance indices under various environmental conditioning. Field Crop Res. 98: 222-229.