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Full Length Research Paper

Evaluation of drought tolerance indices among some winter rapeseed cultivars

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The main purpose of this study was to evaluate the effect of drought stress on seed yield of some winter rapeseed cultivars and to study relevant drought tolerance indices, along with identifying resistant cultivars to drought stress. Plant materials were sown in split plot arrangement based on a randomized complete blocks design, at Islamic Azad University of Tabriz research field. Three drought stress levels which include 80, 130, and 180 mm water evaporation from class A pan were considered as the main factor levels, while seven winter rapeseed cultivars which include Licord, Okapi, Opera, S.L.M.046, Zarfam, Modena, and Talaye were arranged to sub plots. Studied quantitative drought tolerance indices were, tolerance index (TOL), mean productivity (MP), stress susceptibility index (SSI), stress tolerance index (STI), geometric mean productivity (GMP), yield index (YI), yield stability index (YSI), and percentage of yield reduction (%Reduction). The yield stability analysis of the studied cultivars was done by GGE biplot method. According to the results derived from principal component analysis and regarding evaluation of correlation coefficients among indices, STI and GMP were selected as the two superior indices for identifying drought resistant cultivars. Three dimensional scatter plots based on STI and GMP indices showed that Licord and Talaye were the most suitable cultivars, and were situated in group, A. In addition, Modena and Zarfam were identified as sensitive and resistant to drought stress, respectively.

Key words: *Brassica napus* L, principal component analysis, drought stress, drought tolerance indices, stability analysis (GGE biplot), 3D scatter plot.

INTRODUCTION

Drought is one of the most important abiotic stresses that cause a considerable part of plant productions to be destroyed each year in different regions of the world. Approximately, 20,000,000 km^2 of the lands throughout the world are in semi-arid regions (Alyari and Shekari, 2000). Rapeseed, (*Brassica napus* L.), due to having desirable traits such as relative resistance to coldness, water deficiency and salinity, having spring and winter types, low production costs and high oil yield per unit of surface compared with other oil seeds, as well as the high quality of its seed oil which contains a high percentage of fatty acids particularly oleic acid and linoleic acid, has attracted so much attention (Alyari and Shekari, 2000). According to a report by the Food and Agriculture Organization, the rapeseed-harvested area in Iran was about 185,000 ha (FAO, 2009). Upon the introduction of different rapeseed cultivars in recent years, many studies have been conducted on the effect of drought stress on this plant. Some researchers have reported several physiological and morphological properties that are effective in the drought stress tolerance (Kaiserlatif and Sadaqat, 2004; Qifuma et al., 2006).

The most sensitive time of irrigation for rapeseed has been specified as the flowering and early siliqua formation stages. Usually, water deficiency stress in this plant causes its yield, number of siliquae per plant and the number of seeds per siliqua to decrease (Passban-Eslam et al., 2000). Qifuma et al. (2006) reported that less-watering stress resulted in the reduction of yield and

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yield components such as the number of siliquae per plant and the number of seeds per siliqua. Also, Malcolm and Doug (2002) believed that the number of flowers per plant and the number and sizes of seeds decreased during the drought stress. Sadaqut et al. (2003) reported that there is a positive significant correlation between the number of siliquae per plant and the seed yield. Hence, by reducing the number of siliquae per plant, drought stress would cause the number of seeds per plant and consequently, the yield to decrease.

Measuring drought tolerance criteria is one of the common methods of evaluating cultivars in terms of their drought tolerance (Clark et al., 1992). Blum (1988) studied the mode of gene action, the hereditability of yield and drought tolerance indices in rapeseed and reported that only two indices, drought response index (DRI) and mean productivity (MP), had a narrow sense hereditability. Simane et al. (1993) believes that yield stability and the comparison of yield under stress and non-stress conditions are more suitable criteria for studying the reaction of cultivars to less-watering stress. Fischer and Mourer (1987) suggested the stress susceptibility index (SSI). Generally, lower SSI is an indication of the fewer variations of a cultivar's yield under stress and non-stress conditions. Fernandez (1992) introduced the stress tolerance index (STI). Normally, more stable cultivars have higher values of this index. By studying the yields of mungbean (*Vigna radiata* L.) cultivars in stress and non-stress environments, Fernandez (1992) classified them into four groups with regards to reactions shown in the two environments: Group A- cultivars which have the same expressions in both the said environments; Group B- cultivars which have a good expression only under non-stress conditions; Group C- cultivars which have a high yield in a stress environment and Group D- cultivars which have a weak expression in both environments. He stated that the most suitable selection criterion for stress is an index capable of identifying group A among other groups. In order to determine cultivars' susceptibility to stress due to different drought stress intensities in different years, Fernandez (1992) and Kristin et al. (1997) used the geometric mean productivity (GMP) of cultivars in both environments.

Also, Gavuzzi et al. (1997), Bouslama and Schapaugh (1984) and Choukan et al. (2006) introduced the yield index (YI), yield stability index (YSI), and yield reduction percentage (% Reduction), respectively. While studying drought tolerance indices in corn, Moghaddam and Hadizadeh (2002) stated that low tolerance index (TOL) did not necessarily mean a cultivar's high yield in a stress environment because a certain cultivar's yield might be low under irrigation conditions, but would entail a less drop under stress conditions that might result in a low TOL and so, it could be introduced as a drought-tolerant cultivar. Moreover, Fernandez (1992) believed that TOL and SSI are incapable of separating A and C groups, and they are more affected by high yields under stress conditions. It is noteworthy that Naeemi et al. (2008) described using SSI as deceptive. They believed that since the calculation formula for this index which was the proportion of a certain cultivar's yield under stress conditions to that of the non-stress conditions and also, the proportion of the yield under stress conditions to that of the non-stress conditions in all experimental cultivars, two cultivars with high or low yields in both environments could have equal SSI values.

Regarding the MP, they stated that using the mean productivity index often leads to selecting cultivars with high yields under normal conditions which are less tolerant of stress conditions. Malek-Shahi et al. (2009) introduced MP as a suitable index. Shirani Rad and Abbasian (2011) studied stress susceptibility and used drought tolerance indices to indentify drought-resistant cultivars in six winter rapeseed cultivars, and reported that GMP, STI and MP were the most suitable indices for identifying the most drought tolerant cultivars. Sio-Se-Mardeh et al. (2006) reported that under moderate drought stress conditions, GMP, STI and MP were the most effective indices for identifying cultivars with high yields under both drought stress and non- stress conditions.

The objective of this research was to study winter rapeseed cultivars in terms of their drought tolerances based on drought tolerance indices, to determine the best index and to identify drought-tolerant cultivars.

MATERIALS AND METHODS

In the present research, seven winter rapeseed cultivars were provided by Seed and Plant Improvement Institute, Karaj, Iran (Table 1). Rapeseed cultivars were cultivated in split plot arrangement based on randomized complete block design (RCBD) with three replications in the experimental field of the Islamic Azad University (IAU) Tabriz branch, during the 2009 to 2010 cropping season. The site is located at latitude of 46°17´E, longitude 38°05´N, with an altitude of 1360 m above the sea level and its precipitation rate was 260.83 mm throughout the experimental period. In order to study the soil physico-chemical properties with care to the depth of the rapeseed root's penetration, randomized soil samples were taken from a 0 to 30 cm depth and its existing elements were analyzed (Table 2). Each experimental plot consisting of six rows (4 m long and row spacing of 25 cm). After the land preparation and implementation of the experimental plan, first, 4 cm deep blanks were created on the ridges and then, 100 kg/ha of urea was distributed at planting rows. Later, on October 2nd, the seeds were sown manually with 1 cm distance inside blanks (furrows) after which the whole field was irrigated. On October 9th, while the seeds had germinated or at the beginning of seedling emergence stage, the second round of irrigation was done. Subsequent irrigations were done once a week until regular precipitations started. At the rosette stage, irrigation stopped. In early spring 2010, at first, the field's water capacity was determined and then to increase the distance between plants up to 5 cm, thinning was performed. During the crop management stage, 100 kg/ha of urea as top dressings was applied at planting rows in two portions (2nd and 15th of May 2010). On May 15th, in order to apply less-watering stress treatment, an evaporation pan (EP) was used. The pan was filled with water up to 21 cm. Water level in pan was measured on a daily basis until harvest and the next irrigations were done with consideration of water evaporation from the pan

Table 1. List of Rapeseed cultivars used in the experiment with their characteristics.

S/N	Cultivar	Origin	Type of cultivar	Oil content%	Oil quality	(GSL)[1]	Cultivation area
1	Licord	Germany	Open- pollination	40-43	double low[2]	260-280	Cold and Mild-Cold
2	Okapi	France	Open- pollination	43-45	double low	260-280	Cold and Mild-Cold
3	Opera	Sweden	Open- pollination	42-45	double low	260-280	Cold and Mild-Cold
4	SLM046	Germany	Open- pollination	40-43	double low	260-280	Cold and Mild-Cold
5	Zarfam	Iran	Open- pollination	43-45	double low	250-270	Cold and Mild-Cold
6	Modena	Denmark	Open- pollination	43-45	double low	260-280	Cold and Mild-Cold
7	Talaye	Germany	Open- pollination	40-43	double low	260-280	Cold and Mild-Cold

[1]GSL: Growing season length, [2]"double low": low erucic acid and low glucosinolate.

Table 2. Physical and chemical properties of experimental soil before planting.

Available k (ppm)	Available p (ppm)	T.N (%)	OC (%)	T.N.V. (%)	pH	EC × 10^3 (ds/m)	Soil texture	Soil sample depth (cm)
577	44	0.136	1.27	3.5	8.14	0.73	Sandy-loam	0.30

Electrical conductivity (EC); total neutralizing value *(*TNV*)*; organic carbon (OC); total nitrogen (T.N).

Table 3. Irrigation "time-table" in order to apply less watering stress treatments.

S/N	Irrigation date	Stress level	S/N	Irrigation date	Stress level
1	31 May 2010	S1	5	18 June 2010	S2
2	6 June 2010	S2	6	24 June 2010	S3
3	8 June 2010	S1, S3	7	25 June 2010	S1
4	16 June 2010	S1	8	30 June 2010	S2

S1, S2, S3: 80,130 and 180 mm evaporation from class 'A' pan, respectively.

surface.

During vegetative and reproductive growth stages, except for green aphid (*Myzus persica*) that was observed at the seed maturity stage, no specific pest or disease symptoms were seen. To fight green aphid, the whole field was sprayed with 2 ml/L Confidor. In order to perform less-watering stress treatments, Irrigation "time-table" was done based on Table 3.

For computing the seed yield at full maturity stage, the seeds weight of each experimental plot was measured by a 0.001 g precision scale and expressed as g/m^2. Then, using the seed yield under stress (Ys) and no-stress (Yp) conditions, the drought tolerance indices of each cultivar were calculated. Different indices have been given for evaluating the reaction of cultivars in different environmental conditions and for determining their tolerance and susceptibility. In this regard, Rosille and Hambilin (1981) introduced the tolerance index (TOL) and mean productivity (MP). Generally, a high TOL is an indication of a cultivar's susceptibility to stress. Stress intensity (SI) was calculated using the following relation:

$$SI = 1 - \left(\frac{\overline{Y}_S}{\overline{Y}_P}\right)$$ (Fischer and Mourer, 1987) (1)

In addition, the quantitative criteria for stress resistance were calculated as follows:

$$SSI = \frac{1-\left(\frac{Y_S}{Y_P}\right)}{SI}$$

(Fischer and Mourer, 1987) (2)

Where, Y_s, Y_p, $\overline{Y}_P$, $\overline{Y}_S$, SSI and SI were each cultivar's yield under stress and non-stress conditions, mean yield of cultivars under stress and non-stress conditions, stress susceptibility index and stress intensity, respectively.

Also, the tolerance index and a cultivar's mean productivity under stress and non-stress conditions were calculated using Rosille and Hambilin (1981) method:

$$TOL = Y_P - Y_S$$ (3)

$$MP = \frac{Y_P + Y_S}{2}$$ (4)

GMP, STI, YI, YSI and % Reduction values were calculated using the following relations:

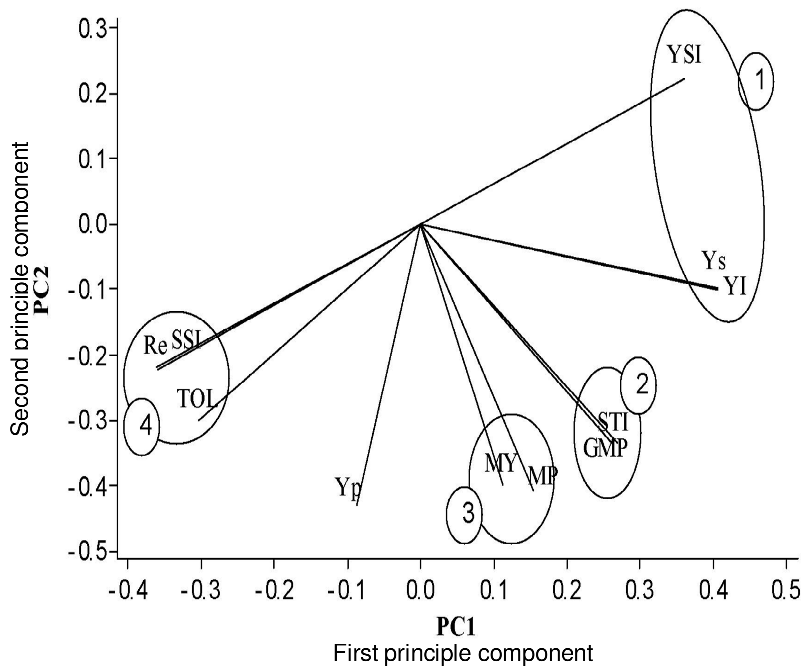

Figure 1. The biplot diagram of principle components analysis of 7 cultivars of winter rapeseed according to mean measured indices together with mean seed yield under stress (Ys) and irrigation (Yp) conditions. Re: % reduction; STI: stress tolerance index; GMP: geometric mean productivity; SSI: stress susceptibility index; YSI: yield stability index; MP: mean productivity; TOL: tolerance index; YI: yield index; MY: mean yield.

$$GMP = \sqrt{Y_P \times Y_S} \quad \text{(Fernandez, 1992)} \quad (5)$$

$$STI = \frac{Y_P \times Y_S}{\bar{Y}_P^2} \quad \text{(Fernandez, 1992)} \quad (6)$$

$$YI = \frac{Y_S}{\bar{Y}_S} \quad \text{(Gavuzzi et al., 1997)} \quad (7)$$

$$YSI = \frac{Y_S}{Y_P} \quad \text{(Bouslama and Schapaugh, 1984)} \quad (8)$$

$$\mathrm{Reduction}(\%) = \left(\frac{Y_P - Y_S}{Y_P}\right) \times 100 \quad \text{(Choukan et al., 2006)} \quad (9)$$

Principal components analysis (PCA) was done based on mean indices, total mean of the seed yield and mean seed yield under stress and non-stress conditions. Correlations between tolerance indices, total mean of the seed yield and mean seed yield were calculated under stress and non-stress conditions and considering the correlation between these indices and the yield, and also by taking the PCA results into account, the most suitable drought tolerance indices were selected. Then, based on the selected indices, drought-tolerant cultivars with optimum yields in both environments were identified using a 3-dimensional display.

In order to obtain data analysis, SPSS ver. 15 and MINITAB 14 software were used. Also, yield stability analysis was done using GGE biplot software. In order to do this, each one of the drought stress treatment levels were considered as an environment and the mean yield (per unit surface) of the studied cultivars at different levels of the less-watering stress was analyzed for stability.

RESULTS AND DISCUSSION

In this study, stress intensity index (STI) was estimated at 0.52. As stated by Fischer and Mourer (1987), STI is used for comparing between different experiments. It has been found that the efficiency of selection indices depends on the intensity of the target environment (Panthuwan et al., 2002)

Results of the principal components analysis are given in Figure 1 which showed that the first principal component separated YSI, YI, STI and GMP from SSI and Re indices. Also, Figure 1 indicates that YSI and YI were put in group 1; STI and GMP were placed in group 2; MP was in group 3 and Re, SSI and TOL were put in group 4. Moreover, YSI and YI were the most closely related to the seed yield under stress conditions. Group 2, (STI and GMP) were at the interval between yield under irrigation and stress conditions, which shows that it is correlated with both traits.

Farshadfar et al. (2001) believe that the most suitable index for selecting stress-tolerant cultivars is an index, which has a relatively strong correlation with the seed yield under stress and non-stress conditions. Therefore, evaluating correlations between stress tolerance indices and the seed yield in both environments can lead to identifying the most suitable index. In this research, STI and GMP were significantly correlated with the seed yield under irrigation and stress conditions. YI was correlated with the seed yield only under stress conditions. Also, TOL and MP had shown a significant correlation with the seed yield only under irrigation conditions (Table 5). On the other hand, correlation between STI, GMP and MP was significant with the total mean of the seed yield. Correlation between SSI, Re and YSI with seed yield was not significant under stress and non-stress conditions. Based on these results (Table 5) and those obtained from the principal components analysis, which have put these two indices in the same group and yield interval under stress and irrigation conditions (Figure 1), both STI and GMP can be introduced as the most suitable indices for selecting drought-tolerant cultivars in winter rapeseed cultivars. Several reports have introduced these two indices as the most suitable ones (Khalilzade and Karbalai-Khiavi, 2002; Fernandez, 1992; Naeemi et al., 2008; Malek-Shahi et al., 2009).

Based on the said indices, Licord and Talaye were the most tolerant cultivars of the less-watering stress (Table 4). It is obvious that selection on MP, SSI and TOL basis, which had not shown a significant correlation with the seed yield under stress conditions, would not be able to select drought-tolerant cultivars. In support of this result, Rosille and Hambilin (1981) reported that selection based on the tolerance index often leads to selecting cultivars which have low yields under non-stress conditions. Also, Naeemi et al. (2008) identified TOL unsuccessful in selecting cultivars with suitable yields in both irrigation and stress environments. They believe that the said index is actually somehow an indication of a change caused by applying stress. Therefore, cultivars with low TOL values would have lower yields in a stress environment. In support of these results, Moghaddam and Hadizadeh (2002) stated that low TOL values do not necessarily mean the high yield of a given cultivar in the said environment. Fernandez (1992) and Naeemi et al. (2008) believe that TOL and SSI are not suitable indices for separating group A from group C. In agreement with the results of this research, Naeemi et al. (2008) reported that MP results in selecting cultivars which are less tolerant of stress. However, Malek-Shahi et al. (2009) intro-duced MP as a suitable index. In this research, Zarfam with the lowest SSI (0.42) and TOL (57.93) values was the most tolerant cultivar. Moreover, based on MP, Licord (321.07) and Talaye (309.73) were the most desirable cultivars in terms of stress tolerance. YI showed to be only correlated with cultivars' yields under stress conditions, which caused cultivar scoring to be based on their yields under the said conditions. Thus, according to Gavuzzi et al. (1997), it cannot be considered a suitable index for selecting group A cultivars. In this research, YI resulted in the identification of Talaye and Licord as cultivars with the highest yields in a stress environment (Table 4). Usually, yield stability index (YSI) and yield reduction (% Reduction) act inversely. Indeed, a cultivar which is selected as a suitable cultivar based on its YSI, had the highest yield stability and should logically show the least yield reduction. Results showed that Zarfam had the highest YSI (0.78), while having 21.59% yield reduction which was the lowest value for this index. Also, these two indices introduced Modena as a cultivar with the highest yield reduction (69.46%) and the lowest yield stability (0.31) (Table 4). Based on the above-mentioned results, STI and GMP were studied for selecting drought-tolerant cultivars in winter rapeseed cultivars. To do so, the 3D scatter plot was used because it allowed drought-tolerant cultivars with high yields to be selected using three different indices or traits (Figures 2 and 3). Figure 2 shows the scatter plot of cultivars based on their mean yield under stress conditions (Y_s), mean yield under irrigation conditions (Y_p) and stress tolerance index (STI). Based on Figure 2, Licord and Talaye were placed in the suitable cultivars group (group A). Figure 3 also indicates the cultivars' scatter plot based on their mean yield under stress conditions (Y_s), mean yield under irrigation conditions (Y_p) and the geometric mean productivity (GMP). Again in this figure, Licord and Talaye are placed in the most suitable cultivars group (A).

In both figures, Modena belonged to group B, a group of cultivars, which only in non-stress conditions have an optimum yield. Zarfam was put in group C, which only under stress conditions showed an optimum yield and had enhanced adaptation to stress. We suggest that this cultivar can be used for breeding drought-tolerant cultivars. In both plots, Opera belonged to group D where cultivars that do not have an optimum yield in irrigation and stress conditions are placed.

In order to do more research on the results obtained from studying drought tolerance indices, the yield stability analysis of the studied cultivars was done by GGE biplot method. One of the advantages of yield stability analysis via GGE biplot method is that in the output of this software, the environments or the studied experimental conditions, which are considered as an environment, are also being tested, and the environments with no significant difference form a bigger group entitled mega-environment. For instance, there are three types of lines in Figure 4a: dotted lines, green lines (which form a pentagon) and gray lines (which divide the plot into different sections totaling 5 parts). It is obvious that both drought stress levels (D1 and D2) are located in the same part, therefore, they have no significant difference and is considered as an environment (in this analysis, drought levels were considered as environment). In this

Table 4. Evaluation of tolerance /susceptibility indices of 7 winter rapeseed cultivars to drought stress.

Cultivar	MY(g/m^2)	Yp(g/m^2)	Ys(g/m^2)	SSI	STI	TOL	MP	GMP	YI	YSI	Reduction (%)
Modena	260.40	387.37	118.30	1.35	0.37	269.07	252.83	214.07	0.65	0.31	69.46
Talaye	296.39	383.50	235.97	0.75	0.72	147.53	309.73	300.82	1.29	0.62	38.47
S.L.M 046	259.86	384.37	164.63	1.11	0.51	219.73	274.50	251.55	0.90	0.43	57.17
Zarfam	244.96	268.37	210.43	0.42	0.45	57.93	239.40	237.64	1.15	0.78	21.59
Opera	194.38	274.13	166.77	0.76	0.37	107.37	220.45	213.81	0.91	0.61	39.17
Okapi	263.91	355.00	164.73	1.04	0.47	190.27	259.87	241.83	0.90	0.46	53.60
Licord	303.81	424.23	217.90	0.94	0.74	206.33	321.07	304.04	1.19	0.51	48.64

Re: % Reduction; STI: Stress tolerance Index; GMP: geometric mean productivity; SSI: stress susceptibility index; YSI: yield stability index; MP: mean productivity; TOL: tolerance index; YI: yield Index; MY: mean yield; yield performance under irrigation (Yp); yield performance under less-watering stress (Ys).

Table 5. Correlation coefficients between mean yield (MY), yield performance under irrigation (Yp), yield performance under less-watering stress (Ys) and drought tolerance/ susceptibility indices of studied winter rapeseed cultivars.

Parameter	MY	Yp	Ys	SSI	STI	TOL	MP	GMP	YI	YSI	Re
MY	1										
Yp	0.83*	1									
Ys	0.46	0.02	1								
SSI	0.21	0.67	-0.72	1							
STI	0.83*	0.62*	0.79*	-0.16	1						
TOL	0.43	0.83*	-0.55	0.97**	0.07	1					
MP	0.93**	0.83*	0.57	0.15	0.95**	0.37	1				
GMP	0.84*	0.6*	0.80*	-0.17	1.00**	0.05	0.94**	1			
YI	0.46	0.02	1.00**	-0.72	0.79*	-0.55	0.57	0.80*	1		
YSI	-0.21	-0.67	0.72	-1.00**	0.15	-0.97**	-0.15	0.17	0.72	1	
Re	0.21	0.67	-0.72	1.00**	-0.15	0.97**	0.15	-0.17	-0.72	-1.00**	1

*, **significant at 5 and 1% of probability level, respectively. Re: % reduction; STI: Stress tolerance index; GMP: geometric mean productivity; SSI: stress susceptibility index; YSI: yield stability index; MP: mean productivity; TOL: tolerance index; YI: yield index; MY: mean yield.

part of scatter plot, one angle of pentagon, which indicates Licord cultivar, is located. This implies that Licord cultivar for D1 and D2 environments have more adaptation over other studied cultivars and shows the higher yield in these environments. Accordingly, Talaye cultivar is located in the third level of drought stress (D3) which indicates the superiority of this cultivar in this environment and its highest amount of yield. On one hand, Licord and Talaye had the highest STI (Licord: 0.74, Talaye: 0.72) among other cultivars and on the other hand, their mean yields (MY) at different levels of drought treatment (Licord: 303.81, and Talaye: 296.39 g/m^2) were higher than those of the studied cultivars (Table 4). Figure 4b shows that in terms of mean yield and yield stability, Licord, Okapi and Opera were the most stable cultivars in this research. With consideration of the

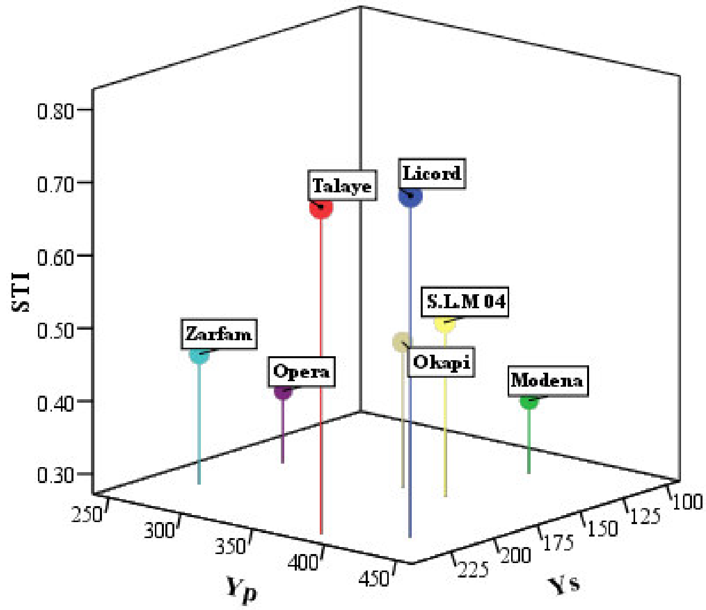

Figure 2. 3D scatter plot of studied cultivars based on mean yield under irrigation (Yp), mean yield under stress conditions (Ys) and stress tolerance index (STI).

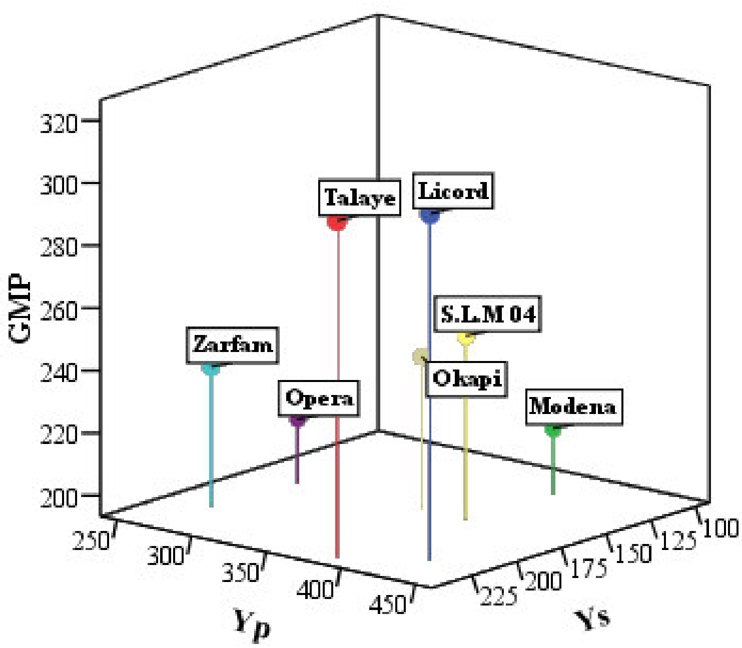

Figure 3. 3D scatter plot of studied cultivars based on mean yield under irrigation (Yp: yield potential), mean yield under stress condition (Ys) and geometric mean productivity (GMP).

fact that Licord had a much higher yield than other cultivars, it was recognized as the most suitable studied cultivar.

In Figure 4b, a cultivar being nearer to the horizontal line has a better yield stability as well. Also, the mean yields of cultivars being on the right side of this figure are higher than those on the left side. The small circle on the plot indicates that the nearer a cultivar to this point, the more superior it would be to others in terms of yield and yield stability.

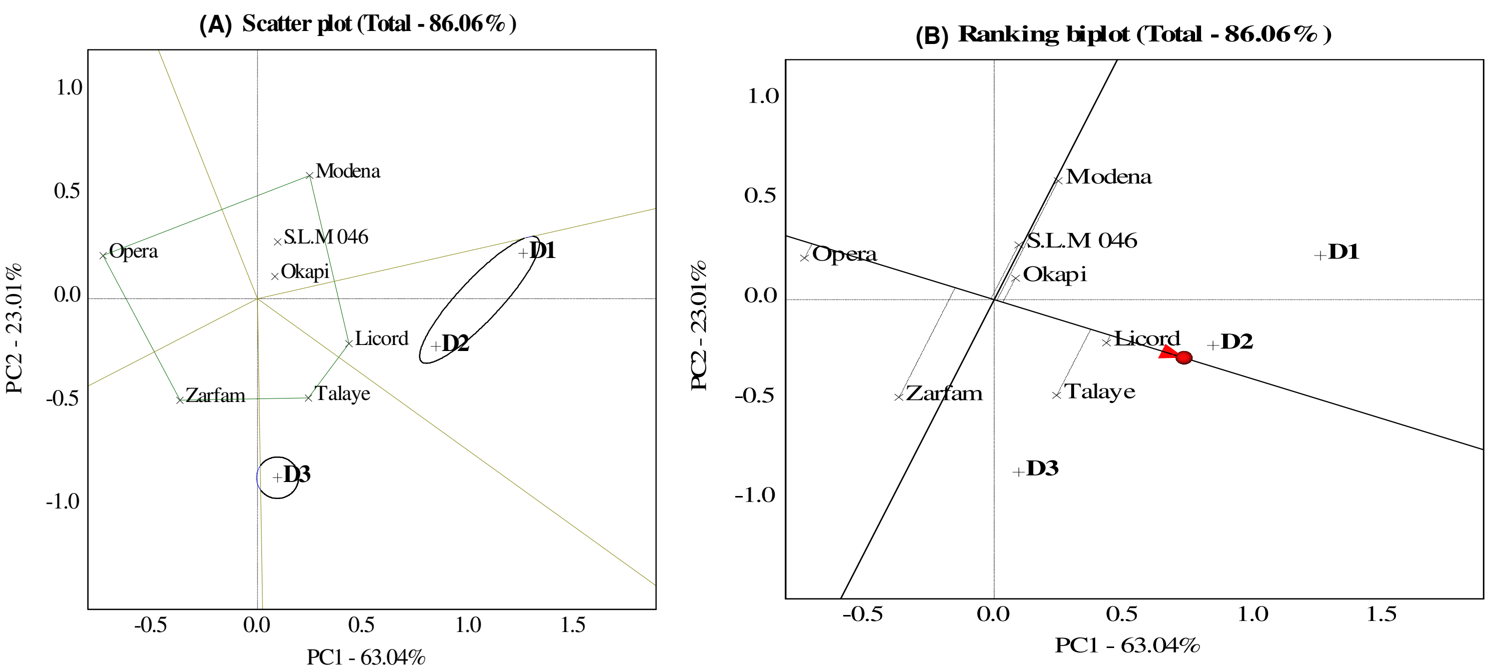

Figure 4. The Biplot diagram of yield stability analysis of seven rapeseed cultivars (Licord, Okapi, Opera, S.L.M.046, Zarfam, Modena, and Talaye) using GGE biplot method. A- Scatter plot of cultivars based on relative advantage in the experimental units (different levels of drought stress, D1, D2, and D3). B- Ranking Biplot of cultivars based on mean yield and yield stability in the studied experimental units.

Conclusion

The study of correlation coefficients and the principal components analysis revealed that YSI and YI were most closely related by the seed yield under stress conditions; while STI and GMP, being correlated with the yield in both stress and non-stress conditions, were the most suitable indices for selecting cultivars in drought stress and non-stress conditions. Moreover, Licord and Talaye were the most suitable studied cultivars. Zarfam having the lowest SSI (0.42) and TOL (57.93) was the most tolerant cultivar. In addition, based on MP rates, Licord(321.07) and Talaye (309.73) were the most suitable cultivars in terms of stress tolerance.

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