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Evaluation of soybean genotypes using drought stress tolerant indices

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Key words: Soybean, drought stress, drought resistance indices, biplot, scatter plot.

Abstract

This experiment was conducted on a research farm of Mahidasht in the west part of Iran in RCBD design with three replications under normal and drought stress conditions. The analysis of variances demonstrated high significant results between studied genotypes on evaluated traits under both conditions. The varieties including Union, Clark, Elgine, L_{17} and Hy-1 had the highest while Williams, Halcor, Hack and Flanklin had the least grain yield per hectar under normal condition. In drought stress condition, the varieties such as Clark, LD_9 and Elgine had the highest while Steel, Halcor and Baj-maj had the least grain yield. The M_9 had the highest number of grain and pods per plant. Similarly L_{17} had the highest amount of grain weight under normal condition while L_{17}, M_9 and Steel had the highest number of grain and pods per plant under drought stress. In this study 6 drought tolerant indices on 14 soybean genotypes, indentified L_{17} as the highest potential yield 0.590 kg/plot while Baj-maj and Hack as the lowest 0.326 and 0.313 kg/plot. On the other hand, Clark and L_{17} had the highest yield stability while Halcor and Baj-maj showed the lowest stability of yield. The highest amounts of STI, GMP, MP, HARM indices was obtained for L_{17} but Baj-maj showed the least amounts of STI, GMP and HARM. The evaluation of biplot on six studied indices and 14 soybean genotypes revealed that GMP and STI had positive correlation with both stress and non-stress yields. Considering three dimensional plot in genotypes scattering using STI, L_{17}, Hy-1, Elgine, LD_9 and Clark were in A region of plot. On the other hand, Halcor, Steel, Flanklin, Williams, Hack and Baj-maj were in D region of plot. It means they had low yield under stress and non-stress conditions.

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Introduction

According to F.A.O reports, soybean is cultivated in about 102 million hectares, It had the most cultivation area between oil seeds and its seed is the main source of oil and plant protein (www.fao.org).The soybean *Glycin max* (L.)merr belongs to *Glycin* wild genus (Wilcox, 1987). The drought tolerance indices which using the loss of yield under drought in comparison to normal irrigation condition have been used for screening drought tolerant genotypes (Mitra, 2001). Several indices have been utilized to evaluate genotypes for drought tolerance based on grain yield such as Mean Productivity (MP), (Rosielle and Hamblin, 1981), Stress Susceptibility Index (SSI) (Fischer and Maurer, 1978), Stress Tolerance Index (STI) (Fernandez, 1992), Geometric Mean Productivity (GMP) (Fernandez, 1992) Tolerance (TOL)(Rosielle and Hamblin, 1981) and Harmonic Mean Productivity (HARM). These indices have been studied by some researchers on maung bean (Fernandez, 1992; Shiri and Akhavan, 2005) corn (Shirinzadeh *et al*., 2009) soybean (Bouslama and Schaupaugh, 1984) wheat (Bansal and Sinha, 1991; Clarke *et al*., 1992; Rajaram and Van Ginkle, 2001) and safflower (pourdad, 2008). Biplot is an useful data visualization technique to display the multivariate data into a two dimensional scatter plot. The concept of biplot was first developed by Gabriel (1971). This technique has extensively been used for analysis of multi-environmental trails (Ahmadi *et al*., 2000; Golabadi *et al*., 2006; Yan and Rajcan, 2002). Abdipour *et al* (2008) reported the MP, GMP, HARM, STI as the best indices for separating drought tolerant genotypes. In addition, they identified Williams and Hack cultivars were tolerant under stress in flowering stage and as though under drought stress in seed filling stage, Williams was the tolerant cultivar. Sheng *et al* (2012) reported the cultivars such as $Xudou_{12}$, $Zhongzuo_{00\text{-}683}$ and Zhonghuang, would be elite soybean germplasm for production in dry areas. Tint *et al*. (2008) reported the SJ-4 cultivar as the most drought tolerant cultivar that indicating both the appropriate genotype for cultivar improvement and cultivation in drought-prone areas. They identified STI as the most appropriate index to identification better yielding cultivars for a drought-stress environment followed by GMP.Li G*et al*., (2006) studied ten soybean cultivars of various ecotypes under pot culture and field condition. They reported $Jinda_{74}$ and $Jinda_{53}$ as two cultivars with strong drought-resistance. Kobraee and Shamsi, (2011) had an investigation on M_{71}, M_{91}, Gorgan and Williams cultivars and reported that under drought stress, Williams was better than the other cultivars while $Gorgan_3$ was weaker. Dornbos and Mullen, (1991) reported water and high air-temperature stresses that occur during soybean seed fill stage, greatly reduce seed yield. Masoumi, (2011) in a study on responses of five soybean cultivars (L_{17}, Clean, T.M.S, Williams×Chippewa and M_9) under three levels of irrigation showed, among cultivars, L_{17} and Williams×Chippewa as the highest seed and oil yield at the normal condition of irrigation and both levels of water deficit stress, respectively. Kim *et al*., (2007) reported that drought stress caused a large decrease in seed yield although its effect was not 100% completely. They showed all drought treated cultivars except DC exhibited a significant increase in wax amount leaves. More over seed yield inversely correlated with wax amount after drought treatment. Their results indicated, drought induction on leaf wax does not contribute directly to seed set. Saba *et al*., (2001), reported that SP (standard superiority measure) and STI might be better drought resistance indices based on grain yield to be employed in plant breeding programs because their moderate narrow-sense heritabilities and the inherent ability is high to selecting high yield genotypes in either stressed and non-stressed conditions. Mohammadi *et al*., (2010) in a study on durum wheat showed the drought tolerance indices including stress tolerance index (STI), geometric mean productivity (GMP), mean productivity (MP) and superiority index (Pi) were effective to identify the high yielding genotypes with high drought tolerance. Pourdad, (2008) reported STI was the best index to identify superior genotypes in drought stress and non-stress condition. Kargar *et*

al., (2004) evaluated 49 soybean genotypes and identified five tolerant genotypes including L_{17}, Union, Bonus, Williams and M_9. The objectives of this study were to compare the different drought resistance indices in soybean and the evaluationof the most resistant soybean genotypes under deficit irrigation and reflection of their traits under normal and stress conditions.

Materials and methods

Study site

This experiment was conducted on research farm of Mahidasht 15 kilometers far from Kermanshah located at the west of Iran as 46°,26′ Eastern and 34°,8′ Northern. Experimented design was RCBD with three replications in two normal and drought stress conditions. The soil of farm was tested considering micro and macro elements and the manures consumed.

Experiment design and treatments

In present study 14 soybean genotypes were evaluated including Baj-Maj, M_9, Hy-1, L_{17}, Union, Bonus, Williams, Hack,Clark,Halcor,Flanklin,LD_9,Steel andElgine from II and III maturity group. The drought stress was induced as interval irrigation 7 versus 14 days from flowering stage. The method was basin irrigation using counter and consumed water was 300 lit/plot in each irrigation stage considering water essential of soybean (Panndy, 1987)**.** Each plot was included four rows with four meters length and 50 cm row spacing and plant to plant spacewas 10 cm.

Experimental procedure

Eleven traits were measured as follow: days to germination as date of emergence of majority of plantlets from cultivation time, days to maturity of the most of plot plant. Average leaf area as calculation of ratio surface of 20 dry leaves from 9 random plants to dry mass of total leaves of them. One hundred grains weight using seed counter and digital balance with 0.001 gram sensitiveness. The number of grain per plant and the number of pods per plant, inter nod by counting number of nods on main branch and divided to plant height. The number of sub branches. Plant height was measured by length of ultimate shoot to collar. The yield grain was estimated by whole harvested plants per plot and converted to yield per hectare.

Data analysis

The analysis of variances and comparison of means were performed using MSTAT-C software and drought indices that introduced by Fernandez, 1992 (STI, GMP), Fisher and Maurer, 1978 (SSI), Rosielle and Habblin, 1981 (MP, TOL,) and (Harm). Biplots were performed using Excel and SPSS softwares.

Drought resistance indices were calculated as below:

(Stress susceptibility index , Stress intensity)

$$SSI = \frac{1-(Ys/Yp)}{1-(SI)} \qquad SI = 1-\left[\frac{\bar{Y}s}{\bar{Y}p}\right]$$

(Fischer and Maurer, 1978)(Mean of productivity ; Tolerance)

$$MP = \frac{(Yp+Ys)}{2} \quad ; \quad TOL = Yp - Ys$$

(Rosielle and Hamblin, 1981)

(Stress tolerance index; Geometric mean of productivity)

$$STI = \left(\frac{Yp}{\bar{Y}p}\right)\left(\frac{Ys}{\bar{Y}s}\right)\left(\frac{\bar{Y}s}{\bar{Y}p}\right) = \frac{(Yp)(Ys)}{(\bar{Y}_p{}^2)}; GMP = \sqrt{(Ys)(Yp)}$$

(Fernandez,1992)(Harmonic mean of productivity)

$$HARM = \frac{2(Yp \cdot Ys)}{Yp + Ys}$$

Ys:Acquired yield of each genotype under stress condition.

Yp: Acquired yield of each genotype under non-stress condition.

Results

The Analysis of Variance under normal condition

Analysis of variances showed high significant variation in genotypes on different traits under normal condition. There was low C.V. (1.07%) that belong to days to maturity. The majority others

belonged to number of pods per plant (10.06%) (Table. 1).

Mean Comparison

The comparison of means under normal condition showed that the highest of number of pod per plant belonged to M_9, Baj-maj and L_{17} (50.77, 47.32 and 43.02) and the lowest were Halcor, Hack, Flanklin and Clark (23.46, 20.24, 19.40 and 17.11) respectively. The highest number of one hundred grain weight belonged to L_{17} and union as 112.7 and 104.7. The lowest were Flanklin, Elgine, Steel, M_9, Halcor, Hack and Baj-maj (88.56, 87.94, 86.47, 84.62, 81.99, 80.08 and 78.17) respectively. The highest of number of grain per plant belonged to Hy-1, M_9, Halcor (117.2, 120.5, 115.0). The lowest were union, Elgine, Bonus and Steel (94.22, 84.44, 82.76 and 81.10). The highest of yield per hectare belonged to union, Elgine, L_{17}, Hy-1 and Steel (684.2, 668.8, 654.9, 653.8 and 594.4). The lowest were Williams, Halcor, Hack and Flanklin (337.6, 336.3, 330.1 and 274.8) (Table.2). Heatherly, (1993) reported the importance of irrigation effect and its necessity on yield at grain maturity.

Table 1. The analysis of variance of traits under 7days irrigation condition.

S.o.V	*D.f.*	*Days to maturity(Day)*	*Number of sub branch*	*Plant height*	*Inter nod*	*Number of pod/plant*	*Number of grain/plant*	*Average leaf area*	*W1000*	*Yield/ hectare*
Block	2	0.125	0.320	3.796	0.090	10.828	4.484	1.473	11.812	1010.839
Treatment	13	111.496**	1.716**	250.225**	0.387**	328.735**	1035.826**	11.452**	286.544**	70619.162**
Error	26	1.561	0.138	3.975	0.033	11.830	33.029	1.060	19.909	1379.455
Total	41	-	-	-	-	-	-	-	-	-
Coefficient of variation	-	1.07%	8.40%	6.56%	7.61%	10.06%	6.05%	6.93%	4.86%	**7.25%**

Table 2. Mean comparison of 14 soybean genotypes using Duncan's method under 7 days irrigation condition at 1% level of probability.

Genotype	*Days to maturity*		*Number of sub branch*		*Plant height*		*Inter nod*		*Number of pod/plant*		*Number of grain/plant*	
	Mean	Group	Mean	Group	Mean	Group	Mean	Group	Mean	Group	Mean	Group
Baj-Maj	107.0	h	6.3	a	15.68	g	1.673	f	47.32	ab	100.2	cd
M9	111.7	fg	4.5	bcd	40.85	ab	2.693	ab	50.77	a	117.2	a
Hy-1	115.5	e	4.8	bc	39.76	abc	2.472	abcd	39.25	bc	120.5	a
L17	119.0	cd	4.9	bc	36.17	bcd	2.597	abc	43.02	abc	110.4	abc
Union	117.5	de	4.5	bcd	42.25	a	2.840	a	35.58	cd	94.22	def
Bonus	117.7	de	5.4	b	28.37	ef	2.637	ab	39.44	bc	82.76	ef
Williams	124. 7	b	4.3	cde	25.27	f	2.477	abcd	37.93	cd	96.24	cde
Hack	109.3	gh	4.5	bcd	18.97	g	1.790	ef	20.23	f	67.47	g
Clark	119.5	cd	3.7	de	35.19	cd	2.800	a	17.11	f	99.38	cd
Halcor	128.0	a	3.8	de	19.99	g	2.070	def	24.46	ef	115.0	ab
Flanklin	111.0	fg	3.6	e	19.73	g	2.143	cde	19.40	f	57.82	g
LD9	121. 7	c	4.1	cde	39.69	abc	2.607	ab	36.69	cd	102.9	bcd
Steel	112.5	f	4.1	cde	31.77	de	2.282	bcd	37.22	cd	81.10	f
Elgine	122.0	bc	3.8	de	32.05	de	2.330	bcd	30.38	de	84.44	**ef**

Genotype	Average leaf area		Hundred grain weight		Yield pre hectare	
	Mean	Group	Mean	Group	Mean	Group
Baj-Maj	12.75	de	78.17	f	408.2	c
M9	13.28	de	84.62	ef	531.8	b
Hy-1	13.19	de	93.46	cde	653.8	a
L17	16.94	ab	112.7	a	654.9	a
Union	17.71	a	104.7	ab	684.2	a
Bonus	14.55	bcde	99.22	bc	533.7	b
Williams	16.59	abc	97.46	bcd	337.6	cd
Hack	15.28	abcd	80.08	f	330.1	cd
Clark	13.62	de	96.30	bcd	680.8	a
Halcor	14.11	cde	81.99	f	336.3	cd
Flanklin	12.97	de	88.56	cdef	247.8	d
LD9	12.43	e	93.35	cde	511.1	b
Steel	16.92	ab	86.47	def	594.4	ab
Elgine	17.75	a	87.94	cdef	668.8	a

The Analysis of Variance under stress condition

The analysis of variances demonstrated high significant results at 1% level between studied genotypes on evaluated traits under stress condition. The lowest C.V. belonged to days to maturity (1%). The majority others belonged to average leaf area (12.73%)(Table.3).

Table 3. The analysis of variance of traits under 14 days irrigation condition.

S.o.V	Df	Days to maturity	Number of sub branch	Plant hight	Internod	Number of pod/plant	Number of grain/plant	Average leaf area	Hundered grain wight	Yield/hectar
Block	2	0.013**	0.070	1.893	0.015	9.654*	40.143	1.339	2.527	0.1300
Treatment	13	81.463**	0.943**	132.123**	0.231**	175.754**	746.505**	14.369**	135.877**	17854.360**
Error	26	1.324	0.134	5.808	0.013	2.82	26.480	3.443	5.840	776.215
Total	41	-	-	-	-	-	-	-	-	-
Coefficient of variation	-	1%	7.71%	9.76%	5.11%	6.25%	8.41%	12.73%	3.38%	8.41%

Table 4. Mean comparison of 14 soybean genotypes using Duncan's method under 14 days irrigation condition at 1% level of probability.

Genotype	Days to maturity		Number of sub branch		Plant hight		Internod		Number of pod per plant		Number of grain per plant	
	Mean	Group	Mean	Group	Mean	Group	Mean	Group	Mean	Group	Mean	Group
Baj-Maj	111.6	c	3.9	de	20.93	ef	2.160	def	24.52	def	49.33	def
M9	106.7	d	4.4	cde	26.96	cd	2.460	bc	37.23	ab	86.08	a
Hy-1	117.5	b	4.6	abcd	26.67	cd	2.190	cdef	33.40	bc	73.88	ab
L17	119.0	ab	5.1	abc	31.74	abc	1.980	efg	38.19	a	75.63	ab
Union	121.0	a	5.4	ab	29.63	abc	2.253	cde	25.36	de	56.46	cd
Bonus	117.5	b	5.3	ab	16.70	f	2.003	efg	27.60	d	56.85	cd
Williams	119.7	ab	4.4	cde	19.15	ef	2.063	defg	12.78	h	38.94	f
Hack	114.0	c	4.8	abcd	17.14	ef	1.913	fg	21.79	efg	51.83	cde
Clark	119.7	ab	4.8	abcd	35.42	a	2.777	a	31.49	c	75.38	ab
Halcor	117.2	b	5.4	ab	19.59	ef	2.133	def	24.95	def	63.16	bc
Flanklin	107.5	d	5.5	a	16.06	f	1.820	g	19.00	g	40.29	ef
LD9	119.0	ab	4.7	abcd	34.22	ab	2.690	ab	36.94	ab	82.73	a
Steel	106.5	d	4.5	bcde	23.04	de	2.203	cdef	21.61	efg	42.00	ef
Elgine	119.0	ab	3.6	e	28.47	bcd	2.343	cd	21.00	fg	63.77	bc

Genotype	Average leaf area		Hundered grain wight		Yield pre hectar	
	Mean	Group	Mean	Group	Mean	Group
Baj-Maj	12.11	cd	70.14	de	225.2	e
M9	13.34	abcd	68.00	def	288.1	de
Hy-1	13.35	abcd	69.39	de	399.8	bc
L17	16.48	abc	83.70	a	345.7	cd
Union	15.73	abc	80.81	ab	331.8	d
Bonus	13.03	bcd	73.00	cd	330.7	d
Williams	16.31	abc	71.27	cd	331.2	d
Hack	13.36	abcd	76.27	bc	293.5	de
Clark	16.66	abc	76.62	bc	474.6	a
Halcor	10.64	d	64.70	efg	241.3	e
Flanklin	12.91	bcd	59.33	g	277.7	de
LD9	18.05	a	73.98	cd	425.5	ab
Steel	17.13	ab	72.21	cd	241.5	e
Elgine	14.94	abcd	62.41	fg	428.6	**ab**

Table 5. Susceptibile and tolerant indices in 14 soybean genotypes.

Row		*YP*	*YS*	*STI*	*GMP*	*MP*	*Tol*	*HARM*	*SSI*
1	Baj-Maj	0.326	0.120	0.090	0.197	0.223	0.206	0.175	1.250
2	M9	0.463	0.223	0.238	0.321	0.343	0.240	0.301	1.023
3	Hy-1	0.560	0.260	0.335	0.381	0.410	0.300	0.355	1.059
4	L17	0.590	0.273	0.372	0.401	0.431	0.316	0.373	1.061
5	Union	0.586	0.170	0.230	0.315	0.378	0.416	0.263	1.404
6	Bonus	0.453	0.193	0.202	0.296	0.323	0.260	0.271	1.133
7	Williams	0.336	0.190	0.147	0.252	0.263	0.146	0.242	0.861
8	Hack	0.313	0.206	0.149	0.254	0.260	0.106	0.249	0.672
9	Clark	0.456	0.323	0.340	0.384	0.390	0.133	0.378	0.577
10	Halcor	0.420	0.160	0.155	0.259	0.290	0.260	0.231	1.223
11	Flanklin	0.320	0.190	0.140	0.246	0.255	0.130	0.238	0.803
12	LD9	0.513	0.290	0.343	0.385	0.401	0.223	0.370	0.860
13	Steel	0.416	0.200	0.192	0.288	0.308	0.216	0.270	1.027
14	Elgine	0.510	0.296	0.349	0.388	0.403	0.213	0.375	0.826

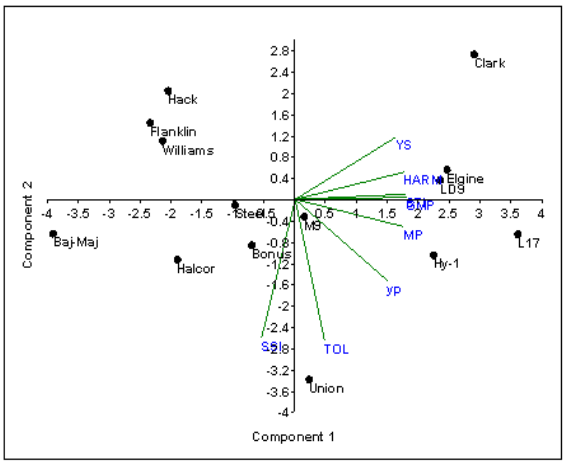

Fig. 1. Display six drought tolerance indices on 14 soybean gynotypes.

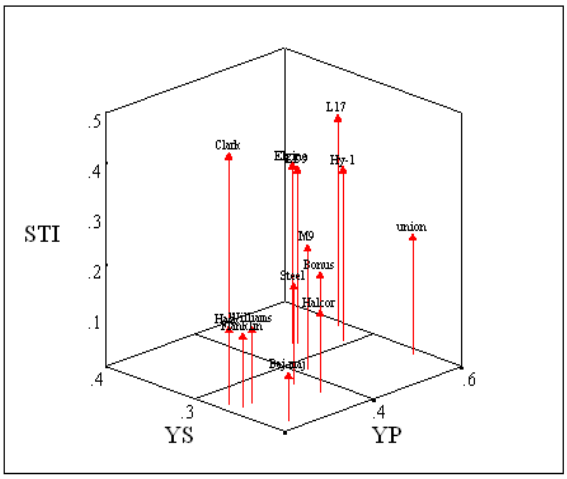

Fig. 2. Mean of yield under stressed and non-stressed conditions and STI in soybean varieties.

Mean Comparison

The comparison of means under normal condition showed that the highest number of pods per plant belonged to L_{17}, M_9 and LD_9 (38.19, 37.23 and 36.94) and the lowest were Hack, Steel, Elgine and Flanklin (21.79, 21.61, 21.00 and 19.00). The highest number of grain per plant belonged to M_9, LD_9, L_{17} and Clark (86.08, 82.73, 75.63 and 75.38) and the lowest were in Baj-maj, Steel, Flanklin and Williams (49.33, 42.00, 40.29 38.94). The highest one hundred grain weight belonged to L_{17} and union (83.70 and 80.81) and the lowest were in Halcor, Elgine and Flanklin (64.70, 62.41 and 59.33). The highest yield per hectare belonged to Clark, Elgine and LD_9 (474.6, 428.6 and 425.5) and the lowest were in Hack, M9, Flanklin, Steel, Halcor and Baj-maj (293.5, 288.1, 277.7, 241.5 and 225.5)(Table.4).(It was argued that different types of stress lead to more deficiency on yield during R_1-R_5 growth stage (Board and Harville, 1998; Board and Tan, 1995; Linkermer *et al.*, 1998). Kargar *et al.*, (2004) reported the highest yield in L_{17} and the lowest in Flanklin under both normal and stress conditions. Abdipour *et al.*, (2008) reported that Williams and Hack cultivars were tolerant under stress in flowering stage and so under drought stress in seed filling stage. In sum Williams was the tolerant cultivar. In this study, 6 tolerant indices on 14 soybean genotypes were used. Based on them, it is

resulted that L_{17} had the highest of potential yield (0.590) and Baj-maj and Hack as the lowest (0.326 and 0.313). Clark and L_{17} had the highest stability yield (0.350, 0.300), while Halcor and Baj-maj had the lowest (0.160 and 0.120) (Table.5). Masoumi, (2011) reported the cultivars of L_{17} and Williams × Chippewa produced the highest seed at the optimum condition of irrigation and both levels of water deficit stress, respectively.

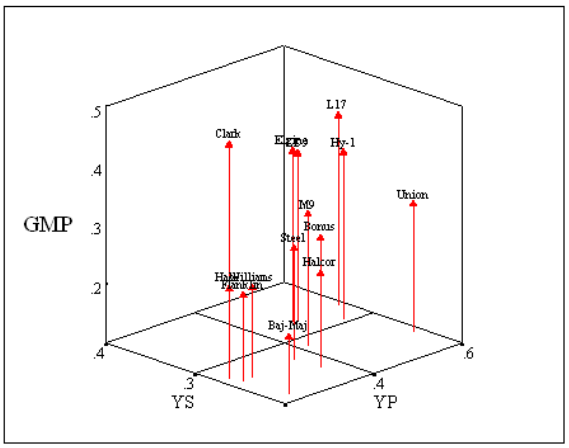

Fig. 3. Mean of yield under stressed and non-stressed conditions and GMP in soybean varieties.

The study drought indices on soybean cultivars

The L_{17} cultivar considering STI, GMP, MP, HARM had the most amounts as 0.408, 0.420, 0.455 and 0.397 and so union considering TOL and SSI had the amounts 0.416 and 1.404 respectively. Considering TOL, L_{17} was the second cultivar after union with 0.290. Considering HARM, Clark was the second cultivar after L_{17} with 0.396. Considering SSI, Baj-maj was the second cultivar after union with 1.250. It had the lowest as 0.090, 0.197 and 0.175 considering STI, GMP and HARM indices, respectively. Clark had the least amounts as 0.106 and 0.461 about TOL and SSI indices respectively and considering TOL, Flanklin was the second cultivar with 0.130 after Clark (Table.5). In this study stress intensity was estimated as 0.49. Abdipour *et al.*, (2008) reported the MP, GMP, HARM, STI as the best indices for separating drought tolerant genotypes. Kargar *et al.*, (2004) identified GMP and STI as the best indices in separation superior genotypes in stress and non-stress condition. The evaluation of biplot on six studied indices and 14 soybean genotypes showed GMP and STI had correlation with both stress and non-stress yields. MP with non-stress and HARM with stress yields had correlation. The SSI and TOL were correlated only with non-stress yield and TOL correlation was more than SSI. Considering situation indices on biplot, the first component was named sensitiveness and the second component was named resistance and tolerance (Fig.1). The results of (Shiri, 2005) in Principal component analysis revealed that the first PCA explained 70.5% of the total variation and named as the yield potential and drought tolerance component. Second PCA explained 28.3% of the total variability thus named as stress-susceptibility component**.** Two indices SSI and Tol had strong correlation with yp while GMP, STI, TOL and HARM had correlation with both of ys and yp.The results of Shiri, (2005) showed (a) strong negative association between SSI and TOL with Ys, as indicated by the large obtuse angles between their vectors, (b) a near zero correlation between SSI with GMP, HARM and STI, as indicated by the near vertical vectors and (c) a positive association between Yp and Ys with MP, HARM, GMP and STI, as indicated by the acute angles. The Elgine, LD_9, L_{17} and Hy-1 had considerable correlation with HARM, STI, GMP and MP. Union had considerable correlation with TOL and SSI while M9 and Bonus were in later degrees. The Steel, Halcor and Baj-maj were related with SSI index relatively. The Clark was related only with HARM index (Fig.1). Considering three dimensional plot (Fig.2) in genotypes scattering using STI, the L_{17}, Hy-1, Elgine, LD_9 and Clark were in A region of plot and based on Fernandez, (1992) idea they had potential and stability yield under stress and non-stress conditions. on the other hand Halcor, Steel, Flanklin, Williams, Hack and Baj-maj were in D region of plot (Fig.2). It means, they had low yield under stress and non-stress condition. Eight tolerant genotypes were identified by Kargar *et al.*, (2004) while Bonus, L_{17} and Williams were among them.Based on genotypes under this study in three dimensional scatterplot by GMP, the above mentioned results are confirmed (Fig.3).

Discussion

Considering to amounts of C.V., in days to maturity under non-stress (1.07%) and stress (1%) it is concluded that the most of studied cultivars were matured simultaneously. The number of pods per plant had the highest C.V. (10.06%) under non-stress so the studied cultivars demonstrate various reactions under humidity and it will be selectable trait for improvement soybean cultivars for cultivation under normal irrigation.

On the other hand, the average leaf area had the highest C.V. (12.73%) under drought stress and it means, drought stress caused high variation between soybean cultivars on this traits so that some of them had small leaf while the others had big. It seems the most effects of drought stress been on vegetative organs of soybean plants.

Based on results comparison of means, Hy-1, L_{17} and Union had the highest grain yield pre hectare under non-stress condition. Although M_9 was in group of (b) on grain yield but it had the highest in the number of pods and grain per plant. The cultivars such as Flankline, Halcor and Hack had the lowest of grain yield per hectare, the number of pods and sub branches per plant under non-stress condition.

Based on results comparison of means, Clark, LD_9 and Elgine had the highest grain yield per hectare under stress condition. L_{17} and M_9 had the highest number of grain and pods per plant. Steel, Halcor and Baj-Maj had the lowest grain yield per hectare and the cultivars such as Flanklin and Hack had low number of pods and grain per plant under stress condition.
Consequently, based on drought indices, L_{17}, Clark, LD_9 and Elgine with the highest GMP and STI, were the resistant cultivars while Baj-Maj with the lowest of mentioned indices, was susceptible cultivar.

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