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Evaluation of pinto bean different genotypes (*Phaseolus vulgaris* L.) with respect to yield and yield component at two places under water deficit

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Abstract

In order to evaluate the response of different genotypes of pinto bean (*Phaseolus vulgaris* L.) to water stress in field conditions three landraces of Shabestar, Maragheh and Zanjan along with two improved varieties of Talash and COS16 in Tabriz and Maragheh were studied. In field conditions genotypes were compared in three levels of water stress (once irrigation cut at 4-5 leaves stage, 50% flowering and 50% pod-forming stages) along with normal irrigation in two locations (Tabriz and Maragheh) with using from split plot design based on randomized complete block design (RCBD) with three replication. There was a significant difference between two locations in terms of biological yield, grain yield, number of pod per plant and harvest index. The difference of water stress levels was significant for all evaluated traits. It is noteworthy that different stress levels in two locations showed diverse responses. Also genotypes had significant difference in terms of all studied traits. The reaction of genotypes was different in two locations. Genotypes also had significant difference taking into account all traits. While the genotypes showed similar reaction to the different levels of water stress. However, genotype, stress and location interaction was significant for all traits. These results represented the location interaction with other under assessment factors. In the selection of tolerant genotypes to water stress with irrigation cut at three phonological stages COS16 and Talash improved cultivars in Maragheh and Tabriz had the best situation considering the most of drought tolerance indices, respectively.

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Introduction

Grains are valuable food source of protein (with contain 18% to 32% protein) (Schoonhoven and Voysest, 1991), in addition from the perspective of agronomy also have special importance and place, so that their position in crop rotation in some environmental condition cause the fertility of the soil, reduce weeds and pests and diseases. (Lopez-Bellido *et al.*, 2005). Beans are one of the most valuable grains and the earliest products of new world that constitute about half the consumable seed legumes in worldwide (McClean *et al.*, 2004). Nowadays bean is a major product in most parts of the world. This plant is an excellent food for humans that has no cholesterol and plays a significant role in providing of protein, phosphorus, iron, B1 vitamin and fiber (Anderson, 2003). In general legumes and particularly bean are complete source of carbohydrates, protein, edible fiber, kinds of vitamins and mineral that can create a high energy and hence are an important source for human nutrition (Costa *et al.*, 2006).

Drought stress is biggest dilemma in crop production and yield stability in many regions of the world. Drought is the main contributing factor in the security and stability of food supplier sources in various countries and limits plant growth more than any other environmental factors (Shekari *et al.*, 2006). In fact this phenomenon is most common environmental stress and restrictive crop production about 28% of land in the world (Dent, 1980). According to Ramirez and Kelly (1998) opinion drought stress is the main limiting factor global production of bean. As about 60% of the bean crop product in developing countries in terms of drought stress and thus drought is second factor in performance diminution of the plant after the disease (Singh, 1995; Turkan *et al.*, 2005).
Identifying of appropriate separation tools makes easy process plant breeding for drought tolerance (Marcelo and John, 2007). STI, SSI, TOL, MP and GMP are indices that can be used to select varieties are tolerant to water stress in farm conditions. Essentially these indicators are estimated based on performance.

The objective of this study was to identify most crop cultivars of pinto bean under conditions of normal and limited irrigation in Tabriz and Maragheh based on field characteristics and tolerance indices.

Materials and methods

Measure of traits

Five pinto bean genotypes under water stress in two locations of Tabriz and Maragheh with using split plot design based on randomized complete block design and three replications were evaluated. The main factor had four levels of irrigation (normal and once irrigation cut at 4-5 leaves stage, 50% flowering and 50% pod-forming stages) and sub-plot had five genotypes of pinto bean. Each unit consisted of four rows with spacing of 25 cm and length of 5 m. Distance of plants in rows 10 cm and depth of planting seeds 5-4 cm was considered. Weeds were controlled manually. For combat to heliothis pest and fusarium fungus was used from diazinon and benomyl poison with appropriate concentration. According to local conditions and temperature, Irrigation in no stress units was performed at interval about a week. In plots of under drought stress respectively irrigation was discontinued once in 4-5 leaves stage, 50% flowering and 50% pod-forming stages. Number of pods per plant, number of seed per pod, biological yield, grain yield, 1000 grain weight and harvest index were measured.

Evaluation methods of tolerance to water stress

After review and approval of assumptions combined analysis of variance according to split plot design with randomized complete block design was performed. Required means using Duncan's test at 5% probability level for all traits were compared. For evaluation tolerance of genotypes to water stress in two locations and based on three different levels of stress were used from indicators of SSI, STI, GMP, TOL and MP on basis of grain yield. For analyze of data and graph drawing was used from Excel, MSTAT-C and MATLAB software.

Results and discussion

Combined analysis of variance

Combined analysis of variance different characteristics showed significant differences between locations for biological function (biological yield), grain yield, number of pod per plant and harvest index, between different levels of water stress for biological yield, grain yield, number of pod per plant, number of seed per pod, 1000 grain weight and harvest index (all characters) and between different genotypes of pinto bean for all evaluated traits. Also between location and genotype interaction, location and different levels of irrigation interaction and the between of three factors were significant for all traits. While genotype and different levels of irrigation interaction there was no significant (Table 1). Significant interaction indicates that these factors do not operate independently of each other. Due to the effect of location in be significant of interaction was necessary at each location are examined studied genotypes tolerant to water stress.

Table 1. Combined analysis of variance for studied traits in different genotypes of pinto bean and different levels of water stress in two places.

		Mean Square					
Sources	DF	Biological yield (per plant)	Grain yield (per plant)	N. of pod per plant	N. of seed per pod	1000 grain weight	Harvest index
Location (L)	1	2557.44**	42.79**	54.33**	0.61^{ns}	46148.62^{ns}	70.32**
Repeat / L	4	4.30	0.25	1.77	0.78	9041.08	1.83
Water stress (S)	3	175.98**	11.86**	25.70**	1.60**	54077.7**	159.86**
L × S	3	17.33*	1.15**	2.44**	1.45**	22796.10*	14.09**
Error 1	12	3.79	0.18	0.23	0.09	4472.50	2.25
Genotype (G)	4	118.17**	13.97**	9.08**	0.61**	37092.30**	71.78**
G × L	4	192.38**	5.44**	8.55**	0.26*	5272.41**	19.25**
G × S	12	11.41^{ns}	0.52^{ns}	1.21^{ns}	0.11^{ns}	1012.64^{ns}	4.21^{ns}
G × S × L	2	21.15**	0.95*	2.88**	0.19*	3455.11**	9.52**
Error 2	64	7.90	0.45	0.62	0.09	1244.48	3.46

ns, * and **: not significant and significant at 5% and 1% probability levels, respectively.

Table 2. Grain yield in different levels of irrigation and drought tolerance assessment indices based on grain yield in conditions of Maragheh.

		Yp	Ys	Ys	Ys	TOL	TOL	TOL	MP	MP	MP
			4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming
Conditions of Maragheh	Shabestar landrace	7.28	6.15	5.01	6.45	1.13	2.27	0.83	6.72	6.15	6.87
	Talash	7.52	6.66	5.75	6.43	0.86	1.77	1.09	7.09	6.64	6.98
	COS16	9.54	8.13	7.40	8.98	1.41	2.14	0.56	8.84	8.47	9.26
	Zanjan landrace	6.11	6.07	4.35	5.37	0.04	1.76	0.74	6.09	5.23	5.74
	Maragheh landrace	7.48	6.72	5.27	6.42	0.76	2.21	1.06	7.10	6.38	6.95

Evaluation tolerance of genotypes to water stress in two locations

For assess tolerance of bean studied genotypes to water stress from drought tolerance indices in two locations and three different levels of water stress based on grain yield were used (Table 2 and 3). In Maragheh with irrigation cut at 4-5 leaves stage in the terms of TOL and SSI indices Zanjan landrace and in the terms of MP, GMP and STI indices COS16 improved cultivar were more tolerant to water stress. With irrigation cut at 50% flowering in terms of TOL index Talash improved cultivar and Zanjan landrace, in terms of SSI index Talash and COS16 improved varieties and in terms of MP, GMP and STI indices COS16 improved cultivar were tolerant to water stress. With irrigation cut at 50% pod-forming stage in terms of all indicators COS16 improved cultivar was more tolerant than the rest of the genotypes.

Table 2. (continued)

		GMP	GMP	GMP	SSI	SSI	SSI	STI	STI	STI
		4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming
Conditions of Maragheh	Shabestar landrace	6.69	6.04	6.85	1.40	1.17	1.01	0.78	0.63	0.82
	Talash	7.08	6.58	6.95	1.03	0.88	1.28	0.87	0.75	0.84
	COS16	8.81	8.40	9.26	1.33	0.84	0.52	1.35	1.23	1.49
	Zanjan landrace	6.09	5.16	5.73	0.06	1.08	1.07	0.64	0.46	0.57
	Maragheh landrace	7.09	6.28	6.93	0.92	1.10	1.26	0.87	0.68	0.83

Yp and Ys: grain yield in normal and water stress conditions, respectively.

Table 3. Grain yield in different levels of irrigation and drought tolerance assessment indices based on grain yield in conditions of Tabriz.

		Yp	Ys	Ys	Ys	TOL	TOL	TOL	MP	MP	MP
			4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming
Conditions of Tabriz	Shabestar landrace	5.93	5.53	4.71	4.97	0.40	1.22	0.96	5.73	5.32	5.45
	Talash	6.67	6.43	5.67	5.93	0.24	1.00	0.74	6.55	6.17	6.30
	COS16	6.80	6.07	5.33	5.60	0.73	1.47	1.20	6.44	6.07	6.20
	Zanjan landrace	5.72	5.34	4.65	4.93	0.38	1.07	0.79	5.53	5.19	5.33
	Maragheh landrace	5.10	4.93	4.27	4.63	0.17	0.83	0.47	5.02	4.69	4.87

In Tabriz by irrigation cut in all three stages in terms of TOL index Maragheh landrace and in terms of SSI index Talash improved cultivar and Maragheh landrace were more tolerant to water stress. Talash and COS16 Improved varieties in terms of MP, GMP and STI indices were in a better position toward tolerance of water stress.

In general results showed that in Maragheh despite the cessation of irrigation at phenological different stages had different effect on pinto bean genotypes but with irrigation cut at three stages COS16 improved cultivar in terms of most indicators had a better position to tolerance of water stress. In Tabriz conditions in all three stages of irrigation cut despite difference in the selection of tolerant genotypes in terms of different indicators Talash improved cultivar had a better position to tolerance of water stress.

Distribution of evaluated cultivars in climatic conditions of Maragheh

To benefit from the division of Fernandez (1992) the distribution of studied cultivars based on obtained results using STI index in all the three stages of stress and on the climatic conditions of Maragheh and Tabriz is visible in the three dimensional graphs (Fig. 1 to 6). The climatic conditions of Maragheh and all the three stages of stress COS16 cultivar in group A and Shabestar, Talash, Zanjan and Maragheh landrace and landrace Maragheh in Group D were placed. Groups B and C did not include any cultivar (Fig. 1 to 3).

Table 3. (continued)

Conditions of Tabriz	GMP	GMP	GMP	SSI	SSI	SSI	STI	STI	STI
	4-5 leaves stage	50% flowering	50% pod-forming	4-5 leaves stage	50% flowering	50% pod-forming	4-5 l leaves stage	50% flowering	50% pod-forming
Shabestar landrace	5..73	5.28	5.43	1.06	1.11	1.18	0.90	0.76	0.81
Talash	6.55	6.15	6.29	0.57	0.81	0.81	1.17	1.04	1.08
COS16	6.42	6.02	6.17	1.69	1.17	1.28	1.13	0.99	1.04
Zanjan landrace	5.53	5.16	5.31	1.05	1.01	1.00	0.84	0.73	0.77
Maragheh landrace	5.01	4.67	4.86	0.52	0.88	0.67	0.69	0.60	0.65

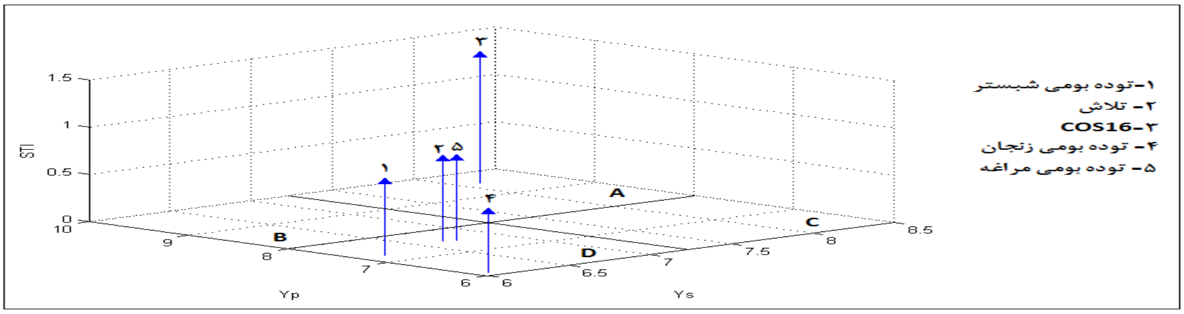

Fig. 1. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at the 4-5 leaves stage in Maragheh based on STI index.

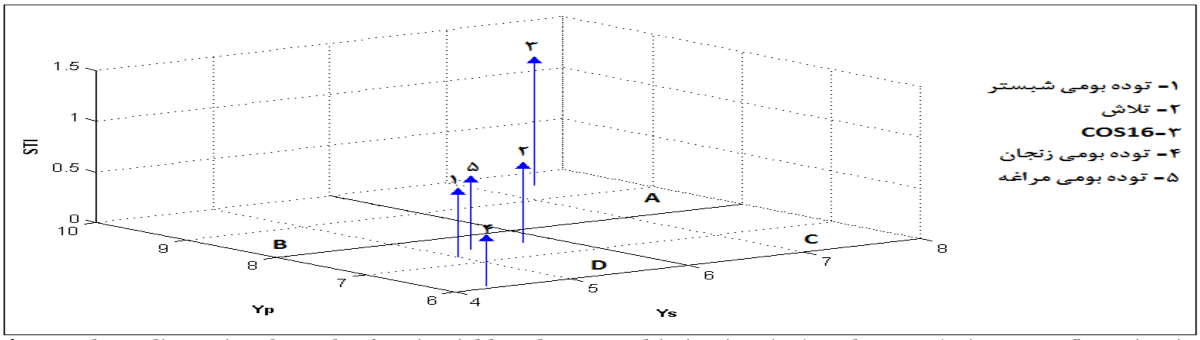

Fig. 2. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at 50% flowering in Maragheh based on STI index.

Distribution of evaluated cultivars in climatic conditions of Tabriz

In the climatic conditions of Tabriz with apply of stress at 4-5 leaves stage COS16 and Talash cultivars in group A, Shabestar landrace in group C and Zanjan and Maragheh landrace in Group D were placed. In group B did not place any cultivar (Fig. 4). With apply of Stress at 50% flowering and 50% pod-forming stages in these climate conditions COS16 and Talash varieties in Group A, Shabestar, Zanjan and Maragha landraces in Group D were placed and Group B and C did not include any cultivar (Fig. 5 and 6).

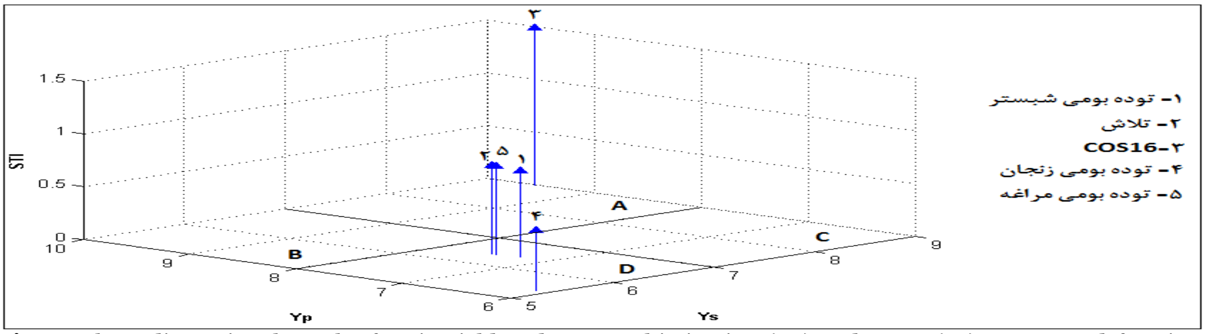

Fig. 3. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at 50% pod-forming in Maragheh based on STI index.

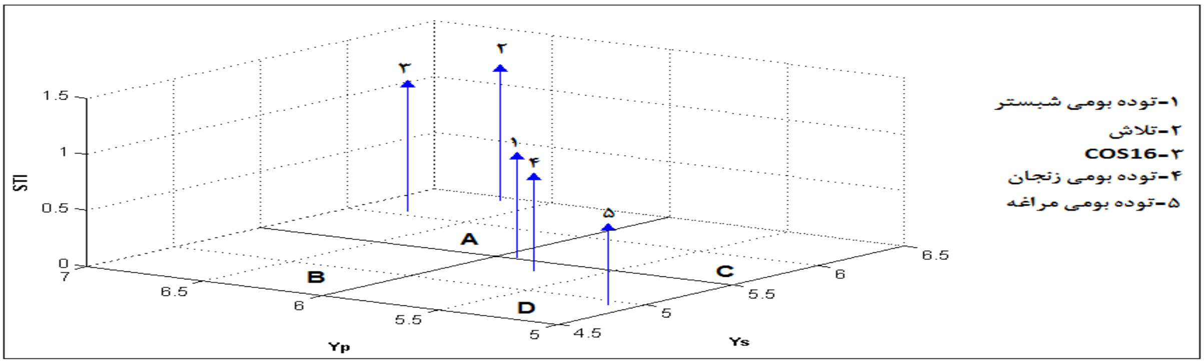

Fig. 4. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at the 4-5 leaves stage in Tabriz based on STI index.

In the results of Habibi (2011) on white bean, STI was introduced as the best index for selection of tolerant genotypes. Aminian *et al* (2007) with studying on common beans in drought conditions using Yp, Ys and STI (suitable index for selection of drought tolerant varieties) and drawing three-dimensional graph were classified the cultivars into four groups (A-D).

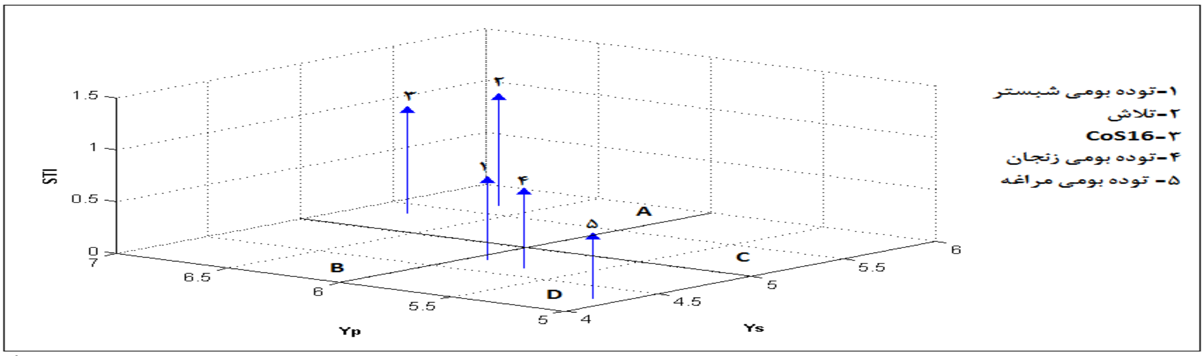

Fig. 5. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at 50% flowering in Tabriz based on STI index.

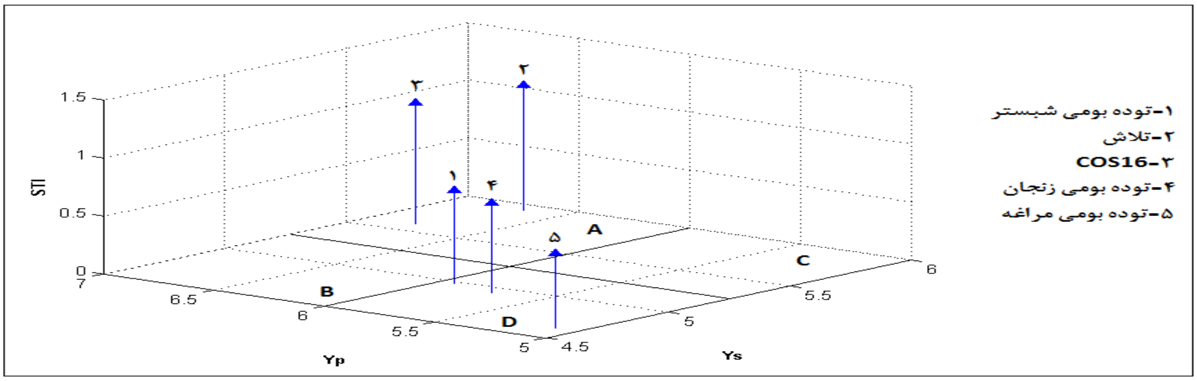

Fig. 6. Three dimensional graph of grain yield under normal irrigation (Yp) and stress (Ys) at 50% pod-forming in Tabriz based on STI index.

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