

## Study of Limit Irrigation on Yield of Lentil (*Lens culinaris*) Genotypes of National Plant Gene Bank of Iran by Drought Resistance Indices

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**Abstract:** In order to study of limit water stress effect on yield of 18 selected lentil genotypes, irrigation stop was applied in all plots after 50% flowering and then irrigation interrupted till harvest stage. This was conducted in two separate experiment (normal and stress) on base of randomized complete block design, in stress experiment irrigation interrupted after 50% flowering. With study of drought indices stress tolerance index (STI) and geometric mean productivity (GMP) had positive and significant correlation in %1 level with yield in drought and normal condition and on basis of both indexes Naeen and Shiraz7 genotypes showed the highest tolerance than other genotypes. Principal components analysis showed two components explained 82.94% variation.

**Key words:** Lentil • Water stress • Yield • Drought indices • Principal component

### INTRODUCTION

Drought is an important factor limiting crop production in arid and semi-arid conditions especially in Sistan because of water deficit in Hirmand river. Breeding for drought tolerance by selecting solely for grain yield is difficult, because the heritability of yield under drought conditions is low, due to small genotypic variance or to large genotype-environment interaction variances [1,2]. In Iran, lentil (*Lens culinaris* Med.) seed is an important source of protein in the human diet and its straw is a valued animal feed. Farmers usually sown the crop in late winter, from late December to early February. Lentil is a moderately drought resistant crop and is grown mainly for human consumption. Fisher and Maurer [3] noted that quantification of drought tolerance should be based on seed yield under limited moisture conditions even in the absence of an understanding of specific mechanisms of tolerance. Drought is an important factor limiting crop production in arid and semi-arid conditions [1,2] The genetic structure and phenotypic expression of a quantitative trait are highly influenced by environmental factors, thus one barrier for understanding the inheritance of a quantitative trait is genotype-environment interactions [4]. The relative yield performance of genotypes in drought stressed and more favorable environments seems to be a common starting point in the selection of genotypes for use in breeding for dry

environment [5]. Several drought stress indices or selection criteria, such as TOL = stress tolerance [6]; MP = mean productivity; GMP = geometric mean productivity [7]; SSI = stress susceptibility index [3]; STI = stress tolerance index [8], have been proposed as ways to identify genotypes with better stress tolerance. A larger value of TOL and SSI show relatively more sensitivity to stress, thus a smaller values of TOL and SSI are favored. Several authors noticed that selection based on these two indexes favors genotypes with low yield under non-stress conditions and high yield under stress conditions [9]. To reduce the disadvantage due to the significant correlation between SSI and yield under non-stress, Saulescu [10] suggested the use of deviations from the linear regression of SSI on yield in favorable conditions. Fernandez [8] claimed that selection based on STI and GMP would result in genotypes with higher stress tolerance and good yield potential. Our study is an attempt to compare the usefulness of several drought stress indices for identification of genotypes with better performance at different levels of water stress.

### MATERIALS AND METHODS

Eighteen field trials were conducted during 2006 at Agriculture Research Stations, Zahak-Zabol, in Sistan and Baluchistan Province, south east of Iran (483m above sea level, 30°54' N, 61°41' E) has 9.1mm with average of ten

years rainfall. experimental site have warm and dry summers. Eighteen lentil genotypes were chosen for study based on their reputed differences in yield performance under irrigated and non-irrigated conditions. Each plot consisted of four rows with two meter in length, row to row space 20 cm apart. A complete randomized block design with three replications was used. The irrigated plots were watered at planting, 50% flowering and grain filling stages. Non-irrigated plots received no water after 50% flowering. Grain yield were measured in each plot at crop maturity.

Six selection indices including stress susceptibility index (SSI, Fischer and Maurer) [3], stress tolerance index (STI, Fernandez) [8], tolerance (TOL, Hossain) [11], regression coefficient of cultivar yield on environmental index, mean productivity (MP, Hossain) [11], geometric mean productivity (GMP, Fernandez) [8] and were calculated based on grain yield under drought-stressed and irrigated conditions. Stress tolerance attributes were calculated by the following formula:  $SSI = [1 - (Y_s) / (Y_p)] / SI$ . SI is the stress intensity and calculated as:  $SI = [1 - (Y_s) / (Y_p)]$ ,  $STI = [(Y_p) \times (Y_s) / (Y_p)^2]$ ,  $GMP = \sqrt{(Y_p \times Y_s)}$ ,  $TOL = (Y_p - Y_s)$  and  $MP = (Y_p + Y_s) / 2$  and (b) is regression relation between STI and YS, where  $Y_s$  and  $Y_p$  are the yields of genotypes evaluated under stress and non-stress conditions and  $Y_s$  and  $Y_p$  are the mean yields over all genotypes evaluated under stress and non-stress conditions.

## RESULTS AND DISCUSSION

From the stress tolerance point of view (TOL) the lowest values were recorded in genotypes Shiraz 9 and Birjand (Table 1). Obviously, this index only pointed out the genotypes with the lowest yield in normal conditions. The highest average yield (MP) and geometric mean productivity yield (GMP) were recorded in genotypes Shiraz7 (MP = 485.1 gr/plot and GMP = 484. gr/plot), Naeen (MP = 465.2 gr/plot and GMP = 464.7 gr/plot) (Table 1). Based on GMP and STI values in this group, the cultivar Naeen and Shiraz7 could be considered relatively drought tolerant (Table 1). Both cultivars had yields over 2000 kg/ha under stress. An analysis of correlations between the various stress tolerance parameters used in this study provides interesting observations about the information reflected by each of them (Table 2).

Yields in the normal irrigation ( $Y_p$ ) were correlated with yields in the water stress ( $Y_s$ ) ( $r = 0.762^{**}$ ). Stress tolerance (TOL) was strongly correlated with yield in non-stress conditions and had less negatively correlated with yield under stress. Having in mind the fact that a small value of TOL is desirable, selection for this parameter would tend to favor low yielding genotypes. As expected, mean productivity (MP) have not correlated with the yield in stress and non stress conditions but Cengiz and ilhan [12] reported that the mean productivity was positively and significantly ( $p < 0.01$ ) correlated with

Table 1: Stress tolerance attributes in lentil genotypes, estimated from yields obtained in a normal and drought stress conditions

Genotype	STI	SSI	GMP	MP	TOL	YSgr/plot	YPgr/plot
Naeen	1.713	0.265	464.7	465.2	40.8	444.8	485.6
Zahedan1	1.37	1.64	415.7	444.4	314.2	287.3	601.5
Shiraz1	0.227	0.89	169.5	171.8	56.5	143.6	2001.1
Ferdows1	0.571	1.1	268.3	274.5	116	216.5	332.5
Ferdows2	0.455	1.14	239.5	245.7	109.3	191.1	300.4
Shiraz2	1.065	1.08	366.4	374.7	156.4	296.5	452.9
Shiraz3	0.255	0.768	179.5	181.35	50.3	156.2	206.5
Shiraz4	0.248	0.818	176.9	179	53.4	152.3	205.7
Shiraz5	0.131	1.56	377.5	400.1	264.6	267.8	532.4
Shiraz6	1.01	1.09	357.4	365.5	154.1	288.6	442.7
Shiraz7	1.86	0.324	484.3	485.1	52.6	458.8	511.4
Kashmar	0.237	2.06	173.1	198	192.1	101.9	294.1
Birjand	0.653	0.269	287	287.3	25.6	274.5	300.1
Taft	0.414	0.543	228.4	229.4	43.3	207.8	251.1
Shiraz8	0.557	1.48	265	278.6	171.8	192.7	364.5
Zahedan2	1.238	0.792	395	399.1	114.7	341.8	456.5
Shiraz9	0.391	0.239	221.7	221.9	17.5	213.2	230.7
Shiraz10	0.229	1.29	169.9	175.9	91.3	130.3	221.6

Table 2: Correlation between several stress tolerance parameters

	YP	YS	TOL	MP	GMP	SSI
YP	1					
YS	0.762**	1				
TOL	0.629**	-0.024	1			
MP	0.102	0.076	0.066	1		
GMP	0.927**	0.949**	0.291	0.098	1	
SSI	0.176	-0.468*	0.835**	0.048	-0.188	1
STI	0.904**	0.955**	0.249	0.063	0.991**	-0.221

\* and \*\* respectively significant at 5% and 1% levels

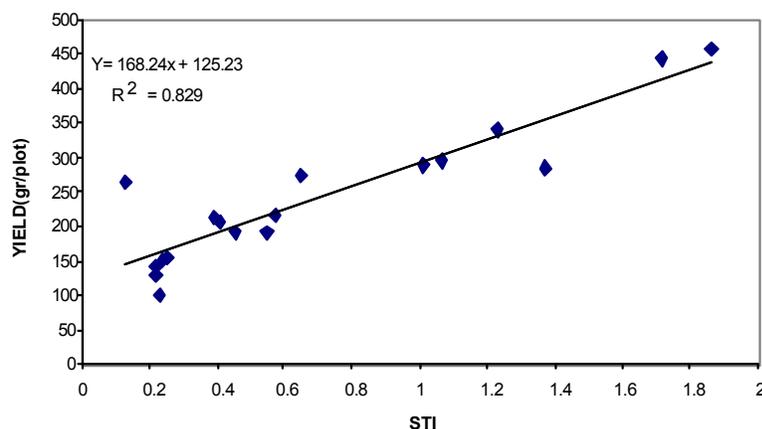


Fig. 1: The relationship between drought stress grain yield (gr/plot) and stress tolerance index (STI)

seed yield ( $r=0.885$ ) and tolerance to drought index (STI) ( $r=-0.426$ ) under drought stress and non-drought stress conditions for Chickpea, respectively. Geometric mean productivity (GMP) was strongly correlated with both Yp and Ys, if there was significant correlation between MP and GMP, GMP can be considered to reflect a little better the performance under stress than MP. The stress susceptibility index (SSI) introduced by Fisher and Maurer [3] was significant slightly negatively correlated with yield under stress and presented a lower positive correlation with yield in normal conditions. Having in mind the fact that a small value of SSI is desirable and on base of this index genotypes Naeen and Shiraz 9 had the least index among genotypes, selection for this parameter would also tend to favor low yielding genotypes, but to a much smaller extent than selection for TOL. The stress tolerance index (STI) introduced by Fernandez [8] was perfectly correlated with GMP and this was according to Khaghani [13] results about Faba bean. From which it is calculated and therefore we can consider that it contains the same information. Like GMP it is correlated with both Yp and Ys, the correlation with yield under stress being slightly better (0.90 vs. 0.95). From the farmer's point of view, the best genotypes should be top yielders both in normal and stress conditions. From the two-way

distribution of genotypes according to the yield in this study one can identify 2 cultivars, which produced over 2500 kg/ha. Therefore, from this point of view STI and GMP seem to be more useful, Fernandez [8] proposed STI index which discriminates genotypes with high yield and stress tolerance potentials. In this study, a general linear model regression of grain yield under drought stress on STI revealed a positive correlation between these criteria with yield in stress condition ( $R^2=0.82$ ) (Fig. 1).

Baker [14] introduced to the definition of stress tolerance and selection index. It was concluded that selection index in non-stress environments would be more effective than direct selection for productivity under stress whenever the correlation between the two types of environments exceeds the heritability of productivity under stress. There is the need to be incorporate drought tolerance mechanisms into germplasm with high yielding capacity to develop both high yielding and drought tolerant cultivars. SSI does not differentiate between potentially drought-tolerant genotypes and those that possessed low overall yield potential. Although low TOL has been used as a basis for selecting cultivars with resistance to water stress, the likelihood of selecting low yielding cultivars with a small yield differential can be anticipated [7]. Principal component analysis (PCA)

Table 3: Principal components and that coefficients for each indices and yield in stress and normal irrigation condition

Components	STI	SSI	GMP	MP	TOL	YS	YP	Cumulative %
PC1	0.93	-0.25	0.99	0.98	0.20	0.96	0.01	55.27
PC2	0.06	0.92	0.15	0.23	0.98	-0.15	0.04	27.66
								82.94

revealed that the first PCA explained 55.27% variation among variables (Table3) and have positive and high correlation with Ys, MP, GMP and STI. Thus, the first principal component can be named as the yield potential in drought stress condition. Second component have high and positive correlation with TOL and SSI Therefore can be named as a stress-tolerant dimension and it separates the stress-tolerant genotypes from non-stresstolerant ones. Thus, selection of genotypes that have high PCA1 and PCA2 are suitable for both stress and non-stress environments. Farshadfar and Sutka [15] obtained different results in first principal component analysis of drought tolerance and obtained similar results for second component. They suggested that PCA1 and PCA2 explained 66% and 34% of the variation respectively. But in first component Ys, MP, GMP and STI had high coefficients and second component had positive correlation with TOL and SSI indices.

### CONCLUSION

The findings of this study showed that the breeders should choose the indices on the basis of stress severity in the target environment; GMP and STI are suggested as useful indicators for lentil breeding and on basis of this indices genotypes Naeen and Shiraz7 introduced as tolerant genotypes.

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