International Meeting on Soil Fertility Land Management and Agroclimatology. Turkey, 2008. p: 757-763

Evaluation the Genetic Diversity of Advanced Lentil Genotypes under the Drought Stress and Non-Stress Conditions

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ABSTRACT

To evaluate genetic diversity of advanced lentil lines, screening quantitative indices of drought resistance, and identifying drought resistant lines, 11 varieties, one advanced lentil line and one selected genotype from Ardabil local mass in a randomized complete block design (RCBD) with 3 replications under both stress (rain-fed) and non-stress (irrigated) conditions in the Station of Agricultural and Natural Research of Ardabil. Based on yields obtained under irrigation (YP) and rain-fed (YS) conditions, several quantitative drought tolerance indices, like mean productivity (MP), tolerance index (TOL), geometric mean productivity (GMP), harmonic mean (HARM), stress susceptibility index (SSI) and stress tolerance index (STI) were used to evaluate the drought responses of these genotypes. Evaluation of quantitative indices of drought resistance and considering the means quantities and correlation coefficients between such indices, based on grain yield and under both rain-fed and irrigated conditions indicated that indices (MP), (HARM), (GMP) and (STI) are considered as the best indices of Lentil genotypes response with stress intensity of (SI = 0.29) under drought stress. In 3-D graph, it has been showed that with considering these indices and grain yield and under rain-fed and irrigated conditions, genotypes ILL 6031, ILL 9893 and ILL 8095 will be as the produced highest seed yields and drought resistant lines in group A. Multivariate Biplot graph indicated that genotypes ILL 6031, ILL 9893 and ILL 8095 were located next to the vectors of drought resistance indices, as: MP, HARM, GMP and STI. Distribution of the genotypes in the Biplot space indicated the presence of genetic diversity among the lines for drought stress. Diagrams obtained from cluster analysis based on above indices showed that the farthest genetic distance in related to drought resistant lines with highest seed yields (ILL 6031, ILL 9893 and ILL 8095) and drought susceptible lines and lowest seed yields (ILL 8173, ILL 9832, ILL 1878 and ILL 8146).

Key Words: Lentil (*Lens culinaris L.*), Seed yield, Drought sensitivity and tolerance indices, Biplot, Cluster analysis.

INTRODUCTION

From the initial agriculture activities, always drought has been an important factor, with reduction of performance has caused famine and fatality. Water shortage damage major agricultural products in most part of the world. (Yu and Stter, 2003). Iran, with a mean annual rainfall of 250 m.m., is considered an acid to semi-arid country (Soltani et al., 2001). The limited available water during growing season in some regions, such as Ardabil, reduces crop yield considerably (Soltani et al., 2001; Yu & Stter, 2003).

Lentil (*Lens culinaris L.*) contains large amounts of proteins, and has the ability to fix, symbiotically with certain bacteria, atmospheric nitrogen, and thus contribute greatly to soil fertility (Karim Mojein et al., 2003 and Anjam et al., 2005).

Lentil is a plant that can adapt itself to arid and semiarid climate (Karim Mojein et al, 2003). In Iran and most other countries of the world to assure their protein needs, use cereals such as pea, bean, vetch and lentil.Cultivating of these crops and gaining lines with maximum operation in shortage of water situation is an important problem in Iran to investigate about it (Soltani et al, 2001). So accessing genotypes which can tolerate drought, we can prevent reduction of crops significantly. In this regard selection of lentils that can tolerate drought by means of a suitable index which is able to distinguish these types of genotypes always has been a subject that breeders pay attention to it (Mostafaei, 1999).

Salehi et al., (2005) after studying resistance index said that, indexes such as "MP", "HARM", "GMP" and "STI" are the best indexes to screen lentil genotypes.

The goal of this project is evaluation of genetic diversity of lentil genotypes resistance to drought, in order to identify genotypes that can adapt themselves to both conditions of water tensity and without water tensity. This will be done by comparing some drought sensitivity and tolerance indexes to select high yielding and drought tolerant crops.

MATERIALS and METHODS

To study the response of as promising lentil lines, plus a native one as control, to drought an experiment was conducted at Ardabil Agriculture and Natural Resources Research Station in a Clay loam soil with a pH = 7.7 using a randomized complete block design with 3 replications under both drought stress (rain-fed) and non-stress (irrigated) conditions. Seed were planted in April, 13, 2005, in plots with 4 rows 4 meters long, spaced 25cm.

Evaluation of lentil genotypes was done on basis of dry farming (YS) and irrigation (YP), quantative indexes of drought tolerance such as mean of mean productivity (MP), tolerance index (TOL), geometric mean productivity (GMP), harmonic mean (HARM), stress susceptibility index (SSI) and stress tolerance index (STI).

1. Stress susceptibility index (SSI)(Fischer and Maurer, 1987):

$SSI = (1- (Ysi/Ypi))/SI$

Where:

Ysi =yield of genotype in stress condition.

Ypi = yield of genotype in normal condition.

SI = Stress Intensity

And SI= 1 – (Ys/Yp)

Where:

Ys = total yield mean in stress condition.

Yp = total yield mean in normal condition.

2. Tolerance index (TOL) (Rosielle and Hamblim, 1981):

TOL= Ypi – Ysi

3. Mean productivity (MP) (Rosielle and Hamblim, 1981):

MP= (Ypi – Ysi)/2

4. Geometric mean productivity (GMP) (Fernandez, 1992):

GMP= √Ypi – Ysi

5. Stress tolerance index (STI) (Fernandez, 1992):

STI= $(Ypi – Ysi)/Yp^2$

6. harmonic mean (HARM):

HARM = 2(Yp×YS)/Yp+Ys

Statistical calculations include combined analysis and calculation quantative index of drought sensitivity was done by MSTAT-C software and identification of simple correlation between above indexes, irrigation and dry farming were done using SPSS and Stat graphics softwares. Finally cluster analysis presented according to indexes and seed yield and UPGMA method and outcome was presented by a diagram.

RESULTS and DISCUSSION

Analysis of combined variance showed that there is significant difference between seed yielding and environment conditions (irrigated and rain-fed) that is about1% (Table 1). The intensity of tension in this test was 29 percent.

This issue shows that lentil crop will reduce by drought under condition of this test yield reduction was more than 29 percent.

Average values of grain yield and drought tolerance indexes (table 2) and simple correlation coefficients of indexes with irrigation and dry farm yield (table 3) showed that rating genotypes on basis of MP, HARM, GMP and STI indexes are equal, and grain yield on irrigation condition with index of SSI has a negative and significant correlation and with TOL index a positive and insignificant correlation, and on condition of dry farming showed a negative and significant correlation and with TOL a negative and insignificant correlation.

In 3 dimensional graph, referring to STI, GMP, MP and HARM indexes and grain yield in dry farming and irrigation condition, genotypes ILL 6031, ILL 9893 and ILL 8095 were identified as genotypes with high production and tolerant of intensed drought in group A (figure 1).

Actually these genotypes yielded the most in both irrigation and dry farming conditions.

had the highest grain yield in both of. Salehi et al., (2005) reach to the same output in study of resistance indexes against drought in lentil.

Multi variable Biplot showed that, genotypes ILL 6031, ILL 9893 and ILL 8095 are in adjacent refers related to, HARM, GMP, MP and STI indexes.

Lines distribution in Biplot spaces shows genetic diversity between researched lines in relation to drought.

cluster analysis of diagram on basis of GMP, MP, HARM and STI in figure 2 showed the most genetic differences between drought tolerant lines with high yield (ILL 6031, ILL 9893 and ILL 8095) and lines that are sensitive to drought and are low yield ILL 8173 ، ILL 9832, ILL 1878 and ILL 8146).

Using Biplot diagram and cluster analysis for selection of drought resistant items in lentil was assessed and confirmed by Salehi et al, (2005), Neiestani and Azimzadeh (2003), and Fernandz (1999) in bean and Farshadfar et al, (2001) in Chickpea.

In whole referring to outcome of indexes assessment MP, HARM, GMP and STI identified as the best indexes show interaction of lentil with intensity of tension in drought condition and genotypes ILL 8095, ILL 9893 and ILL 6031 as high yield and tolerant to drought and genotypes sensitive to drought.

Table 1. Combined variance analysis of grain yield of lentil genotypes in two irrigation and dry farming environment.

Source	df	Sum of Square	Mean Square	F
Location	1	1175760.056	1175760.056	8.0160*
Error 1	4	586706.373	146676.593	
Factor A	11	3562455.195	323859.563	18.1400**
L * A	11	117002.358	10636.578	0.5958^{ns}
Error 2	44	785548.856	17853.383	
Total	71	6227472.838		
Cv %			18.04	

ns, * & ** : not significant, significant at the 5% & 1% levels of probability, respectively

Table 2. Average values of grain yield and drought tolerance and sensitivity indices in lentil genotypes.

genotypes No.	genotypes	Ysi (kg/ha)	Ypi (kg/ha)	SSI	TOL	MP	GMP	HARM	STI
1	**ILL 8173**	362.20	586.63	1.31	224.43	474.41	460.95	447.87	0.28
2	**ILL 9919**	655.53	727.73	0.34	72.20	691.63	690.69	689.74	0.63
3	**ILL 9832**	291.10	622.20	1.83	331.10	465.65	425.58	396.63	0.24
4	**ILL 323**	639.96	969.96	1/17	330.00	804.96	787.87	771.14	0.82
5	**ILL 1878**	275.52	588.86	1.83	313.34	432.19	402.79	375.40	0.21
6	**ILL 8146**	357.63	595.53	1.38	237/90	476.58	461.50	446.89	0.28
7	**ILL 6031**	842.20	1101.80	0.79	259.60	972.00	963.29	954.66	1.23
8	**ILL 7677**	617.73	918.33	1.14	300.60	768.03	753.18	738.62	0.75
9	**ILL 9893**	895.50	1131.66	0.72	236.16	1013.58	1006.68	999.82	1.34
10	**ILL 8095**	928.86	1220.30	0.83	291.44	1074.58	1064.65	1054.81	1.50
11	**ILL 8105**	666.60	1011.06	1.17	344.46	838.83	820.96	803.47	0.89
12	**Native genotype**	822.20	947.73	0.45	125.53	884.96	882.74	880.51	1.03

(Stress Intensity = 0.29%)

Table 3. Correlation factors among indices drought tolerance and sensitivity with grain yield under rain-fed and irrigated conditions

	YP	YS	SSI	TOL	MP	GMP	STI	HARM
YP	1							
YS	0.933^{**}	1						
SSI	-0.581^{*}	-0.825^{**}	1					
TOL	0.117^{ns}	-0.239^{ns}	0.722^{**}	1				
MP	0.984^{**}	0.983^{**}	-0.715^{**}	-0.064^{ns}	1			
GMP	0.978^{**}	0.988^{**}	-0.735^{**}	-0.093^{ns}	1.000^{**}	1		
STI	0.977^{**}	0.975^{**}	-0.692^{*}	-0.062^{ns}	0.993^{**}	0.993^{**}	1	
HARM	0.972^{**}	0.992^{**}	-0.753^{**}	-0.119^{ns}	0.998^{**}	1.000^{**}	0.991^{**}	1

ns, * & ** : not significant, significant at the 5% & 1% levels of probability, respectively

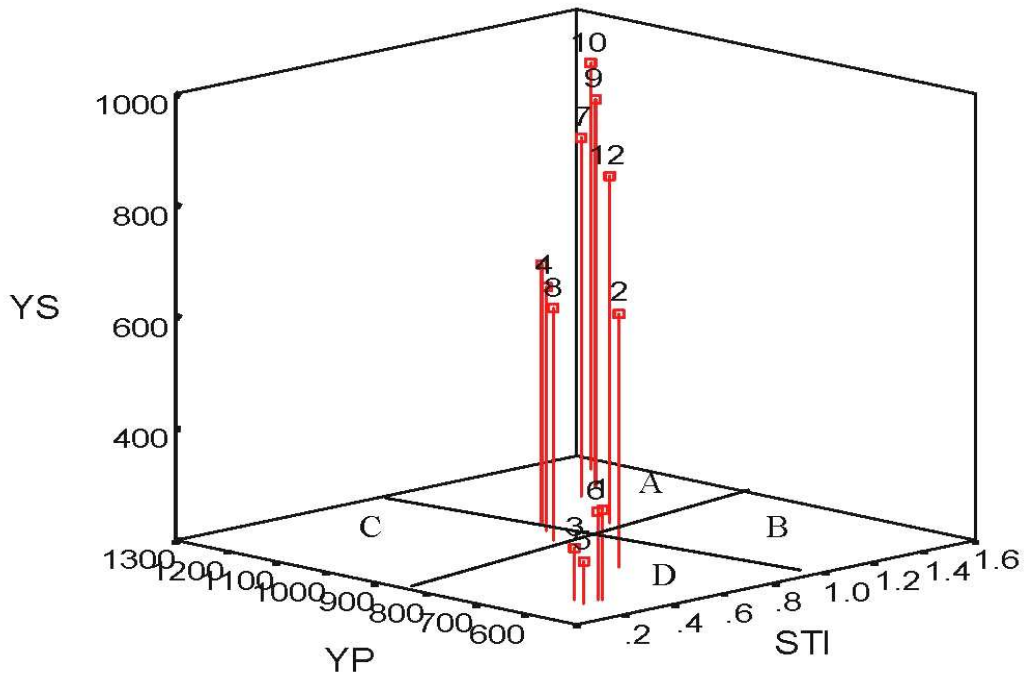

Figure 1. 3-D diagram for specifying the drought tolerance genotypes based on YP, YS and STI index.

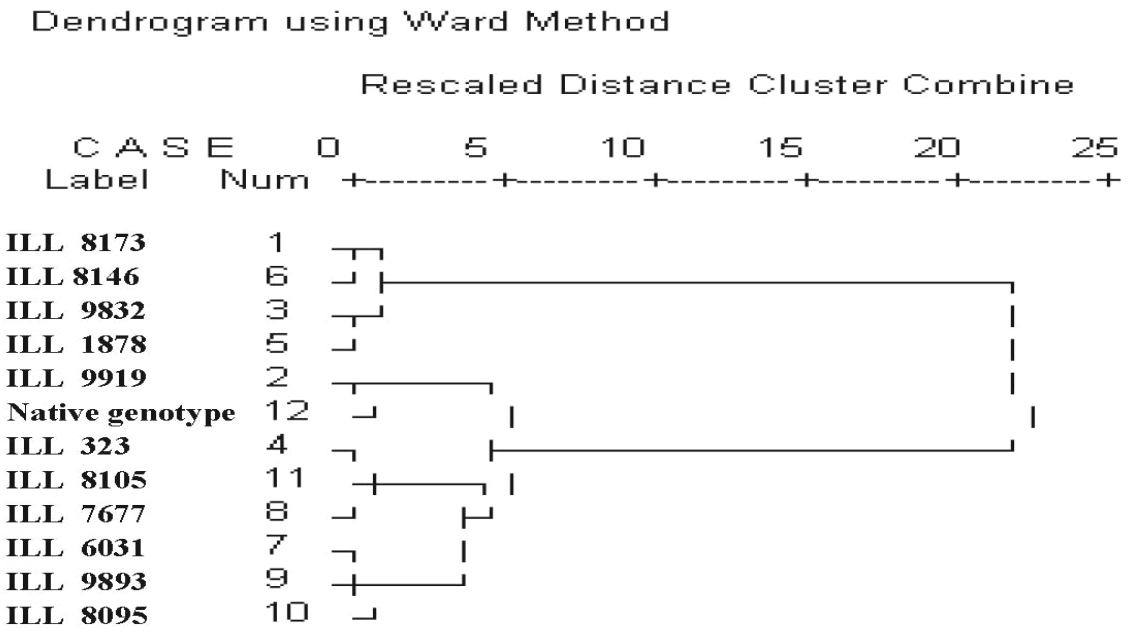

Figure 2. Grouping of 12 lentil genotypes based on MP, HARM, GMP and STI indices.

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