Middle-East Journal of Scientific Research 8 (5): 880-884, 2011
ISSN 1990-9233

Evaluation of Drought Tolerance Indices and Grain Yield in Wheat Genotypes Using Principal Components Analysis

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Abstract: Production and release of high yielding and drought tolerant varieties along with advance agronomic practices are effective ways to manage drought and water deficit in agriculture. In order to study the response of different wheat (T. aestivum L.) genotypes to terminal drought stress, this experiment was conducted in the Agriculture and Natural Research center, Ardabil in 2009/2010 cropping season. Ten promising wheat genotypes were evaluated in two separate experiments, (stress and non stress). A randomized complete block design with three replications was used.For identifying tolerant genotypes the indices of GMP, MP, STI, HARM,SSI, TOL, YI and YSI were used. The First and second components 99.65% of variations the justifiy. Based on the coefficients of components the first and second components were considering tolerance and sensitivity respectively. Using the biplot analysis genotypes C-86-4,C-86-5,Shahryar and 5509 were identified as tolerant and C-85-4 and C-85-7 were detected as sensitive to drought.

Key words: Wheat · Tolerance indices · Principal components · Terminal Drought stress

INTRODUCTION

Wheat in dry areas and Semi-dry to dry conditions The common occurrence drought stress during germination and Green and the terminal drought stress [1].

Drought stress is one of the most important abiotic stressesStages that can influence plant growth and development[11]. In such areas the genotypes as well as drought tolerance at germination and emergence, also have high yield is important [2].

Iran has limited water resource in a way that the average rainfall of 250 mm, a third of the world's average rainfall [3].

Economic important wheat are required to Any solution for optimization for the system.

Be evaluated and used in its production.Seems to produce and introduce high product variety and Early terminal drought stress resistant varieties the Crops of effective solutions that In integration with other methods of water management can Reduce the impact of these factors [4-6].

Yield and stability in regions where there are several environmental stress.

Always as an important criterion in the selection and Identified genotype is used [5].

Evaluation indicators, stress tolerance Multiple have suggests and used [4, 611]. Indicators were used to assess stress tolerance and multiple suggest.

The strengths and weaknesses of each of these items has been evaluation by many researchers [8, 12]. For identification of genotypes resistant to drought: Stress Susceptibility Index (SSI) Fischer and Maurer [13], Stress Tolerance Index(STI) Fernández [7], Mean Productivity(MP) Rosielle and Hamblin [14], Geometric Mean Productivity(GMP) Fernández [7], Harmonic Mean(HM) Fernández [7], Stress Tolerance (TOL) Rosielle and Hamblin [14], Yield Stability Index (YSI). Bouslama and Schapaugh [15], Yield index(YI) Gavuzzi *et al*. [16] used. Azizinia *et al*., [17] Forty wheat genotypes were evaluated in terms of drought tolerance Fernandez and the use of indicators and analysis of the main components of resistant and susceptible varieties were detect.

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Table 1: Names of under-study genotypes in this experiment

Number	Genotype	Number	Genotype
1	Shahryar	6	C-85-7
2	C-80-4	7	C-86-4
3	5509	8	C-86-5
4	C-85-3	9	S-4
5	C-85-4	10	S-10

MATERIALS AND METHODS

Ten promising wheat genotypes(Table 1) during two separate field experiments In two randomized complete block design with three replications Ardabil Agricultural Research Station.

Located at 12 km road to Ardabil –khalkhal (Latitude and longitude location of the experiment, respectively, 48 and 20 degrees north and 1350 m altitude of sea) Crop year in 2009-2010, Cultivation were. Plots size 7.2 m was considered. Seeding density on grain weight, based on 450 seeds per square meter were considered.

Irrigation of a non-stress condition, based on plant needs and regional common And stress, irrigation was stopped from the stage of pollination.

After physiological maturity and harvest, grain yield of genotypes in the two condition (stress and non stress) weighing And to evaluate the drought tolerance of the following indices were used.

Drought tolerance indices

Index	Formula	Reference
Stress Tolerance Index	STI = [(GYi) × (GYp) / (G $\bar{Y}$ i)2]	[7]
Mean Productivity	MP = (GYi + GYp) / 2	[14]
Geometric Mean Productivity	GMP = $[(GYi) \times (GYp)]^{0.5}$	[7]
Harmonic Mean	HM=(2× GYp× GYi) /(GYi+GYp)	[7]
Stress Tolerance	TOL = (GYi - GYp)	[14]
Stress Susceptibility Index	SSI = [1 - (GYp) / (GYi)] / SI	[13]
(Stress Intensity)	SI = [1 - (G $\bar{Y}$ p) / (G $\bar{Y}$ i)]	
Yield Stability Index	YSI = GYp / GYi	[15]
Yield index	YI = Ysi / Ys	[16]

For data Analysis, software MSTAT-C, SPSS19, EXCEL, MINITAB 16 was used

RESULTS AND DISCUSSION

The combined analysis results (Table 2) the effect of irrigation on Grain yield and harvest index at the 5% level and For grain weight and days to physiological maturity in 1% level was significant. Terms traits among genotypes for days to physiological maturity And harvest index and grain yield at the 1% level There is a significant difference at 5% level, indicating There is genetic variation for these traits.

Results compared using Duncan's multiple range test (Table 3) showed that genotypes with a yield of C-86-5 and C-86-4 respectively 4.38 and 4.22 tons per hectare and the earliest and high yield and Genotype and S-10 late maturity and the lowest yield was 2.51 tons per ectare.,The genotypes C-86-4 and S-10,Harvest index had the highest and lowest, respectively.

The results of the correlation between grain yield and drought tolerance indices (table 4) can be measure for to select the best genotypes and indices used.yield in non-stress conditions with indicators MP (r = 0 / 946 **), GMP (r = 0 / 911 **), STI (r = 0 / 896 **), HM (r = 0 / 872 **), YI (r = 0 / 705 *), TOL (r = 0 / 662 *) showed significant positive correlation. The results with the findings of Mohammadi et al [17], Gol-Abadi et al [13] and Mollasadeghi and *et al*. [18] conforms.They showed compared yield on most tests,Correlation between the MP,Yp,YS is positive.

Yield indicators of stress MP (r = 0 / 899 **), GMP (r = 0 / 936 **), STI (r = 0 / 941 **), HM (r = 0 / 963 **), YI (r = 1 / 000 **),Showed significant positive correlation But with the index TOL (r = -0/060) and SSI (r = -0/469) But non-significant negative correlation with the findings showed that sio-se mardeh and *et al*. [20], Ahari D'S [21], choukan *et al*. [22] and Mollasadeghi and *et al*. [19] conforms. Table (4) shows that the yield grain with indices MP, GMP, STI, YI and HM ompared with TOL and SSI indices of the correlation is highly'. The indices MP, GMP, STI, YI and HM indices to identify genotypes with high yield is higher than in TOL and SSI.

Table 2: Analysis of Variance Combined For Traits in Stress and non Stress

		Mean of Square			
S.O.V	df	Days to maturity	1000 seed weight (gr)	HI	Grain yield (ton/ha)
Condition	1	410.817**	1852.593**	472.138*	26.321*
Error	4	1.167	38.001	51.313	2.312
Genotype* Condition	9	3.935**	34.405	144.406**	2.552*
Genotype	9	2.483**	12.141	12.690	0.487
Error	36	0.815	24.588	21.069	0.942
C.V%	-	0.39	16.17	12.93	28.58

* and ** Significantly at $p < 0.05$ and < 0.01, respectively.

Table 3: Rating and comparison of yield means in stress and non-stress

Genotype	Days to maturity	HI	Grain yield (ton/ha)
shahryar	231.5 cd	34.36 bc	3.70 abc
C-80-4	231.7 bc	34.07 bc	2.87 bc
5509	232.5 abc	39.37 ab	3.28 abc
C-85-3	232.2 abc	36.15 bc	2.77 bc
C-85-4	231.3 cd	37.17 ab	3.92 ab
C-85-7	232.5 abc	34.67 bc	3.48 abc
C-86-4	230.8 d	42.86 a	4.22 a
C-86-5	230.8 d	40.17 ab	4.38 a
S-4	232.8 ab	30.40 cd	2.80 bc
S-10	233.2 a	25.89 d	2.51 c

Table 4. Correlation coefficients between GYi, GYp and stress tolerance indices

	YP	YS	MP	GMP	STI	TOL	SSI	HM	YSI	YI
YP	1	0.709*	0.946**	0.911**	0.896**	0.662*	0.279	0.872**	-0.278	0.705*
YS	0.709*	1	0.899**	0.936**	0.941**	-0.060	-0.469	0.963**	0.470	1.000**

* and ** Significantly at $p < 0.05$ and < 0.01, respectively.

Table 5: Estimation of stress tolerance indices from the YP and YS for10 promising wheat genotypes

Genotypes	YP (t.he^{-1})	YS (t.he^{-1})	MP	R	GMP	R	STI	R	TOL	R	SSI	R	HM	R	YSI	R	YI	R
Shahryar	4.37	3.03	3.70	(4)	3.64	(4)	0.81	(4)	1.34	(7)	0.94	(6)	3.58	(3)	0.69	(5)	1.11	(5)
C-80-4	3.44	2.31	12.88	(7)	2.82	(7)	0.51	(7)	1.13	(4)	1.00	(7)	2.76	(7)	0.67	(6)	0.85	(8)
5509	13.57	2.99	3.28	(6)	3.27	(6)	0.69	(6)	0.58	(1)	0.49	(1)	3.25	(5)	0.84	(1)	1.10	(4)
C-85-3	3.52	2.03	2.78	(9)	2.67	(9)	0.46	(9)	1.49	(8)	1.28	(8)	2.57	(9)	0.58	(7)	0.74	(10)
C-85-4	5.18	2.67	3.93	(3)	3.72	(3)	0.89	(3)	2.51	(10)	1.47	(10)	3.52	(4)	0.52	(9)	0.98	(5)
C-85-7	4.48	2.49	3.46	(5)	3.34	(5)	0.72	(5)	1.99	(9)	1.35	(9)	3.20	(6)	0.56	(8)	0.91	(6)
C-86-4	4.88	3.56	4.22	(2)	4.17	(2)	1.12	(2)	1.32	(6)	0.82	(3)	4.12	(2)	0.73	(3)	1.30	(2)
C-86-5	4.95	3.81	4.38	(1)	4.34	(1)	1.21	(1)	1.14	(5)	0.70	(2)	4.31	(1)	0.77	(2)	1.40	(1)
S-4	3.27	2.34	2.81	(8)	2.77	(8)	0.49	(8)	0.93	(3)	0.86	(5)	2.73	(8)	0.72	(4)	0.86	(7)
S-10	2.92	2.10	2.51	(10)	2.48	(10)	0.49	(10)	0.82	(2)	0.85	(4)	2.44	(10)	0.72	(5)	0.77	(9)
Meane	4.05	2.73	3.40		3.32		0.73		1.33		0.98		3.25		0.68		1.00	

Table 6: Results of principal component analysis for Yp, Ys and drought tolerance indices on 10 promising wheat genotypes

Traits	Component 1	Component 2
YP	0.899	0.435
YS	0.946	-0.323
MP	0.992	0.121
GMP	0.999	0.029
STI	0.996	0.005
TOL	0.267	0.959
SSI	-0.162	0.985
HM	0.998	-0.057
YSI	0.163	-0.984
YI	0.944	-0.329
Eigenvalue	6.690	3.277
%of variance	66.904	32.770
Cumulative%	66.904	99.675

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

Khalil Zadeh and Karbalayi Khiavi [23] and Farshadfar *et al*. [24] Believe that most suitable indices for selection of drought tolerant cultivars, Is an indicator which has a relatively high correlation with grain yield in both conditions is stressed.Therefore the correlation between indices of stress tolerance and Yield in both conditions, without stress, identify the most suitable indicators is possible.

The numerical values of the indicators HM, YI, GMP, MP, STI (Table 5) Genotypes C-86-4 and C-86-5 as genotypes with high yield in both stress and non stress and Tolerant stress, were identified And genotype C-85-3 and S-10 has the lowest indices values for the HM, GMP, MP, STI who have low yield in terms of Yield in both conditions. Genotypes 5509 and C-86-5, respectively, with sensitivity to stress of 0/49 and 0/70 as the drought

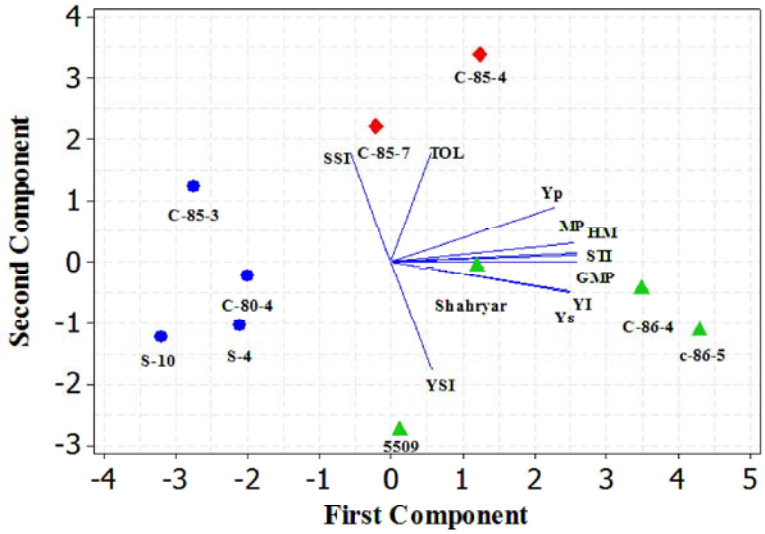

Fig. 1: Drawing bi-plot based on first and second components for 10 promising wheat genotypes

tolerant genotypes and Genotypes C-85-4 and C-85 - 7 respectively, Susceptibility indicator of stress 1/47 and 1/35 as susceptible genotypes Drought were identified.

The tolerance indices (TOL) and low value, Relative tolerance to Water deficit stress is shown.

Considering the Table (5) Genotypes 5509 and S-10, respectively, with tolerance of 0.58 and 0.82 were identified as tolerant genotypes. The genotypes of the YSI 5509 and C -86-5 ranked higher than other genotypes were And genotype C-85-3 and C-85-4 was allocated to the lowest level of Yield stability Index (YSI), Indicating the high sensitivity of these genotypes is attributed to stress.

Principal component Analysis: Principal components analysis for relationship between genotype and resistance to drought, the performed(Table 6).The results of this analysis showed that the first and second components of the total 99.65 percent of all data variations are included. Because most of the variance explained by these two components, bi-plot charting (Figure 1) according to first and second components.

The first component has high positive coefficients for Indicators GMP, HM, STI, MP, Ys, YI and the YP With regard to the desirability of high levels of these indicators. If the first component is high, Genotypes that are selected with high yield in both conditions and In particular, they stress condition Thus the first component as a component of stability and tolerance to drought stress will be named.This component explained 66.99% of the variation of the data.

The second component of the positive coefficients for SSI and Tol and negative coefficient for the YSI This component can be used as components Sensitivity to stress was name.

That genotypes with low yield stress of the other genotypes Are separated. This component explained 32.77% of the variation of the data.So if second component is low, genotypes that are selected high Indicators(GMP, HM, STI, MP, YI and Yield stress) and low values of SSI and TOL.

Bi-plot diagram showing the high the first component and the second component is lower for genotypes C-86-4,C-86-5,Shahryar and 5509.

The bi-plot diagram indices GMP, HM, STI, MP and YI To more suitable indices and genotype C-86-4,C-86-5,Shahryar and 5509. the genotypes with stability yield and tolerant to drought stress were identified.

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