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Research Article

Assessment of wheat genotypes for yield potential and stress adaptation

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Abstract

Post-anthesis drought stress is the most important factor affecting wheat production adversely in dry-land area. In order to evaluate drought tolerance in bread wheat varieties, an experiment was conducted with 125 promising genotypes in randomized block design with two replications each in no-stress and stress environments. Post-anthesis stress was created after 14 days after anthesis. Different drought tolerance indices viz., stress susceptibility index, relative drought index, mean productivity, stress tolerance index, geometric mean productivity, yield index, yield stability index, drought resistance index were evaluated based on grain yield under stress and non-stress conditions. Thirty-one varieties recorded significantly higher grain yield under stress environments along with significant favourable most of the drought indices viz., SSI, RDI, MP, STI, YI, YSI and DRI. Only 2 genotypes, 31ESWYT-147 and C-306 produced significantly high grain yield in both stress and non-stress conditions. Further, 31ESWYT-147 also showed significant favourable values of all drought tolerance indices except GMP, whereas, C-306 showed significant favorable values only for MP, STI, YI and DRI, respectively. STI and MP showed mostly positive and meaningful genotypic and phenotypic correlation with yield in both stress and non-stress environments and with other drought tolerance indices. Thus application of both indices could be appropriate while screening the varieties for drought tolerance. However, according to both STI and MP indices, promising genotypes varied differentially for drought tolerance. MP index leads the selection towards more efficient genotypes in both stress and non-stress environment. Thus screening for drought tolerances could be made either one or both of these two indices would be more effective in bread wheat. Drought indices had low heritability and genetic gain which were comparable to yield in stress but higher than yield in non-stress condition. Hence the improvement for yield potential under drought could be achieved through direct selection in stress or screening through STI and MP indices.

Keywords: Bread wheat, drought stress indices, screening techniques, post anthesis drought

1. Introduction

Drought is worldwide a major constraint of crop production. Crop breeding for drought tolerance has long been part of the breeding process in most of crops that have been or are being grown under dry condition. Drought tolerance improvement has become a breeder's major aim in dry areas. Nevertheless, drought tolerance is a complex trait results from the contributing of numerous factors. Wheat is one of the cereal crop, which are cultivated in large scale in semi-arid areas. Considering the low heritability of drought tolerance and lack of efficient selection strategies, improvement for drought tolerant cultivars is difficult (Kirigiwi *et al.,* 2004). Drought exacerbate the effects of the other stresses to which plants are submitted (abiotic or biotic)and several different abiotic stresses results in water stress (like salt and cold stress).Drought indices which provide a measure of drought based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought tolerant genotypes (Mitra, 2001). These indices are either based on drought resistance or susceptibility of genotypes (Fernandez, 1992).Achieving a genetic increase in yield under stress environment has been recognized to be difficult challenge for plant breeders while progress in grain yield has been much higher in favourable environments. Grain filling stress or terminal drought (end season or post anthesis) is the most common drought stress in many semi-arid areas of wheat. Thus present study was undertaken to assess varieties for different drought tolerance indices and to identify most suitable selection criteria for improvement of high grain yield potential of bread wheat for a frequent post- anthesis stress condition.

2. Materials and methods

The experimental material consisted of 125 promising genotypes of wheat (*Triticum aestivum* L.). The 60 entries were selected from National Genetic Stock Nursery (NGSN), 60 from Elite International Germplasm Nursery (EIGN) and 5 promising genotypes including checks (MP 4010, RVW 4106, GW 190, HS 507 and HD 2932). Experiments was sown in first week of November, 2012 in randomized complete block design with 2 replications each in induced stress condition (post anthesis drought) and in non-stress condition (Normal irrigated condition). Precipitation 49.80 mm was received on 1st March, 2013 i.e. at heading stage. The single seed was dibbled per hill with spacing of 20 cm apart and 4-6 cm within row. Gross as well as net plot area was 0.20 m x 1 m. The border row was sown both side of the block to eliminate border effect. The recommended package of practices were adopted for optimum crop growth. The soil is sandy loam, low in available nitrogen, medium in phosphorus and high in potash with pH of 8.5.

Post anthesis drought was induced by desiccation treatment, which was applied by spraying the whole plant canopy to full wetting with an aqueous solution of potassium iodide (KI, 0.5 % w/v) in two replications after 14 days after anthesis (Post anthesis crop stage),while the another two replications were kept untreated and fully irrigated as per recommended schedule of irrigation. Stress plots received 3 irrigations up to pre anthesis stage as per fully irrigated package of six irrigations**.** Non-stress plot irrigated three times after anthesis, while stressed plots received no irrigation. Observations were recorded on 5 randomly selected plants for grain yield in non-stress (*YNS*) and grain yield in stress (*YS*) under non-tress and induced stress plot of each genotypes and drought resistance indices were calculated using different relationships (Ezatollah *et al.*, 2012).The data were analyzed for drought indices viz., stress susceptibility index (SSI), relative drought index (RDI), mean productivity (MP), stress tolerance index (STI), geometric mean productivity (GMP), yield index (YI),yield stability index (YSI) and drought resistance index (DRI) as proposed by various authors as under

Parameters	Equations	Authors
Stress susceptibility index	$1-(Ys/Yp)/-(\bar{Y}s/\bar{Y}p)$*	Fischer RA, Maurer R, (1978)
Relative drought index	$(Ys/Yp)/(\bar{Y}s/\bar{Y}p)$	Fischer *et al.* (1979)
Mean productivity	$(Ys + Yp)/2$	Rosielle and Hamblin, (1981)
Stress tolerance index	$(Ys \times Yp)/ \bar{Y}p^2$	Fernandez,(1992)
Geometric mean productivity	$\sqrt{(Ys)} \times (Yp)$	Fernandez GCJ, (1992)
Yield index	$Ys / \bar{Y}s$	Gavuzzi *et al.*, (1997)
Yield stability index	Ys / Yp	Bouslama and Schapaugh, (1984)
Drought resistance index	$Ys \times (Ys / Yp)/ \bar{Y}s$	Lan, (1998)

**Yp and Ys: Potential yield and stress yield, respectively*

Analysis of variance, phenotypic and genotypic coefficient of variations, correlation coefficients were worked out for yield under non-stress and stress environments and all drought indices (Bozokalfa Kadri *et al.*, 2010 and Searle, 1961).

3. Results and discussion

*3.1 Assessments of genotypes for grain yield under stress and non- stress Environments***:** The 125 promising genotypes of wheat were evaluated for drought tolerance indices under normal and drought environments. A field experiment revealed that genotypes were significantly differed for grain yield in both non-stress as well as in stress conditions. Stress-environment decreased grain yield by 41.82 % as compared to non-stress environment. Varieties were also significantly differed for all drought tolerance indices. These results indicated high diversity among the genotypes that may enable breeder to select genotypes under stress as well as non-stress environments for grain yield potential and drought tolerance mechanism (Table 1). Several researchers also reported the similar results for grain yield under stress and non-stress conditions and for most of the drought tolerance indices Shahryari and Mollasadeghi 2011; and Ahmadizadeh *et al*., 2012).

Out of 125 genotypes tested for grain yield, only eighteen common genotypes were significantly superior for grain yield over other varieties under both stress and non- stress condition (Table 2 & 3). Out of these, PHS-1103(30.60 g/plant) followed by 10HLWSN-5050(29.70 g/plant), A-9-30-1(29.40g/plant), PHS-1107(29.00 g/plant) and 21HRWSN-2056(28.90 g/plant) produced significantly higher grain yield. Although reduced grain yield under stress condition, 95 varieties recorded significantly higher grain yield, thereby, suggesting large number of promising genotypes for drought tolerance condition. Among these, VW-0770 (12.75 g/plant) followed by PBW-621(12.70 g/plant), HD-2864(12.50 g/plant), 31ESWYT-147(12.40 g/plant) and HS-523(12.40 g/plant) produced significantly higher grain yield under non-stress condition. GW-190 and HS-507 recorded significantly poor yields of 21.05 and 20.85 g/plant in non-stress condition and 7.90 and 7.85 g/plant in stress condition, respectively. 31st ESWYT 147,C 306, NW 3087, HD 3012 and 18th SAWYT 311 produced significantly high grain yield compared to other genotype in both stress and non-stress conditions, thereby, suggesting their potential under both stress and non-stress conditions and thus may be expected better drought indices with high yield potential.

3.2 Evaluation of genotypes for drought tolerance indices: Drought indices which provide a measure of drought tolerance based on yield loss under drought conditions in comparison to normal conditions have been used for screening drought tolerant genotypes (Mitra, 2001). Drought tolerance can only be evaluated, if drought stress causes significant reduction in yield (Blum, 1993). Several drought resistance indices have been suggested on the basis of a mathematical relationship between favourable and stress conditions (Ahmadizadeh *et al.* 2011). These indices are either based on drought resistance or susceptibility of genotypes (Fernandez, 1992). The identification of drought tolerant genotypes based on single criterion reported contradictory. In the present investigation, genotypes showed significantly reduced grain yield in post-anthesis drought made by spraying an aqueous solution of potassium iodide (KI, 0.5 % w/v).

The stress susceptibility index (SSI) is designed on mean yield of plants under non-stress and stress conditions. A low magnitude of SSI is due to low change of plant yield in stress condition in comparison to non-stress condition which results in more drought tolerance of the plant (Fischer and Maurer, 1978). Fifty one genotypes recorded significantly low stress susceptibility index (SSI) as compared to other genotypes suggesting more post-anthesis drought tolerances mechanism in these genotypes.

Table 1. Analysis of variance for drought tolence indices assessed from non-stress and stress environments in bread wheat

Source of variation	D.F	Grain yield under non- stress environment (GYNS)	Grain yield under stress environment (GYS)	Stress susceptibility index (SSI)	Relative drought index (RDI)	Mean productivity (MP)	Stress tolerance index (STI)	Geometric mean productivity (GMP)	Yield index (YI)	Yield stability index (YSI)	Drought resistance index (DRI)
Replications	1	342.6697**	926.6758**	2.5548**	4.9641**	528.6890**	2.5793**	4.4322**	9.4549**	0.8662**	4.8274**
Varieties	124	10.4871*	5.5820*	0.0451**	0.0876**	3.8723*	0.0121*	0.0860*	0.0570*	0.0153**	0.0430**
Error	124	7.6625	3.9611	0.0275	0.0535	2.7905	0.0089	0.0639	0.0404	0.0093	0.0265

***and *significant at 5 % and 1 % probability levels, respectively.*

Table 2. Common promising genotypes for grain yield under non- stress and stress environments in bread wheat

Variety	Grain yield (NS) (g)	Grain yield (S) (g)	Variety	Grain yield (NS) (g)	Grain yield (S) (g)
PHS-1103	30.60	10.00	43 IBWSH 1157	26.10	9.25
10 HLWSN 5050	29.70	10.00	31ESWYT-147	25.95	12.40
A-9-30-1	29.40	10.75	C-306	25.70	11.15
PHS-1107	29.00	9.25	UAS 419	25.65	10.20
21 HRWSN 2056	28.90	10.75	GW-322	25.50	10.35
PHS-1106	28.30	9.25	21HRWSN-2054	25.50	10.70
43 IBWSH 1043	27.30	9.25	MACS-5009	25.35	10.50
WH-1021	26.90	10.50	GW190 (Check)	21.05	7.90
18 SAWYT 311	26.70	10.75	HS 507(Check)	20.85	7.85
NW 3087	26.40	10.90	CD 5%	5.42	3.90

PBW 621(0.62) followed by RS 945(0.63), HD 2864(0.67), PHS 1104 (0.70) and PHS 1101(0.72) showed significantly lowest value of SSI. Assessments of relative drought index (RDI) revealed that 52 genotypes showed significantly high estimates, thereby, signifying these are promising stress tolerance genotypes. Genotypes RS 945(1.52) followed by PBW 621(1.51), HD 2864(1.46), VW 0770(1.40) and GW 173(1.39) noted significantly highest RDI value.

Mean productivity (MP) is defined as average yield of genotype under drought stress and non-stress environments and high mean productivity designated more tolerance to stress. There are 59 genotypes recorded significantly high mean productivity representing promising for post anthesis drought. PHS 1103(20.30) followed by 21st HRWSN 2056(19.83), PHS 1107(19.80), A-9-30-1 (19.70) and 31st ESWYT 147(19.18) recorded significantly highest MP values. Stress tolerance index (STI) as a useful tool for determining high yield and stress tolerance potential of genotypes revealed that 94 genotypes recorded significantly higher values of STI, thereby promising for drought tolerance. 31st ESWYT 147(0.58) followed by DBW 50(0.56), HS 523 (0.56), PHS 1103(0.55) and 21st HRWSN 2056(0.55) recorded significantly highest STI magnitudes. Selection based on MP and STI will results in genotypes with higher stress tolerance and yield potential thus will be more efficient for improving drought tolerance. Similar results were also reported by Fernandez (1992).

Geometric mean productivity (GMP) is often used by breeders interested in relative performance, since drought stress can vary in severity in field environment over years. Only 23 genotypes had significantly high geometric mean productivity compared to other genotypes. Genotypes DL 803-3(2.29) followed by 18th SAWYT 303(2.28), 43rd IBWSH 1062(2.18), 10th HLWSN 5050(2.02) and WH 1078(2.00) recorded significantly highest mean values of GMP. Whereas, HI 1560(1.82) followed by PHS 1103(1.80), MACS 6222(1.80), UP 2691(1.79) and HS 512(1.79) showed significantly lowest GMP values, thereby, indicating poor genotypes for drought tolerance.

Yield index (YI) and yield stability index (YSI) are expected to have high yield under stressed and low yield under non stressed condition Mohammadi *et al.*(2010). Ninety three genotypes for yield index (YI), 56 genotypes for yield stability index (YSI) and 45 genotypes for drought resistance index (DRI)showed significantly higher index values compared to other genotypes, thus common promising genotypes for all three indices may be considered as stress tolerant and could be used these indices as criteria for improvement in high yield potential under post drought condition. The common genotypes VW 0770, RS 945, PBW 621, 31st ESWYT 147, HD 2864, PHS 1104 and any more recorded significantly highest values for YI, YSI and DRI could be used in future breeding for high yield potential under post drought condition.

Genotypes 31st ESWYT 147 had significantly higher grain yield in both non-stress and stress environments along with significant favourable for all drought tolerance Indies except GMP compared to susceptible check varieties GW 190 and HS 507 (Table 4). DBW 51, HD 2932, 31st ESWYT 125, 31st ESWYT 141, DBW 50, HD 2987, MACS 6273, VW 0770, LOK 62, HI 1571, GW 366, RAJ 1555 and DL 788-2 recorded significantly higher grain yield under stress environments along with significant favourable for SSI, RDI, MP, STI, YI, YSI and DRI.

Table 3. Common genotypes showing promising for grain yield under stress and drought tolerance indices in bread wheat

Variety	Grain yield (NS)	Grain yield (S)	SSI	RDI	MP	STI	GMP	YI	YSI	DRI
DBW 51	23.15	11.45	0.87	1.19	17.30	0.48	1.42	1.16	0.50	0.57
HI 8629	23.50	11.00	0.92	1.11	15.25	0.47	1.47	1.11	0.46	0.52
HD 2932	23.10	11.55	0.85	1.21	17.33	0.48	1.41	1.17	0.50	0.59
31 ESWYT 125	23.20	11.80	0.84	1.22	17.50	0.49	1.40	1.19	0.51	0.61
31 ESWYT 141	22.50	12.20	0.79	1.29	17.35	0.49	1.36	1.23	0.54	0.67
31ESWYT 147	25.95	12.40	0.90	1.14	19.18	0.58	1.45	1.25	0.48	0.60
DBW 50	24.95	12.35	0.87	1.18	18.65	0.56	1.43	1.25	0.49	0.62
PBW 621	20.10	12.70	0.62	1.51	16.40	0.45	1.27	1.28	0.63	0.83
WH 1063	22.40	11.50	0.84	1.23	16.95	0.46	1.40	1.16	0.51	0.60
WH 1061	20.80	11.10	0.80	1.28	15.95	0.41	1.37	1.12	0.53	0.60
VL 920	22.05	10.60	0.90	1.14	16.33	0.42	1.47	1.07	0.48	0.53
HD 2987	24.20	11.60	0.89	1.15	17.90	0.50	1.46	1.17	0.48	0.58
MACS 6273	24.90	11.20	0.94	1.09	18.05	0.49	1.49	1.13	0.45	0.52
SONALIKA	21.85	11.50	0.82	1.25	16.68	0.45	1.41	1.16	0.52	0.64
HI 8498	22.75	10.55	0.92	1.11	16.65	0.43	1.47	1.07	0.46	0.49
DBW 39	20.95	11.90	0.74	1.36	16.43	0.44	1.33	1.20	0.57	0.69
HD 2998	22.20	10.70	0.89	1.15	16.45	0.42	1.48	1.08	0.48	0.48
MACS 3313	25.10	11.60	0.93	1.10	16.60	0.54	1.48	1.17	0.46	0.54
HS 523	25.00	12.40	0.87	1.18	18.70	0.56	1.43	1.25	0.40	0.41
K 0716	23.40	11.80	0.85	1.22	17.60	0.51	1.40	1.19	0.51	0.63
PHS 1101	20.30	11.85	0.71	1.40	16.08	0.43	1.31	1.20	0.58	0.70
PHS 1102	20.90	11.50	0.77	1.31	16.20	0.43	1.35	1.16	0.55	0.64
PHS 1104	20.80	12.40	0.70	1.42	16.60	0.47	1.31	1.25	0.59	0.75
PHS 1105	21.90	11.20	0.84	1.23	16.55	0.44	1.40	1.13	0.51	0.58
PHS 1109	21.20	11.50	0.79	1.30	16.35	0.44	1.36	1.16	0.54	0.63
RS 945	18.60	11.80	0.63	1.52	15.20	0.40	1.26	1.19	0.63	0.76
VW 0770	22.50	12.75	0.71	1.40	17.63	0.53	1.31	1.29	0.58	0.74
LOK 62	21.90	11.40	0.82	1.25	16.65	0.45	1.38	1.15	0.52	0.60
HI 1571	23.20	11.50	0.86	1.20	17.35	0.49	1.41	1.16	0.50	0.58
NIAW 34	20.60	11.60	0.75	1.34	16.10	0.43	1.34	1.17	0.56	0.66
HD 2864	20.40	12.50	0.67	1.46	16.45	0.46	1.28	1.26	0.61	0.78
C 306	25.70	11.15	0.99	1.02	18.43	0.44	1.54	1.13	0.43	0.50
GW 173	21.00	11.90	0.72	1.39	16.45	0.46	1.32	1.20	0.58	0.69
GW 366	24.25	11.00	0.94	1.09	17.63	0.47	1.48	1.11	0.45	0.50
RAJ 1555	24.60	11.70	0.88	1.17	18.15	0.51	1.46	1.18	0.49	0.59
DL 788 2	24.60	11.40	0.93	1.10	18.00	0.51	1.48	1.15	0.46	0.54
GW190 (C)	21.05	7.90	1.07	0.90	14.48	0.30	1.64	0.80	0.38	0.30
38. HS 507 (C)	20.85	7.85	1.07	0.90	14.35	0.48	1.68	0.79	0.37	0.32
SEm±	1.96	1.41	0.12	0.16	1.18	0.07	0.18	0.14	0.07	0.12
CD 5%	5.42	3.90	0.33	0.45	3.27	0.18	0.50	0.39	0.19	0.32
CV %	11.69	20.10	16.72	22.86	9.96	22.26	15.76	20.10	22.86	35.78
No of significant promising entries	27	95	51	52	59	94	23	93	56	45

Genotypes HI 8629, PBW 621, WH 1063, WH 1061, VL 920, SONALIKA, HI 8498, DBW 39, MACS 3313, PHS 1101, PHS 1102, PHS 1104, PHS 1105, PHS 1109, RS 945, NIAW 34, HD 2864 and GW 1732 registered significantly higher grain yield under stress environments along with significant favourable for SSI, RDI,STI, YI and YSI. Only C 306 had significantly highest grain yield in both non stress and stress environments along with significant favourable for MP, STI, YI and DRI. However, GW 173 showed significantly higher grain yield under stress environment and significant favourable for SSI, RDI, STI, YI, YSI and DRI.

3.3 Genetic analysis for drought tolerant indices: Genetic improvement in yield under stress environments has been recognized to be a difficult due to low heritability of grain yield under stress environments, thus drought indices may help as selection criteria to improve in genetic gain in grain yield. Drought indices with high heritability and strong desirable correlations with grain yield would give correlated response, as a result of which selection process would be hastened for drought tolerance selection with high yield. Grain yield showed high GCV and PCV per cent but low heritability value of 15.56 and 16.99 per cent under stress and non-stress environments, respectively, thus difficult to improve grain yield under stress condition. Almost all drought indices recorded low GCV and PCV per cent. SSI, YSI and RDI recorded identical but high estimates of heritability in broad sense (24.21%) may be attributed due mathematical relationship among these indices (Table 4). DRI also exhibited high heritability value of 23.70 per cent. Other indices had low heritability and genetic gain which were comparable to yield in stress but higher than yield in non-stress condition. Hence the improvement for yield potential under drought could be achieved through direct selection.

3.4 Correlation analysis: A suitable drought index must have a significant correlation with grain yield under both stress and non-stress conditions. Both phenotypic and genotypic correlation coefficient analysis revealed that in the stress environment, grain yield recorded significant positive correlation with RDI, MP,STI,YI, YSI and DRI, whereas, it was significant and negative with GYNS, SSI and GMP (Table 5& 6). Yield in non-stress condition (YNS) showed significant positive correlation with SSI, MP and GMP, whereas, it was negative with RDI, YI, YSI and DRI. Positive relationship at genetic level of MP and STI with yield under both conditions would be more effective criteria in identifying high yielding genotypes under normal as well as different moisture stress conditions. Farshadfar *et al.* (2012) also reported similar results for correlations of grain yield with MP and STI under both stress and non-stress environments.

Stress tolerance index (STI) showed positive significant genotypic correlation with RDI, MP, YI, and YSI. Mean productivity (MP) was significantly and positively correlated with STI and YI. Relative drought index (RDI) was significantly and positively correlated with STI, YI, YSI and DRI. Absolute correlations of RDI with SSI and YSI, GYS with YI and YSI with SSI indicated mathematical similarity in their formulae. So, these cannot be a proper index for selecting the genotypes which have a high yield in normal and drought stress environments (Sio-Se Mardeh, 2006).

Thirty-one varieties recorded significantly higher grain yield under stress environments along with significant favourable most of the drought indices viz., SSI, RDI, MP, STI, YI, YSI and DRI. Genotypes 31st ESWYT 147 and C-306 produced significantly high grain yield in both stress and non-stress conditions. Further, 31st ESWYT 147 showed significant favourable for all drought tolerance indices except GMP, whereas, C 306 showed significant favourable only for MP, STI, YI and DRI, respectively. Only two STI and MP showed mostly positive and meaningful genotypic and phenotypic correlation with yield in both stress and non-stress conditions and with other drought tolerance indices. Thus application of both indices could be appropriate while screening the varieties for drought tolerance. However, according to both STI and MP indices promising genotypes varied differentially for drought tolerance.

Table 4. Variability components for drought resistance / tolerance indices in wheat

Parameter	GYNS	GYS	SSI	RDI	MP	STI	GMP	YI	YSI	DRI
GCV	5.97	8.19	0.89	1.69	3.23	0.38	0.69	0.83	0.71	1.81
PCV	38.33	48.19	3.66	6.97	19.87	2.48	4.67	4.87	2.91	7.63
Heritability	15.56	16.99	24.21	24.21	16.24	15.37	14.73	16.99	24.21	**23.70**
Genetic gain	4.08	7.72	9.58	13.09	3.64	7.66	5.18	7.72	13.09	**19.99**

Table 5. Simple correlation coefficients between drought tolerance indices in bread wheat

Trait	GYNS	GYS	SSI	RDI	MP	STI	GMP	YI	YSI
GYS	-0.1192								
SSI	0.5530**	-0.8826**							
RDI	-0.5530**	0.8826**	-1.0000**						
MP	0.7834**	0.5237**	-0.0906	0.0906					
STI	0.4120**	0.8457**	-0.4822**	0.4822**	0.7940**				
GMP	0.4601**	-0.8828**	0.9440**	-0.9440**	-0.1594	-0.5375**			
YI	-0.1192	1.0000**	-0.8826**	0.8826**	0.5081**	0.8143**	-0.8828**		
YSI	-0.5530**	0.8826**	-1.0000**	1.0000	0.0906	0.4822**	-0.9440**	0.8826**	
DRI	-0.4050**	0.9359**	-0.9726**	0.9726**	0.2302**	0.6102**	-0.8906**	0.9359**	0.9726**

** and ** significant at 5 and 1% probability levels, respectively.*

Table 6. Genotypic and phenotypic correlation coefficients among drought tolerance indices in bread wheat

Trait	GYNS	GYS	SSI	RDI	MP	STI	GMP	YI	YSI	DRI
GYNS		-0.6134**	0.7432**	-0.7432**	0.6605**	-0.1009	0.6757**	-0.6134**	-0.7432**	-0.8437**
GYS	-0.0389		-0.9978**	0.9978**	0.2761*	0.8530**	-1.0895**	1.0000**	0.9978**	0.9739**
SSI	0.5183**	-0.8616**		-1.0000**	-0.0648	-0.7079**	1.0537**	-0.9978**	-1.0000**	-1.0384**
RDI	-0.5183**	0.8616**	-1.0000**		0.0648	0.7079**	-1.0537**	0.9978**	1.0000**	1.0384**
MP	0.7544**	0.5466**	-0.0961	0.0961		0.6955**	-0.3805*	0.2761*	0.0648	-0.0434
STI	0.4532**	0.8082**	-0.4407**	0.4407 **	0.8096**		-0.8197**	0.8530**	0.7079**	0.6818**
GMP	0.4275**	-0.8504**	0.9280**	-0.9280**	-0.1653	-0.4951**		-1.0895	-1.0537**	-1.1599**
YI	-0.0389	1.0000**	-0.8616**	0.8616**	0.5466**	0.8082**	-0.8504**		0.9978**	0.9739**
YSI	-0.5183**	0.8616**	-1.0000**	1.0000**	0.0961	0.4407**	-0.9280**	0.8616**		1.0384**
DRI	-0.3222**	0.9304**	-0.9569**	0.9569**	0.2845**	0.5988**	-0.8442**	0.9304**	0.9569**	

** &** significant at 5 and 1 per cent probability levels, respectively. Upper half and lower half diagonal showed genotypic and phenotypic correlation coefficients, respectively*

MP index leads the selection towards more efficient genotypes in both stress and non-stress environment. Screening for drought tolerances could be made preferably on MP or either any one or both indices would be more effective. Various researchers were also approved that STI and MP could be more appropriate for screening drought tolerant high yielding genotypes in the both stress and non-stress conditions (Abdi *et al.*,2012; Mohammadi *et al.*,2010; Talebi *et al.*,2009; Fernandez, 1992). Nazari and Pakniat (2010) also reported that STI and MP were the best criteria for the selection of high yielding barely genotypes both under stress and non-stress conditions.

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