GENETIC DIVERGENCE ANALYSIS AND SCREENING OF DROUGHT TOLERANT BREAD WHEAT (*Triticum aestivum* L.) GENOTYPES UNDER LIMITED WATER FOR TIMELY SOWN CONDITION

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ABSTRACT

To investigate the drought stress effect on yield and some agronomic traits on wheat, 40 bread wheat cultivars were evaluated under normal irrigation and limited irrigation condition (stopping irrigation 65 days after sowning) in a Randomized Block Design (RBD) with three replications at Wheat Research Station, JAU, Junagadh in 2013-14. The significant mean squares due to genotypes for all the traits suggested the presence of considerable genetic variability for all the traits studied. In the present study, D^2-statistic estimated on 40 genotypes of wheat for 12 characters showed that the generalized distance ($\sqrt{D^2}$) between two genotypes varied from 177.31 to 275.97, which was an indicator of considerable diversity available in the material studied. On the basis of D^2-values, 11 clusters were formed from 40 genotypes. The lowest intra-cluster distance was in cluster III (D=177.31), whereas the highest intra-cluster distance was in cluster II (D=275.97). The maximum inter-cluster distance (D=1471.93) was found between clusters VII and X followed by that between clusters III and X (D=1377.44), whereas minimum inter-cluster distance was observed between clusters IV and V (D=138.02) followed by cluster III and IV (D=174.04). The analysis of per cent contribution of various characters towards the expression of total genetic divergence indicated that days to 50 per cent flowering, grain weight per main spike, number of productive tillers per plant, ear length, plant height and days to maturity contributed maximum towards total genetic divergence in the present study. Stress susceptibility index(S) was worked-out for the screening of drought tolerance genotypes. Based on stress susceptibility index (S) for grain yield per plant, genotypes HPW 347, HUW 629, UAS 327, HPW 289, HUW 635, DBW 17, Sonalika and MP 3336 were identified as drought tolerant genotypes.

KEY WORDS: Divergence, Stress Susceptibility Index, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the staple food for a large part of the world population including India. India accounts an area, production and a productivity of 29.9 million hectares, 93.9 million metric tonnes and 3140 kg/h, respectively (Anonymous, 2012). For an efficient breeding programme, selection of genetically divergent parents is important. Genetic divergence is used to measure genetic distance between different genotypes and to classify the genetic stocks into distinct groups. Intercrossing between more divergent groups would increase variability and range of frequency distribution. Mahalanobis (1936) D^2 statistic is a powerful tool in quantifying the degree of divergence among the populations and has extensively been utilized to assess diversity. Genetically diverse parents are likely to produce high heterotic effect, when utilized in cross breeding programme.

Drought is a major factor limiting the productivity of wheat throughout the world particularly in arid, semi arid and Mediterranean climates due to the unpredictable and erratic rainfall in these regions. Breeding and selection for high yield under drought has been an important objective of crop breeders working in these environments. Drought tolerance is a quantitative trait and there is no direct measuring method for it. It makes difficult to identify drought tolerant genotypes. But in recent past a few desirable drought tolerance parameters indicating drought tolerance with high heritability have been identified and used in breeding programme. In present study, stress susceptibility index has been used for screening drought tolerance genotypes of wheat.

MATERIALS AND METHODS

The experimental material consisted of 40 diverse genotypes of wheat (*Triticum aestivum* L.) and were sown under normal irrigation and limited irrigation condition in a Randomized Block Design with three replications during *Rabi* 2013-2014 at Wheat Research Station, Junagadh Agricultural University, Junagadh. Under limited irrigated condition, irrigation was stopped 65 days after sowing. Each entry was accommodated in a single row of 2.0 m length with a spacing of 22.5 cm. Five competitive plants per genotype in each replication were selected randomly and observations were recorded on different characters and their averages were used for statistical analysis except for days to 50 per cent flowering and days to maturity, were recorded on plot basis. Mahalanobis (1936) D^2 statistics was employed to estimate genetic divergence. For formation of clusters, the general criteria of grouping as suggested by Tocher were followed in the present study. The inter-cluster distance was calculated by measuring the distance between clusters I and II, between I and III, between I and IV and so on. Likewise, one by one cluster was taken and their distances from each other were calculated. The cluster means for all the 12 characters were computed using character means for the genotypes included in the clusters. Stress susceptibility index indicates the performance of a genotype under stress condition compared to maximum potential under normal conditions and was calculated using formula suggested by Fisher and Mather (1978).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the 12 characters indicating the existence of genetic variability in the material studied. In all, the 40 genotypes were grouped into 11 clusters indicating the presence of ample diversity in the material for 12 characters (Table 1). Cluster I was the largest having 21 genotypes indicating overall genetic similarity among them, whereas cluster II had eight genotypes. Cluster III consisted of three genotypes. The clusters, IV, V, VI, VII, VIII, IX, X and XI had solitary genotypes. Bergale *et al.* (2001) in diversity analysis has also reported 11 clusters with variable number of genotypes.

The inter- and intra-cluster distance (D=$\sqrt{D^2}$) values were worked out from divergence analysis and are presented in Table 2. The intra-cluster distance values were lower than the inter-cluster distance values. The intra-cluster distance ranged from 177.31 to 275.97, the maximum being in cluster II (275.97) and minimum in cluster III (177.31). The clusters IV, V, VI, VII, VIII, IX, X and XI contained single genotype and therefore, their intra-cluster distance was zero. The maximum inter-cluster distance (D=1471.93) was found between clusters VII and X followed by between clusters III and X (D=1377.44), IV and X (D=1279.15), suggesting the presence of more variability in genetic make-up of the genotypes included in these clusters. The minimum inter-cluster distance was observed between clusters VI and V (D=138.02) indicating existence of closer proximity between these clusters. The genotypes belonging to the clusters separated by high statistical distance could be used in hybridization programme for obtaining a wide spectrum of variation among the segregates.

Greater range of mean values among the clusters was recorded for different traits presented in Table 3. The cluster V had the highest mean values for grain yield per plant (8.44g), biological yield per plant (16.30g) and harvest index (51.77%). The cluster VI and XI were good for days to 50 per cent flowering (47.33). The cluster X was good for days to maturity (90.00). The cluster II was good for grain filling period (38.00). The cluster IX had highest mean values for plant height (77.37cm). The cluster III and VIII was good for number of productive tillers per plant (4.33), while the cluster XI was the best for ear length (10.70cm), grain weight per main spike (2.62g) and 100 grain weight (5.07g). The cluster IV was good for number of grains per main spike (60.73). Sethi *et al.* (1992) also reported wide range of variation for plant height, grain yield per plant, biological yield per plant and harvest index. Therefore, intercrossing of genotypes involved in these clusters could be practiced for inducing variability in the respective characters and their rationale improvement for increasing grain yield. Similar approach was also suggested by Sharma *et al.* (1998), while studying genetic diversity in large collections of wheat. The characters which showed more contribution (%) towards the divergence should be considered during selection. The analysis of per cent contribution of various characters towards the expression of total genetic divergence indicated that days to 50 per cent flowering (29.10%) followed by grain weight per main spike (20.00%), number of productive tillers per plant (17.56%), ear length (14.87%), plant height (8.33%) and days to maturity (5.13%) contributed maximum towards total genetic divergence in the present study (Table 3). These characters accounted for more than 94 per cent of total divergence in the material studied. The present results are in agreement with those of Nimbalkar *et al.* (2002).

Stress susceptibility index(S) was worked-out for the screening of drought tolerance genotypes (Table 4). Based on stress susceptibility index (SST) genotypes were categorised as highly drought tolerant (0.00-0.50), drought tolerant (0.51-0.75), moderate drought tolerant (0.76-1.00) and drought susceptible (1.00 or above) as given by Fisher and Mather (1978). According to estimation of stress susceptibility index (S), the genotypes HPW 347, UAS 327, HUW 629, HPW 289, HUW 635, DBW 17, Sonalika, and MP 3336 were found as highly drought tolerant for grain yield followed by number of productive tillers per plant, grain weight per main spike, and biological yield per plant. The genotypes, UAS 327 and HPW 347 were found drought tolerance for all the characters included in study. Considering D-value i.e. drought stress intensity, it was revealed that days to maturity, grain filling period and plant height were less affected by limited water condition, while grain yield per plant, grain weight per main spike, biological yield per plant, number of productive tillers per plant and 100 grain weight were highly suffered under limited water environment. This clearly indicated that grain yield per plant depends upon number of productive tillers per plant, grain weight per main spike and biological yield per plant. It indicated that selection for high biological yield should bring about positive improvement in grain yield. Thus, biological yield could be improved by plant height. In the present study, plant height significantly contributed towards biological yield per plant because less reduction in plant height (D=0.0437) under limited water condition. Thus, selection for biological yield is one of the most important ways to improve the productivity under limited water condition.

CONCLUSION

From the results of present study, it can be concluded that materials evaluated in the present investigation was genetically diverse. The genotypes belonging to the clusters separated by high statistical distance (clusters VII and X, cluster III and X) could be used in hybridization programme for obtaining a wide spectrum of variation among the segregates. The characters viz., days to 50 per cent flowering, grain weight per main spike, number of productive tillers per plant, ear length, plant height and days to maturity, which showed more contribution (> 94%) towards the divergence should be considered during selection. Stress susceptibility index(S) was worked-out for the screening of drought tolerance genotypes. Based on stress susceptibility index (S) for grain yield per plant, genotypes HPW 347, HUW 629, UAS 327, HPW 289, HUW 635, DBW 17, Sonalika and MP 3336 were identified as drought tolerant genotypes.

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Table 1: Grouping of 40 genotypes of wheat in various clusters on the basis of D^2-statistics

Cluster	Number of Genotypes	Name of the Genotypes	Source
I	21	PBW 417, PBW 640, PBW 635, PBW 628	Panjab
		Raj 4205, Raj 4238,	Rajasthan
		DBW 60, LBPY 08-11, DBW 62, WH 1094	Haryana
		Sonalika, HD 3002	New Delhi
		HI 1569, MP 3336	Madhya Pradesh
		HUW 629, VL 930, NW 4081	Uttar Pradesh
		HPW 289, HPW 347, HS 525	Himachal Pradesh
		UAS 324	Karnataka
II	8	AKDW 4537	Maharashtra
		DBPY-08-9, DBPY 08-4, DBPY-08-6, DBPY 08-1	Haryana
		HI 8498	Madhya Pradesh
		VL 943	Uttar Pradesh
		HS 522	Himachal Pradesh
III	3	HS 533, HUP 635	Himachal Pradesh
		DBW 17	Haryana
IV	1	UAS 327	Karnataka
V	1	NW 4091	Uttar Pradesh
VI	1	KRL 250	Haryana
VII	1	VL 931	Uttar Pradesh
VIII	1	HPW 338	Himachal Pradesh
IX	1	PHS 1101	--------
X	1	DL 1015	New Delhi
XI	1	PHS 1103	--------

Table 2: Average inter and intra-cluster distance ($D=\sqrt{D^2}$) values in wheat

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	262.03	437.92	431.56	360.35	322.76	342.37	331.87	316.20	395.65	657.77	650.82
II		275.97	488.63	631.66	493.17	796.68	491.81	416.81	703.35	795.64	1150.71
III			177.31	174.04	180.46	437.14	516.06	629.48	586.60	1377.44	568.76
IV				0.00	138.02	261.15	534.70	437.94	721.16	1279.15	792.18
V					0.00	316.05	532.17	608.29	583.40	996.60	539.00
VI						0.00	513.48	256.66	568.42	749.85	1078.81
VII							0.00	515.59	913.06	1471.93	1072.73
VIII								0.00	555.21	646.65	1177.22
IX									0.00	411.00	297.45
X										0.00	917.89
XI											0.00

Table 3: Cluster means for 12 different characters in wheat

Clusters	Grain Yield Per Plant (g)	Days to 50% Flowering	Days to Maturity	Grain Filling Period (Days)	Plant Height (cm)	Number of Productive Tillers Per Plant	Ear Length (cm)	Number of Grains Per Main Spike	Grain Weight Per Main Spike (g)	Biological Yield Per Plant (g)	Harvest Index (%)	100-Grain Weight (g)
I	5.66	53.59	98.6	45.02	66.56	3.30	8.63	46.59	1.65	12.14	46.16	3.64
II	4.81	65.00	103.00	38.00	70.04	3.08	7.50	42.72	1.44	11.33	42.20	3.55
III	6.22	62.22	103.11	40.89	69.38	4.33	8.48	59.91	1.79	14.97	41.85	2.89
IV	7.26	57.67	99.33	41.67	72.40	3.73	9.43	60.73	2.18	14.6	49.72	3.31
V	8.44	56.00	105.67	49.67	66.43	4.27	7.59	56.27	1.91	16.30	51.77	3.50
VI	5.26	47.33	91.67	44.33	59.33	2.53	8.42	58.07	1.98	11.20	47.00	3.64
VII	2.40	55.00	101.33	46.33	71.03	1.80	9.71	48.80	1.18	6.53	36.4	2.46
VIII	5.52	51.00	102.67	51.67	70.10	4.33	7.85	38.80	1.16	16.13	34.62	3.04
IX	4.52	47.67	92.00	44.33	77.37	2.33	9.78	37.53	1.95	10.00	45.03	4.65
X	3.61	48.67	90.00	41.33	60.53	2.67	8.27	23.33	1.27	8.40	42.55	4.60
XI	5.11	47.33	91.33	44.00	64.97	2.33	10.70	42.47	2.62	10.37	49.34	5.07
Mean	5.45	56.07	99.45	43.38	67.71	3.28	8.46	46.65	1.64	12.10	44.72	3.59
SEm ±	0.273	0.358	0.331	0.412	0.465	0.104	0.085	0.523	0.018	0.448	1.190	0.054
C.V.%	15.022	1.915	0.997	2.851	2.059	9.522	3.013	3.361	3.373	11.117	7.983	4.473
Percentage Contribution of Characters Towards Total Divergence												
No. of Times Appearing First	2	227	40	0	65	12	116	137	156	1	0	24
% Contribution	0.26	29.10	5.13	0.00	8.33	1.54	14.87	17.56	20.0	0.13	0.00	3.08

Table 4: Stress Susceptibility Index (S) for different 11 characters of 40 wheat genotypes under normal and limited water for timely sowing condition.

Sr. No.	Genotype	Days to Maturity	Grain Filling Period (Days)	Plant Height (cm)	Number of Productive Tillers Per Plant	Ear Length (cm)	Number of Grains Per Main Spike	Grain Weight Per Main Spike (g)	Grain Yield Per Plant (g)	Biological Yield Per Plant (g)	Harvest Index (%)	100-Grain Weight (g)
1	DBW 62	0.614	0.907	0.544	1.643	1.770	0.059	0.364	0.770	0.996	0.107	0.803
2	HPD 338	0.281	0.079	0.829	1.674	0.670	1.415	1.156	1.273	0.998	1.896	0.644
3	HS 522	1.498	1.386	1.206	0.947	0.125	0.242	0.466	0.527	0.597	0.275	0.896
4	HS 533	0.963	1.231	1.112	0.322	1.422	0.163	0.134	0.643	-1.160	2.790	1.039
5	HUW 629	1.134	0.057	1.843	-0.021	0.895	0.338	0.459	0.304	0.355	0.136	0.886
6	KRL 250	3.027	2.441	4.206	1.515	1.326	0.088	0.330	0.544	0.647	0.226	0.016
7	NW 4091	0.348	-0.161	1.008	0.383	0.917	0.968	0.716	0.759	0.973	0.154	0.756
8	PBW 635	1.933	1.911	2.405	0.779	0.560	0.581	1.024	0.629	0.817	0.086	0.453
9	UAS 327	0.654	0.997	0.505	0.095	0.376	0.098	0.040	0.433	0.186	0.856	0.511
10	HD 3002	1.267	1.781	1.532	1.910	1.028	1.288	1.348	1.564	1.533	2.065	1.439
11	HPW 289	0.713	0.074	1.784	0.294	0.512	0.071	0.833	0.437	0.117	1.036	1.281
12	VL 931	1.188	0.935	-0.073	2.273	0.288	1.186	1.195	1.692	1.797	1.970	1.230
13	VL 943	1.018	1.226	0.466	1.606	1.172	1.414	1.141	1.392	1.066	2.330	0.545
14	HPW 347	0.502	0.086	-0.660	0.338	0.893	0.989	0.800	0.560	0.567	0.461	0.881
15	HS 525	0.286	0.090	-0.060	1.578	0.194	1.356	1.143	1.030	1.047	1.019	0.309
16	VL 930	0.782	0.323	1.302	2.240	0.640	0.963	1.175	1.644	1.976	1.114	1.380
17	HI 1569	1.208	0.888	1.724	2.324	1.688	1.394	1.326	1.594	1.891	1.090	0.056
18	HUW 635	0.711	1.154	0.202	0.182	0.840	0.081	1.545	0.198	-0.432	1.325	1.538
19	PBW 617	0.245	0.180	0.593	0.346	0.995	1.759	1.252	0.633	0.467	0.906	0.946
20	DBW 60	2.163	2.353	1.395	0.432	0.198	0.232	0.207	0.511	0.550	0.168	0.599

Contd…

Table 4: Contd…..

Sr. No.	Genotype	Days to Maturity	Grain Filling Period (Days)	Plant Height (cm)	Number of Productive Tillers Per Plant	Ear Length (cm)	Number of Grains Per Main Spike	Grain Weight Per Main Spike (g)	Grain Yield Per Plant (g)	Biological Yield Per Plant (g)	Harvest Index (%)	100-Grain Weight (g)
21	**PBW-640**	0.569	0.072	6.033	1.124	2.728	1.420	0.901	1.236	1.387	0.945	0.796
22	**WH-1094**	0.433	0.359	2.806	0.136	2.849	2.466	1.544	0.953	1.122	0.499	0.004
23	**NW-4081**	0.913	1.472	1.226	0.389	0.163	1.280	0.333	1.172	0.697	2.309	1.926
24	**PBW-628**	1.289	1.191	0.113	0.667	0.047	1.320	1.328	1.127	1.209	1.019	1.551
25	**UAS-324**	0.765	0.469	0.180	1.036	1.522	2.356	1.415	1.611	1.482	2.440	1.164
26	**PHS 1101**	0.161	-0.016	0.179	0.606	1.496	1.492	1.396	0.848	0.771	1.119	1.596
27	**PHS 1103**	0.480	0.244	0.168	0.719	1.126	2.049	0.695	1.201	1.524	0.367	0.925
28	**AKDW 4537**	0.284	-0.005	-0.060	1.226	0.129	1.372	1.801	1.056	0.977	1.398	0.961
29	**DBPY 08-1**	2.022	3.055	0.141	1.113	0.137	1.533	0.969	1.264	1.365	1.232	0.281
30	**DBPY 08-4**	1.158	1.776	-0.215	0.382	0.855	1.568	1.357	0.749	0.354	1.480	1.218
31	**DBPY 08-6**	0.847	1.166	0.799	1.515	0.922	0.064	0.912	1.100	1.273	0.658	1.281
32	**DBPY 08-9**	0.705	1.329	-0.542	1.392	1.088	1.653	1.730	1.486	1.254	2.472	1.565
33	**DL 1015**	0.794	0.951	-0.286	0.816	1.438	3.215	1.738	1.195	1.192	1.432	0.932
34	**DBW 17**	1.026	2.032	-0.248	0.154	2.144	0.052	0.573	0.382	0.256	0.558	2.069
35	**Sonalika**	0.311	0.461	1.088	0.867	1.152	0.183	0.102	0.476	0.614	0.071	0.575
36	**HI 8498**	1.099	0.945	1.880	0.309	0.158	0.166	1.583	0.754	0.919	0.353	1.589
37	**Raj 4238**	0.719	0.621	2.233	0.260	0.870	0.040	0.251	0.541	0.680	0.135	1.655
38	**MP 3336**	0.149	0.527	0.842	1.122	0.637	0.052	0.120	0.484	0.609	0.114	0.545
39	**Raj 4205**	4.070	3.600	0.368	1.588	1.543	1.345	1.060	1.268	1.597	0.383	0.568
40	**LBPY 08-11**	0.857	0.350	0.670	1.672	0.376	1.528	1.578	1.452	1.771	0.744	1.523
	D-value	0.0447	0.0849	0.0437	0.1947	0.1094	0.1356	0.2787	0.3391	0.2521	0.1150	0.1508

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