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Association studies for agro-physiological and quality traits of triticale X bread wheat derivatives in relation to drought and cold stress

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Abstract: *Correlation coefficient analysis conducted on 22 triticale x bread wheat derivatives along with six checks to select true- breeding derivative(s) for future hybridization programme with tolerance to drought and cold stress conditions as well as better quality traits revealed significant correlation of grain yield with spikelets per spike, biological yield, harvest index, leaf area index. Interestingly, the grain yield and drought susceptibility index showed no association. However, with cold tolerance it showed significant positive correlation indicating the desirability of certain plant traits under cold stress. The grain yield exhibited no association with quality traits which might assist in the predictability of high yielding varieties with high protein, total sugars, reducing sugars and non-reducing sugars. Path coefficient analysis revealed that biological yield had the highest positive direct effect on grain yield followed by harvest index, specific leaf weight, stomatal number, 1000 grain weight, stomatal size, spikelets per spike and days to heading. Therefore, indirect selection for these plant traits in order should be exercised in selecting drought tolerant genotypes. Two genotypes (RL-124-2P_2 and RL 111P_2) were found to be drought and cold tolerant with high grain yield, spikes per plant, spikelets per spike and leaf area index.*

Key words: *Correlation studies, Path coefficient, Drought stress, Cold stress, Triticale x beard wheat derivatives*

Introduction

Bread wheat *(Triticum aestivum* L. em. Theil.) is endowed with a wide array of relatives varying in their adaptation to different environmental conditions. The genetic variability of bread wheat is being supplemented by transferring alien chromatin from related genera (Friebe *et al.*, 1996). Of these, rye *(Secale cereale* L.) is particularly useful due to its better adaptability to marginal environments along with tolerance to a number of biotic and abiotic stresses. Besides diseases, abiotic stresses such as, drought and cold limit the productivity and adaptability of bread wheat. Rye possesses genes conferring drought tolerance and some better quality traits, (Merker, 1984) and has since been recognized as the most cold tolerant cereal (Sethi *et al.,* 1993). For the improvement of stress tolerance of crops, the efficient breeding programme does not depend solely on grain yield performance under stress. Therefore, some other easily observable morpho physiological traits should also be identified that ultimately contribute to grain yield under stress. Since the yield potential has a very high effect on yield performance under stress, the ideotype must be of reasonably high yield potential and stress tolerant (Blum, 1988).

Materials and Methods

Twenty two triticale x bread wheat derivatives along with six checks (TL 1210, TL 1217, HD 2380, CPAN 1922, HPW 42 and HS 240)already screened for drought tolerance at Palampur and classified as drought tolerant, moderately sensitive and sensitive based on their drought susceptibility index, were sown in the plots of 4.00 x 1.75 m^2 with inter row spacing of 20cm in randomized block design with three replications at experimental farm of department of Plant Breeding and Genetics, CSK HPKV Palampur under irrigated conditions only. Five plants per replication were randomly taken for recording the data on grain yield per plot (g), days to heading, days to maturity, spikes per plant, spikelets per spike, 1000 grain weight (g), biological yield (kg), harvest index (%), flag leaf area (cm^2), leaf area index, specific leaf weight (g/cm^2), stomatal size (µm), stomatal number, grain protein (%), total sugar (%), reducing sugar (%) and non reducing sugars (%). The parameters of variability were calculated as suggested by Johnson *et al.* (1955). Correlation coefficients between all the possible character pairs were computed from the mean values and were partitioned into direct and indirect effects following the path coefficient analysis (Dewey and Lu, 1959). These genotypes were also screened for cold tolerance after freezing, followed by triphenyl tetrazolium chloride (TTC) test. In the healthy cells, the colourless oxidized form of TTC, was reduced to a coloured form (formazan), which was estimated colorimetrically (Kittock and Law, 1968).

Results and Discussion

In general, the estimates of genotypic correlations were relatively higher than their respective phenotypic correlations. Grain yield showed significant positive association with spikelets/ spike, biological yield, harvest index, leaf area index (Table 1).

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Table - 1: Correlation coefficients among different plant traits

Traits		Days to heading	Days to maturity	Spikes /plant	Spike lets/ spike	1000-grain weight	BY	HI	FLA	LAI	SLW	Stomatal size	Stomatal number	Protein (%)	Total sugar	RS	NRS	CT	DSI
Grain yield per plot	P	-0.156	0.010	0.020	0.374*	0.121	0.800*	0.398*	0.318	0.490*	-0.123	0.126	-0.038	0.169	-	-	-	-	-
	S	-0.150	0.033	0.110	0.458*	0.089	0.861*	0.399*	0.251	0.593*	-0.313	0.239	0.029	0.213	0.293	-0.048	0.306	0.464*	-0.152
Days to heading	P		0.289	-0.190	-0.245	-0.238	-0.079	-0.159	-0.012	0.084	0.136	-0.152	-0.113	0.197	-	-	-	-	-
	S		0.324	-0.106	-0.321	-0.234	-0.090	-0.137	0.066	0.122	0.280	-0.234	-0.106	0.180	-0.098	0.103	-0.146	-0.086	0.028
Days to maturity	P			-0.120	0.231	0.149	0.170	-0.271	0.446*	0.296	0.245	0.116	0.175	-0.054	-	-	-	-	-
	S			-0.216	0.362	0.249	0.218	-0.362	0.564*	0.292	0.130	0.170	0.250	-0.117	0.095	-0.318	0.251	0.073	0.015
Spikes /plant	P				0.220	-0.051	-0.035	0.129	0.076	-0.094	-0.153	-0.224	0.221	0.121	-	-	-	-	-
	S				0.194	-0.139	-0.013	0.292	-0.080	-0.310	-0.212	-0.037	0.050	0.587*	-0.061	0.048048	-0.083	0.328	0.200
Spikelets /spike	P					0.0137	0.366	0.030	0.335	0.205	0.139	0.118	0.173	0.125	-	-	-	-	-
	S					0.160	0.504*	-0.016	0.444*	0.348	0.117	0.316	0.272	0.095	0.350	-0.127	0.401*	0.323	0.161
1000grain weight	P						0.246	-0.204	0.165	0.146	-0.087	0.140	-0.026	-0.268	-	-	-	-	-
	S						0.263	0.319	0.194	0.223	-0.401*	0.242	-0.068	-0.291	0.074	0.166	-0.012	0.065	0.114
Biological yield	P							-0.215	0.402*	0.590*	-0.151	0.198	-0.067	-0.047	-	-	-	-	-
	S							-0.115	0.397*	0.724*	-0.310	0.366	0.008	-0.100	0.323	0.108	0.256	0.362	0.241
Harvest Index	P								-0.092	-0.085	-0.033	-0.110	0.005	0.373*	-	-	-	-	-
	S								-0.280	-0.097	-0.108	-0.154	0.017	0.640*	-0.001	-0.226	0.111	0.287	-0.081
Flag leaf area	P									0.198	0.111	-0.184	0.096	0.069	-	-	-	-	-
	S									0.229	0.038	-0.251	0.366	-0.223	0.413*	-0.176	0.485*	0.222	0.239
LAI	P										0.016	0.236	-0.019	-0.031	-	-	-	-	-
	S										-0.229	0.319	-0.087	0.048	0.292	0.083	0.239	0.112	0.067
SLW	P											-0.097	-0.099	-0.144	-	-	-	-	-
	S											-0.181	-0.028	-0.024	0.052	-0.243	0.172	-0.360	-0.420*
Stomatal size	P												-0.189	0.020	-	-	-	-	-
	S												-0.226	0.004	0.116	0.067	0.078	0.022	-0.170
Stomatal number	P													0.095	-	-	-	-	-
	S													0.102	0.235	-0.266	0.358	0.148	0.125
Protein															0.141	-0.033	0.153	0.249	0.050
Total sugar																0.180	0.870*	0.025	0.186
RS																	-0.326	-0.035	0.468*
NRS																		0.042	-0.075
CT																			0.031

P= Phenotypic correlation coefficient, S= Simple correlation coefficient, *= significant at p≤ 0.05; BY= Biological yield, HI= Harvest index; FLA= Flag leaf area, LAI= Leaf area index, SLW= Specific leaf weight, RS= Reducing sugar, NRS= Non reducing sugar CT= Cold tolerance, DSI= Drought susceptibility index

Table - 2: Estimates of direct and indirect effects of different traits on grain yield at phenotypic level

Traits	Days to heading	Days to maturity	Spikes /plant	Spikelets /spike	1000-grain weight	Biological yield	Harvest index	Flag leaf area	Leaf area index (LAI)	Specific leaf weight (SLW)	Stomatal size	Stomatal number	Correlation with yield
Days to heading	0.033	-0.003	0.004	-0.004	-0.005	-0.076	-0.098	0.000	-0.003	0.006	-0.003	-0.005	-0.156
Days to maturity	0.009	-0.009	0.003	0.004	0.003	0.162	0.168	-0.005	-0.009	-0.010	0.002	0.007	0.010
Spikes/ plant	-0.006	0.001	-0.022	0.003	-0.001	-0.033	0.080	-0.001	0.003	-0.006	-0.004	0.009	0.020
Spikelets/ spike	-0.008	-0.002	-0.005	0.015	0.003	0.349	0.019	-0.004	-0.006	0.006	0.002	0.007	0.374
1000-grain weight	-0.008	-0.001	0.001	0.002	0.022	0.234	-0.126	-0.002	-0.005	-0.004	0.003	-0.001	0.121
Biological yield	-0.003	-0.002	0.001	0.006	0.005	0.954	-0.133	-0.005	-0.019	-0.006	0.004	-0.003	0.800
Harvest Index	-0.005	0.002	-0.003	0.000	-0.004	-0.206	0.619	0.001	0.003	-0.001	-0.002	0.000	0.398
Flag leaf Area	0.000	-0.004	-0.002	0.005	0.004	0.384	-0.057	-0.012	-0.006	0.004	-0.003	0.004	0.318
Leaf area Index	0.003	-0.003	0.002	0.003	0.003	0.563	-0.053	-0.002	-0.032	0.001	0.004	-0.001	0.490
Specific leaf weight	0.004	-0.002	0.003	0.002	-0.002	-0.144	-0.021	-0.001	0.000	0.041	-0.002	-0.004	-0.123
Stomatal size	-0.005	-0.001	0.005	0.002	0.003	0.189	-0.068	0.002	-0.007	-0.004	0.018	-0.008	0.126
Stomatal number	-0.004	-0.002	-0.005	0.003	-0.001	-0.064	0.003	-0.001	0.001	-0.004	-0.003	0.040	-0.038

Table - 3: Relative ranking of genotypes for drought and cold tolerance based on drought susceptibility index and colorimetric estimation of formazan respectively

Genotype	Drought susceptibility index		Colorimetric estimation of formazan	
	DSI	Rank	Absorbance	Rank
TW9309	0.95	5	0.141	9
TW9322	1.21	1	0.130	14
TW9325	1.09	2	0.100	19
TW9327	0.80	12	0.135	11
TW9333	0.80	12	0.151	6
TW9334	1.09	2	0.124	15
TW9335	0.83	11	0.136	10
TW9336	0.65	18	0.083	22
RL 6-3-4	0.93	7	0.165	4
RL 16/83 P_2	1.09	2	0.095	20
RL 20/83 P_1	0.68	17	0.083	22
RL 88/22	0.85	10	0.112	17
RL75/83	0.93	7	0.144	8
RL 122 P_1	0.62	19	0.131	12
RL 136 P_1	0.73	15	0.065	26
RL 136-1 P_1	0.43	21	0.077	25
RL 111 P_2	0.22	24	0.152	5
RL 111-3 P_2	0.69	16	0.113	16
RL 124-2 P_2	0.28	23	0.180	2
RL 138 P_2	0.76	14	0.024	28
RL 139-1 P_1	0.40	22	0.105	18
RL 143 P_2	0.95	5	0.131	12
TL 1210	-	-	0.170	3
TL 1217	-	-	0.182	1
HD 2380	-	-	0.090	21
CPAN 1922	-	-	0.036	27
HPW 42	0.46	20	0.079	24
HS 240	0.86	9	0.151	7

Table - 4: Mean performance of 22 triticale x bread wheat derivatives along with 6 checks for seventeen traits

Genotype	Grain yield/plot (g)	Days to heading	Days to maturity	Spikes/ plant	Spikelets/ spike	1000-grain weight (g)	BY (Kg)	HI (%)	FLA (cm^2)	LAI	SLW (g/cm^2)	SS (µm)	SN	Protein (%)	TS (%)	RS (%)	NRS (%)
TW9309	618.67	134.00	171.67	6.67	18.87	33.44	2.57	25.64	17.21	2.02	0.035	52.88	3.07	10.44	2.98	1.89	1.09
TW9322	706.33	131.00	174.00	6.47	17.07	31.91	2.63	27.28	18.62	2.02	0.033	49.00	3.80	9.34	2.04	0.65	1.39
TW9325	690.33	139.67	173.67	7.07	17.67	32.62	2.67	25.80	18.16	2.06	0.038	50.25	3.43	9.28	1.08	1.05	0.03
TW9327	815.83	146.67	176.67	6.40	18.00	32.71	3.20	25.56	19.59	2.18	0.038	51.38	4.03	9.78	2.83	0.42	2.41
TW9333	734.33	148.00	184.00	5.73	17.13	43.82	3.17	23.43	17.09	2.63	0.034	56.00	3.20	9.14	2.42	1.07	1.35
TW9334	734.00	145.33	180.33	6.07	17.47	37.29	2.87	25.69	19.71	2.21	0.041	49.63	2.87	8.86	1.47	1.08	0.39
TW9335	658.83	148.00	176.33	6.33	18.87	38.15	3.00	22.02	20.29	2.39	0.041	50.25	3.20	8.05	1.40	1.22	0.18
TW9336	605.50	147.33	181.00	5.93	18.33	43.44	2.50	24.25	19.84	1.91	0.035	50.88	3.97	9.36	1.59	0.58	1.01
RL 6-3-4	768.17	145.33	178.00	7.00	17.47	49.13	3.30	23.32	21.37	2.50	0.032	49.38	3.37	9.87	1.62	1.31	0.31
RL 16/83 P_2	646.17	120.00	174.33	5.80	17.47	43.73	2.57	25.23	19.17	1.75	0.031	51.00	4.37	8.60	1.64	1.01	0.63
RL 20/83 P_1	592.50	135.33	183.33	6.20	18.40	32.55	3.07	19.34	18.82	2.30	0.036	52.63	3.60	8.51	0.97	0.55	0.42
RL 88/22	896.50	145.33	180.67	5.80	18.20	36.58	3.40	26.32	21.88	2.62	0.037	49.97	3.10	9.22	0.91	0.22	0.89
RL75/83	781.50	142.67	179.33	7.20	18.93	35.81	2.40	32.70	17.23	2.52	0.032	52.25	3.40	10.99	1.17	0.47	0.70
RL 122 P_1	612.00	136.67	175.00	6.07	17.67	32.83	2.40	25.51	17.57	1.52	0.036	52.50	3.03	9.27	0.55	0.35	0.20
RL 136 P_1	611.33	135.00	173.67	7.00	17.93	32.34	2.20	27.73	13.83	1.64	0.036	53.00	3.10	10.23	0.92	0.58	0.34
RL 136-1 P_1	699.67	136.67	173.67	6.40	16.60	30.78	2.33	30.14	16.39	2.37	0.035	51.50	3.50	9.47	1.18	0.52	0.66
RL 111 P_2	786.17	137.33	177.33	6.40	17.07	38.33	2.73	28.87	16.11	2.26	0.036	51.50	3.13	9.74	1.06	0.43	0.63
RL 111-3 P_2	356.17	141.67	186.67	6.13	18.80	39.01	1.50	24.13	21.09	1.22	0.047	50.50	3.83	9.32	1.15	0.15	1.00
RL 124-2 P_2	806.00	139.67	175.67	5.53	17.87	31.02	2.77	29.14	18.02	2.16	0.038	50.13	3.67	9.25	1.36	0.29	1.07
RL 138 P_2	702.67	138.67	177.67	7.40	18.67	29.53	2.43	29.30	20.78	1.79	0.035	49.63	4.13	10.30	1.78	0.09	1.69
RL 139-1 P_1	630.50	144.00	175.67	6.60	17.40	31.09	2.70	23.38	19.73	2.06	0.035	51.75	3.40	9.37	1.51	0.73	0.78
RL 143 P_2	870.17	145.33	177.00	5.80	17.87	30.71	3.07	28.85	20.97	1.95	0.037	50.75	3.27	9.31	2.25	1.24	1.01
TL 1210	83.17	121.33	181.00	6.40	22.67	41.15	3.93	25.16	20.52	3.00	0.039	54.00	3.90	9.13	2.28	0.63	1.65
TL 1217	1077.83	118.00	178.67	6.67	20.00	46.30	4.17	25.84	21.69	2.46	0.034	56.00	3.10	8.79	2.04	0.38	1.66
HD 2380	551.00	146.67	187.33	6.07	18.66	34.95	2.73	20.62	25.13	2.67	0.035	51.50	3.80	8.77	2.71	0.39	2.32
CPAN 1922	737.67	146.00	177.00	5.87	18.20	35.81	2.93	25.24	17.82	2.64	0.045	53.63	3.27	9.58	3.12	0.62	2.50
HPW 42	536.33	119.33	173.33	6.13	17.93	41.42	2.00	26.58	20.15	1.82	0.041	49.75	3.10	8.63	3.09	0.35	2.74
HS 240	1107.33	138.67	183.33	6.73	20.67	33.03	3.80	28.86	24.42	2.40	0.037	50.75	4.17	10.58	3.76	0.45	3.31

BY= Biological yield, HI= Harvest index, FLA= Flag leaf area LAI= Leaf area index, SLW= Specific leaf weight, SS= Stomatal size, SN= Stomatal number, RS= Reducing sugar, NRS= Non reducing sugar

Positive association of grain yield with biological yield, harvest index and spikelets/spike had also been reported earlier by Amin *et al.* (1992) and Singh and Sethi (1995). With respect to the quality traits, the grain yield exhibited no association with protein, total sugar, reducing and non reducing sugar, which might assist in the predictability of high yielding varieties with high protein, total sugar, reducing sugar and non reducing sugar. However, total sugar had shown positive significant correlation with non reducing sugar. No association of grain yield was observed with other characters indicating the possibility of improvement of grain yield without any adverse effect on the expression of such traits. Interestingly, the grain yield and drought susceptibility index showed no association. Ehdaie *et al.* (1988) also found no association between these two traits indicating these to be independent attributes. Grain yield showed significant positive correlation with cold tolerance which showed that there are certain plant traits, which are desirable under cold stress environment and undesirable under favourable environmental conditions. As far as drought susceptibility index (DSI) was concerned, it showed significant negative correlation with reducing sugar content and positive correlation with specific leaf weight.

Biological yield had the positive direct effect on grain yield at phenotypic level followed by harvest index, specific leaf weight, stomatal number, 1000 grain weight, stomatal size, spikelets/spike and days to heading (Table 2). Similar results were reported by Kumar *et al.* (2005). However, days to maturity, spikes per plant, flag-leaf area and leaf area index had negative direct effect on grain yield. Stomatal size had positive direct effect on grain yield which indicates about efficiency in gaseous exchange, which results in higher photosynthesis, responsible for more grain yield. Whereas, days to heading showed positive and days to maturity showed negative direct effect on grain yield which signifies the effect of grain-filling period. Singh *et al.* (1987) reported that biological yield had positive direct effect on grain yield in triticale. The results of the present study revealed that, stomatal size, stomatal number and specific leaf weight which directly contributed to grain yield, are the traits of physiological base could be used as selection criteria for higher yielding genotypes for drought and cold stress conditions. Biological yield appears to be an important yield determinant as it had high positive direct effect, which indicated that the improvement in the grain yield can be sought by improving the total biomass. Thus, biological yield, harvest index, specific leaf weight, 1000 grain weight, spikelets per spike and stomatal number, appear to be the traits of importance for selecting drought tolerant varieties.

Two derivatives *viz.*, RL-124-2P_2 and RL-111P_2, categorized as cold and drought tolerant (Table 3) with high grain yield, spikes per plant, spikelets per spikes and leaf area index (Table 4) were selected for future hybridization programme.

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