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SHORT COMMUNICATION

GENETIC ANALYSIS OF WHEAT (*TRITICUM AESTIVUM L.*) GENOTYPES FOR PHYSIOLOGICAL TRAITS UNDER DIFFERENT MOISTURE REGIMES

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A study was conducted to work out the phenotypic and genotypic variance, heritability, genetic advance, correlation coefficients and path analysis for yield and physiological traits under three sowing conditions *viz.*, timely sown irrigated, timely sown restricted irrigated and rainfed conditions. All the characters studied showed significant variation in respect of the genotypes under the present investigation. High heritability estimates were found for characters such as canopy temperature depression, grain per spike, membrane injury and relative water content under all the sowing conditions. Positive and significant correlation was observed for canopy temperature depression at anthesis (0.500), and relative water content (0.502). The path coefficients were studied for all the traits under three environments viz., timely sown irrigated, restricted irrigation and rainfed conditions. Canopy temperature depression and membrane injury percent had direct positive effect on yield both at genotypic and phenotypic levels across the three environments.

Key words: **Bread wheat, moisture stress, physiological traits.**

Wheat is grown over 200 mha in a range of environments globally with an annual production likely to reach more than 650 million metric tons in 2009-10 (Yadav *et al.* 2010). Despite remarkable growth in food production, the risks were exposed by food crisis in the recent years. Therefore, wheat production must continue to increase by 2% annually, more particularly in developing world including south-east Asia until 2020 to meet future demands imposed by population and prosperity growth (Reynolds and Tuberosa 2008). This challenge will probably be further compounded by reduced water availability (Shiklomanov & Rodda 2003) and increased temperature due to global warming.

Food security in the world is challenged by increasing food demand and threatened by declining water availability (Zwart and Bastiaanssen 2004). Water deficit is considered to be among the most severe environmental stresses and the major constraint on plant productivity; losses in crop yield due to water stress probably exceeds the loss from all other causes combined (Rampino *et al.* 2006). The deficit has an evident effect on plant growth determined both by severity and duration of the stress (Araus *et al.* 2002; Bartel and Souer 2004). Selection of different genotypes under the environmental stress conditions is one of the main tasks of plant breeders for exploiting the genetic variation to improve the stress tolerant cultivars (Talebi *et al.* 2009). This present study was undertaken to assess the genetic variability and association studies in wheat genotypes for assessment of selection criteria and identification of drought tolerant wheat genotypes, so that suitable genotypes can be recommended for incorporation in the breeding programmes for the development of stress tolerant genotypes.

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Field experiments were conducted at Experimental Farm, Division of Genetics, Indian Agricultural Research Institute, New Delhi, India. The experiment was done under three agronomic conditions (rainfed, restricted irrigation and irrigated conditions) during crop season 2007-2008. Material for the present study comprised of 36 elite genotypes of bread wheat meant for all the agronomic conditions like timely sown irrigated conditions, late sown irrigated conditions and also timely sown rainfed conditions. The experiment was laid out in a 6 x 6 double lattice design with gross plot size 1.38 x 6.0 m. The data was recorded on yield per plot, grains spike^{-1}, canopy temperature depression (CTD), which was measured at anthesis and 10 days after anthesis of the unirrigated crop. Relative water content was determined following the method described by Weatherley (1950). Membrane thermal stability was estimated using procedures as described by Blum and Ebercon (1981). The statistical analysis was carried out using software MSTAT C (1989).

All the characters studied showed significant variation in respect of the genotypes under the present investigation. This variability may be because all the genotypes selected in the present experiment were genetically distinct with more genetic variability for the traits under consideration. The results obtained from present study reveals that the test genotypes behave differently for the studied characters under moisture stress.

The mean performance of the genotypes for all the 6 characters showing variability among the genotypes under three environments viz., optimum environment (timely sown irrigated) and stress environment (restricted irrigation and rainfed conditions) has been presented in Table 1. A significant amount of variation was displayed by 36 bread wheat genotypes grown under three agronomic conditions. This observation clearly explains the high level influence of moisture stress on different characters studied. All characters expressed significant interaction with environment. This indicates that all characters respond to high temperature in different ways in different genotypes.

The values of PCV, GCV, heritability and expected genetic advance are presented in Table 2. It is revealed from the table that more coefficient of variation were observed at phenotypic level for all the 6 characters when compared with the coefficient of variation over in all the three dates of sowing and also in the pooled analysis over the sowing conditions at the genotypic level.

Table 1. Mean performance of genotypes for six characters in irrigated, restricted irrigation and rainfed conditions

Characters	Mean				Range				CD (0.05)			
	Agronomic condition				Agronomic condition				Agronomic condition			
	I	II	III	P	I	II	III	P	I	II	III	P
Yield (grams/plot)	3113.7	2634.7	2180.8	**2643.0**	2185-3915	1950-3367.5	1550-2650	**1895-3326.5**	471.9	343.2	248.3	**211.7**
Grains spike-^{1}	40.8	39.5	38.9	**39.7**	33.8-50.6	34.0-47.5	33.0-49.0	**33.5-47.3**	5.54	6.10	4.43	**3.12**
CTDI	4.6	4.5	4.2	**4.4**	2.4-6.9	2.6-6.6	2.3-6.6	**0.9-4.4**	0.46	0.40	0.42	**0.25**
CTD II	2.7	2.5	2.26	**2.5**	1.5-4.1	1.00-4.9	1.0-3.9	**0.9-4.4**	0.46	0.40	0.42	**0.25**
Membrane Injury (%)	51.4	51.9	54.6	**52.6**	24.9-89.0	30.2-86.0	28.0-88.0	**26.2-86.6**	3.49	3.59	3.63	**2.05**
Relative water content (%)	79.2	76.5	73.0	**76.2**	71.7-85.8	62.5-84.5	61.0-80.5	**66.7-83.2**	1.12	3.94	2.45	**1.58**

I Irrigated, II Restricted irrigation, III Rainfed condition and P pooled

Table 2. Heritability (%), genetic advance, genetic advance as percent of mean, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for six characters in irrigated, restricted irrigated and rainfed conditions

Characters	Heritability (%)				Genetic advance				GA as percentage				GCV				PCV			
	Agronomic condition				Agronomic condition				Agronomic condition				Agronomic condition				Agronomic condition			
	I	II	III	P	I	II	III	P	I	II	III	P	I	II	III	P	I	II	III	P
Yield (grams/plot)	67.6	82.9	87.0	75.9	575.3	704.5	614.4	581.5	18.5	704.6	28.2	22.0	10.9	14.3	14.7	12.3	13.3	15.7	15.7	14.1
Grains spike-1	70.6	53.7	80.8	68.1	7.4	5.0	8.39	6.7	18.1	5.0	21.6	16.8	10.5	8.3	11.6	9.9	12.5	11.3	13.0	12.0
CTDI	97.3	97.7	97.7	97.5	2.8	2.8	2.84	2.8	61.9	2.8	67.0	62.8	30.4	29.9	32.9	30.9	30.9	30.3	33.3	31.3
CTD II	98.8	99.1	98.9	98.9	2.8	2.7	2.45	2.6	105.9	2.7	108.0	106.3	51.8	52.7	52.8	51.9	52.1	52.9	53.1	52.2
Membrane Injury (%)	99.2	99.2	99.2	99.2	39.8	41.1	42.6	41.1	77.5	41.1	78.0	78.2	37.8	38.6	38.0	38.1	37.9	38.8	38.2	38.3
Relative water content (%)	98.0	85.0	96.3	86.9	8.0	8.9	12.6	6.8	10.1	8.9	17.2	8.9	5.0	6.1	8.5	4.6	5.0	6.6	8.7	5.0

I Irrigated, II Restricted irrigation, III Rainfed condition and P pooled

The highest phenotypic coefficient was observed for the character CTD II (10 days after anthesis, 52.2%) pooled over the three sowing conditions followed by CDT I (at anthesis), membrane injury percentage for timely sown irrigated, restricted irrigation, rainfed conditions and pooled over three sowing conditions. It was observed that the phenotypic coefficient of variability was lowest in the optimum sowing conditions which increased under the stress environments (restricted irrigation and rainfed conditions). This may be due to different parentage background of the genotypes. These results indicate that the above traits offer a better opportunity for improvement for selection. The maximum genotypic coefficient of variability was observed for the character CTD II (10 days after anthesis), 51.82, 52.65, 52.76 and 51.92% respectively for irrigated, restricted irrigated, rainfed and pooled over the three environments followed by membrane injury percentage, CTD I (at anthesis). As in the case of phenotypic coefficient of variability, the genotypic coefficient of variability was of lower order in the optimum sowing conditions which gradually increased in the stress environments.

Maximum characters which were investigated, showed high values of broad sense heritability. The physiological traits membrane injury, CTD I, CTD II at 10 days after anthesis and relative water content showed a very high order of broad sense heritability. Some traits have shown very high level of broad sense heritability in the individual environments, but when the heritability was pooled over the sowing conditions, the heritability percentage came down. The heritability expresses the reliability of the phenotypic value as a guide to the breeding value. Heritability in broad sense is the proportion of genotypic variance to phenotypic variance. It also indicates the relative success of selection.

Under timely sown irrigated conditions, the maximum value for the expected genetic advance was observed for CTD I (at anthesis) followed by membrane injury percent, CTD II (at 10 days after anthesis). Under stress environments, the similar trend of expected genetic advance over per cent of mean was observed. The characters which showed the maximum genetic advance as per cent of mean was CTD I (at anthesis) followed by membrane injury, CTD II (at 10 days after anthesis

The amount of expected genetic advance in the rainfed conditions was higher than the moderate stress environment which is restriction irrigation. Generally high heritability percentage is related with higher genetic advance. The genetic advance expected from selection can be best explained if the estimates of heritability and genotypic coefficient of variation were considered together. These characters which gave high GCV coupled with high to moderate heritability and genetic gain support the fact that there is scope of improvement for these traits particularly under high moisture stress conditions.

One of the major objectives of this investigation was to study the association of grain yield with physiological traits under stress as well as under normal environments. The phenotypic correlation is the association between two traits that can be visualized directly and its estimation is done by simple correlation. The genotypic correlation in true sense may be interpreted as the correlation of breeding value. The phenotypic and genotypic correlation coefficients among all the 6 characters under study are presented in Table 3 under all the three agronomic conditions, namely timely sown irrigated, restricted irrigation and rainfed conditions. A perusal of table indicates positive and significant genotypic correlation of grain yield with grains per spike (0.531), CTD II and membrane injury under irrigated conditions. Under the stress conditions, the grain yield was significantly correlated with grains per spike, CTD I, CTD II, membrane injury and relative water content. Similar trend was observed for the pooled analysis over the three agronomic conditions of sowing. Similar results were obtained by Talebi *et al*. (2009) who reported that drought stress caused marked reductions in grain yield and most of its attributes. Phenotypic correlation coefficients between yield and its attributes were estimated for all progenies grown under normal and drought stressed conditions. Both the number of spikes per plant and number of grains per spike were the most important traits associated with grain yield per plant.

The path coefficients were studied for all the traits under three environments viz., optimum condition, restricted irrigation and rainfed condition and are presented in Table 4. A perusal of Table 4 shows direct positive effects of CTD I and CTD II and membrane injury index on yield, both at genotypic and phenotypic levels across the three environments. This result is similar to the findings of Shamsudding (1987) and Singh and Sharma (1994). This indicates that selection for harvest index and biological yield and other traits can be practiced under all the environments for improving yield. Plant breeder also argues that selection for yield components is more effective than that for yield *per se* (Graffius 1956). So, it can be concluded that factors showing significant positive correlation with grain yield should be given priority especially where breeding for varietal improvement for moisture stress condition is concerned.

Table 3. Genotypic and phenotypic correlation coefficient among six characters under irrigated, restricted irrigation and rainfed conditions

Characters	Irrigated conditions		Res. irrigated conditions		Rainfed conditions		Pooled analysis	
	Correlation with yield		Correlation with yield		Correlation with yield		Correlation with yield	
	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic
Grain spike^{-1}	0.531**	0.416*	0.367*	0.330*	0.199	0.212	0.018	-0.015
CTDI	0.316	0.263	0.532**	0.572**	0.499**	0.464**	0.563**	0.500**
CTD II	0.497**	0.448**	0.494*	0.461*	0.514**	0.472*	0.430*	0.375*
Membrane Injury (%)	-0.546**	-0.503**	-0.411*	-0.483*	-0.697**	-0.659**	-0.336*	-0.288
Relative water content (%)	0.241	0.185	0.351*	0.343*	0.606**	0.541**	0.543**	0.502**

Table 4. Genotypic and phenotypic path among six characters under irrigated, restricted irrigation and rainfed conditions.

Characters	Irrigated conditions		Res. irrigated conditions		Rainfed conditions		Pooled analysis	
	Direct effect on yield		Direct effect on yield		Direct effect on yield		Direct effect on yield	
	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic
Grain spike^{-1}	-0.639	-0.245	-0.455	-0.176	-0.092	0.050	0.013	-0.421
CTDI	-0.788	-0.302	0.456	-0.360	0.113	0.410	0.206	0.422
CTD II	0.217	0.718	0.774	0.871	0.606	0.881	0.807	0.587
Membrane Injury (%)	-0.289	-0.152	-0.894	0.237	0.744	0.597	0.136	0.471
Relative water content (%)	-0.590	-0.345	-0.884	-0.042	0.864	0.438	0.616	-0.353
Residual Effect	-0.8139	0.4703	0.4571	0.5073	0.1001	0.3793	0.7708	0.4494

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