



Association of physiological and morphological traits with grain yield under moisture stress conditions in bread wheat (*Triticum aestivum*)

KALLESHT¹, G P SINGH², ANJU M SINGH³, R K SHARMA⁴, AJAY ARORA⁵ and ARVIND AHLAWAT⁶

Indian Agricultural Research Institute, New Delhi 110 012

Received: 30 July 2011; Revised accepted: 17 September 2013

Key words: Bread wheat, Genetic variability, Morpho-physiological traits, Moisture stress

Developing high yielding wheat (*Triticum aestivum* L.) cultivars under drought conditions in arid and semi-arid a region is an important objective of breeding programme (Leilah and Khateeb 2005). Simulating performance of wheat under soil moisture deficit presents special challenge for wheat modelers, due to wide variation in grain yield under normal and water stress conditions (Gupta *et al.* 2001). The uncertainty of water availability and of temperature conditions during the crop growth period calls for better resilience under fluctuating water and temperature regimes (Richards *et al.* 2002.). The ideal genotype for moisture stress condition must combine a reasonably high yield potential under varied environmental conditions with specific plant characters which could buffer yield against severe moisture stress (Condon *et al.* 2002). This study was conducted to clarify the relationship between grain yield in wheat and its components under drought conditions. The aim was to provide information to the wheat breeders regarding genetic correlations of the main agronomic characters along with the physiological traits that influence the wheat productivity under drought conditions.

Field experiments were conducted at Indian Agricultural Research Institute, New Delhi, India in two agronomic conditions (rainfed and restricted irrigation conditions) during crop season 2008-10. Material for the present study comprised 150 genotypes of bread wheat. The experiment was laid out in a lattice design with two replications. The gross plot size of the experiment was 1.38 m × 4.0 m, with rows at 23 cm apart. The data were recorded on 10 plants from each plot on

early vigour (EV), number of tillers, flag leaf area (FLA), relative water content (RWC), canopy temperature depression (CTD), days to maturity, grains/spike, 1000 kernel weight, harvest index and grain yield/plot. The statistical analysis was carried out using software MSTAT C (1989).

The genotypic variance for all the ten characters was found highly significant for restricted irrigation and for restricted irrigation conditions all the characters except number of grains/spike thereby indicating the availability of sufficient variability was present for making selection in all the ten characters. The percent phenotypic and genotypic coefficient of variation for all the ten characters studied under rainfed and restricted irrigation conditions are presented in the Table 1. Higher coefficient of variation was observed at phenotypic level for both the agronomic conditions and also the pooled analysis. The characters showing higher values of phenotypic coefficient of variability (PCV) in pooled analysis were early vigour, CTD, number of tillers, number of grains/spike, grain weight/spike. Decrease in the PCV values of pooled analysis in comparison to rainfed and restricted irrigation were observed for traits grains/spike, grain weight/spike and early vigour. In the present investigation, the estimates of phenotypic coefficients of variation were higher than the genotypic coefficient of variation for all the characters under study. This may be due to the fact that variability at the phenotypic level includes both genotypic and environmental variability. In case of characters which had deviation of genotypic coefficient of variability (GCV) from PCV may be attributed to environmental variables like photoperiod and temperature, changing time sequence of flower initiation and concomitantly affecting tillering behavior and grain size. In general, all the characters showed high estimates of heritability for all the characters except early vigour that had moderate estimates of heritability. In rainfed conditions, high estimates of heritability were recorded for days to maturity, harvest index, grain weight/spike, CTD, 1000 kernel weight, days to heading and number of tillers. Under the restricted irrigation conditions

Based on complete M Sc Thesis of the first author submitted to IARI, New Delhi

¹Ph D Student (email:kalleshtd@gmail.com), ^{2&3}Senior Scientist (email: gyanendrapsingh@hotmail.com, anju_mahendru@yahoo.co.in, ⁴Principal Scientist (email: sharma.rk.rk@gmail.com), ⁶Technical Officer (email: ahlawatavind@yahoo.com) Division of Genetics, ⁵Principal Scientist, Division of Plant Physiology (email: romiarora@yahoo.com), IARI, New Delhi 110 012

Table 1 Heritability (%), genetic advance as percent of mean, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for ten characters in restricted irrigated and rainfed conditions

Characters	General Mean		Heritability		Genetic advance		GA as percentage		GCV		PCV							
	Agronomic Condition		Agronomic condition		Agronomic condition		Agronomic condition		Agronomic condition		Agronomic condition							
	I	II	I	II	I	II	I	II	I	II	I	II						
Early vigour	3.20	3.06	0.446	0.560	0.388	0.95	0.95	0.79	30.55	33.56	27.23	23.85	20.33	20.08	33.89	28.97	21.95	
No. of tillers	99.41	102.6	0.84	0.94	0.78	35.64	39.21	30.23	34.55	45.25	33.19	19.52	26.37	16.64	22.23	26.31	19.22	
Flag leaf area	22.13	24.21	23.02	0.81	0.85	0.79	3.65	4.52	6.64	11.20	11.67	10.28	3.67	3.98	3.01	4.67	4.84	4.88
Relative water content	12.4	12.3	12.6	0.85	0.88	0.56	4.23	4.58	3.67	10.12	12.03	9.67	18.62	11.23	10.33	19.63	15.65	12.34
Canopy temp. dep.	4.95	4.02	4.53	0.90	0.92	0.77	2.11	1.88	1.36	45.67	47.88	36.21	22.31	22.89	18.98	25.64	24.60	22.31
Days/maturity	122.08	120.3	115.6	0.94	0.95	0.78	8.58	6.36	5.46	9.00	7.54	6.08	4.99	4.29	3.18	5.07	4.64	4.18
Grains per spike	46.25	39.67	42.56	0.79	0.85	0.64	15.88	12.66	8.29	33.64	36.41	19.24	19.63	19.85	14.56	22.63	20.09	15.08
1000 kernel weight	38.64	41.23	40.01	0.85	0.88	0.88	10.33	11.37	9.55	27.64	25.22	21.31	14.60	12.04	9.44	14.85	11.13	10.21
Harvest Index	0.39	0.40	0.39	0.94	0.95	0.82	0.10	0.08	0.07	22.18	17.56	13.67	11.68	8.97	5.14	13.67	8.25	5.79
Grain yield /plot	1239.2	1562.9	1344.6	0.85	0.89	0.52	415.2	422.9	308.9	33.56	32.94	24.69	17.64	16.58	14.98	18.95	16.54	17.39

also the similar trend was observed. In pooled analysis, highest estimate of heritability was observed for 1000 kernel weight, grain weight/spike, harvest index, days to maturity, CTD, number of tillers. Moderate values of heritability were observed for grains/spike, grain yield. Prasad *et al.* (2006) reported high heritability estimates for most of the characters which supports the results obtained.

The expected genetic advance for ten characters is presented in the Table 1. The results indicated that characters CTD, grain weight/spike, and number of tillers have higher values and grains/spike, early vigour, grain yield, 1000 kernel weight and harvest index have the moderate estimates, while lower estimates of genetic advance was observed for days to heading, days to maturity under rainfed conditions. In the pooled analysis higher values were obtained for character tillers, CTD and grain weight/spike and moderate values early vigour, 1000 grain weight and grain yield. The characteristics which had high genetic advance coupled with high heritability estimates such as number of tillers, CTD and grain weight/spike suggested that genotypic variation in the present material for these characters may possibly be due to high additive genetic variance. Character grain yield had moderate genetic advance coupled with moderate heritability estimates indicating the presence of positive alleles which are inherited from generation to generation and could be improved by simple selection procedure

Table 2 shows the genotypic correlation coefficients under timely sown restricted irrigation and rainfed condition. A perusal of table indicates positive and significant genotypic correlation of grain yield with early vigour (0.356*), number of tillers (0.623**), CTD (0.566**) under restricted irrigated conditions. Under the stress conditions, the grain yield was significantly correlated with early vigour, number of tillers, relative water content, canopy temperature depression, grains/spike, and 1000 kernel weight. Similar trend was observed for the pooled analysis over the two agronomic conditions of sowing. Similar results were obtained by Sobieh *et al.* (2007), Kendice *et al.* (2009), Rashidi *et al.* (2011), Gowda *et al.* (2011), Bilgen *et al.* (2011) and Xio-li *et al.* (2012) who reported that drought stress caused marked reductions in grain yield and most of its attributes.

A perusal of the Table 2 shows that in the rainfed environment, early vigour, flag leaf area, relative water content, canopy temperature depression, 1000 kernel weight and harvest index had positive direct effects on grain yield/plot. The high positive correlation of the above traits and high positive direct effects give ample proof that these characters contribute most to the grain yield and they are the ones to be given utmost consideration during genetic improvement of the wheat crop under rainfed environments. These results are in agreement with Munjal and Dhanda (2004) and Gowda *et al.* (2011). It is evident from the results presented in the Table 4 showing phenotypic and genotypic

Table 2 Genotypic & Phenotypic correlation coefficient among ten characters under restricted irrigation & rainfed conditions

Characters	Res. irrigated conditions				Rainfed conditions				Pooled analysis			
	Correlation with yield		Direct effect on yield		Correlation with yield		Direct effect on yield		Correlation with grain yield		Direct effect on yield	
	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic
Early vigour	0.356*	0.122	0.007	0.003	0.448**	0.412**	0.320	0.231	0.399*	0.309*	0.014	0.011
No. of tillers	0.623**	0.557**	0.03	0.03	0.701**	0.641**	0.023	0.017	0.112	0.098	0.004	0.026
Flag leaf area	0.127	0.112	0.231	0.109	0.204	0.200	0.218	0.210	0.155	0.140	0.196	0.155
Relative water content	0.129	0.110	0.216	0.162	0.427**	0.413**	0.521	0.499	0.456**	0.432**	0.426	-0.226
Canopy temp. dep.	0.566**	0.503**	0.217	0.718	0.441*	0.419*	0.604	0.511	0.502**	0.476*	0.881	0.807
Days to maturity	0.102	0.099	-0.014	-0.013	0.189	0.177	-0.017	-0.012	-0.169	-0.155	-0.129	-0.019
Grains per spike	0.241	0.185	-0.011	0.010	0.351*	0.343*	0.347	0.29	0.598**	0.541**	0.041	0.031
1000 kernel weight	0.297	0.179	0.102	0.110	0.369*	0.326*	0.317	0.019	0.455**	0.418**	-0.016	-0.049
Harvest Index	0.150	0.097	0.641	0.623	0.196	0.159	0.588	0.589	0.085	0.095	0.777	0.633
Residual effect			0.0072	0.0087			0.0046	0.0066			0.0013	0.0155

path values of the pooled analysis that days to heading, flag leaf area, relative water content, canopy temperature depression, harvest index had high positive direct effect on grain yield. It was interesting to note that the residual effects were more than 20% that infers that more than 98% of the total genetic variability in yield has been explained by the traits included in the study.

SUMMARY

Based on the GCV, PCV, heritability, genetic advance, correlation and path coefficient analysis (grain yield as dependent variable) the selection on the characters had direct effect on grain yield like, harvest index, CTD, relative water content of wheat (*Triticum aestivum* L.). Selection could also be done for those characters through which the indirect effects of 1 000 grain weight, number of grains/spike and grain weight/spike were acting. The characters like effective tillers and phenological traits have scope of selection for better yield under high moisture stress conditions as indirect effects were reflected through them.

REFERENCES

- Bilgen O, Korkut K Z, Baser I, Daglioglu, Ozturk I, Khamran T and Balkan A. 2011. Genetic variation and interrelationship of some morphological traits in durum wheat. *Pakistan Journal of Botany* **43(1)**: 253–60.
- Condon A G, Richards R A, Rebetzke G J and Farquhar G D. 2002. Improving intrinsic water use efficiency and crop yield. *Crop Science* **42**: 122–31.
- Gupta N K, Gupta S and Kumar A. 2001. Effect of water stress on physiological attributes and their relationship with growth and yield of wheat cultivars at different stages. *Journal of Agronomy and Crop Science* **186(1)**: 55.
- Kandice V, Dodig D, Jovic M, Nikolic B and Prodanovic S. 2009. The importance of physiological traits in wheat breeding under irrigated and drought conditions. *Genetika* **41(1)**: 11–20.
- Leilah A A and Al-Khateeb S A. 2005. Statistical analysis of wheat yield under drought conditions. *Journal of Arid Environments* **61**: 483–96.
- MSTAT C. 1989. MSTAT-C Software, Version 1.4. Crop and Soil Science Department, Michigan State University, East Lansing, MI.
- Prasada J, Kerketta V, Prasad K D and Verma A K. 2006. Study of genetic parameter under different environment conditions in wheat (*Triticum aestivum* L.). *Journal of Research (BAU)* **18(1)**: 135–40.
- Rashidi V. 2011. Genetic parameters of some morphological and physiological traits in durum wheat. *African Journal of Agricultural Research* **6(10)**: 2 285–88.
- Renu M and Dhanda S S. 2004. Association of heat tolerance in bread wheat. *National Journal of Plant Improvement* **6(1)**: 71–3.
- Richards R A, Rebetzke G J, Condon A G and van Herwaarden A F. 2002. Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals. *Crop Science* **42**: 111–21.

- Robinson H. F, Comstock R E and Harvey P H. 1951. Estimates of genetic and environmental variability in soybean. *Agronomy Journal* **47**: 314–18.
- Samrat Gowda DS, Singh G P and Anju M Singh. 2011. Relationship between canopy temperature depression, membrane injury, relative water content with grain yield in wheat under hot environments. *Indian Journal of Agricultural Research* **81(3)**: 197–202.
- Sobieh S E S, Moustafa R A K and El Gendy RW. 2007. Selection for drought tolerance in advanced generation of some bread wheat crosses. *Egyptian Journal of Plant Breeding* **11(3)**: 55–68.
- Xio-li W U and Wei-Kai Bao. 2012. Statistical analysis of leaf water use efficiency and physiological traits of winter wheat under drought conditions. *Journal of Integrative Agriculture* **11(1)**: 82–89.