The Bioscan 10(2): 841-845, 2015 (Supplement on Genetics and Plant Breeding)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

GENETIC STUDY OF GRAIN MORPHOLOGICAL TRAITS AND RELATION TO GRAIN YIELD IN BREAD WHEAT GENOTYPES

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KEYWORDS
Grain morphology
Character association
Combining ability
Wheat

Received on :
18.01.2015

Accepted on :
22.04.2015

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ABSTRACT
Present investigation includes six bread wheat cultivars with fifteen F_1's hybrid in three replications using randomized block design (RBD). ANOVA for combining ability revealed that non-additive components of genetic variation were present in governing the inheritance of all grain characteristics, Therefore, good success can be achieved when selection for number of grains per panicle (GW-273), grain length and grain width (C-306),having a high value of *gca*. Characteristics with a high *sca* can be used for hybrid wheat production or application haploid production *via* anther culture on F_1's progenies, (HW-147/GW-273, GW-273/C-306, HD-2864/HW-147 and HI-1544/HD-2864). Thus, it is also suggested from these results that selection for the right characteristics will ensure to improvement of more than one characteristic simultaneously, due to the correlation among different traits. The results obtained from this study might be helpful for wheat breeders trying to develop new varieties with better grain features to improve the milling and baking quality of wheat.

INTRODUCTION

One of the main components of the domestication syndrome in cereals is an increase in grain shape or size (Fuller, 2007; Brown *et al.,* 2009).Grain shape or size does not appear to have been a major component of the wheat domestication syndrome, in contrast with other cereal species, such as rice (*Oryza sativa*), where the domestication process involved strong selection both for grain size and shape (Kovach *et al.*, 2007). Therefore grain shape and size in wheat are recent breeding targets dictated by the market and industry requirements. Indeed, these grain characters are important attributes for determining the market value of wheat grain since they influence the milling performance (*i.e.*, flour quality and yield).Theoretical models predict that milling yield could be increased by optimizing grain shape and size with large and spherical grains being the optimum grain morphology (Evers *et al.,* 1990). Grain size was also found to be associated with various characteristics of flour, such as protein content and hydrolytic enzymes activity, which in turn determine baking quality and end-use suitability (Millar *et al.*, 1997; Evers, 2000).Previous studies used a limited number of metrics that were analyzed discretely largely in single mapping populations (Giura and Saulescu, 1996; Campbell *et al.,* 1999; Dholakia *et al.,* 2003; Breseghello and Sorrels, 2007; Sun *et al.,* 2009). The present study was conducted to estimate the association of different grain morphological traits with grain yields along with the gene action and their extent contribution to yield.

MATERIALS AND METHODS

Six cultivars of spring bread wheat (*Triticum aestivum* L.) were crossed in a diallel design Griffing's (1956), excluding reciprocals. These six parents (HI-1544, HD-2864, HW-147, GW-273, C-306 and JWS-17) were selected because of the diversity of their grain characteristics and widely used as commercial cultivars. Fifteen F_1's hybrids, together with the six parents, were planted on *Rabi 2012* according to a randomized blocked design with 3 replications at the College farm, College of Agriculture, Rewa, JNKVV (MP). Plots of F_1's hybrids and their parents consisted of 3 rows 1m long containing 10 plants that were spaced 10 cm within the rows. Spacing between rows was 22cm. Ten competitive plants from the parents and F_1's were sampled randomly from the 10 marked plants from each plot. Plants were harvested when grain moisture was about 13 per cent. Data on different spike characteristics number of grains/spike, grain yield/spike, test weight and grain yield/plant were recorded from the 10 marked main stems of plants in each plot. The data on different physical properties of grain were also collected from the main stem spikes of the same 10 marked plants of each genotype/cross. For uniformity, spikes of the main stem were divided into 3 parts: central, apical, and basal, grains from each of the portions of spikes were separated manually. Five grains were randomly selected from each of the central, apical, and basal portions of the spike in order to measure different grain physical properties. In total, 9,450 grains were analyzed: 15 grains (5 grains from each part of spike of the main stem) of each of 10 randomly selected plants from each of 21 genotype/crosses with 3 replications. Grain length (mm), grain width (mm), and grain-length width ratio (%) were calculated by using High Throughput Phenotyping Software "SmartGrain" image pixel adjusted to (1mm=10mm) for data accuracy (Tanabata T.*et al.,* 2012).The analyses of variance for general combining ability (*gca*) and specific combining ability (*sca*) and association among traits were carried out using Griffing's (1956) Method 1 and Model II (including parents and F_1's) using the Indostat 9.1 Agriculture Statistical Analysis Program.

RESULTS AND DISCUSSION

The diallel analysis between six bread wheat cultivars was performed in order to evaluate the mode of inheritance and combining ability of grain characteristics and some yield characteristics. The mean values of six parents and their fifteen F_1's hybrids for all characteristics under consideration are presented in (Table 1). The analysis of variance for combining ability (*gca*) and specific combining ability (*sca*) were highly significant for all the traits studied (Table 2). This study is in agreement with previously established literature, which reported significant differences between genotypes for different grain characteristics (Borghi and Perenzin, 1994; Li *et al.,* 1997; Pecetti *et al.,* 2001; Sharma *et al.,* 2003; Joshi *et al.,* 2004; Singh *et al.,* 2004; Daðustu, 2008; Çifci, 2012; Singh *et al.,* 2014).

Variance of *gca* was higher for number of grains/ panicle and grain length, while the traits grain width, length width ratio, test weight, grain yield/ panicle and grain yield/ plant showed high *sca* variance. Non-additive gene action prominent in controlling of all the traits studied, in accordance lowest (*gca*/*sca*) ratios observed as 0.034 (grain yield/ plant), 0.058 (grain width), 0.061 (grain yield/ panicle) and 0.063 (length width ratio) respectively, as reported by Sharma and Sain (2004). The importance of dominant gene effects was reported by Gorjanovic and Balalic 2005; Singh *et al.,* 2013; Kumar and Kerkhi, 2014).

Estimates of general combining ability *gca* (Table 3) revealed that the parent HW-147, C-306 and JWS-17 were good combiners for number of grains/ panicle; C-306, HD-2864 and JWS-17 for grain length; C-306 was only good general combiner for grain width; similarly HD-2864 for length width ratio; JWS-17, HI-1544 and HD-2864 for test weight; HW-147 and JWS-17 for grain yield/ panicle and HW-147, GW-273 and C-306 was found to be good general combiners for grain yield/plant. The choice of appropriate components for crossing is the first and foremost step in the creation of a new crop cultivar. Breeders used combining ability to select those parents that have maximum potential of transmitting desirable genes in the progenies (Gorjanovic and Balalic, 2005; Çifci, 2012; Kumar and Kerkhi, 2014).

Estimates of specific combining ability (*sca*) of the crosses are given in (Table 3). HI-1544/C-306, HD-2864/JWS-17 and HW-147/C-306 combination can be used to develop desirable progenies for trait number of grains/panicle, whereas HW-147/GW-273 and GW-273/JWS-17 for grain length; HW-147/GW-273, GW-273/JWS-17 and C-306/JWS-17 had high *sca* effect for grain width; HD-2864/HW-147 and HD2864/GW-273 combination had high *sca* effect for grain length width ratio; furthermore HW-147/JWS-17 and HI-1544/GW-273 can

Table 1: Means of grain morphological traits of parents and their F_1 progeny in 6 x 6 diallel cross of bread wheat

Parents/ Crosses	NGPP	GL	GW	LWR	TW	GYP	GYPP
HI-1544	27.20	48.91	22.95	2.15	42.87	2.15	2.95
HI-1544/HD-2864	34.43	48.74	22.95	2.15	42.49	3.09	23.27
HI-1544/HW-147	43.73	48.74	21.03	2.34	37.93	3.00	7.32
HI-1544/GW-273	33.40	49.36	21.91	2.27	45.81	1.74	10.66
HI-1544/C-306	50.77	50.67	22.30	2.29	36.37	2.96	19.71
HI-1544/JWS-17	37.53	49.99	22.80	2.21	38.25	2.42	15.55
HD-2864	22.00	55.74	24.46	2.30	47.41	2.47	4.51
HD-2864/HW-147	48.40	53.84	21.61	2.52	35.45	2.76	29.24
HD-2864/GW-273	42.80	50.88	20.99	2.45	37.57	2.46	3.52
HD-2864/C-306	26.87	51.57	23.82	2.18	36.65	2.60	7.53
HD-2864/JWS-17	49.17	50.93	21.43	2.40	36.97	2.12	12.64
HW-147	43.33	49.82	22.94	2.19	39.43	2.82	3.23
HW-147/GW-273	48.77	55.66	25.76	2.18	34.65	2.12	45.10
HW-147/C-306	58.97	50.27	23.51	2.16	32.07	2.27	22.05
HW-147/JWS-17	52.60	50.20	21.88	2.32	54.25	3.86	16.05
GW-273	29.03	50.87	22.78	2.25	38.07	2.30	4.44
GW-273/C-306	50.63	52.43	23.71	2.23	32.63	2.41	33.27
GW-273JWS-17	46.20	54.64	24.43	2.26	40.13	3.35	11.67
C-306	30.97	54.18	23.46	2.40	41.47	2.24	3.86
C-306/JWS-17	44.93	54.28	24.64	2.22	35.93	2.84	19.93
JWS-17	31.97	50.97	21.97	2.33	43.63	2.11	4.24
Mean	40.65	51.55	22.92	2.28	39.52	2.58	14.32
C.V.	3.82	0.12	3.73	4.07	2.58	3.39	7.01
S.E.	0.90	0.04	0.49	0.05	0.59	0.05	0.58
C.D. 5%	2.56	0.10	1.41	0.15	1.68	0.14	1.66
Range Lowest	22.00	48.74	20.99	2.15	32.07	1.74	2.95
Range Highest	58.97	55.74	25.76	2.52	54.25	3.86	45.10

NGPP: grains/panicle, GL: grain length, GW: grain width, LWR: length width ratio, TW: test weight, GYP grain yield per panicle, GYPP: grain yield per plant.

Table 2: Analysis of variance for combining ability of grain morphological traits in bread wheat

Source of variation	df	NGPP	GL	GW	LWR	TW	GYP	GYPP
GCA	5.000	140.446**	8.806 **	0.976**	0.007*	23.033 **	0.13***	43.400**
SCA	15.000	91.386**	3.946 **	1.835**	0.012**	29.040**	0.279**	160.587**
Error	40.000	0.803	0.001	0.244	0.003	0.347	0.003	0.336
sl² g		17.455	1.101	0.092	0.001	2.836	0.017	5.383
sl² s		90.583	3.944	1.592	0.009	28.693	0.277	160.252
GCA/SCA Ratio		0.193	0.279	0.058	0.063	0.099	0.061	0.034

*, ** Significant at $P < 0.05$, $P < 0.01$ probability level, respectively

Table 3: Estimation of general combining ability (GCA), specific combining ability (SCA) in the F_1 generation for grain morphological traits in bread wheat

Parents	NGPP	GL	GW	LWR	TW	GYP	GYPP
HI-1544	-3.788**	-1.947**	-0.444 **	-0.046 *	1.239 ***	-0.063 **	-2.23 **
HD-2864	-4.862**	0.818**	-0.09	0.046 *	0.909 ***	-0.007	-1.879 **
HW-147	6.821**	-0.318 **	-0.097	-0.006	-0.433 *	0.203 **	3.245 **
GW-273	-0.588*	0.477 **	0.24	-0.004	-1.218 **	-0.169 **	1.607 **
C-306	1.192**	0.835 **	0.557**	-0.006	-2.511 **	-0.058 **	1.246 **
JWS-17	1.225**	0.135 **	-0.166	0.017	2.014 **	0.095 **	-1.989 **
CD 5%	0.743	0.03	0.41	0.044	0.489	0.042	0.481
S.E.	1.152	0.047	0.635	0.069	0.757	0.065	0.745
HI-1544/HD-2864	2.431**	-1.685**	0.564	-0.126*	0.816	0.587**	13.054**
HI-1544/HW-147	0.048	-0.552**	-1.35**	0.116**	-2.401**	0.287**	-8.017**
HI-1544/GW-273	-2.877**	-0.727**	-0.806	0.047	6.264**	-0.604**	-3.039**
HI-1544/C-306	12.71**	0.225**	-0.734	0.069	-1.884**	0.508**	6.370**
HI-1544/JWS-17	-0.557	0.245**	0.49	-0.037	-4.529**	-0.185**	5.448**
HD-2864/HW-147	5.789**	1.783**	-1.124*	0.201**	-4.551**	-0.009	13.549**
HD-2864/GW-273	7.598**	-1.972**	-2.08**	0.135*	-1.646**	0.06	-10.53**
HD-2864/C-306	-10.115**	-1.640**	0.433	-0.132*	-1.274*	0.089	-6.155**
HD-2864/JWS-17	12.152**	-1.580**	-1.234*	0.065	-5.479**	-0.548**	2.190**
HW-147/GW-273	1.881*	3.945**	2.696**	-0.086	-3.224**	-0.487**	25.926**
HW-147/C-306	10.302**	-1.804**	0.129	-0.104*	-4.511**	-0.452**	3.235**
HW-147/JWS-17	3.902**	-1.174**	-0.778	0.03	13.144**	0.981**	0.47
GW-273/C-306	9.377**	-0.439**	-0.007	-0.033	-3.166**	0.064	16.099**
GW-273JWS-17	4.910**	2.471**	1.436**	-0.032	-0.191	0.851**	-2.266**
C-306/JWS-17	1.864*	1.753**	1.329**	-0.066	-3.099**	0.223**	6.356**
CD 5%	1.704	0.069	0.939	0.102	1.12	0.096	1.101
S.E.	2.542	0.103	1.401	0.152	1.672	0.143	1.644

*, ** : Significant at $P < 0.05$, $P < 0.01$ probability level, respectively.

be used to improve test weight; HW-147/JWS-17 and GW-273/JWS-17 had high *sca* effect for grain yield/ panicle and HW-147/GW-273, GW-273/C-306, HD-2864/HW-147, HI-1544/HD-2864 produce significant *sca* value for grain yield/ plant. For self-pollinated crops like wheat, *sca* based on heterotic effect is likely to have a small contribution toward the improvement of any particular trait. The crosses having high *sca* were higher yielding, and in most of the crosses one of the parents involved was a good general combiner, indicating that these combinations would yield desirable transgressive segregants (Joshi *et al.*, 2004; Cifci, 2012; Kumar and Kerkhi, 2014).

Correlation coefficient for different grain characters showed that significant and positive correlations exist between most of the traits (Table 4); Correlation analysis for different grain characters revealed that the number of grains/panicle had a significant positive association with grain yield/ panicle and grain yield/ plant and significant negatively association with test weight; grain length had significant positive association with grain width and grain yield/plant; grain width had significant positive association with grain yield/ plant and significant negatively associate with length width ratio; test weight had positively associate with grain yield/ panicle but negative association with grain yield/ plant was observed. Correlation between different traits is generally due to the presence of linked genes and the epistatic effect of different genes. Environment plays an important role in correlation. In some cases, environment affects both the traits simultaneously in the same direction or sometimes in different directions. This contradicts the findings of Topal *et al.* (2004), Acreche and Slafer (2005), Daðustu (2008) Çifci (2012); who discovered a positive correlation between grain length and grain yield in durum wheat. From the results of the correlation analysis, it could be concluded that the size of the wheat grain can be improved by selecting progenies with grain width and length of grains, whereas the effects of other features cannot be omitted.

In this study, we observed that non-additive components of genetic variation were present in governing the inheritance of all grain characteristics, Therefore, good success can be achieved when selection for number of grains per panicle (GW-273), grain length and grain width (C-306), having a high value of *gca*. Characteristics with a high *sca* can be used for hybrid wheat production or application of double haploid

Table 4: Correlation coefficients among spike and grain morphological traits in bread wheat

Character's	NGPP	GL	GW	LWR	TW	GYP	GYPP
NGPP	1	0.0067	-0.0781	0.0975	-0.3934**	0.3343**	0.5915**
GL		1	0.5786**	0.1624	-0.1478	-0.0235	0.3246**
GW			1	-0.6922**	-0.1456	-0.057	0.343**
LWR				1	0.0353	0.0352	-0.1385
TW					1	0.2767*	-0.4198**
GYP						1	0.0668
GYPP							1

*, ** Significant at $P < 0.05$, $P < 0.01$ probability level, respectively d.f.: degree of freedom; NGPP: grains/panicle, GL: grain length, GW: grain width, LWR: length width ratio, TW: test weight, GYP grain yield per panicle, GYPP: grain yield per plant.

production *via* anther culture on F_1's progenies, (HW-147/GW-273, GW-273/C-306, HD-2864/HW-147, HI-1544/HD-2864). Thus, it is also suggested from these results that selection for the right characteristics will ensure improvement of more than one characteristic simultaneously, due to the correlation among different traits. In some countries (*e.g.,* the US, Australia, and Canada) a new cultivar must meet a prescribed minimum level of quality before it is recommended for registration for commercial production. Therefore, in these countries, a simple test known as 'Single Kernel Wheat Characterization System (SKCS)' has been widely used to test the quality of wheat grains. This test was developed to determine morphology of wheat grain, such as grain weight, size of grain, hardness, thickness, and length of grains that become prominent for end-use quality and for wheat importers throughout the world. Moreover, the knowledge of morphology of wheat grains is important for designing a machine for sowing, handling, milling, cleaning, storing, and conveying purposes. This strategy might be helpful for wheat breeders to develop new varieties with better grain features to improve the milling and baking quality of wheat.

REFERENCES

Acreche, M. M. and Slafer, G.A. 2005. Grain weight response to increases in number of grains in wheat in a Mediterranean area. *Field Crops Res.* **98:** 52-59.

Borghi, B. and Perenzin, M. 1994. Diallel analysis to predict heterosis and combining ability for grain yield, yield components and bread making quality in bread wheat (*T. aestivum*). *Theoretical and Applied Genetics.* **89:** 975-981.

Breseghello, F. and Sorrels, M. E. 2007. QTL analysis of kernel size and shape in two hexaploid wheat mapping populations. *Field Crops Res.* **101:** 172-179.

Brown, T. A., Jones, M. K., Powell, W. and Allaby, R. G. 2009. The complex origins of domesticated crops in the Fertile Crescent.*Trends Ecol. Evol.* **24:** 103-109.

Campbell, K. G., Bergman, C. J., Gualberto, D. G., Anderson, J. A., Giroux, M. J., Hareland, G., Fulcher, R. G., Sorrells, M. E. and Finney, P.L. 1999. Quantitative trait loci associated with kernel traitsin a soft x hard wheat cross. *Crop Sci.* **39:** 1184-1195.

Çifci, E. A. 2012. Estimate of heterosis, correlation and path analysis for grain yield per spike and some agronomic traits on durum wheat (*Triticum durum* desf). *The J. Ani. and Plant Sci.* **22(3):** 747-752.

Daðustu, N. 2008. Genetic analysis of grain yield per spike and some agronomic traits in diallel crosses of bread wheat (*Triticum aestivum* L). *Turk. J. Agric. For.* **32:** 249-258.

Dholakia, B. B., Ammiraju, J. S. S., Singh, H., Lagu, M. D., Ro¨der, M. S., Rao, V. S., Dhaliwal, H. S., Ranjekar, P. K., Gupta, V. S. and Weber, W. E. 2003. Molecular marker analysis of kernel size and shape inbread wheat. *Plant Breed.* **122:** 392-395.

Evers, A. D. 2000. Grain size and morphology: Implications for quality. In Wheat Structure, Biochemistry and Functionality, *D. Schofield, ed (London: Royal Society of Chemistry).* pp. 19-24.

Evers, A. D., Cox, R. I., Shaheedullah, M. Z. and Withey, R. P. 1990. Predicting milling extraction rate by image analysis of wheat grains. *Appl. Biol.* **25:** 417-426.

Fuller, D. Q. 2007. Contrasting patterns in crop domestication and domestication rates: Recent archaeobotanical insights from the Old World. *Ann. Bot.* (Lond.) **100:** 903-924.

Giura, A. and Saulescu, N. N. 1996. Chromosomal location of genes controlling grain size in a large grained selection of wheat (*Triticum aestivum* L.). *Euphytica.* **89:** 77-80.

Gorjanovic, B. and Balalic, M. K. 2005. Inheritance of plant height and spike length in wheat. *Genetika.* **37:** 25-31.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. *Aust. J. Bio. Sci.* pp. 463-493.

Joshi, S. K., Sharma, S. N., Singhania, D. L. and Sain, R. S. 2004. Combining ability in F_1 and F_2 generations of diallel cross in hexaploid wheat. *Hereditas.* **141:** 115-121.

Kovach, M. J., Sweeney, M. T. and McCouch, S. R. 2007. New insights into the history of rice domestication. *Trends Genet.* **23:** 578-587.

Kumar Dinesh and Kerkhi, S. A. 2014. Heterosis studies for yield component traits and quality in spring wheat (*Triticum aestivum* L.).*The Bioscan.* **9(4):** 1725-1731

Li, Y., Peng, J. and Lue, Z. 1997. Heterosis and combining ability for plant height and its components in hybrid wheat with (*Triticum timopheevi*) cytoplasm. *Euphytica.* **95:** 337-345.

Millar, S. J., Whitworth, M. B. and Evers, A. D. 1997. Image analysis: The prediction and assessment of wheat quality and milling properties. *In Proceedings of the International Wheat Quality Conference, J.L. Steele and K.O. Chung, eds (Manhattan, KS: Grain Industry Alliance),* pp. 141-151.

Pecetti, L., Doust, M. A., Calcagno, L., Raciti, C. N. and Boggini, C. 2001. Variation in morphological and agronomic traits, and protein composition in durum wheat germ plasm in Eastern Europe.*Genetic Reso. and Crop Evo.* **48:** 609-620.

Sharma, S. N. and Sain, R. S. 2003. Genetic architecture of grain weight in durum wheat under normal and late sowing environments. *Wheat Info. Servi.* **96:** 28-32.

Sharma, S. N. and Sain, R. S. 2004. Genetics of grain per spike in durum wheat under normal and late planting conditions. *Euphytica.* **39:** 1-7.

Singh, H., Sharma, S. N. and Sain, R. S. 2004. Combining ability for some quantitative characters in hexaploid wheat (*Triticum aestivum* L. Em. Thell). *In: Proceedings of 4th International Crop Science Congress. Brisbane, Australia.*

Singh, M. N., Sharma, P. K., Tyagi, B. S. and Singh, G. 2014. Heterosis for Yield Component Traits and Protein Content in Bread Wheat under Normal and Heat-stress Environment. Cereal Res. Communications. **42(1):** 151-162.

Singh, M., Devi, E. L., Aglawe, S., Kousar, N. and Behera, C. 2013. Estimation of heterosis in diffent crosses of bread wheat (*Triticum aestivum* L.). *The Bioscan*. **8(4):** 1393-1401.

Sun, X. Y., Wu, K., Zhao, Y., Kong, F. M., Han, G. Z., Jiang, H. M., Huang, X. J., Li, R. J., Wang, H. G. and Li, S. S. 2009. QTLanalysis of kernel shape and weight using recombinant inbred lines inwheat. *Euphytica*. **165:** 615-624.

Tanabata, T., Shibaya, T., Hori, K., Ebana, K. and Yano, M. 2012. SmartGrain: high-throughput phenotyping software for measuring seed shape through image analysis. *Plant Physiology*. **160:** 71-80.

Topal, A., Aydin, C., Akgun, N. and Babaoglu, M. 2004. Diallel cross analysis in durum wheat (*Triticum durum* Desf): Identification of best parents for kernel physical features. *Field Crops Res*. **87:** 1-2.