J. Wheat Res. 5 (2) : 22-26

Received: 16 November, 2013/ Accepted: 14 December, 2013
@ Society for Advancement of Wheat Research

Generation mean analysis for some heat tolerance and quantitative characters in bread wheat (*Triticum aestivum* L.)

Chhagan Lal, Shiv Ratan Maloo and Vishnu Kumar[1*]

Maharana Pratap University of Agriculture and Technology
Udaipur-313 001, India

Abstract

Genetic analyses were performed for heat tolerance parameters viz. heat injury and chlorophyll stability index, grain protein content, grain yield and its components in bread wheat. Three crosses namely Raj 3765 x PBW 343, Raj 3765 x Raj 4037 and Raj 3765 x Raj 4083 of four parents were used for genetic analyses. The mean days to maturity were depicted as 112.59, 1000 grain weight (38.39 g) and grain yield (16.14 g), respectively. General means for grain protein content, heat injury and chlorophyll stability index were exhibited as 12.58, 44.02 and 14.32 per cents, respectively. A, B, C and D scaling tests revealed that additive-dominance model was inadequate for all the three crosses for days to maturity, two crosses for days to heading, and one cross for grain protein content, which indicated presence of non-allelic interactions. However, all the three crosses showed adequacy of additive-dominance model for grain yield and its components. Among digenic interaction dominance x dominance (l) and additive x additive (i) were more important as compared to additive x dominance (j) for most of the characters. Duplicate type of epistasis was exhibited for days to maturity in two crosses viz. Raj 3765 x PBW 343 and Raj 3765 x Raj 4037, while for grain protein content in one cross Raj 3765 x Raj 4037.

Keywords: Scaling test, six parameter model, heat injury, bread wheat

Introduction

Wheat is one of the most important cereals of India and known to be cultivated since pre-historic times (Tandon, 2000). Bread wheat belongs to the tribe *triticeae* and family *poaceae*. In wheat, plants can be injured at seedling emergence, reproductive development, stem elongation, heading and grain filling stages by high temperature. Even 1^0C increment in temperature reduces 8 to 10 per cent grain yield (Abrol and Ingram, 1996). Wheat is especially sensitive to temperature that exceeds 32^0C for any significant period. This occurs at the grain filling stage in wheat resulting in the development of shriveled grain which reduces yield and decreases quality. Many studies (Al-Khatib and Paulsen, 1984; Reynolds *et al.,* 1994; Wardlaw *et al.*, 1989; Saint *et al.*, 2010; Usman *et al.*, 2013) have shown that genetic variability for heat tolerance exists in germplasm lines and varieties. They also suggested use of landraces in conventional breeding of wheat to incorporate genes for heat tolerance. The other approach is to use wild species viz. *Aegilops* and other *Triticum* species with same or different genomes with cultivated wheat.

Improvement for heat tolerance depends on hybridization using heat tolerant donors and high yielding commercial cultivars. The study of gene effects in most of the crops including wheat population is an important tool in interpreting genetic parameters. The nature and magnitude of gene effect governing the inheritance of quantitative characters could play a vital role for the plant breeder in formulating the appropriate breeding procedure. The success of any breeding programme depends primarily upon the proper selection of parents, mating system employed and finally the breeder's keen judgment in selecting superior genotypes from more abundant and less desirable plants within the segregating populations.

Therefore, keeping in view the aforesaid conditions, an attempt was made to evaluate important biometrical characters, protein content and as well heat tolerance parameters in six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of wheat crosses involving four diverse parents.

Materials and methods

The present investigations were carried out at Instructional Farm, Department of Plant Breeding Genetics, Rajasthan College of Agriculture, Udaipur from *rabi*, 2007-08 to *rabi*, 2009-10. Four diverse wheat genotypes namely Raj 3765, PBW 373, Raj 4037 and Raj 4083 were selected as parents on the basis of their origin, adaptability, yield potential and heat tolerance characters. Crosses were attempted during *rabi*, 2007-08 to generate F_1s and during 2008-09 F_1s were advanced in F_2s and backcrosses were also attempted by keeping one common heat tolerant parent viz. Raj 3765. Details of pedigree of parents, F_1s, F_2s, BC_1 and BC_2 are given in Table 1.

Final experimental trial, comprising 4 parents along with their 3 F_1s, 3 F_2s and 6 back cross generations were evaluated during *rabi*, 2009-10 in randomized block design with three replications. Parents, F_1s and back cross generations were grown in single row, while F_2s in

[1] Current address: Directorate of Wheat Research, Karnal
* Corresponding author's e-mail: *vishnupbg@gmail.com*

three rows. Sowing was done by dibbling the seeds at a distance of 10 cm in the rows of 2 m length with row to row spacing of 25 cm. Non experimental rows were planted around the layout to eliminate border effects. 60 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} were applied at the time of sowing. 60 kg N/ha was top-dressed 21 days after sowing coinciding with crown root initiation. Five irrigations were applied during the entire crop period and recommended agronomic practices were adopted to raise the good crop.

Data were recorded on plot basis for days to heading and days to maturity, while rest of the quantitative characters viz. plant height (cm), 1000 grain weight (g) and grain yield (g) were recorded on 10 randomly selected plants for parents, F_1s and backcrosses, while 30 plants for F_2s. Two samples of grains per treatment per replication were analyzed by standard micro-Kjeldhal's method to obtain nitrogen content (per cent) and the values so obtained were multiplied by a factor of 5.70 to obtain grain protein content. Heat injury (HI) and chlorophyll stability index (CSI) were estimated in per cents as per standard methods (Murty and Majumdar 1962, Sullivan 1972). The generation means for each character were subjected to standard statistical analysis to test the difference among various generations studied as per standard procedures (Panse and Sukhatme 1985). Scaling test was used to check the adequacy of the additive – dominance model for different characters in each cross (Hayman and Mather, 1955). The significance of any one of these scales was taken to indicate the presence of epistasis i.e. non-allelic intraction. In the presence of non-allelic interaction, various gene effects were estimated using 6 parameter model (Hayman, 1958).

Results and discussion

Analysis of variance revealed significant differences (p>0.01) among the genotypes and crosses for all the characters. The mean days to heading were depicted as 78.22 days, days to maturity 112.59 days, plant height 85.01 centimeter, 1000 grain weight (38.39 g), grain yield (16.14 g), respectively. General means for grain protein content, heat injury and chlorophyll stability index were exhibited as 12.58, 44.02 and 14.32 per cents, respectively. All the four scales (A, B, C and D) were not significant for any cross, however, at least one or more than one scales were found significant in some crosses for days to heading, days to maturity and grain protein content (Table 2). The A and B scales were non-significant for all the characters, while C scale was found significant in Raj 3765/Raj 4083 (days to heading) and Raj 3765/PBW 343, Raj 3765/Raj 4037 and Raj 3765/Raj 4083 (days to maturity) which indicated inadequacy of simple additive-dominance model and presence of epistasis. The D scales were non-significant for all the crosses, except Raj 3765/PBW 343 and Raj 3765/Raj 4037 (days to maturity) and Raj 3765/Raj 4037 (grain protein content) indicating presence of non-allelic interactions for these characters in mentioned crosses.

In general, the A, B, C and D scaling tests depicted the adequacy of additive-dominance model for most of the characters. However, C and D scaling tests were found significant in some crosses for days to heading and maturity and grain protein content indicating presence of additive x additive (D) and dominance x dominance (C) interactions, respectively.

The estimates of mean (m) were highly significant for all the characters in all the crosses. In general, magnitudes of the dominance effects were high for all the characters, except heat injury in crosses Raj 3765/PBW 343. However, in the present study the magnitude of additive x additive (i) gene effects and dominance x dominance effects were quite high in comparison of additive x dominance gene effects (Table 3).

The presence of dominance component (h) with additive x additive (i) gene effects were significant in the crosses Raj 3765 x PBW 343 and Raj 3765 x Raj 4037 for days to maturity. Estimates of digenic interactions revealed that additive x additive (i) and dominance x dominance (l) type of gene interactions were found significant in the crosses Raj 3765 x PBW 343 and Raj 3765 x Raj 4037 for days to maturity. Similar findings reported by various researchers (Dhayal *et al.,* 2003; Kavar *et al.,* 2007; Sonia *et al.,* 2005). For 1000 grain weight the dominance effects were high with preponderance of dominance x dominance interactions, suggesting complex inheritance. Thus, hybridization, reciprocal recurrent selection and bi-parental mating would be quite useful for improvement in 1000 grain weight.

Grain yield per plant predominantly controlled by dominance gene effect (h) and magnitude was higher than additive gene effects (d). Similar finding was also reported in earlier study and also suggest recurrent reciprocal selection or bi-parental mating for improvement in various generations (Shekhawat *et al.,* 2006). The presence of dominance component (h) with additive x additive (i) and dominance x dominance (l) gene effects were significant in cross Raj 3765 x Raj 4037 for grain protein content. These findings are in accordance with previous studies (Dhayal *et al.,* 2003; Kavar *et al.,* 2007; Prakash *et al.,* 2006; Sonia *et al.,* 2005).

Opposite sign of dominance component (h) and dominance x dominance (l) type of gene effect were recorded for days to maturity in two crosses Raj 3765 x PBW 343 and Raj 3765 x Raj 4037, while for grain protein content in one cross Raj 3765 x Raj 4037, which revealed that duplicate type of epistatic gene action was important in the inheritance of both the traits. Hence, on the basis of significant estimates of gene effect above results suggested that days to maturity and grain protein content were predominantly under the control of dominance gene effects (h).

Table 1. Details of parents, filial generations and cross combinations in bread wheat

Parents	Pedigree
Raj 3765	HD 2402 / VL 639
PBW 343	ND/BG1944//KAL//BB/3/BACO'S'/4/BAA//5'S
Raj 4037	DL788-2/Raj3717
Raj 4083	PBW343/UP2442//WR258/UP2425
Filial generations with back crosses	
F_1s and F_2s (1)	Raj 3765/ PBW 343
F_1s and F_2s (2)	Raj 3765/ Raj 4037
F_1s and F_2s (3)	Raj 3765/ Raj 4083
BC_1 and BC_2 (A)	Raj 3765/ PBW 343// Raj 3765 and Raj 3765/ PBW 343// PBW 343
BC_1 and BC_2 (B)	Raj 3765/ Raj 4037//Raj 3765 and Raj 3765/ Raj 4037//Raj 4037
BC_1 and BC_2 (C)	Raj 3765/ Raj 4083//Raj 3765 and Raj 3765/ Raj 4083//Raj 4083

Table 2. Scaling tests for different characters in three crosses of bread wheat

Characters/ cross	Scaling tests			
	A	B	C	D
Days to heading				
Raj 3765 × PBW 343	0.13±3.70	3.93±4.07	8.64±4.65	2.29±3.22
Raj 3765 × Raj 4037	5.47±3.33	6.27±3.33	10.31±5.07	-0.71±2.55
Raj 3765 × Raj 4083	2.33±3.21	5.00±3.14	10.04*±4.13	1.36±2.53
Days to maturity				
Raj 3765 × PBW 343	-5.67±2.51	2.13±4.28	17.22**±5.06	10.38**±3.20
Raj 3765 × Raj 4037	-5.87±3.30	-7.40±3.23	20.20**±4.45	16.73**±2.84
Raj 3765 × Raj 4083	-0.67±3.75	4.27±3.39	14.53*±6.00	5.47±3.51
Plant height				
Raj 3765 × PBW 343	-5.13±6.97	0.20±12.57	-17.33±9.20	-6.20±7.70
Raj 3765 × Raj 4037	-7.87±7.89	-4.07±8.12	-14.38±12.51	-1.22±5.79
Raj 3765 × Raj 4083	-0.73±6.55	4.00±6.46	-13.04±9.98	-8.16±4.71
1000-grain weight				
Raj 3765 × PBW 343	-5.20±6.61	-4.13±7.54	-6.00±9.28	1.67±5.12
Raj 3765 × Raj 4037	-6.60±5.12	-4.20±5.30	-7.87±7.14	1.47±3.89
Raj 3765 × Raj 4083	-5.60±8.92	-3.80±8.39	-4.96±9.07	2.22±6.16
Grain yield/plant				
Raj 3765 × PBW 343	2.40±6.73	0.67±5.78	7.24±7.60	2.09±4.64
Raj 3765 × Raj 4037	-3.60±5.88	-2.73±6.27	-6.87±8.02	-0.27±4.33
Raj 3765 × Raj 4083	-0.47±7.21	-0.93±6.23	-5.04±10.16	-1.82±3.95
Grain protein content				
Raj 3765 × PBW 343	-1.21±1.86	2.37±2.21	-4.01±2.77	-2.58±1.53
Raj 3765 × Raj 4037	1.82±2.16	3.37±1.97	-5.01±3.78	-5.10*±1.79
Raj 3765 × Raj 4083	1.07±1.92	-0.47±1.63	-1.36±3.23	-0.98±1.75
Heat injury				
Raj 3765 × PBW 343	-12.34±20.48	13.08±24.76	2.23±33.73	0.74±13.47
Raj 3765 × Raj 4037	4.13±28.76	-11.59±20.74	-25.02±33.05	-8.78±16.97
Raj 3765 × Raj 4083	1.62±22.62	3.31±33.06	-11.06±34.96	-8.00±19.69
Chlorophyll stability index				
Raj 3765 × PBW 343	3.51±17.25	0.03±16.22	-11.72±20.39	-7.63±10.36
Raj 3765 × Raj 4037	2.53±11.67	4.14±13.11	1.61±16.58	-2.53±9.44
Raj 3765 × Raj 4083	0.81±9.97	-1.65±14.50	3.52±16.20	2.18±8.39

* , ** Significant at 5 and 1 per cent level respectively

Table 3. Estimates of gene effects for different characters in bread wheat

Character/ cross	Parameter					
	m	d	h	i	j	l
Days to heading						
Raj 3765 × PBW 343	78.04**±1.00	-0.60±2.52	-8.61±6.54	-4.58±6.44	-1.90±2.71	0.51±11.11
Raj 3765 × Raj 4037	78.44**±0.92	-0.13±1.75	-5.91±5.38	1.42±5.10	-0.40±2.24	-13.16±8.66
Raj 3765 × Raj 4083	77.38**±0.82	-0.07±1.93	-9.78±5.21	-2.71±5.06	-1.33±2.19	-4.62±8.75
Days to maturity						
Raj 3765 × PBW 343	126.96**±1.13	-1.80±2.27	-28.46**±6.50	-20.76**±6.40	-3.90±2.42	24.29*±10.40
Raj 3765 × Raj 4037	127.80**±0.96	2.73±2.11	-41.23**±5.80	-33.47**±5.69	0.77±2.22	46.73**±9.53
Raj 3765 × Raj 4083	126.60**±1.34	-0.13±2.26	-16.33*±7.14	-10.93±7.01	-2.47±2.42	7.33±10.86
Plant height						
Raj 3765 × PBW 343	84.60**±1.83	-1.27±6.78	11.07±15.66	12.40±15.41	-2.67±7.03	-7.47±28.65
Raj 3765 × Raj 4037	78.76**±2.10	-0.47±3.97	-5.59±12.47	2.44±11.58	-1.90±5.18	9.49±20.23
Raj 3765 × Raj 4083	82.36**±1.64	-0.47±3.38	15.61±10.14	16.31±9.41	-2.37±4.08	-19.58±16.81
1000-grain weight						
Raj 3765 × PBW 343	38.53**±1.55	1.13±4.08	-1.80±10.81	-3.33±10.24	-0.53±4.66	12.67±18.77
Raj 3765 × Raj 4037	37.87**±1.24	0.53±3.01	-1.80±8.20	-2.93±7.78	-1.20±3.39	13.73±13.99
Raj 3765 × Raj 4083	37.71**±1.41	0.00±5.48	-3.94±12.83	-4.44±12.33	-0.90±5.69	13.84±23.72
Grain yield/plant						
Raj 3765 × PBW 343	16.11**±1.28	1.87±3.88	-5.31±9.70	-4.18±9.28	0.87±4.05	1.11±17.27
Raj 3765 × Raj 4037	15.67**±1.28	-0.13±3.50	3.23±9.70	0.53±8.66	-0.43±3.89	5.80±16.13
Raj 3765 × Raj 4083	14.89**±1.06	0.27±3.33	4.94±9.15	3.64±7.90	0.23±3.60	-2.24±16.75
Grain protein content						
Raj 3765 × PBW 343	11.46**±0.49	-1.37±1.18	9.02*±3.22	5.16±3.06	-1.79±1.35	-6.31±5.46
Raj 3765 × Raj 4037	11.77**±0.71	-0.57±1.09	11.55**±3.79	10.20*±3.58	-0.78±1.25	-15.39*±5.76
Raj 3765 × Raj 4083	12.71**±0.70	1.93±1.06	3.53±3.59	1.96±3.50	0.77±1.18	-2.5±65.32
Heat injury						
Raj 3765 × PBW 343	46.50**±3.73	-6.63±11.21	1.33±30.89	-1.49±26.94	-12.71±12.73	0.75±56.11
Raj 3765 × Raj 4037	41.72**±5.29	8.04±13.26	19.97±36.23	17.56±33.94	7.86±17.08	-10.09±62.50
Raj 3765 × Raj 4083	43.31**±5.57	-0.02±16.23	18.98±41.61	16.00±39.37	-0.85±18.92	-20.93±73.72
Chlorophyll stability index						
Raj 3765 × PBW 343	11.20**±2.31	2.36±9.28	16.35±22.63	15.26±20.72	1.74±10.56	-18.80±42.35
Raj 3765 × Raj 4037	12.19**±2.97	-0.67±7.34	7.98±19.75	5.05±18.89	-0.81±8.18	-11.72±33.71
Raj 3765 × Raj 4083	12.62**±2.52	2.55±6.71	-6.15±17.94	-4.36±16.78	1.23±8.34	5.20±31.34

*, ** Significant at 5 and 1 per cent level respectively

Gene interactions additive x additive (i) and dominance x dominance (l) were also found for character days to maturity and grain protein content.

For heat tolerance parameters viz. heat injury and chlorophyll stability index the magnitudes of dominance effects (h) were high to the additive gene effects. For heat injury the magnitude of additive x additive interactions were high in the crosses Raj 3765/PBW 343 and Raj 3765/Raj 4037, while dominance x dominance interactions were high in cross Raj 3765/Raj 4083. Similarly, for chlorophyll stability index, dominance x dominance interactions were higher with dominance effects.

Grain yield is a complex character, depended upon the contribution of a large number of components affecting directly or indirectly. The preponderance of dominance x dominance effects was depicted for 1000 grain weight, grain protein content and chlorophyll stability index. Duplicate type of epistasis noticed for days to maturity in two crosses and grain protein content in one cross. The preponderance of non-fixable gene effects (non-additive) than fixable components (additive) and presence of additive x additive (i) and dominance x dominance (l) interactions indicated employment of bi-parental mating or reciprocal recurrent selection would be more realistic for further improvement in grain yield, protein content and heat tolerance parameters in bread wheat. However, reciprocal recurrent selection deployment would not be easy for applicability in wheat, thus the hybridization followed by selection and some cyclic crosses in segregating generations would be more efficient to set positive and favourable gene constellations.

References

1. Abrol YP and Ingram KT (1996). Effect of higher day and night temperature on growth and yield of some crops. Food and Agriculture Organization. John and Sons, New York. pp 123-40
2. Al-Khatib K and Paulsen GM (1984). Mode of high temperature injury to wheat during grain development. *Plant Physiology* **61**:363-68.
3. Dhayal LS, Sastry EVD and Jakhar ML (2003). Genetic architecture of yield and its component traits in bread wheat grown under saline and normal environments. *Indian Journal of Genetics and Plant Breeding* **63**:335-36.
4. Hayman BI and Mather K (1955). The description of genetic interactions in continuous variation. *Biometrics* **11**:69-82.
5. Hayman BI (1958). The separation of epistatic from additive and dominance in generation means. *Heredity* **12**:371-90.
6. Kavar SA, Mehta DR and Chovatia VP (2007). An analysis of generation means for yield and its component traits in macaroni wheat [*Triticum durum* Desf.]. *National Journal of Plant Improvement* **9**:39-42.
7. Murty KS and Majumdar SK (1962). Modifications of the technique for determination of chlorophyll stability index in relation to studies of drought resistance in rice. *Current Science* **11**:470-71.
8. Panse VG and Sukhatme PV (1985). *Statistical methods for agricultural workers.* Published by Indian Council of Agric. Res., New Delhi.
9. Prakash V, Saini DD and Pancholi SR (2006). Genetic basis of heterosis for grain yield and its traits in wheat [*Triticum aestivum* L.] under normal and late sown conditions. *Crop Research* **31**:245-49.
10. Reynolds MP, Balota M, Delgado MI, Amani I and Fischer RA (1994). Physiological and morphological traits associated with spring wheat yield under hot, irrigated conditions. *Australian Journal of Plant Physiology* **21**:717-30.
11. Saint PC, Crossa J, Manes Y, and Reynolds MP (2010). Gene action of canopy temperature in bread wheat under diverse environments. *Theoretical and Applied Genetics* **120**:1107-17.
12. Shekhawat US, Bhardwaj RP and Prakash V (2006). Inheritance of grain yield and tillers per plant in wheat [*Triticum aestivum* L.]. *Indian Journal of Genetics and Plant Breeding* **66**:16-18.
13. Sonia C, Gupta SK and Satija DR (2005). Genetic architecture for some quality traits in wheat [*Triticum aestivum* L.]. *Indian Journal of Genetics and Plant Breeding* **65**:278-80.
14. Sullivan CY (1972). Mechanisms of heat and drought resistance in grain sorghum and method of measurement. pp: 247-264. N.G.P Rao and L. R. House (eds.).
15. Tandon JP (2000). Wheat breeding in India during the twentieth century. *Crop Improvement* **27**:1-18.
16. Usman I, Smiullah and Muhammad K (2013). Genetic study of quantitative traits in spring wheat through generation means analysis. *American-Eurasian Journal of Agricultural and Environmental Science* **13**: 191-97.
17. Wardlaw IF, Dawson IA, Munibi P and Fewster R (1989). The tolerance of wheat to high temperatures during reproductive growth. I Survey procedures and general response patterns. *Australian Journal of Agricultural Research* **40**:1-13.