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Heterosis and inbreeding depression for some quantitative and heat tolerance characters in bread wheat (*Triticum aestivum* L.)

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Abstract

The present investigations were undertaken to estimate the heterosis, heterobeltiosis and inbreeding depression for some quantitative and heat tolerance characters in three crosses involving four parents of bread wheat. General means for 1000-grain weight and grain yield were revealed as 38.39 and 16.14 gram per plant, respectively. The average grain protein content, heat injury and chlorophyll stability index were exhibited as 12.58, 44.02 and 14.32 per cent, respectively. For grain yield heterosis over mid parent ranged from -7.62 (Raj 3765/ PBW 343) to 16.84 per cent (Raj 3765/ Raj 4037), while heterobeltiosis ranged from 8.15 (Raj 3765/ Raj 4083) to 14.69 per cent (Raj 3765/ Raj 4037). Inbreeding depression for grain yield was ranged from –17.31 (Raj 3765/ PBW 343) to 16.37 per cent (Raj 3765 x Raj 4037), respectively. The cross Raj 3765/ Raj 4037 was found to be promising for days to heading, days to maturity, plant height, grain yield and chlorophyll stability index, while the cross Raj 3765/ PBW 343 was heterotic for 1000-grain weight and grain protein content.

Keywords: Heterosis, heterobeltiosis, inbreeding depression, heat injury, chlorophyll stability index, bread wheat

Introduction

Wheat is the second most important cereal of India and known to be cultivated since pre-historic times (Tandon, 2000; Kumar and Maloo, 2011). Wheat belongs to the tribe *triticeae* and family *Poaceae*. Hexaploid wheat [2n = 6x = 42 = AABBDD] is widely grown and consumed as food grain all over the world. Globally, India is the second largest wheat producer and achieved an all time highest ever production of 94.88 million tons, during 2011-12 (Anonymous 2013). However, to keep continuous rise in future wheat production, we will have to have solutions for rigid challenges ahead as climate change, burgeoning population, depleting natural resources, biotic and abiotic stress etc.

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. The study of heterosis and inbreeding depression in most of the crops including wheat is an important tool in interpreting genetic parameters. The nature and magnitude of heterosis and inbreeding depression could play a vital role for the plant breeder in formulating the appropriate breeding procedures.

Therefore, present study was carried out to delineate the magnitude of heterosis, heterobeltiosis and inbreeding depression in bread wheat and identified superior parents and crosses would be gainfully utilized in future wheat improvement programmes.

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Materials and methods

The present investigations were carried out at Instructional Farm, Department of Plant Breeding and 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.

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 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 centimeter. Non experimental rows were planted around the layout to eliminate border effects. 60 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} were applied at the time of sowing. 60 kg N ha^{-1} 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 characters viz. plant height (cm), 1000 grain weight (g), grain yield (g) and harvest index per cent (Donald 1962) 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 converted to obtain grain protein content. Heat injury and chlorophyll stability index were estimated in per cents as per standard methods (Murty and Majumdar, 1962; Sullivan, 1972) Analysis of variance, heterosis, heterobeltiosis and inbreeding depression were calculated as per standard procedures (Fonseca and Patterson, 1968; Matinzinger, 1968; Panse and Sukhatme, 1985).

Results and discussion

Analysis of variance revealed significant differences ($p>0.01$) among the genotypes and crosses for all the characters, except harvest index. The mean days to heading were exhibited as 78.22, days to maturity (112.59), plant height (85.01 cm), 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. Average value for 1000 grain weight ranged from 37.60 gram (PBW 343) to 40.51 gram (Raj 3765) among the parents, while for the hybrids, it ranged from 39.20 gram (Raj 3765/ Raj 4083) to 40.80 (Raj 3765/ PBW 343).

The earliness in days to heading and days to maturity has been considered as desirable trait in wheat crop. For days to heading and days to maturity mean heterosis were depicted as -7.80 and -5.50 per cent, while mean heterobeltiosis and average inbreeding depression were

Table 1. Heterosis, heterobeltiosis and inbreeding depression for different characters in bread wheat

Character	Cross	Heterosis	Heterobeltiosis	Inbreeding depression
Days to heading				
	Raj 3765 / PBW 343	-5.18*	-3.57	-5.66**
	Raj 3765 / Raj 4037	-9.22**	-8.92*	-8.65**
	Raj 3765 / Raj 4083	-9.01**	-7.52*	-8.47**
Days to maturity				
	Raj 3765 / PBW 343	-6.09**	-4.50*	-6.86**
	Raj 3765 / Raj 4037	-6.13**	-4.65**	-7.52**
	Raj 3765 / Raj 4083	-4.30**	-2.49	-5.27**
Plant height				
	Raj 3765 / PBW 343	-1.49	-	4.15
	Raj 3765 / Raj 4037	-9.30	-	-0.54
	Raj 3765 / Raj 4083	-0.81	-	3.41
1000-grain weight				
	Raj 3765 / PBW 343	3.90	-	5.56
	Raj 3765 / Raj 4037	2.89	-	6.27
	Raj 3765 / Raj 4083	1.29	-	3.80
Grain yield plant-1				
	Raj 3765 / PBW 343	-7.62	-	-17.31
	Raj 3765 / Raj 4037	16.84	14.69	16.37
	Raj 3765 / Raj 4083	8.39	8.15	11.38
Grain protein content				
	Raj 3765 / PBW 343	29.63**	27.91*	20.38**
	Raj 3765 / Raj 4037	10.94	9.08	14.07
	Raj 3765 / Raj 4083	12.77	2.98	8.13
Heat injury				
	Raj 3765 / PBW 343	6.33	-	1.80
	Raj 3765 / Raj 4037	5.16	-	15.17
	Raj 3765 / Raj 4083	6.68	-	8.95
Chlorophyll stability index				
	Raj 3765 / PBW 343	8.02	3.33	23.69
	Raj 3765 / Raj 4037	28.36	26.72	8.00
	Raj 3765 / Raj 4083	-14.14	-	-16.35

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

Table 2. Mean heterosis, heterobeltiosis and inbreeding depression and range for different characters in bread wheat

Character	Mean heterosis	Heterobeltiosis	Inbreeding depression
Days to heading	-7.80 (-9.22 to -5.18)	-6.67 (-8.92 to -3.57)	-7.59 (-8.65 to -5.66)
Days to maturity	-5.50 (-6.13 to -4.30)	-3.57 (-4.65 to -2.49)	-6.55 (-7.52 to -5.27)
Plant height	-3.86 (-9.30 to -0.81)	-	2.34 (-0.54 to 4.15)
1000 grain weight	2.69 (1.29-3.90)	-	5.21 (3.80-6.27)
Grain yield/plant	5.87 (-7.62 to 16.84)	11.42 (8.15 to 14.69)	3.48 (-17.31 to 16.37)
Grain protein content	20.13 (10.94 to 29.63)	14.49 (2.98 to 27.91)	14.19 (8.13 to 20.38)
Heat injury	6.05 (5.16 to 6.68)	-	8.64 (1.80 to 15.17)
Chlorophyll stability index	7.41 (-14.14 to 28.36)	15.02 (3.33 to 26.72)	5.11 (-16.35 to 23.69

revealed -6.67 and -3.57 per cent and -7.59 and -6.55 per cent, respectively. As evident (Table 1) significant negative heterosis as well as heterobeltiosis with also significant negative inbreeding depression were recorded for days to heading in cross Raj 3765/ Raj 4037 and Raj 3765 / Raj 4083, while cross Raj 3765 / PBW 343 depicted significant negative heterosis (-5.18*) and inbreeding depression (-5.66), respectively (Table 1). Yadav and Narshinghani, 2000; Prakash and Joshi, 2003 also observed significant negative heterosis followed by negative inbreeding depression for days to heading and days to maturity in wheat. For plant height none of the crosses displayed significant heterosis and mean heterosis was depicted as -3.86, which ranged from -9.30 to -0.81 per cent. Similar results were also reported (Singh, 2003; Sharma and Tandon, 1998; Jahanzeb and Khaliq, 2004; Deshpande and Nayeem 1999).

For 1000-grain weight average heterosis and inbreeding depression were exhibited as 2.69 and 5.21, respectively. The mean heterosis for grain yield was 5.87 per cent, while heterobeltiosis reported as 11.42 per cent, respectively. Heterosis for grain yield ranged from -7.62 to 16.84 per cent (2 crosses positive), while heterobeltiosis ranged from 8.15 to 14.69 per cent. Considering inbreeding depression for grain yield was 3.48 per cent. None of the cross showed significant value for heterosis, heterobeltiosis as well as inbreeding depression for grain yield. These findings are in confirmation (Khan and Khan, 1996; Larik *et al.*, 1999; Singh and Prasad, 2001; Ijaz *et al.,* 2002; Hussain *et al.,* 2004; Jahanzeb and Khaliq, 2004; Sharma *et al.,* 2004).

For grain protein content out of three crosses, Raj 3765 / PBW 343 showed positive significant heterosis as well as heterobeltiosis with positive significant inbreeding depression. Mean value for heterosis and heterobeltiosis were 20.13 per cent and 14.49 per cent respectively, whereas heterosis ranged from 10.94 to 29.63 per cent for grain protein content.

None of hybrids showed significant heterosis for heat tolerance traits viz. heat injury and chlorophyll stability index. Mean heterosis values were depicted as 6.05 and 7.41 per cents for heat injury and chlorophyll stability index, which ranged from 5.16 to 6.68 per cent and -14.14 to 28.36 per cent, respectively. Based on estimates of mean performance and heterosis for grain yield and its component traits Raj 3765 was identified as superior parent. The cross Raj 3765/ Raj 4037 was found promising for days to heading, days to maturity, plant height, grain yield and chlorophyll stability index, while the cross Raj 3765/ PBW 343 was heterotic for 1000 grain weight and grain protein content. For heat injury the cross Raj 3765/ Raj 4083 was heterotic, however, the cross Raj 3765/ PBW 343 may be again considered for heat injury due to less magnitude of inbreeding depression. In the light of the above studies, the improvement in these crosses may be expected through standard selection procedures, which may first exploit the additive gene effects. Simultaneously, care should be taken that non-additive effects should not be dissipated, rather concentrated. It is therefore, suggested to develop pure lines by progeny selection for early improvement.

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