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MANIFESTATION OF HETEROSIS FOR GRAIN WEIGHT IN WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

Five lines having different grain weights were selected from populations of three crosses, viz., UP368 × WC457, UP368 × Shailza, and WH157 × Bulk 1858, which were passed through three cycles of mechanical mass selection. These lines along with variety Sonalika were crossed in all possible combinations excluding reciprocals. The boldest seeded (65 g) line had almost similar grain weight as the hybrid with highest grain weight. The hybrids involving parents with different degree of association were equal or inferior to midvalue depending on the degree of association and thus exhibited negative or no heterosis. The hybrids involving parents with dispersed allelic state had high grain weight as well as high positive heterosis. Thus, allelic dispersion was the major cause of heterosis. The combining ability effects were affected by the pattern of allelic distribution among parents. Parents with association state exhibited positive general combining ability (gca) effects, while those with dispersion state showed negative gca effects.

Key words: Heterosis, grain weight, wheat.

Several theories have been put forward to explain the genetic basis of heterosis in crop plants but the dominant linked gene hypothesis [1] has found favour in self-pollinated crops to explain the phenomenon. In wheat, standard heterosis up to 25% has been reported for grain yield and its components. Both additive and nonadditive gene effects have been suggested to explain heterosis. However, dispersion of alleles, as one of the major causes of heterosis, cannot be ruled out as enough evidence now supports dispersion of complementary genes as the major cause of heterosis [2]. Keeping this in view, breeding lines were developed which represented association/dispersion of alleles for their grain weight and their state was correlated with the manifestation of heterosis.

MATERIALS AND METHODS

The segregating populations of three crosses, viz., UP368 × WC457, UP368 × Shailza and WH157 × Bulk1858, were passed through mechanical mass selection for grain size using size six sieve. Several lines were isolated at the end of three cycles of selection. Out of these, five lines each with high, medium and low grain weight were developed. These five lines along with variety Sonalika were crossed in all possible combinations to produce 15 hybrids. Twenty-one genotypes (6 parents + 15 F_1) were grown in randomized block design with three replications. Single-row plots of 3 m length with the rows and plants spaced at 30 cm and 10 cm, respectively, were raised. Observations on 1000-grain weight (g) were recorded on 10 random plants in each genotype in all the replications. Plot means were used for statistical analysis. Heterosis (%) was calculated over better parent. Combining ability analysis was carried out following Method 2 Model 1 of Griffing [3].

RESULTS AND DISCUSSION

The analysis of 1000-grain weight (Table 1) revealed that Line 1 had the highest grain weight (65.0 g), which is identical to the maximum 1000-grain weight ever reported in breadwheat. The other extreme with minimum grain weight of 25 g has been reported by Singh and Behl [4]. Thus, 65 and 25 g seed weight represent the two extremes of grain size in wheat. Moreover, the highest 1000-grain weight of hybrid observed in the present study was 68.67 g. It is being emphasized that in self-pollinated crops homozygotes equal in performance to the hybrids may be extracted from segregating generations [2, 5]. Thus, Line 1 had the maximum grain weight, which is almost similar to the best hybrid. It may be assumed that all the positive alleles for grain weight have accumulated in this line. Similarly, most of the positive alleles have accumulated in Line 2 also. Line 3 had considerably higher grain weight (56.0 g) than either of its parents. It is interesting that Line 6 developed from the same cross as Line 3 had the lowest seed weight (41.0 g). Thus, Lines 3 and 6 differ for the same alleles as their parents, which are accumulated in Line 3 but not received by Line 6.

Table 1. Pedigree, mean performance, state of allelic distribution and gca effects for 1000-grain weight in wheat

Line	Pedigree	1000-grain weight (g)	State of allelic distribution	gca effect
Line 1	UP368 × WC457	65.0	Complete association	2.06**
Line 2	UP368 × WC457	59.0	Partial association	1.72**
Line 3	WH157 × Bulk 1858	56.0	—do—	2.93**
Line 4	Sonalika	53.0	—do—	0.61
Line 5	UP368 × Shailza	41.0	Dispersion	−2.94**
Line 6	WH157 × Bulk 1858	41.0	—do—	−3.15**

**Significant at P = 0.01.

Heterosis was also influenced by the state of allelic distribution (Table 2). The hybrids between parents with complete or partial association exhibited negative or no heterosis. However, hybrid between Lines 2 and 3 showed positive heterosis. This may be due to the fact that both these lines have partial association, having been developed from different crosses. These partially associated lines may have some positive alleles in dispersed state which were pooled on hybridization and caused higher grain weight than the parents. In the light of the dominant linked gene hypothesis [1], it is possible to accumulate all the positive alleles in an inbred line [6]. Such lines may have complete or partial association of alleles. The hybrids of lines with associated alleles will always show negative heterosis or its absence because these lines will differ largely for identical alleles. However, the extent of heterosis will depend on the degree of association of alleles. On the other hand, the desirable alleles are equally distributed among the parents in case of complete dispersion (r = 0), and alleles from both parents accumulate in the hybrid and exhibit better performance [5]. The hybrid between Lines 5 and 6 exhibited high grain weight with maximum positive heterosis. This observation also supports dispersion of alleles between Lines 5 and 6. Thus, manifestation of heterosis for grain weight appears to be largely dependent on dispersion, as proposed earlier [6, 7].

Table 2. Mean performance of hybrids and heterosis over better parent for 1000-grain weight in wheat

Hybrid	1000-grain weight, g		Heterosis over better parent, %
	F_1	better parent	
Line 1 × Line 2	45.0	65.0	−30.76**
Line 1 × Line 3	66.0	65.0	1.54
Line 1 × Line 4	62.67	65.0	−3.58
Line 1 × Line 5	53.0	65.0	−18.46**
Line 1 × Line 6	52.0	65.0	−20.00**
Line 2 × Line 3	68.67	59.0	15.74**
Line 2 × Line 4	61.0	59.0	2.81
Line 2 × Line 5	52.0	59.0	−12.35**
Line 2 × Line 6	60.67	59.0	2.26
Line 3 × Line 4	52.67	56.0	−5.95*
Line 3 × Line 5	66.67	56.0	19.05**
Line 3 × Line 6	49.67	56.0	−11.30**
Line 4 × Line 5	48.67	53.0	−8.17*
Line 4 × Line 6	56.33	53.0	6.28*
Line 5 × Line 6	66.33	41.0	61.78**

Significant at *p = 0.05 and **p = 0.01.

The gca effects of parents (Table 1) were also in agreement with the state of allelic distribution among the parents. Lines 1, 2 and 3 with complete or partial association of positive alleles, exhibited positive gca effects. On the other hand, Lines 5 and 6 with complete dispersion of alleles exhibited negative gca effects. Interestingly, the positive and negative gca effects were in accordance with the degree of allelic distribution among the parents. Genetically, the apparent contribution of directional dominance is inflated in the crosses involving lines with dispersion state leading to negative gca effects. On the contrary, in the crosses with association, the dominance component exceeds the magnitude of additive component and leads to positive gca effects.

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