Heterosis Analysis in F₁ Hybrids of Bread Wheat (Triticum aestivum L. em. Thell.) Over Environments

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A B S T R A C T

The present investigation entitled “Heterosis Analysis in F₁ Hybrids of Bread wheat (Triticum aestivum L. em. Thell.) Over Environments” was undertaken using ten genetically diverse parents following diallel mating design excluding reciprocals. The resultant 45 F₁s and all the ten parents were evaluated in randomized block design with three replications under three different environments created by three dates of sowing [15 November (E₁), 1 December (E₂), 15 December (E₃)]. Sufficient degree of heterosis and heterobeltiosis was observed for all the attributes. The crosses WH 1021 x PBW 550, Raj 3765 x Raj 3077 and WH 1021 x PBW 550, Raj 3765 x Raj 3077 and DBW 90 x PBW 550 in E₁; WH 1021 x PBW 550, Raj 4238 x WH 1021 and Raj 3765 x HD 3086 in E₂ emerged as heterotic as well as heterobeltiotic crosses for grain yield per plant. These crosses were the product of good x good, good x poor or poor x poor general combiners. These crosses were considered promising for their use for yield improvement in wheat. Heterosis and heterobeltiosis were also observed maximum for grain yield per plant.

Keywords
Heterosis, Heterobeltiosis, Bread wheat

Introduction

Bread wheat is considered as a staple food source for a large population of the world and also provides a range of diversified baked food products. Hence, wheat and its production are the chief food sources for human diet (Kumar et al., 2013). To feed flourishing population of India; the genetic improvement of wheat genotypes for high yield potential is a dire need. For this purpose, the exploitation of maximum genetic potential from available genetic resources of wheat is a pre-requisite.

F₁ hybrid carrying heterotic effects, which are featured in all crop species, the yield gains are limited to the F₁ generation. The F₂ and succeeding generations obtained through selfing are discarded since reduced yields and
developmental characters (Wang et al., 2015). Heterosis is considered as the superiority of the hybrids in comparisons to either of its parents. It is the allelic or non-allelic interaction of genes under the influence of specific environment. Heterosis has been estimated in a range of cultivated crops and has been the purpose of considerable importance to study as mean of increasing productivity of crop plant.

It is now well established that heterosis does occur with proper combination of parents. Formerly, utilization of heterotic effects for grain yield was mainly ascribed to cross-pollinated crops. However, later it was reported in wheat as being predominantly self-pollinated for the first time by Freeman (1919), who well-versed the supremacies of F₁ crosses over their parents (Özgen, 1989). Briggle (1963) described existence of heterosis in substantial quantity for grain yield components in different F₁ wheat crosses. Keeping in view the above facts, the current research was designed to estimate heterotic effects in forty five crosses of wheat.

Materials and Methods

The present investigation aimed to gather information’s on the genetic basis of yield and its contributing traits in ten diverse genotypes of bread wheat (Triticum aestivum L. em. Thell.). These selected genotypes were planted at Research Farm, College of Agriculture, Swami Keshawanand Rajasthan Agricultural University, Bikaner for hybridization in diallel fashion excluding reciprocals. The experiment was laid out in a randomized block design with three replications. Row to row and plant to plant spacing was maintained at 22.5 cm and 10 cm. Observations were recorded on ten randomly selected competitive plants of each parent and 45 F₁’s. Observations on days to heading, days to maturity and grain filling period were recorded on whole plot basis. The data on plant height, flag leaf area, number of effective tillers per plant, spike length, number of grains per spike were recorded on the tagged plant in the field, while data for characters like 1000 seed weight (g), grain yield per plant and harvest index were recorded after uprooting the randomly selected plants from the field. The heterosis (H%) and heterobeltiosis (HB%) values were estimated as the deviation of the F₁ value from the mid-parent and the better-parent values as suggested by Matzinger et al., (1962) and Fonseca and Patterson (1968), respectively.

Results and Discussion

In present investigation, heterosis over mid parent and better parent has been estimated in order to explore the possibility of using in the production of hybrids. The expression of heterosis and heterobeltiosis, in general, was variable for different traits under all the environments. Heterotic expression was fairly high and desirable for grain yield per plant (82.72 per cent in E₂), number of effective tillers per plant (67.50 per cent in E₁), biological yield per plant (49.64 per cent in E₃), harvest index (44.82 per cent in E₃), number of grains per spike (37.89 in E₃), grain filling period (36.36 per cent in E₂), spike length (35.72 per cent in E₃), flag leaf area (35.16 per cent in E₃) and 1000-seed weight (25.03 per cent in E₃). Similarly, magnitude of heterobeltiosis was fairly high and desirable for grain yield per plant (76.59 per cent in E₂), number of effective tillers per plant (58.77 per cent in E₁), biological yield per plant (42.24 per cent in E₃), grain filling period (35.01 per cent in E₂), number of grains per spike (32.46 per cent in E₃), flag leaf area (32.24 per cent in E₁), harvest index (32.22 per cent in E₃), spike length (30.07 per cent in E₃) and 1000-seed weight (22.46 per cent in E₃). The results are in agreement with
those of others obtained in varying environments for different characters Afiah et al., (2000), Rasul et al., (2002), Singh and Singh (2003), Singh et al., (2004), Akbar et al., (2010), Kumar and Maloo (2011), Beche et al., (2013), Kumar et al., (2014) and Saren (2018) also reported maximum heterosis for grain yield per plant.

In current study, the highest range of heterosis has been estimated for all the attributes. The range of heterosis over mid-parent for grain yield per plant from -46.28 per cent to 60.86 per cent in E₁, -47.42 per cent to 82.72 per cent in E₂ and -41.22 per cent to 81.05 per cent in E₃. The results in varying environments for different characters are in conformity with the findings of Rasul et al. (2002), Punia et al., (2005), Akinci (2009), Lal et al., (2013) and Gaur et al., (2014). The superiority of hybrids particularly over better parent (heterobeltiosis) is more important and useful in determining the feasibility of commercial exploitation of heterosis and also indicating the parental combinations capable of producing the highest level of transgressive segregants.

Three best heterotic and heterobeltiotic crosses for grain yield per plant along with their SCA effects and per se performance in different environments are presented in Table 1. Perusal of this table indicated that the crosses WH 1021 x PBW 550 in all three environments, Raj 3765 x Raj 3077 in E₁ and E₂ and Raj 4238 x WH 1021 in E₁ and E₃ emerged as good heterotic as well as heterobeltiotic crosses for grain yield per plant. Among top three crosses for grain yield per plant in all the environments, the crosses WH 1021 x PBW 550 and Raj 4238 x WH 1021 showed desirable heterosis and heterobeltiosis for one or more characters in all the environments.

Table 1 Best three heterotic and heterobeltiotic crosses for grain yield per plant along with their SCA effects and per se performance in different environments

| Envs. | Heterotic crosses | Heterosis | SCA effect | Per se performance (g) | Heterobeltiotic crosses | Heterobeltiosis | SCA effect | Per se performance (g) |
|-------|------------------|-----------|------------|------------------------|-------------------------|----------------|------------|------------------------|
| E₁    | WH 1021 x PBW 550 | 60.86     | 10.06**    | 29.59                  | WH 1021 x PBW 550       | 52.84          | 10.06**    | 29.59                  |
|       | Raj 3765 x Raj 3077 | 55.99     | 10.31**    | 30.16                  | Raj 4238 x WH 1021      | 49.71          | 7.69**     | 26.17                  |
|       | Raj 4238 x WH 1021 | 49.93     | 7.69**     | 26.17                  | DBW 90 x PBW 550        | 36.83          | 7.74**     | 26.49                  |
| E₂    | WH 1021 x PBW 550 | 82.72     | 9.75**     | 25.80                  | WH 1021 x PBW 550       | 76.59          | 9.75**     | 25.80                  |
|       | Raj 3765 x Raj 3077 | 54.07     | 8.39**     | 26.57                  | DBW 90 x PBW 550        | 43.98          | 7.13**     | 23.44                  |
|       | DBW 90 x PBW 550   | 51.76     | 7.13**     | 23.44                  | Raj 3765 x Raj 3077     | 35.29          | 8.39**     | 26.57                  |
| E₃    | WH 1021 x PBW 550 | 81.05     | 7.48**     | 20.35                  | Raj 4238 x WH 1021      | 67.79          | 7.04**     | 18.91                  |
|       | Raj 4238 x WH 1021 | 75.09     | 7.04**     | 18.91                  | WH 1021 x PBW 550       | 67.49          | 7.48**     | 20.35                  |
|       | Raj 3765 x HD 3086 | 59.79     | 7.00**     | 19.35                  | DBW 90 x PBW 550        | 35.88          | 5.65**     | 16.51                  |
**Table 2** Crosses possessing high heterosis and heterobeltiosis for grain yield per plant along with desirable (+) heterotic expression for other characters in different environments

| Particulars | Environments | Crosses | Magnitude of SCA effect of grain yield per plant | Per se performance for grain yield per plant | Magnitude of heterosis or heterobeltiosis in per cent | Days to heading | Days to maturity | Grain filling period | Plant height | Flag leaf area | Number of effective tillers per plant | Spike length | Number of grains per spike | 1000-Seed weight | Biological yield per plant | Harvest index |
|-------------|--------------|---------|-----------------------------------------------|-------------------------------------------|------------------------------------------------------|----------------|---------------|---------------------|-------------|----------------|-------------------------------------|-------------|---------------------------|-----------------|---------------------------|-------------|
| **Heterosis** | E<sub>1</sub> | WH 1021 x PBW 550 | 10.06 | 29.59 | 60.86 | + | - | - | + | + | + | + | + | + | + | + | + |
|              |              | Raj 3765 x Raj 3077 | 10.31 | 30.16 | 55.99 | + | - | + | - | - | - | + | + | + | + | + | + |
|              |              | Raj 4238 x WH 1021 | 7.69 | 26.17 | 49.93 | + | + | - | - | + | + | + | + | + | + | + | + |
|              | E<sub>2</sub> | WH 1021 x PBW 550 | 9.75 | 25.80 | 82.72 | + | + | + | - | + | + | + | + | + | + | + | + |
|              |              | Raj 3765 x Raj 3077 | 8.39 | 26.57 | 54.07 | - | - | + | - | - | - | + | + | + | + | + | + |
|              |              | DBW 90 x PBW 550 | 7.13 | 23.44 | 51.76 | + | + | - | - | - | - | + | + | + | + | + | + |
|              | E<sub>3</sub> | WH 1021 x PBW 550 | 7.48 | 20.35 | 81.05 | + | + | + | - | + | + | + | + | + | + | + | + |
|              |              | Raj 4238 x WH 1021 | 7.04 | 18.91 | 75.09 | + | + | + | - | - | - | + | + | + | + | + | + |
|              |              | Raj 3765 x HD 3086 | 7.00 | 19.35 | 59.79 | + | - | + | - | - | - | + | + | + | + | + | + |
| **Heterobeltiosis** | E<sub>1</sub> | WH 1021 x PBW 550 | 10.06 | 29.59 | 52.84 | + | + | - | - | - | + | + | + | + | + | + | + | + |
|              |              | Raj 4238 x WH 1021 | 7.69 | 26.17 | 49.71 | + | + | - | - | + | + | + | + | + | + | + | + | + |
|              |              | DBW 90 x PBW 550 | 7.74 | 26.49 | 36.83 | + | + | - | - | + | - | + | + | + | + | + | + | + |
|              | E<sub>2</sub> | WH 1021 x PBW 550 | 9.75 | 25.80 | 76.59 | + | + | + | - | + | + | + | + | + | + | + | + | + |
|              |              | DBW 90 x PBW 550 | 7.13 | 23.44 | 43.98 | + | + | - | - | - | - | + | - | + | + | + | + | + |
|              |              | Raj 3765 x Raj 3077 | 8.39 | 26.57 | 35.29 | + | - | - | - | + | + | + | + | + | + | + | + | + |
|              | E<sub>3</sub> | Raj 4238 x WH 1021 | 7.04 | 18.91 | 67.79 | + | + | - | - | + | + | + | + | + | + | + | + | + |
|              |              | WH 1021 x PBW 550 | 7.48 | 20.35 | 67.49 | + | + | - | - | + | + | + | + | + | + | + | + | + |
|              |              | DBW 90 x PBW 550 | 5.65 | 16.51 | 35.88 | - | + | - | - | + | + | - | + | + | + | + | + | + |
Hence, these crosses may be considered as promising type for tangible advancement of bread wheat yield under normal sown and thermal stress condition. Crosses possessing high heterosis and heterobeltiosis for grain yield per plant along with desirable (+) heterotic expressions for other traits in different environments are presented in Table 2. Assessment of Table 2 divulged an interesting relation between heterosis and heterobeltiosis of grain yield per plant and other yield attributing traits.

The parents, who showed desirable heterosis and heterobeltiosis for grain yield per plant, also exhibited desirable heterosis and heterobeltiosis at least for one or more yield attributing traits. Such as, heterosis for grain yield per plant was mainly contributed by number of grains per spike and number of effective tillers per plant while heterobeltiosis by number of grains per spike and number of effective tillers per plant in all the three environments. Findings of this investigation supported the contentions of Grafius (1959), who suggested that there could be no separate gene system for yield per se as yield is an end product of the multiplicative interactions among its various contributing attributes.

Thus, heterobeltiosis for various yield contributing characters might be result in the expression of heterobeltiosis for grain yield. However, the crosses showing heterotic expression for grain yield per plant were not heterotic for all the characters. It was also noted that the expression of heterosis and heterobeltiosis was influenced by the environments for almost all the characters. This was because of significant G x E interaction. The results are in harmony with Singh et al., (2004), Kumar and Sharma (2005), Hassan et al., (2007), Akbar et al., (2010), Kumar and Maloo (2011), Lal et al., (2013) and Baloch et al., (2016).

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