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Association of Heterosis and Heterobeltiosis for Yield and its Contributing Traits in Indian Mustard (*Brassica juncea* L. Czern & Coss)

Swarnlata Kumawat [a*¥], Anil Kumar Sharma [b#], Komal Shekhawat [a¥], Anil Kumar [a¥] and Priyanka Kumawat [a¥]

[a] Department of Genetics and Plant Breeding, College of Agriculture, SKRAU, Bikaner, India.
[b] Department of Horticulture, College of Agriculture, SKRAU, Bikaner, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The heterosis breeding strategy is one of the most successful technological approaches for improving Indian mustard varieties for seed yield quality and quantity, as well as other yield contributing character. The present investigation was undertaken ten genetically diverse parents following diallel mating design excluding reciprocals. The resultant 45 F_1s and all the ten parents were evaluated in a randomized complete block design with three replications under three different environments. Data on quantitative characters were recorded and heterosis and heterobeltosis were determined that showed sufficient degree of heterosis and heterobeltiosis for all the attributes. The crosses, RGN-13 x RH-406 was identified for days to 50 per cent flowering, days to maturity, number of secondary branches per plant, number of siliquae per plant, 1000-seed weight, oil content, leaf area index and harvest index and the cross RGN-303 x RGN-229 was identified for days to 50 per cent flowering, days to maturity, number of secondary branches, number of seed per siliqua and 1000-seed weight. Among the 45 crosses, RGN-13 × RH-406 emerged as good heterotic as well as heterobeltiotic crosses for seed yield and other contributing characters.

[¥]Research Scholar;
[#]Professor;
**Corresponding author: E-mail: kumawatswarnlata.sk@gmail.com;*

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1. INTRODUCTION

Brassica is a major angiosperm genus with approximately 3200 species with morphological diversity. Indian mustard (*Brassica juncea*) is an important rabi oilseed crop in India and contributes more than 80% of total rapeseed-mustard production in the country. It is utilised in the production of oil, as well as nourishing vegetables and sauces. India is the world's 4^{th} largest grower and producer of oil-producing crops, accounting for ~19% of worldwide acreage and 2.7% of production [1]. India is the second largest mustard growing country in the world and ranks third next to Canada and China in production. In India, rapeseed-mustard grown in 7.92 million hectares with production of 9.34 MT with average productivity of 1499 kg ha^{-1} [2]. Rajasthan is the largest producer of rapeseed-mustard followed by Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal, Gujarat and Assam. In Rajasthan mustard is cultivated on about 2.71 million hectares with 4.30 mt production and 1586 Kg/ha productivity [3]. Domestic demand for edible oils and fats has been proliferating at 6% per year, but domestic output has only increased by 2% per year. Heterosis breeding could be a potential alternative for achieving quantum jumps in production and productivity. Since then, commercial exploitation of heterosis in a variety of crop species has resulted in a significant increase in yield levels. Keeping this in view, the present study was undertaken to identify potential parental material for producing high yielding varieties, following diallel analysis which helps plant breeders to predict the utility of F1 hybrids and its behavior in subsequent generation.

2. MATERIALS AND METHODS

Ten genetically diverse parents namely, RGN-303, RGN-13, RGN-229, RGN-298, RGN-236, RH-30, RH-406, RB-50, RLM-619 and PBR-378 were crossed in diallel mating design excluding reciprocals. During Rabi 2019-2020 season, ten parents and their 45 F1,s were evaluated in a randomized complete block design (RCBD) under three different environments created by three dates of sowing [1^{st} October (E_1), 15^{th} October (E_2) and 30^{th} October (E_3)] during *Rabi* 2019-2020 season at Research farm, College of Agriculture, SKRAU, Bikaner. Observations were recorded for the characters namely, days to 50% flowering and days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, siliqua length, number of seed per siliqua and leaf area index, 1000 seed weight, oil content, biological yield per plant, harvest index and seed yield per plant. Heterosis is expressed as per cent deviation from mid parent, whereas heterobeltiosis expressed as per cent deviation toward desirable direction over better parent. Heterosis and heterobeltiosis were calculated according to the method suggested by Shull [4] and Fonseca and Patterson [5].

Significance of heterosis was tested by using student "t" test.

$$t_{(r-1)(g-1)} = \frac{\overline{F_1} - \overline{MP}}{SE_{\left(\overline{F_1} - \overline{MP}\right)}}$$

Where,

F_1 = Mean Value of F_1
MP = Mean mid parent value *i.e.* (P_1+P_2)/2

$$SE_{\left(\overline{F_1} - \overline{MP}\right)} = \sqrt{\frac{3EMS}{r}}$$

Where,

EMS = Error mean square
r = Number of replications

$$\text{Heterobeltiosis} = \frac{\left(\overline{F_1} - \overline{BP}\right)}{\overline{BP}}$$

Significance of heterobeltiosis was tested by using student "t" test

$$t_{(r-1)(g-1)} = \frac{\overline{F_1} - \overline{BP}}{SE_{\left(\overline{F_1} - \overline{BP}\right)}}$$

Where,

BP = Value of better parent

$$SE_{\left(\overline{F_1} - \overline{BP}\right)} = \sqrt{\frac{2EMS}{r}}$$

Table 1. Best three heterotic and heterobeltiotic crosses for seed yield per plant and *per se* performance in different environments

Environments	Heterotic crosses	Heterosis	*Per se* performance (g)	Heterobeltiotic crosses	Heterobeltiosis	*Per se* performance (g)
E_1	RGN-13× RH-406	76.18**	44.96	RGN-13× RH-406	72.92**	44.96
	RH-30× RB-50	59.19**	46.36	RH-30× RB-50	49.55**	46.36
	RGN-303× RGN-229	56.79**	50.7	RGN-236× RB-50	48.67**	40.51
E_2	RGN-13× RH-406	54.71**	56.75	RGN-13× RH-406	53.39**	56.75
	RGN-236× RB-50	52.93**	50.96	RGN-236× RB-50	47.1**	50.96
	RGN-229× RGN-236	47.7**	56.3	RGN-303× RGN-229	44.79**	63.71
E_3	RGN-236× RB-50	46.64**	65.87	RGN-236× RB-50	40.64**	65.87
	RGN-13× RH-406	36.54**	64.11	RGN-13× RH-406	36.4**	64.11
	RGN-303×RGN236	36.09**	65.9	RGN-13× RB-50	34.06**	63.01
Pooled	RGN-303× RGN-229	50.75 **	59.83	RGN-13× RH-406	47.65	55.27
	RGN-13× RH-406	48.18 **	55.27	RGN-303× RGN-229	42.92 **	59.83
	RGN-236× PBR-378	41.26 **	53.79	RGN-298× PBR-378	35.38 **	62.81

*** indicates significance of values at 0.01, respectively*

Table 2. Crosses possessing high heterosis and heterobeltiosis for seed yield per plant along with desirable (+) heterotic expression for other characters in different environments

Particulars	Environments	Crosses	*Per se* performance for seed yield per plant	Magnitude of heterosis or heterobeltiosis in per cent	Days to 50% flowering	Days to maturity	Plant height	No. of primary branches per plant	No. of secondary branches per plant	Number of siliquae per plant	Siliqua length	Number of seeds per siliqua	1000-Seed weight	Biological yield per plant	Oil content	Leaf area index	Harvest index
+Heterosis	E_1	RGN-13× RH-406	44.96	76.18**	+	+	-	+	+	-	-	-	+	+	+	+	+
		RH-30× RB-50	46.36	59.19**	+	+	-	-	+	-	-	-	-	-	-	-	+
		RGN-303× RGN-229	50.7	56.79**	-	-	+	+	+	-	-	+	+	+	-	-	+
	E_2	RGN-13× RH-406	56.75	54.71**	+	+	-	+	+	+	-	-	+	-	-	+	+
		RGN-236× RB-50	50.96	52.93**	+	-	-	-	-	-	-	-	-	-	-	-	+
		RGN-229× RGN-236	56.3	47.7**	-	-	-	+	+	+	-	-	+	-	-	-	+
	E_3	RGN-236× RB-50	65.87	46.64**	-	-	+	-	-	-	-	-	-	-	-	-	+
		RGN-13× RH-406	64.11	36.54**	+	+	-	-	+	+	-	-	+	-	+	+	+
		RGN-303×RGN-236	65.9	36.09**	+	+	+	-	-	-	-	-	+	+	-	+	+
	Pooled	RGN-303× RGN-229	59.83	50.75 **	+	-	+	-	+	+	-	+	+	-	-	-	+
		RGN-13× RH-406	55.27	48.18 **	+	+	-	+	+	+	+	-	+	-	+	+	+
		RGN-236× PBR-378	53.79	41.26 **	-	-	+	+	+	-	-	-	+	-	-	+	+
Heterobeltiosis	E_1	RGN-13× RH-406	44.96	72.92**	+	+	-	-	+	-	-	-	+	-	+	+	+
		RH-30× RB-50	46.36	49.55**	+	+	-	-	+	-	-	-	-	-	-	-	+
		RGN-236× RB-50	40.51	48.67**	+	-	+	-	-	-	+	-	-	+	-	-	+
	E_2	RGN-13× RH-406	56.75	53.39**	+	+	-	-	+	+	-	-	+	-	-	+	+
		RGN-236× RB-50	50.96	47.1**	+	-	-	-	-	-	-	-	-	-	-	-	+
		RGN-303× RGN-229	63.71	44.79**	+	+	-	+	+	+	-	+	-	-	-	-	+
	E_3	RGN-236× RB-50	65.87	40.64**	-	-	+	-	-	-	-	-	-	-	-	-	+
		RGN-13× RH-406	64.11	36.4**	+	+	-	-	+	+	-	-	+	-	-	+	+
		RGN-13× RB-50	63.01	34.06**	+	+	-	+	+	+	-	-	-	-	-	+	+
	Pooled	RGN-13× RH-406	55.27	47.65	+	+	-	-	+	+	-	-	+	-	-	+	+
		RGN-303× RGN-229	59.83	42.92 **	+	+	-	-	+	+	-	+	+	-	-	-	+
		RGN-298× PBR-378	62.81	35.38 **	-	-	-	-	-	-	-	-	-	-	-	-	+

*** indicates significance of values at 0.01 & +, - desirable heterotic expression present, absent, respectively*

To calculate heterosis and heterobeltiosis parents with higher mean values were considered desirable for all the characters. Lower mean values of days to 50% flowering and days to maturity were considered desirable.

3. RESULTS AND DISCUSSION

Heterosis has extensively been explored and utilized for boosting various quality traits in *Brassica* and other crops [6]. According to Pal and Sikka, [7] heterosis is a quick, cheap and easy method for increasing crop production. The mean square of parents and crosses were highly significant for most of the characteristics in different environments and over environments in the current study, indicating that there was enough heterosis. Thus, parent study has been done to determine the best cross combinations that should be used for further segregation generation selection. Sufficient degree of heterosis and heterobeltiosis were observed for all the attributes. From Table 1, the performance point of view best hybrids namely, RGN-13× RH-406, RH-30× RB-50, RGN-303× RGN-229, RGN-236× RB-50, RGN-229× RGN-236, RGN-303×RGN236 and RGN-236× PBR-378 for heterosis and RGN-13× RH-406, RH-30× RB-50, RGN-236× RB-50, RGN-303× RGN-229, RGN-13× RB-50 and RGN-298× PBR-378 for heterobeltiosis have been identified to have high significant effect for seed yield and other related traits in desirable direction. These crosses were considered promising for their use for yield improvement in mustard.

Assessment of Table 2 described an interesting relation between heterosis and heterobeltiosis of seed yield and other yield attributing traits. The crosses, RGN-13 x RH-406 for days to 50 per cent flowering, days to maturity, number of secondary branches per plant, number of siliquae per plant, 1000-seed weight, oil content, leaf area index and harvest index and RGN-303 x RGN-229 for days to 50 per cent flowering, days to maturity, number of secondary branches, number of seed per siliqua, 1000-seed weight and harvest index showed desirable heterosis and heterobeltiosis for seed yield per plant and also yield attributing traits. The results of this study backed up Grafius [8] asserted that there could be no separate gene system for yield *per se* because yield is the result of multiplicative interactions among its various contributing attributes. The crosses that showed heterotic expression for seed yield per plant, on the other hand, were not heterotic for all of 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 Patel et al. [9], Vaghela et al. [10], Gami and Chauhan [11], Dholu et al. [12], Adhikari et al. [13], Barupal et al. [14] and Bhinda et al. [15].

4. CONCLUSION

The crosses, RGN-13 × RH-406 and RGN-236 × RB-50 were best crosses for seed yield per plant in all the environments and combined environments, with desirable heterosis and heterobeltiosis for one or more characters. Among these crosses, RGN-13 × RH-406 emerged as good heterotic as well as heterobeltiotic crosses for seed yield and other contributing characters along with high *per se* performance. These crosses could be frequently advanced to obtain high frequency of transgressive sergregants, which reveals good scope for isolation of pure line from the progenies of heterotic F_1 and commercial exploitation of heterosis in Indian mustard.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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