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Heterosis studies for yield and yield attributes over environments in brinjal (*Solanum melongena* L.)

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Brinjal is an important vegetable crop of India and is grown throughout the year. However, it is widely cultivated in both temperate and tropical regions of the globe mainly for its immature fruits as vegetables (Rai *et al.,* 1995), but in the temperate regions it is cultivated mainly during summer season. India is regarded as the primary centre of origin/diversity of brinjal (Genabus, 1963). One of the methods employed is exploitation of hybrid vigour through hybridization. The first time, Bailey and Munson (1891) reported artificial hybridization in brinjal. However, none of the hybrids exhibited any heterosis. Nagai and Kida (1926) were probably the first to observed hybrid vigour in a cross combinations of some Japanese varieties of brinjal to obtain higher yield per unit area, exploitation of hybrid vigour is better way particularly brinjal and obtained more number of seeds percent, where more seeds per fruit are obtained. Therefore, the present investigation was carried out to study the extent of heterosis in 36 F_1 hybrids over mid parents, better parent and standard check in a diallel cross combinations set of 9 parents excluding reciprocals in four different environmental condition. The study would be helpful for selecting desirable parents for hybrid development and to select potent transgressive segregants which can be further evaluated for enhanced yield potential.

The experimental material comprised of nine pure diverse parents viz; Kashi Sandesh, H-8, Pusa Shymal, Pusa Uttam, Pant Samrat, Pant Brinjal-5, Gujarat Oblong Brinjal(GOB-1,) Manjari Gota and Pant Rituraj along with its 36 F_1 hybrids generated by half-diallel in all possible combinations excluding reciprocals in four different date of sowing. The four dates of sowing were July 5, 2013 (E_1), July 25, 2013 (E_2), January 5, 2014 (E_3) and January 25, 2014 (E_4). Pusa Ankur was used as standard check. The experiment was laid out in randomized block design with three replications at Agronomy Farm, College of Agriculture, Bikaner and NICHE Area Research Farm, S.K. Rajasthan Agricultural University, Bikaner. The observations were recorded on five randomly selected plants from each treatment and replication for four characters i.e. plant height, branches per plant, fruit weight and marketable fruit yield per plant. Heterosis expressed as per cent increase or decrease in hybrid (F_1) over its mid parental value, better parent (BP) and standard check (SC) values in the desirable direction was calculated using the following formula.

$$\text{Heterosis}\,(\%) = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} x100$$

$$\text{Heterobeltiosis}\,(\%) = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} x100$$

$$\text{Useful heterosis}\,(\%) = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} x100$$

In the present investigation the parents vs. crosses component of variance was significant for all the characters in different environments as well as over environments, indicating sufficient scope for the presence of sufficient heterosis.

Wide range of variability exists among parents and their F_1 hybrids for different desirable traits under study. Out of 36 hybrids, significant desirable heterotic effects over respective mid, better and standard parents were noticed in 6, 4 and 6 in E_1, 8, 7 and 5 in E_2, 12, 11 and 7 in E_3 and 13, 6 and 5 in E_4 for plant height, 12, 8 and 11 in E_1, 12, 9 and 9 in E_2, 9, 6 and 7 in E_3 and 12, 11 and 10 in E_4 for branches per plant, 17, 8 and 3 in E_1, 18, 16 and 3 in E_2, 15, 10 and 3 in E_3 and 10, 6 and 4 in E_4 for fruit weight, 15, 14 and 9 in E_1, 16, 12 and 9 in E_2, 17, 14 and 7 in E_3 and 14, 12 and 12 in E_4 for marketable fruit yield per plant. The best significant hybrids for different traits with respect to heterosis over mid parent, better parent and check variety over environments were presented in Table 1.

Among the crosses, the wider range in heterosis over mid-parents were observed for marketable fruit yield per plant (-38.89 to 115.40) followed by fruit weight (-40.23 to 93.55), number of branches per plant (-40.43 to 73.68), and plant height (-52.86 to 42.85) respectively in all the environments. Maximum desirable heterosis over better parents (heterobeltiosis) were 104.83 (Pant Samart x Manjari Gota in E_3) for marketable fruit yield per plant, 82.24 (Pusa Shyamal x Manjari Gotain E_3) for fruit weight, 73.68 (Kashi Sandesh x Pusa Shaymal in E_1) for number of branches per plant, 30.46 (Kashi Sandesh x Pant Brinjal in E_3) for plant height in different environments.

The maximum desirable heterosis over standard check (economic heterosis) were 102.07 (Pusa Shyamal x

Pusa Uttam in E_4) for marketable fruit yield per plant, 63.24 (Pusa Shyamal x GOB-1 and Pant Samrat x Manjari Gotain E_4) for number of branches per plant, 45.17 (H-8 x Pusa Uttam in E_3) for fruit weight and 37.59 (Pant Samrat x Manjari Gotain E_2) for plant height in different environments.

Out of thirty six cross combinations, studied 16 crosses indicated significant heterosis in more than one environments, out of which 13 crosses in more than two environments expressed significant heterosis for marketable fruit yield per plant as well as some other characters. These cross combinations were Kashi Sandesh x H-8, Kashi Sandesh x Pusa Uttam, Kashi Sandesh x Manjrigota, H-8 x Pusa Uttam, H-8 x Pant Samrat, Pusa Shyamal x GOB-1, Pusa Shyamal x Manjari Gota, Pusa Shyamal x Pant Rituraj, Pant Samrat x GOB-1, Pant Samrat x Manjrigota, Pant Samrat x Pant Rituraj, Pant Brinjal-5 x Pant Rituraj and Manjari Gota x Pant Rituraj. These cross combinations were considered promising for their use in yield improvement it may be due to having high heterotic effect for yield as well some desirable component characters. Similar results of varying environments for different characters in brinjal were reported by Babu and Thirumurugan (2000) and Biswajit *et al.* (2005).

For heterobeltiosis, out of 36 cross combinations studied, 13 crosses were exhibited significant heterobeltiosis in more than one environments, out of which ten crosses in more than two environments expressed significant heterobeltiosis for marketable fruit yield per plant and also had significant heterobeltiosis for some of the other characters. Such cross combinations were Kashi Sandesh x H-8, Kashi Sandesh x Pusa Uttam, H-8 x Pusa Uttam, H-8 x Pant Samrat, Pusa Shyamal x GOB-1, Pusa Shyamal x Manjari Gota, Pusa Shyamal x Pant Rituraj, Pant Samrat x Manjari Gota and Pant Samrat x Pant Rituraj. Out of 36 crosses, ten crosses showing significant heterosis and heterobeltiosis in at least three environments were Kashi Sandesh x H-8, Kashi Sandesh x Pusa Uttam, H-8 x Pusa Uttam, H-8 x Pant Samrat, Pusa Shyamal x Gujarat Oblong Brinjal(GOB-1,) Pusa Shyamal x Manjari Gota, Pusa Shyamal x Pant Rituraj, Pant Samrat x Manjari Gota and Pant Samrat x Pant Rituraj. These crosses were considered promising for their use in yield improvement. Highly variable heterosis and heterobeltiosis for fruit yield and associated characters were reported by different workers like Singh and Gopalakrishnan (2000) and Chadha *et al.* (2001).

Table 1. The best significant hybrids for different traits with respect to heterosis over mid parent, better parent and check variety over environments

Characters	Heterosis over		
	Mid parent	Better parent	Standard check
Plant height	Kashi Sandesh x Pusa Uttam Kashi Sandesh x Pusa Uttam -1 Pusa Shyamal x GOB-1 Kashi Sandesh xPantBrinjal5 H-8 x GOB-1 Pant Brinjal-5 x GOB-1	Kashi Sandesh x Pusa Uttam Kashi Sandesh x Pusa Uttam -1 Pusa Shyamal x GOB-1 Pant Samrat x Manjari Gota Pant Brinjal-5 x GOB1	Kashi Sandesh x Pusa Uttam Kashi Sandesh x Pusa Uttam -1 Pusa Shyamal x GOB-1 x Manjari Gota Pant Samrat Manjari Gota H-8 x Pant Samrat
Number of branches per plant	Kashi Sandesh x Pusa Uttam H-8 x Pusa Shaymal Pusa Shaymal x GOB-1 Pant Samart x Pant Rituraj Pusa Uttam x Pant Brinjal-5 Pusa Shaymal x Manjri Gota Kashi Sandesh x Pusa Shaymal Kashi Sandesh x H-8	Kashi Sandesh x Pusa Uttam H-8 x Pusa Shaymal Pusa Shaymal x GOB-1 Pant Samart x Pant Rituraj Pusa Uttam x Pant Brinjal-5 Pusa Shaymal x Manjri Gota Kashi Sandesh x Pusa Shaymal Kashi Sandesh x H-8	Kashi Sandesh x Pusa Uttam H-8 x Pusa Shaymal Pusa Shaymal x GOB-1 Pant Samart x Pant Rituraj Pusa Uttam x Pant Brinjal-5 Pusa Shaymal x Manjri Gota Kashi Sandesh x Pusa Shaymal
Fruit weight	H-8 x Pusa Uttam H-8 x Pant Samrat Pusa Shyamal x Manjri Gota Pant Samrat x GOB-1 Kashi Sandesh x H-8 Kashi Sandesh x Pusa Uttam Pusa Shaymal x GOB-1 Pusa Shyamal x Pant Rituraj	H-8 x Pusa Uttam H-8 x Pant Samrat Kashi Sandesh x Pusa Uttam Pant Brinjal-5 x Pant Rituraj	Kashi Sandesh x Pusa Uttam H-8 x Pusa Uttam H-8 x Pant Samrat
Marketable fruit yield per plant(kg)	Kashi Sandesh x H-8 Kashi Sandesh x Pusa Uttam H-8 x Pusa Uttam H-8 x Pant Samrat Pusa Shyamal x GOB-1 Pusa Shyamal x Pant Rituraj Kashi Sanesh x Manjri Gota Pusa Shyamal x Manjri Gota Pant Samrat x Manjri Gota	Kashi Sandesh x H-8 Kashi Sandesh x Pusa Uttam H-8 x Pusa Uttam H-8 x Pant Samrat Pusa Shyamal x GOB-1 Pusa Shyamal x Pant Rituraj Kashi Sanesh x Manjri Gota Pusa Shyamal x Manjri Gota Pant Samrat x Manjri Gota	Kashi Sandesh x H-8 Kashi Sandesh x Pusa Uttam H-8 x Pusa Uttam H-8 x Pant Samrat Pusa Shyamal x GOB-1 Pusa Shyamal x Pant Rituraj Pusa Shyamal x Manjri Gota Pant Samrat x Manjri Gota

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