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Estimation of genetic components of variation and heterosis studies in bitter gourd for horticultural traits

P. Gangadhara Rao*, T.K. Behera, A.D. Munshi and Brihama Dev

Division of Vegetable Science, ICAR-Inadian Agricultural Research Institute, New Delhi 110012

ABSTRACT

Gene action and magnitude of heterosis were studied by using diallel analysis (without reciprocal) of the 21 crosses derived by crossing seven diverse bitter gourd inbreds for earliness and yield components. Data was recorded for eleven quantitative traits. Proportion of genes with positive and negative effects at all loci ($H_2/4H_1$) in the parents were found to be less than 0.25 for most of the traits revealed the asymmetrical distribution of the positive and negative alleles. Days to 50% flowering, days to first harvesting, fruit length (cm), fruit diameter (cm), number of fruits per plant and yield per plant (g) exhibited below 50% narrow sense heritability, which indicated the predominance of non-additive gene action. The average degree of dominance $(H_1/D)^{1/2}$ revealed that over dominance gene action for most of the yield related traits. Heterosis over standard check (Pusa Do Mousami) was also observed for all the traits under study. The best performing F_1 hybrids with high standard heterosis and mean performance for yield were found in crosses DBGS-54 × DBGS-2 (43.00%), DBGS-54 × Pusa Vishesh (37.89%) and Pusa Aushadhi × DBGS-54 (34.57%). Pusa Aushadhi × DBGS-54, Pusa Aushadhi × DBGS-57 and Pusa Aushadhi × DBGS-37 were best early yielding hybrids.

Key words: Bitter gourd, diallel analysis, gene action, heterosis.

INTRODUCTION

Bitter gourd (syn. balsam pear, bitter cucumber, African cucumber and bitter melon; *Momordica charantia* L.) is an economically important member of the family Cucurbitaceae that is widely cultivated in India, China, Malaysia, Africa, and South America. Although the general chemical composition of immature fruit is similar to other cucurbits, bitter gourd possesses comparatively high concentrations of ascorbic acid and iron (Behera, 3). Bitter gourd has been used as a traditional medicine for diabetes and other health-related ailments and contains health promoting substances such as charantin and vicine. Indian bitter gourd provides immense phenotypic variation based on various characters such as growth habit, maturity, fruit shape, size, colour, and surface texture (Robinson *et al*., 10) and sex expression (Behera *et al*., 2). Inspite of the potential economic and medicinal importance of this crop, due attention was not given towards a need based crop improvement programme.

The exploitation of heterosis is much easier in cross-pollinated crops like bitter gourd and being monoecious, it provides ample scope for the utilization of hybrid vigour on commercial scale. Further, the diversified parents from different regions with high yield and quality would also pave way for the development and release of hybrids through heterosis breeding. The hybrid vigour is tremendously increased on crossing genetically diverse inbreds (heterotic groups) and thus heterosis is mostly realised from parents with sufficient genetic diversity. Therefore, the objective of present investigation is to determine genetic component of variance and heterosis by using both indigenous and exotic lines of bitter gourd.

*Corresponding author's E-mail: gangadhararao.pulipati@gmail.com

MATERIALS AND METHODS

The experiment was conducted at Vegetable Research Farm, Division of Vegetable Science, IARI, New Delhi during spring-summer season (February to May) 2015 in a randomized complete block design with three replications with 20 plants per treatment. Seven genetically diverse inbreds of bitter gourd maintained by selfing at IARI, namely, Pusa Aushadhi (PA), DBGS-54 (S-54), Pusa Vishesh (PV), Pusa Do Mousami (PDM), DBGS-2 (S-2), DBGS-57 (S-57) and DBGS-37 (S-37) along with their 21 hybrids developed by using diallel mating system (without reciprocal) were utilised for the present study (Griffing, 7). Seed of 21 F_1 hybrids and the 7 parental lines (total of 28 treatments) were sown in 50-cell plug tray under the polyhouse and the seedlings were transplanted on both sides of the channel with a spacing of 2 m between channel and 60 cm between plants with 90 cm irrigation channels. The recommended NPK fertilizer doses and cultural practices along with plant protection measures were followed to raise an ideal crop. The fruits were harvested at horticultural maturity stage. Ten plants were selected after discarding the

border plants at both ends and were examined for 11 quantitative traits, namely, node at first pistillate flower appearance, days to first pistillate flower appearance, days to 50% flowering, days to first harvesting, fruit length (cm), fruit diameter (cm), number of fruits per plant, average fruit weight (g), yield per plant (g), yield per plot (kg) and yield per ha (q). The expected values of the components of genetic variation were estimated as suggested by Hayman (8). Standard heterosis was expressed as percentage increase or decrease of F_1 over standard parent (Pusa Do Mousami) and was calculated by using the formula (Fonseca and Patterson, 6).

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) revealed that mean sum of squares due to genotype, parent, hybrid and parent *vs* hybrid were highly significant for all traits studied. The magnitude and nature of genetic components of variation in a specific population is of prime importance for the effective prediction of most desirable breeding programme (Debnath, 4). The suitability of breeding methods for improvement of particular trait depends on nature of gene action. The results of diallel analysis revealed over-dominance for all the traits except node at first pistillate flower appearance and days to first pistillate flower appearance (Table 1).

The dominance component of genetic variation (H_1) was higher than additive component (D) for all the characters except node at first pistillate flower appearance and days to first pistillate flower appearance. Heritability in narrow sense (h) was found to be the highest (74.95%) for average fruit weight (g), while lowest value was recorded for fruit length (4.81%). Other traits like days to 50% flowering, days to first harvesting, fruit length (cm), fruit diameter (cm), number of fruits per plant, yield/ plant (g), yield per plot (kg) and yield per ha (q) had the narrow sense heritability less than 50%, which is indicative of predominance of non-additive gene action for these traits under study.

The F value was negative for three traits like, node at first pistillate flower appearance, days to first harvesting and fruit length (cm). This result indicated predominance of recessive gene in parental lines because negative F value is indicative of recessive genetic control and positive F value indicates dominant

Table 1. Estimation of the genetic components of variation for yield and yield related traits in bitter gourd.

Parent	Node at first pistillate flower appearance	Days to first pistillate flower appearance	Days to 50 % flowering	Days to first harvesting	Fruit length (cm)	Fruit dia. (cm)	No. of fruits/ plant	Av. fruit weight (g)	Yield/ plant (kg)	Yield/ plot (kg)	Yield/ ha (q)
D		22.37** ± 3.20	12.13** ± 1.91	14.70** ± 4.22	1.88 ± 3.65	3.97** ± 1.20	46.72** ± 5.50	119.05** ± 23.18	0.03 ± 0.02	10.39 ± 11.32	170.35 ± 339.19
F		11.16 ± 7.49	5.70 ± 4.59	-1.02 ± 10.12	-4.33 ± 8.76	8.07** ± 2.88	51.79** ± 13.20	178.42** ± 55.62	0.04 ± 0.06	14.77 ± 27.18	427.20 ± 813.70
H_1	2.22* ± 1.17	17.79* ± 7.51	18.32** ± 4.60	24.29* ± 10.15	24.78** ± 8.79	11.64** ± 2.89	75.24** ± 13.25	207.18** ± 55.81	0.23** ± 0.06	98.15** ± 27.24	2700.76** ± 816.58
H_2	2.07* ± 1.03	12.57* ± 6.61	15.22** ± 4.06	24.46** ± 8.94	16.98* ± 7.74	6.22** ± 2.54	58.71** ± 11.68	118.05** ± 49.48	0.19** ± 0.05	79.32** ± 24.01	2197.02** ± 719.52
h^2	0.19 ± 0.69	-1.48 ± 4.45	9.34** ± 2.72	16.43** ± 6.01	28.35** ± 5.20	0.08 ± 1.71	153.50** ± 7.84	-0.09 ± 33.03	0.35** ± 0.03	141.08** ± 16.12	3574.30** ± 483.27
E	0.98** ± 0.17	3.04** ± 1.10	2.35** ± 0.68	7.62** ± 1.49	2.04 ± 1.29	0.87* ± 0.42	7.34** ± 1.95	2.76 ± 8.20	0.02* ± 0.01	7.20 ± 4.00	127.78 ± 119.92
$(H_1/D)^{1/2}$	0.43	0.89	1.23	1.29	3.63	1.71	1.27	1.32	2.96	3.07	3.98
$(H_2/4H_1)$	0.23	0.18	0.21	0.25	0.17	0.13	0.20	0.14	0.20	0.20	0.20
$(4DH_1)^{1/2}+F/(4DH_1)^{1/2}-F$	0.39	1.78	1.47	0.95	0.52	3.92	2.55	3.63	1.63	1.60	1.92
h^2/H_2	0.09	-0.12	0.61	0.67	1.67	0.01	2.61	0.00	1.84	1.78	1.63
Heritability (narrow sense)	53.17	54.37	35.53	20.85	4.81	36.00	46.95	74.95	9.04	8.47	5.76
r	0.857**	0.242	0.548**	0.932**	-0.382*	-0.090	-0.955**	0.360	-0.592**	-0.609**	-0.739**

*, ** Significant at 5 and 1% levels

gene control (Hayman, 8). The proportion of genes with positive and negative effect in the parents was found to be less than 0.25 for all the traits under study except days to first harvesting where it was perfectly 0.25. This was indicative of asymmetry at loci showing dominance, which was similar to earlier report of Dey *et al*. (5).

The mean degree of dominance $(H_1/D)^{1/2}$ was found to be more than one for all the characters under study except node at first pistillate flower appearance and days to first female flower appearance. This also confirmed over-dominance for most of the yield related traits under study. These results were in consonance with the report of Dey *et al*. (5). They also revealed the preponderance of non-additive gene action in controlling most of the yield attributes in bitter gourd. The predominance of non-additive gene action and low to moderate narrow sense heritability for the characters suggested that exploitation of heterosis breeding would be more advantageous to enhancing yield in bitter gourd.

Earliness is an important trait for realizing the potential economic yield in a less time. Earliness in bitter gourd is attributed to node at first pistillate flower appearance, days to first pistillate flower appearance and days to first harvesting. The standard heterosis of 21 hybrids for 11 quantitative traits were presented in Table 2 and range of standard heterosis in Fig. 1. The standard heterosis was observed in the range of -48.57% (Pusa Aushadhi × DBGS-54) to 40.00% (DBGS-57 × DBGS-37) for node at first pistillate flower appearance over commercial check Pusa Do Mousami (PDM). Out of 21 hybrids, 12 hybrids showed significant negative (desired) standard heterosis over PDM (Table 3). The hybrids showed highest desirable heterosis over PDM for node at first pistillate flower appearance in the order of their merit were Pusa Aushadhi × DBGS-54 (-48.57%), Pusa Aushadhi × DBGS-2 (-42.85%) and Pusa Aushadhi × Pusa Vishesh (-34.28%). For days to first pistillate flower appearance, eight hybrids showed significant

Table 2. Heterosis for yield and yield related traits in bitter gourd over standard check (Pusa Do Mousami).

Cross	Node at first pistillate flower appearance	Days to first pistillate flower appearance	Days to 50% flowering	Days to first harvesting	Fruit length (cm)	Fruit dia. (cm)	No. of fruits/ plant	Av. fruit weight (g)	Yield/ plant (kg)	Yield/ plot (kg)	Yield/ ha (q)
PA × S-54	-48.57**	-12.96**	-20.86**	-6.78*	-13.63**	24.34**	78.83**	-32.31**	20.55**	20.41**	34.57**
PA × PV	-34.28**	-21.30**	-15.11**	-3.39	-19.55**	20.47**	78.38**	-6.95*	15.67**	15.63**	15.63*
PA × PDM	-34.28**	-11.11**	-9.35**	1.13	-19.77**	16.62**	94.37**	-39.96**	16.84**	16.74**	16.74*
PA × S-2	-42.85**	-13.89**	-17.99**	-3.39	-2.50	4.75**	97.52**	-32.25**	33.57**	33.41**	33.41**
PA × S-57	-20.00**	-14.81**	-15.11**	-6.78*	0.68	48.07**	79.05**	-25.45**	33.37**	33.21**	33.21**
PA × S-37	-22.86**	-11.11**	-13.67**	-6.78*	-4.32**	14.54**	67.79**	-40.02**	0.02	-0.03	-0.03
S-54 × PV	-17.14**	-2.78	-4.32**	-3.39	11.59**	26.12**	58.56**	-35.08**	19.05**	17.15**	37.89**
S-54 × PDM	-11.43**	-7.41**	-15.83**	12.43**	20.00**	15.13**	61.04**	-33.63**	7.33**	7.17*	7.17
S-54 × S-2	-20.00**	7.41**	-2.88	0.00	38.41**	-9.20**	89.64**	-9.43**	36.38**	41.88**	43.00**
S-54 × S-57	-8.57**	-1.85	-5.75**	-3.39	17.27**	10.68**	65.99**	-19.79**	33.07**	32.94**	32.95**
S-54 × S-37	-22.86**	-2.78	-7.91**	4.52	25.00**	16.62**	69.82**	-43.52**	-4.19**	-4.27	-4.27
PV × PDM	8.57**	-3.70	-11.51**	4.52	8.41**	3.86**	79.96**	-35.77**	15.54**	15.37**	15.37*
PV × S-2	8.57**	-3.70	-15.11**	12.43**	18.41**	3.86**	66.89**	-35.10**	7.68**	7.74*	7.74
PV × S-57	14.28**	3.70	-7.91**	0.00	-8.64**	8.01**	77.70**	-33.82**	17.85**	17.74**	17.74**
PV × S-37	11.43**	-3.70	-0.72	0.00	13.64**	17.21**	79.28**	-34.95**	16.19**	16.04**	16.04*
PDM × S-2	14.28**	0.00	-4.32**	0.00	63.64**	-10.38**	66.67**	-28.66**	18.70**	18.51**	18.51**
PDM × S-57	14.28**	-1.85	-9.35**	-3.39	4.78**	19.02**	67.12**	-24.26**	27.36**	27.27**	27.28**
PDM × S-37	-5.71**	-7.41**	-12.23**	0.00	19.32**	23.45**	68.24**	-28.16**	21.35**	21.11**	21.11**
S-2 × S-57	20.00**	-1.85	-5.04**	4.52	56.82**	14.54**	72.30**	-24.72**	30.07**	29.78**	29.78**
S-2 × S-37	28.57**	1.85	-5.04**	16.95**	34.32**	0.89	57.66**	-26.17**	16.34**	16.31**	16.30*
S-57 × S-37	40.00**	20.37**	2.16	7.91**	32.27**	27.90**	72.75**	-36.94**	9.33**	9.20**	9.20
CD at 5%	1.96	4.05	3.44	6.46	3.18	1.79	5.02	3.59	0.23	5.45	14.69

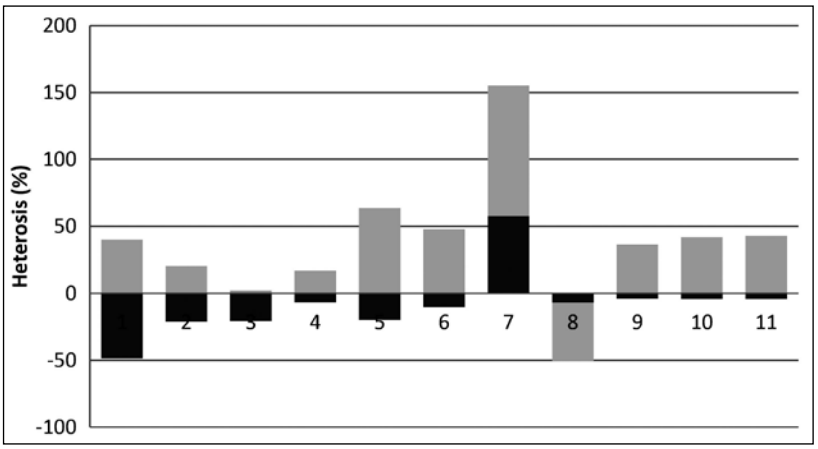
*, ** Significant at 5 and 1% levels

Table 3. Performance and heterosis for yield and yield related traits in bitter gourd over standard check (Pusa Do Mousami).

Trait	Range			No. of hybrids having significant standard heterosis		Better performing hybrids
	Parent	Hybrid	Standard heterosis	+ve	-ve	
Node at first pistillate flower appearance	5.67 to 15.00	6.00 to 16.33	-48.57 to 40.00	9	12	PA × S-54, PA × S-2, PA × PV
Node at first pistillate flower appearance	27.33 to 41.33	28.33 to 43.33	-21.30 to 20.37	2	8	PA × PV, PA × S-57, PA × S-2
Days to 50% flowering	37.33 to 48.67	36.67 to 47.33	-20.86 to 2.16	0	18	PA × S-54, PA × S-2, S-54 × PDM
Days to first harvesting	55.00 to 68.67	55.00 to 69.00	-6.78 to 16.95	4	3	PA × S-54, PA × S-57, PA × S-37
Fruit length (cm)	10.37 to 15.83	11.77 to 24.00	-19.77 to 63.64	14	5	PDM × S-2, S-2 × S-57, S-54 × S-2
Fruit dia. (cm)	9.00 to 15.78	10.07 to 16.63	-10.38 to 48.07	18	2	PA × S-57, S-54 × PV, PA × S-54
No. of fruits/ plant	29.60 to 53.20	46.67 to 58.47	57.66 to 97.52	21	0	PA × S-2, PA × PDM, S-54 × S-2
Av. fruit weight (g)	31.34 to 67.54	38.15 to 61.17	-6.95 to -43.52	0	21	PA × PV, S-54 × S-2, S-54 × S-57
Yield/ plant (kg)	1.67 to 2.29	1.91 to 2.72	-4.19 to 36.38	19	1	S-54 × S-2, PA × S-2, PA × S-57
Yield/ plot (kg)	33.40 to 45.83	38.28 to 56.73	-4.27 to 41.88	19	0	S-54 × S-2, PA × S-2, PA ×S-57
Yield/ ha (q)	148.45 to 197.01	170.14 to 254.14	-4.27 to 43.00	16	0	S-54 × S-2, S-54 × PV, PA × S-54

desirable standard heterosis which ranged from -21.30% (Pusa Aushadhi × Pusa Vishesh) to 20.37% (DBGS-57 × DBGS-37). The cross, Pusa Aushadhi × Pusa Vishesh (-21.30%) followed by Pusa Aushadhi × DBGS-57 (-14.81%), Pusa Aushadhi × DBGS-2 (-13.89%) were recorded desirable standard heterosis for days to first pistillate flower appearance. Eighteen hybrids for days to 50% flowering and three hybrids for days to first harvesting recorded significant desirable standard heterosis (%). The desirable standard heterosis for days to 50% flowering ranging from -20.86% (Pusa Aushadhi × DBGS-54) to 2.16% (DBGS-57 × DBGS-37) and for days to first harvesting ranged from -6.78% (Pusa Aushadhi × DBGS-54) to 16.95% (DBGS-2 × DBGS-37). The highest negative standard heterosis for days to first harvesting was observed in three crosses, *viz.*, Pusa Aushadhi × DBGS-54 (-6.78%), Pusa Aushadhi × DBGS-57 (-6.78%) and Pusa Aushadhi × DBGS-37 (-6.78%). Cross Pusa Aushadhi × DBGS-54 (-20.86%) followed by Pusa Aushadhi × DBGS-2 (-17.99%) and DBGS-54 × Pusa Do Mousami (-15.83%) showed the highest negative standard heterosis for days to 50% flowering. The earliness in these hybrids might be due to use of Pusa Aushadhi, a predominant gynoecious line as one of the parents in which flowering starts at early node (5^{th}-6^{th} node). Similar results were reported earlier by Dey *et al*. (5) particularly in gynoecious based hybrids.

Number of fruits per plant, fruit length, fruit diameter and average fruit weight are main contributing traits for yield. A critical analysis of the data on these traits in the parents, hybrids and standard check indicated that the parents and hybrids have higher mean values for number of fruits as compared to standard check. Fourteen hybrids had shown significant standard heterosis in the positive direction for fruit length, 18 hybrids for fruit diameter and 21 hybrids for number of fruits per plant. The standard heterosis for fruit length ranged from -19.77% (Pusa Aushadhi × Pusa Do Mousami) to 63.64% (Pusa Do Mousami × DBGS-2), for fruit diameter -10.38% (Pusa Do Mousami × DBGS-2) to 48.07% (Pusa Aushadhi × DBGS-57), for number of fruits per plant 57.66% (DBGS-2 × DBGS-37) to 97.52% (Pusa Aushadhi × DBGS-2) and for average fruit weight ranged from -6.95 (Pusa Aushadhi × Pusa Vishesh) to -43.52% (DBGS-54 × DBGS-37). The highest standard heterosis for fruit length was observed in hybrid Pusa Do Mousami × DBGS-2 (63.64%) followed by DBGS-2 × DBGS-57 (56.82%) and DBGS-54 × DBGS-2 (38.41%). The highest standard heterosis was recorded in hybrid Pusa Aushadhi × DBGS-57 (48.07%) followed by DBGS-54 × Pusa Vishesh (26.12%) and Pusa Aushadhi × DBGS-54 (24.34%) for fruit diameter and for number of fruits per plant, the highest standard heterosis was observed



1. Node at first pistillate flower appearance
2. Days to first pistillate flower appearance
3. Days to 50% flowering
4. Days to first harvesting
5. Fruit length (cm)
6. Fruit diameter
7. No. of fruits/plant
8. Av. fruit weight (g)
9. Yield/ plant (kg)
10. Yield/ plot (kg)
11. Yield/ ha (q)

Fig. 1. The range of standard heterosis over check for 11 quantitative traits in bitter gourd.

in hybrid Pusa Aushadhi × DBGS-2 (97.52%) followed by Pusa Aushadhi × Pusa Do Mousami (94.37%) and DBGS-54 × DBGS-2 (89.64%). Similarly, higher standard heterosis for of fruit number per plant and fruit weight (g) was reported earlier by Al-Mamuna *et al*. (1) and Laxuman *et al*. (9). The higher standard heterosis for fruit diameter was observed when DBGS-54 and DBGS-57 were used as one of the parents and they had high fruit diameter of 16 and 12 cm, respectively.

The ultimate goal of a breeder and most important trait is yield, it may be yield per plant, yield per plot and estimated yield per ha. For yield per plant 19 hybrids, for yield per plot 19 hybrids and for yield per ha 16 hybrids showed significant positive standard heterosis out of 21 hybrids. The standard heterosis for yield per plant ranged from -4.19% (DBGS-54 × DBGS-37) to 36.38% (DBGS-54 × DBGS-2), for yield per plot ranged from -4.27% (DBGS-54 × DBGS-37) to 41.88% (DBGS-54 × DBGS-2) and for yield per ha ranged from -4.27% (DBGS-54 × DBGS-37) to 43.00% (DBGS-54 × DBGS-2). The highest standard heterosis for yield per plant was shown by hybrid DBGS-54 × DBGS-2 (36.38%) followed by Pusa Aushadhi × DBGS-2 (33.57%) and Pusa Aushadhi × DBGS-57 (33.37%). For yield per plot, highest standard heterosis was showed by DBGS-54 × DBGS-2 (41.88%) followed by Pusa Aushadhi × DBGS-2 (33.41%) and Pusa Aushadhi × DBGS-57 (33.21%). For yield per ha, highest standard heterosis was observed in hybrid DBGS-54 × DBGS-2 (43.00%) (Fig. 2). These results

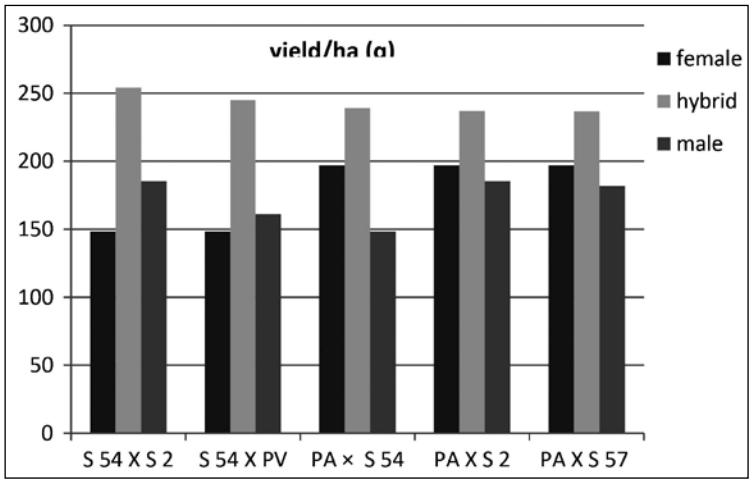


Fig. 2. Relative contributions of male and female parents in promising F_1 for higher standard heterosis in bitter gourd.

are in agreement with those of Singh *et al*. (11) and Thangamani *et al*. (12) for increase in yield per plant.

It is, therefore, suggested that these promising crosses DBGS-54 × DBGS-2, DBGS-54 × Pusa Vishesh and Pusa Aushadhi × DBGS-54 may be exploited for further amelioration of yield and yield components in bitter gourd and directly utilized as promising hybrids.

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