



Heterosis for quantitative traits and mineral contents in ridge gourd (*Luffa acutangula*)

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ABSTRACT

Seven parental lines and 21 F₁ hybrids of ridge gourd resulting from half diallel were studied to investigate the extent of heterosis for earliness, viz. days to first female flower anthesis and days to first fruit harvest, yield and its attributing characters viz. number of fruits per plant, fruit weight and fruit length, and nutrients (Ca, K, Fe, Zn and Mn) content. The crosses Pusa Nasdar × CO-1, DRG-71 × Swarna Uphar and Pusa Nasdar × Swarna Uphar were found to be the most promising for earliness as they showed negative and significant heterosis over better parent and standard variety. Hybrids Pusa Nutan × Arka Sujat, Pusa Nutan × DRG-71 and Pusa Nutan × DRG-7 were found to be best heterotic combinations as they exhibited significant heterosis percentage for yield per plant over the standard variety. The hybrids DRG-71 × Arka Sujat, DRG-7 × DRG-71, DRG-71 × Pusa Nasdar, Pusa Nutan × Pusa Nasdar and Pusa Nutan × Arka Sujat were the best specific combiners for Ca, K, Fe, Zn and Mn contents, respectively. The two most promising F₁ hybrids found were Pusa Nutan × Arka Sujat and Pusa Nutan × DRG-7 which were early in maturity, had higher number of fruits/plant and showed 84.38 and 51.26% heterosis for yield. They also exhibited significantly higher heterosis for most of the mineral contents over standard variety, Pusa Nutan.

Key word: Half- diallel, Heterobeltiosis, Heterosis, Ridge gourd, Standard heterosis

Ridge or ribbed gourd (*Luffa acutangula* Roxb.) is originated in subtropical Asian region particularly India (Kalloo 1993). It is an important cucurbitaceous vegetable in tropical and subtropical countries, especially in Asia and India (Jansen *et al.* 1993) as well as Africa (Neuwinger 1994). Heterosis was reported in ridge gourd for earliness, vigour, number of fruits per vine, fruit diameter, nutritional traits and yield and its contributing character (Kadam 1995, Mole *et al.* 2001, Shaha and Kale 2003 Hedau and Sirohi 2004, Ahmed *et al.* 2006, Karmakar 2011). Attention to the improvement on yielding ability and other characters has been very limited in ridge gourd which is reflected from the presence of very few varieties for commercial cultivation. Earliness and yield are the major criterion for any crop improvement programme as it benefits the grower to reap good profit by catching the high early market price. Ridge gourd as native to India exhibits considerable amount of genetic diversity with respect to different characters. Being monoecious and essentially cross pollinated and having large number of seeds from single pollination provides ample scope for successful exploitation of hybrid vigour. Thus,

there is good scope for improvement of yield and other desirable characters through heterosis breeding. Keeping in view the importance of above studies the present research program was undertaken to determine the magnitude of heterobeltiosis and standard heterosis for yield and its contributing component and mineral contents of ridge gourd.

MATERIALS AND METHODS

Field experiment was carried out at the Research Farm of Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi during the spring-summer and *khari* seasons of the year 2012.

Seven parental lines of ridge gourd, namely, Pusa Nutan, DRG-7, DRG-71, Arka Sujat, Pusa Nasdar, Swarna Uphar and CO-1 were used to make crosses in half diallel fashion to produce 21 F₁ hybrids in spring-summer season of the year 2012. Among these, cultivar Pusa Nutan was used as a standard check variety for the purpose of comparison. Crosses and their parents were evaluated in a Randomized Block Design with three replications. Crop was grown at plant to plant spacing of 75cm and row to row spacing of 2.5m. Data were recorded on days to first female flower anthesis, days to first fruit harvest, fruit length (cm), average fruit weight (g), number of fruits/plant and fruit yield/plant (kg). Apart from the yield and yield related attributes the hybrids were also subjected to mineral analysis.

Procedure for sample preparation, digestion and estimation of nutrients as described by Tandon (1998)

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and Jones (2001) were followed as such or with minor modifications as described below:

Composite samples of 10 fruits selected randomly from each genotype of the replications were collected at edible maturity stage. The fruits were chopped into slices and kept in oven at 75°C till the samples dried properly. Dried slices were then grinded thoroughly in mortar and pestle to a fine powder and were stored in butter paper bag inside the desiccators till further use.

Just before use, the powder was again heated for 2-3 hr at 75°C to make it free from any moisture and then 0.5 g dry powder was transferred into the digestion tube. Tissue samples were pre-digested by adding 10 ml of concentrated HNO₃ in digestion tubes for overnight. Next day, 15 ml of concentrated HNO₃ was added, followed by 5 ml of HClO₄ for its complete digestion in diacid mixture of HNO₃ and HClO₄ in a ratio of 5:1 (v/v). Samples were then heated at 60°C for 30 min, 120°C for 30 min and 255°C for 2 hr or till the digestion mixture became transparent on digestion block. On complete digestion, only 3-4 ml of digestion mixture had been left in the tube. Tubes were then removed from the block and allowed to cool down to room temperature. The content was diluted to 25 ml by adding double distilled water and then filtered through Whatman filter paper (No. 42). For each sample, final volume was made up to 100 ml in volumetric flasks. Now the digested samples were used for the estimation of Ca, K, Zn, Fe, and Mn. Standard solutions for each nutrient element were also prepared to make standard curves for respective element.

Ca and K were analyzed by using flame photometer with facility of internal calibration. Air pressure was kept constant at 10 psi. Characteristic emission of K and Ca was recorded at optical wavelength of 768 and 622 nm, respectively.

These were determined using atomic absorption spectrophotometer. Absorptions were recorded at 324.8, 213.9, and 248.3 nm for Mn, Zn, and Fe, respectively using standard specifications and their respective standard curves. All the elemental concentrations were expressed as per 100g fresh weight (FW) basis.

The data obtained on the above mentioned quantitative character and minerals were subjected to analysis of variance for randomized block design as suggested by Panse and Sukhatme (1967). Heterobeltiosis (better-parent heterosis) and economic heterosis (standard heterosis) for each cross were calculated as percentage deviation from the better parent (BP) and standard variety (SV) values, respectively (Turner 1953, Hayes *et al.* 1955).

RESULTS AND DISCUSSION

Analysis of variances indicated that significant differences existed between parents and hybrids for all traits, indicating the presence of standard heterosis (Table 1). Heterosis was estimated over better parent (BP) and standard variety (SV) for all the characters and mineral content of ridge gourd under study and is presented in Table 2, 3, respectively. Appreciable amount of heterosis

Table 1 Analysis of variance for different characters and nutrients content in ridge gourd

Source	d.f.	Mean sum of squares										
		Days to first female flower anthesis	Days to first fruit harvest	Fruit length (cm)	Average fruit weight (g)	Number of fruits/plant	Total fruit yield/plant (kg)	Ca (mg/100g)	K (mg/100g)	Fe (µg/100g)	Zn (µg/100g)	Mn (µg/100g)
Replication	2	6.54	5.04	19.83**	26.37	105.43**	1.14**	0.92	10.19	354.60	28.52	1.14
Treatment	27	44.27**	48.39**	48.59**	390.42**	63.45**	1.70**	41.04**	39.68**	2593.11**	16171.08**	1408.47**
Error	54	11.94	9.24	3.39	83.69	6.83	0.14	0.98	1.21	60.64	7.56	4.04

*Significant at P = 0.05, **Significant at P = 0.01.

Table 2 Estimation of better parent heterosis (BPH) and standard heterosis (SH) of 21 F1 hybrids for different characters in ridge gourd

Crosses	DFFFA		DFFH		FL		AFW		NFP		TFY	
	BPH%	SH%	BPH%	SH%	BPH%	SH%	BPH%	SH%	BPH%	SH%	BPH%	SH%
Pusa Nutan × DRG-7	-10.57	-10.58	-6.41	-6.41	-1.39	-1.39	12.12*	12.12*	34.57**	34.57**	51.45**	51.26**
Pusa Nutan × DRG-71	-8.45	-12.81*	-7.79	-7.79	-4.04	-4.04	11.70	11.70	28.40*	28.40*	43.80**	43.62**
Pusa Nutan × Arka Sujat	-9.08	-9.08	-2.05	-2.05	6.14	6.14	19.50**	19.50**	54.08**	54.08**	84.62**	84.38**
Pusa Nutan × Pusa Nasdar	-9.84	-9.84	0.41	0.41	-0.65	-0.65	14.07*	14.07*	23.27*	23.27*	40.94**	40.76**
Pusa Nutan × Swarna Uphar	-8.34	-8.34	-5.06	-5.06	-24.41**	-24.41**	10.08	10.08	20.54*	20.54*	32.95*	32.78*
Pusa Nutan × CO-1	-13.99*	-13.40*	-3.69	-3.69	-6.67	-6.67	1.25	1.25	27.38*	27.38*	29.27*	29.11*
DRG-7 × DRG-71	-7.04	-11.47	-9.44	-8.20	10.60*	1.45	17.08*	15.63	17.02	12.99	37.40*	30.77*
DRG-7 × Arka Sujat	-3.08	-1.63	-3.34	2.46	-1.09	-18.91**	12.20	9.13	19.40*	11.61	34.13*	21.94*
DRG-7 × Pusa Nasdar	-0.88	0.60	-1.02	4.92	-9.67	-16.38**	11.13	8.09	26.37*	18.13*	40.61**	27.83*
DRG-7 × Swarna Uphar	-2.64	-1.18	-3.73	2.05	0.87	-17.31**	7.79	4.84	9.89	2.72	18.59	7.81
DRG-7 × CO-1	-12.78*	-11.47	-11.08*	-5.74	9.07	-10.58*	-0.68	-3.40	3.30	-3.44	2.72	-6.62
DRG-71 × Arka Sujat	0.94	-3.87	3.09	4.51	-2.46	-10.52*	7.56	6.22	11.70	7.86	28.30*	22.11*
DRG-71 × Pusa Nasdar	-5.16	-9.68	-2.16	-0.82	9.6	1.45	12.23	10.83	4.95	1.34	18.16	12.46
DRG-71 × Swarna Uphar	-10.80	-15.05*	-11.60*	-10.39*	-4.14	-12.06*	4.20	2.90	10.64	6.83	15.65	10.07
DRG-71 × CO-1	-7.68	-12.07	-11.06*	-9.84	-7.50	-15.15**	0.56	-0.69	18.78*	14.69	19.82	14.04
Arka Sujat × Pusa Nasdar	-7.30	1.34	-6.48	6.56	3.33	-4.35	12.35	4.01	46.15*	-2.41	66.50**	1.62
Arka Sujat × Swaran Uphar	-3.15	1.05	-1.67	5.18	-9.28	-32.12**	3.84	-6.84	46.55*	-12.67	52.64*	-18.57
Arka Sujat × CO-1	-15.40*	-5.05	-13.21**	1.37	-10.80	-33.26**	7.42	-8.71	49.02**	-5.86	62.58*	-13.96
Pusa Nasdar × Swarna Uphar	-17.01*	-13.41*	-14.18**	-8.20	-15.33**	-21.63**	21.92**	12.86*	12.85	-24.65*	42.66*	-12.93
Pusa Nasdar × CO-1	-23.25**	-16.10*	-21.22**	-10.25*	-19.33**	-25.33**	7.58	-0.42	35.39*	-9.60	47.69*	-9.86
Swarna Uphar × CO-1	-1.01	3.29	-5.50	1.09	-7.96	-35.82**	5.76	-5.12	44.36*	-8.56	62.8*	-13.15

*Significant at P = 0.05, **Significant at P = 0.01; DFFFA = Days to first female flower anthesis; FL = Fruit length; AFW = Average fruit weight; NFP = Number of fruits/plant; TFY = Total fruit yield/plant.

Table 3 Estimation of better parent heterosis (BPH) and standard heterosis (SH) of 21 F1 hybrids for Ca, K, Fe, Zn and Mn content of ridge gourd

Crosses	Ca (mg/100g)		K (mg/100g)		Fe (µg/100g)		Zn (µg/100g)		Mn (µg/100g)	
	BPH %	SH %	BPH %	SH %	BPH %	SH %	BPH %	SH %	BPH %	SH %
Pusa Nutan × DRG-7	4.24	4.24	6.93*	16.40**	6.03**	6.03**	13.00**	20.87**	22.22**	22.22**
Pusa Nutan × DRG-71	6.97**	9.29**	14.80**	20.47**	5.76**	5.76**	9.27**	9.27**	35.81**	35.81**
Pusa Nutan × Arka Sujat	-2.48	-2.48	4.24	4.24	7.02**	7.02**	15.42**	15.42**	50.30**	50.30**
Pusa Nutan × Pusa Nasdar	5.26*	5.26*	-1.56	-1.56	0.79	0.79	43.27**	56.93**	27.78**	27.78**
Pusa Nutan × Swarna Uphar	-6.10*	-6.10*	10.04**	10.04**	0.23	0.23	19.60**	19.60**	-1.88	-1.88
Pusa Nutan × CO-1	-4.02	-4.03	12.34**	12.34**	1.56	1.56	0.87*	0.87*	4.94**	4.94**
DRG-7 × DRG-71	8.48**	10.84**	19.69**	30.30**	11.92**	11.00**	8.83**	16.40**	20.42**	14.84**
DRG-7 × Arka Sujat	6.73*	3.10	8.52**	18.14**	11.90**	9.18**	6.07**	13.45**	4.068*	-5.25**
DRG-7 × Pusa Nasdar	-8.65**	-11.76**	13.31**	23.35**	8.10**	5.48**	12.75**	23.54**	16.95**	6.48**
DRG-7 × Swarna Uphar	-2.89	-6.19*	-5.84**	2.50	-4.30**	-6.62**	-4.88**	1.74**	-0.67	-9.56**
DRG-7 × CO-1	11.12**	7.34**	0.1	8.86**	1.79	-0.68	1.74**	8.81**	0.68	-8.33**
DRG-71 × Arka Sujat	12.12**	14.55**	15.89**	21.61**	5.52*	4.66**	5.95**	3.74**	17.80**	12.34**
DRG-71 × Pusa Nasdar	-10.09**	-8.14**	14.80**	20.47**	13.25**	12.33**	-1.38**	8.058**	31.72**	25.62**
DRG-71 × Swarna Uphar	10.06**	12.45**	-6.19*	-1.56	0.49	-0.33	14.15**	11.77**	27.18**	21.30**
DRG-71 × CO-1	2.03	4.24	10.93**	16.40**	-2.61	-3.41*	8.94**	6.67**	44.98**	38.27**
Arka Sujat × Pusa Nasdar	15.95**	7.38**	3.52	-5.038	4.66**	-2.85*	17.41**	28.64**	30.69**	11.73**
Arka Sujat × Swarn Uphar	0.64	-17.43**	11.74**	2.50	-6.12**	-12.85**	2.61**	-1.91**	7.58**	-8.03**
Arka Sujat × CO-1	6.91*	-12.29**	28.79**	18.14**	9.33**	1.49	15.22**	10.14**	56.69**	33.95**
Pusa Nasdar × Swarna Uphar	18.63**	9.82**	6.30	-8.51*	6.34**	-1.38	6.08**	16.23**	23.86**	0.93
Pusa Nasdar × CO-1	19.53**	10.65**	15.06**	-0.97	10.56**	2.54	-1.01**	8.46**	51.51**	23.45**
Swarna Uphar × CO-1	7.90*	-15.39**	24.95**	4.94	4.19**	-6.14**	3.28**	0.35	20.08**	-5.86**

* Significant at P = 0.05; ** Significant at P = 0.01.

was observed in positive and negative directions for all the characters. Heterosis in negative direction is desirable for characters like days to first female flower anthesis and days to first fruit harvest. Out of 21 hybrids, five showed significant negative heterosis over better parent (BPH), and standard variety (SH), respectively, for days to first female flower anthesis. The hybrid Pusa Nasdar \times CO-1 exhibited highest negative heterotic values of -23.25% (BPH) and -16.10% (SH) for this trait. With respect to days to first fruit harvest, heterosis varied from -21.22 to 3.09% for heterobeltiosis and -10.39 to 6.56% for standard heterosis. The cross Pusa Nasdar \times CO-1 exhibited highest significant BPH (-21.22%) while DRG-71 \times Swarna Uphar exhibited highest heterotic value for SH (-10.39%). The crosses Pusa Nasdar \times CO-1, DRG-71 \times Swarna Uphar, Pusa Nasdar \times Swarna Uphar and Arka Sujat \times CO-1 were found to be the most promising for earliness. Heterobeltiosis and standard heterosis value ranged from -24.41 to 10.60% and -35.82 to 6.14%, respectively, for fruit length. Only one cross combination showed significant heterobeltiosis while none of the crosses were found to record significant standard heterosis for fruit length.

Fruit weight is one of the most important yield contributing traits which influences the yield decisively. The hybrids with positive and significant heterosis are desirable for this vital trait. The range of better parent and standard heterosis was -0.68% to 21.92% and -8.71% to 19.50%, respectively for fruit weight. Five and four crosses were significantly superior to the better parent and standard variety, respectively. The maximum significant and positive heterosis for fruit weight over better parent was shown by Pusa Nasdar \times Swarna Uphar (21.92%) while Pusa Nutan \times Arka Sujat exhibited highest heterosis over standard variety (19.50%).

Number of fruits/plant is an important trait and contributes to the yield enhancement, hence positive and

significant heterotic effects would be highly desirable. The extent of heterosis ranged from 3.30 to 54.08% over better parent and -24.65 to 54.08% over standard variety. Highly significant heterosis was noted in 14 and 7 hybrids over better parent and standard check, respectively. The hybrids Pusa Nutan \times Arka Sujat recorded highest significant heterobeltiosis (54.08%) and standard heterosis (54.08%) for number of fruits per plant. The positive and significant value for fruit yield per plant is desirable for exploitation of hybrid vigour. The range of heterosis for this most important economic trait ranged from 2.72 to 84.62% over better parent and -18.57 to 84.38% over standard variety. Such high heterosis for fruit yield per plant was due to additive heterotic effect of one or more components traits. Performance of 16 and 10 crosses was significantly superior to better parent and standard variety, respectively. The highest positive and significant heterosis estimate was recorded in the cross Pusa Nutan \times Arka Sujat over better parent (87.62%) and standard check (84.38%) while Pusa Nutan \times DRG-7 ranked second with heterosis values of 51.45% (BPH) and 51.46% (SH) for total fruit yield.

The results are similar to the report of Singh and Pal (1949). They noticed 57.5% hybrid vigour for yield in ridge gourd. Thakur and Singh (1968) found four hybrids in ridge gourd were higher yielder and early maturing than their parents. Abusaleha and Dutta (1994) also reported significant heterosis for yield and earliness in ridge gourd. In accordance with present findings, Mole *et al.* (2001) Shaha and Kale (2003), Hedau and Sirohi (2004), Ahmed *et al.* (2006) and Karmakar (2011) also observed heterotic effect for earliness, yield and fruit characters in the heterotic combinations in ridge gourd.

The range of heterosis for Ca content over better parent and standard variety ranged from -8.65 to 19.53% and -17.43 to 14.55%, respectively. Twelve and nine crosses showed desirable significant heterosis over better

Table 4 Range and mean performance, heterosis percentage range and number of significant heterosis crosses for different characters in ridge gourd.

Character	Parents		F ₁		Heterosis range		No. of significant heterosis crosses	
	Range	Mean	Range	Mean	BPH %	SH %	BPH	SH
Days to first female flower anthesis	42.60-52.20	47.24	37.53-45.33	41.34	-0.88 to -23.25	-16.10 to 3.29	5	5
Days to first fruit harvest	48.80-60.00	53.54	43.73-52.00	47.64	-21.22 to 3.09	-10.39 to 6.56	6	2
Fruit length (cm)	20.72-32.41	26.61	20.80-34.40	28.06	-24.41 to 10.60	-35.82 to 6.14	1	-
Average fruit weight (g)	100.20-120.50	111.28	110.00-144.00	127.27	-0.68 to 21.92	-8.71 to 19.50	5	4
Number of fruits/plant	10.00-19.47	14.77	14.67-30.00	21.30	3.30 to 54.08	-24.65 to 54.08	14	7
Total fruit yield/plant (kg)	1.003-2.343	1.66	1.908-4.320	2.74	2.72 to 84.62	-18.57 to 84.38	16	10
Ca (mg/100g)	22.80-33.00	28.72	26.67-37.00	32.54	-8.65 to 19.53	-17.43 to 14.55	12	9
K (mg/100g)	23.90-31.33	27.09	26.33-37.50	31.70	-6.19 to 28.79	-8.51 to 30.30	14	12
Fe (μ g/100g)	418.67-476.57	449.52	415.33-535.32	484.24	-6.12 to 13.25	-12.85 to 12.33	13	8
Zn (μ g/100g)	539.33-630.00	575.81	577.00-902.33	653.31	-4.88 to 43.27	-1.91 to 56.93	18	19
Mn (μ g/100g)	76.33-108.00	92.95	97.67-162.33	122.97	-1.88 to 56.69	-9.56 to 50.30	18	14

parent (BP) and standard variety (SH), respectively, for Ca content. The highest desirable standard heterosis (SH) value of 14.55% was recorded in hybrid DRG-71 × Arka Sujat whereas Pusa Nasdar × CO-1 showed highest better parent heterosis (BPH) value (19.53%) for Ca content. The range of heterobeltiosis and standard heterosis for K content were from -6.19 to 28.79% and -8.51 to 30.30%, respectively. 14 and 12 crosses showed desirable significant heterobeltiosis and standard heterosis, respectively. The hybrid DRG-7 × DRG-71 exhibited highest desirable SH value (30.30%) while Arka Sujat × CO-1 recorded highest BPH value (28.79%) for this trait. For Fe content, heterosis ranged from -6.12 to 13.25% for better parent and -12.85 to 12.33% for standard parent. Out of 21 hybrids, thirteen showed desirable significant heterosis over better parent and eight over standard check. The hybrid DRG-71 × Pusa Nasdar showed highest SH (12.33%) and BPH (13.25%) value for Fe content.

Heterosis values ranged from -4.88 to 43.27% over better parent and -1.91 to 56.93% over standard variety for Zn content. Eighteen and 19 hybrids showed desirable significant heterosis over better parent and standard variety, respectively. The highest per cent heterosis over better parent (43.27%) and standard variety (56.93%) was recorded in the hybrid Pusa Nutan × Pusa Nasdar for Zn content. The range of heterosis over better parent and standard variety for Mn content were from -1.88 to 56.69% and -9.56 to 50.30%, respectively. Eighteen and 14 crosses showed desirable significant heterosis over better parent and standard variety, respectively. The hybrid Arka Sujat × CO-1 exhibited highest BPH (56.69%) while cross Pusa Nutan × Arka Sujat recorded highest SH (50.30%). The above results are in conformity with the findings of Sit and Sirohi (2000, 2002 and 2005), Sureja *et al.* (2006) and Karmakar (2011).

The present study demonstrate that two most promising F1 hybrids, viz., Pusa Nutan × Arka Sujat and Pusa Nutan × DRG-7 were early in maturity, had higher number of fruits per plant and showed 84.38% and 51.26% heterosis for yield and also significantly higher heterosis for most of mineral contents over standard variety, Pusa Nutan and these may be tested under multilocation trials. These hybrids can be exploited through heterosis breeding to obtain higher yields and fruit quality. Moreover, these hybrids can be utilized for improvement of characters and for intermating among superior segregants resulting from these heterotic hybrids, which should exhibit desirable progenies in later generations.

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