Mobile No. 9933777603

International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 8(1): 153-161 March 2015
DOI Number: 10.5958/2230-732X.2015.00020.0

GENETICS

Exploitation of heterosis and combining ability for earliness and vegetative traits in ridge gourd [luffa *acutangula* (roxb.) L.]

Mangaldeep Sarkar*[1], Dinesh Kumar Singh[1], Mani Lohani[1], Abhijit Kumar Das[2] and Sankalpa Ojha[3]

[1]Department of Vegetable Science, College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology (G.B.P.U.A.&T.), Pantnagar, Uttarakhand-263145, India.
[2]Division of Genetics, Indian Agricultural Research Institute (IARI), New Delhi-110012, India.
[3]Department of Agril. Statistics, N M College of Agriculture, Navsari Agricultural University, Navsari-396450, Gujarat, India.

Corresponding author: mangaldeepsarkar@gmail.com

Paper No. 304 Received: 16 December 2014 Accepted: 5 March 2015 Published: 25 March 2015

ABSTRACT

Eight parental lines and 28 F_1 hybrids of ridge gourd obtained from half-diallel were studied to investigate the extent of combining ability and heterosis for earliness and vegetative characters. Appreciable heterosis in desirable direction was found over better parent and check parent for the characters *viz*. days to first female flower, node number to first female flower, vine length (m), number of primary branches and days taken to Ist fruit harvesting. Crosses PCPGR 7256 X PRG 142, PRG 117 X PRG 142, PRG 117 X PRG 131, PRG 117 X PRG 132 and PRG 117 X PRG 120 were found promising for earliness. Crosses PCPGR 7256 X PRG 117, PCPGR 7256 X PRG 131 and PRG 132 X PRG 120 were recorded promising for vegetative traits. Regarding general combining ability the parents PRG 117 and PRG 142 found best for earliness and for vegetative growth PRG 131 stood in top. The crosses PRG 131 X PRG 132 and PCPGR 7256 X PRG 142 showed highest specific combining ability for earliness and both the crosses PCPGR 7256 X PRG 117 and PRG 132 X PRG 120 found best for different vegetative traits.

Highlights

- Both additive and non additive gene action have been recorded for different quantitative traits.
- Crosses PCPGR 7256 X PRG 142, PRG 117 X PRG 142, PRG 117 X PRG 131, PRG 117 X PRG 132 and PRG 117 X PRG 120 could commercially be released as early hybrids.

Keywords: Ridge gourd, heterosis, combining ability, earliness, vegetative growth

Ridge gourd [Luffa acutangula (Roxb.) L.], 2n=2x=26, is one of the important cucurbitaceous vegetable crops. It is generally monoecious in nature but hermaphrodite, andrmonoecious, trimopnoecious and gynoecious flowering behaviour has also been reported (Swarup 2006). It is a popular vegetable both as spring-summer and rainy season crop known as ribbed gourd or angled gourd or silky gourd or angled loofah or vegetable gourd. The fruits are eaten as vegetable. This vegetable is low in saturated fat and cholesterol, high in dietary fibre, vitamin C, riboflavin, Zn, thiamin, Fe, Mg and Mn. The nutritional value makes it suitable for maintaining optimum health, weight loss. It has excellent cooling properties and used for fibre extraction. It is easily digestible vegetable. It contains a gelatinous compound called luffein. It has lot of medicinal use. The oil from the seeds is known to cure coetaneous complaints, the roots have laxative effects and the juice from the leaves is used to cure granular conjunctivitis of the eye, adrenal type diabetes and hemorrhoids. The juice prepared from ridge gourd is a natural remedy for jaundice. It helps to purify blood and lowers the blood sugar level, also good for stomach and skin. It is having abortifacient, antitumor, ribosome inactivating and immunomodulatory activities. The fruit is demulcent, diuretic and nutritive. Seeds possess purgative and emetic properties. The pounded leaves are applied locally to aplenitis, haemorrhoides and leprosy. The leaf juice prevents the lids adhering at night from excessive meibomian secretion (Rahman *et al.*, 2008). In spite of wide range of variability in different characters and being an important cucurbit of immense medicinal and nutritional value very little improvement work has been done. Ridge gourd, being predominantly monoecious is a cross pollinated crop and provide ample scope for utilization of the hybrid vigour. Single fruit of this vegetable gives large number of seeds and the cost of production of F1 seeds is not high in comparison to the other cucurbitaceous vegetables. Hence a speedy improvement can be brought about by assessing the genetic variability and exploitation of heterosis. Various breeding techniques have been advocated considering the breeding behaviour of crop species. Out of these F1 hybrid breeding is prominent and used in the improvement of vegetable crops, especially in out breeding species. For development of promising F1 hybrids, the identification of genetically superior plants is an important pre-requisite. A wrong choice of parents at this stage may undo a meticulously planned and well-executed follow up programme. The analysis of combining ability helps in selecting suitable genotypes as parents. A speedy improvement can be brought about by assembling the genetical variability, locating the best combiners and exploiting the heterosis. Combining ability analysis (Sprague and Tatum 1942) is one of the powerful tools available which gives the estimates of combining ability effect and aids in selecting desirable parents and crosses for further exploitation (Munshi and Verma 1999). In actual plant breeding combining abilities have found their principal use in predicting the performance of parents and hybrid populations of outbreeders, often in the form of test-crosses or polycrosses. Diallel analysis is widely used to estimate combining ability effects of the parents and the crosses (Griffin 1956a). Diallel analysis is most balanced and systemic experimental design to examine continuous variation. The genetic information related to parental population becomes available quite in early generation i.e. in F1 and it is thus useful to define breeding strategy without losing much time. In diallel cross system, there is no need for parents to be strictly inbred or to have uniformity. Heterosis has contributed significantly towards increased crop production and it has become the basis of multi-billion dollar agro-business in the world (Phillips 1999). In order to make an effective improvement in the characters related to earliness and vegetative traits, F1 hybrid breeding is prominent among the methods used in the improvement of ridge gourd. Hybrids under optimum crop production and protection management give economically more yield than that the improved varieties and also provide, uniform size, earliness, better keeping quality and resistance to biotic and abiotic stresses (Kalloo *et al.*, 2000. There is not a single F1 hybrid available in this vegetable by public sector till date for commercial cultivation in India. Owing to the existence of large variability it was considered worthwhile to take up the present investigation, therefore an experiment on 28 F1 hybrids obtained by crossing 8 diverse parental lines of hermaphrodite and monoecious ridge gourd through half-diallel method was studied to investigate the extent of combining ability and heterosis for earliness and vegetative characters.

Materials and Methods

The experiment was conducted during May, 2010 to August, 2010 in open field in a Randomized Block Design with three replications at Vegetable Research Centre, GBPUAT Pantnagar. The parental lines consist of one hermaphrodite viz. PCPGR 7256;

Table 1: mean values of parents and their F1 hybrids for different traits in ridge gourd

Genotypes	Days to first female flower	Node number to first female flower	Vine length (m)	Number of primary branches	Days taken to Ist fruit harvesting
PCPGR 7256	42.00	8.33	3.01	3.33	43.00
PRG 117	35.66	12.66	3.62	4.00	41.66
PRG 142	37.00	9.00	4.25	3.33	43.00
PRG 131	40.66	12.66	5.80	4.33	45.00
PRG 137	35.66	6.33	4.23	4.00	40.66
PRG 132	41.00	11.00	5.16	3.33	46.00
PRG 120	36.33	9.00	4.65	3.33	41.00
PRG 7	38.00	9.00	3.88	4.33	43.00
PCPGR 7256 X PRG 117	41.33	11.67	5.77	4.67	45.33
PCPGR 7256 X PRG 142	45.67	3.67	3.60	4.67	50.67
PCPGR 7256 X PRG 131	38.67	10.67	6.20	3.33	44.33
PCPGR 7256 X PRG 137	38.33	13.00	3.73	2.67	42.67
PCPGR 7256 X PRG 132	39.33	7.67	5.43	4.00	44.00
PCPGR 7256 X PRG 120	40.00	9.00	3.95	3.33	45.00
PCPGR 7256 X PRG 7	39.33	8.00	4.27	3.67	44.33
PRG 117 X PRG 142	33.67	8.67	3.30	4.67	40.00
PRG 117 X PRG 131	35.00	7.33	4.57	4.67	40.67
PRG 117 X PRG 137	34.67	6.67	4.33	4.67	40.33
PRG 117 X PRG 132	34.67	9.00	4.70	3.33	39.33
PRG 117 X PRG 120	35.00	9.67	4.83	3.67	39.00
PRG 117 X PRG 7	35.33	10.00	4.03	3.33	39.33
PRG 142 X PRG 131	35.67	9.67	4.35	3.33	39.67
PRG 142 X PRG 137	35.67	6.33	4.03	4.00	40.00
PRG 142 X PRG 132	35.67	9.33	4.17	3.67	40.33
PRG 142 X PRG 120	36.33	7.67	3.43	3.67	40.67
PRG 142 X PRG 7	37.00	8.33	4.13	3.67	41.67
PRG 131 X PRG 137	36.67	8.67	5.72	4.00	41.00
PRG 131 X PRG 132	35.33	9.00	6.17	5.00	40.00
PRG 131 X PRG 120	38.00	9.67	4.08	3.67	42.67
PRG 131 X PRG 7	37.67	10.33	5.53	4.67	43.33
PRG 137 X PRG 132	41.33	11.33	4.08	3.67	46.00
PRG 137 X PRG 120	38.33	8.00	3.43	2.67	42.00
PRG 137 X PRG 7	36.00	10.67	5.20	3.67	41.00
PRG 132 X PRG 120	37.00	8.67	4.80	5.67	42.33
PRG 132 X PRG 7	39.33	10.00	4.02	3.67	44.00
PRG 120 X PRG 7	37.33	10.67	3.27	3.33	42.67
Grand mean	37.62889	9.203889	4.436667	3.861667	42.37917
CD (0.05)	0.861569	0.640713	0.28354	0.218537	0.819114
CD (0.01)	1.155971	0.859648	0.380426	0.293212	1.099009
S.E.m	0.424395	0.315606	0.139667	0.107648	0.403483

* significant at 0.05 levels of probability
** significant at 0.01 levels of probability

and seven monoecious viz. PRG 117, PRG 142, PRG 131, PRG 137, PRG 132, PRG 120 and PRG 7 (Pant Torai 1) ridge gourd. Row to row distance 3.5 m and plant to plant spacing taken 0.6 m and each genotype consist eight plants. Observations were recorded from five randomly selected plants on days to first female flower, node number to first female flower, vine length (m), number of primary branches and days taken to Ist fruit harvesting. Combining ability analysis was carried out according to Griffing (1956b) method II model I. In this approach, using a suitable statistical model the component variances due to general and specific combining ability was estimated. Heterosis was calculated on over better parent (BP) and check parent (CP) for each character. Parent PRG 7 (Pant Torai 1) was taken as check for standard heterosis.

Results and Discussion

There were significant differences among the parental lines with respect to different characters studied. The mean performance of eight parental lines along with 28 F1 hybrids is given in Table 1.

The estimates of general combining ability (gca) effects of eight parental lines for all the five quantitative characters are presented in Table 2. It would be imperative to mention here that for the characters days to first female flower, node number to first female flower and days taken to Ist fruit harvesting, the negative gca and sca effects were considered to be desirable, as it indicates earliness. In the present study good general combiner for different traits have been identified on the basis of estimates of gca. For the character days to first female flower six parents exhibited significant gca effects ranging from -1.70 (PRG 117) to 2.73 (PCPGR 7256). Significant gca effects in negative direction were observed in PRG 117 (-1.70), PRG 137 (-0.70), PRG 142 (-0.57) and PRG 120 (-0.47). Six parents showed significant gca effects out of which two were in negative direction for the trait node number to first female flower. The maximum value for gca effects was recorded in PRG 142 (-1.13) followed by PRG 137 (-0.49). In case of days taken to first fruit harvesting five parents showed highly significant gca effect which is ranged from -1.41 (PRG 117) to 2.09 (PCPGR 7256). Three parents showed the effect in desirable negative direction i.e. PRG 117 (-1.41), PRG 137 (-0.71) and PRG 120 (-0.51). Regarding vine length the extent of gca effect ranged from -0.44 (PRG 142) to 0.83 (PRG 131) where only two parents showed the effect in positive direction i.e. PRG 131 (0.83) and PRG 132 (0.38). Only two parents showed significant gca effects in aspect of number of primary branches i.e. PRG 131 (0.26) and PRG 117 (0.22).

Table 2: Estimates of general combining ability effects of parents for different traits in ridge gourd

Parents	Days to first female flower	Node number to first female flower	Vine length (m)	Number of primary branches	Days taken to Ist fruit harves-ting
PCPGR 7256	2.73**	-0.26	-0.10**	-0.18	2.09**
PRG 117	-1.70**	0.54**	-0.12**	0.22*	-1.41**
PRG 142	-0.57**	-1.13**	-0.44**	-0.04	-0.24
PRG 131	0.30	0.77**	0.83**	0.26**	0.02
PRG 137	-0.70**	-0.49**	-0.09**	-0.14	-0.71**
PRG 132	0.53**	0.41**	0.38**	0.09	0.66**
PRG 120	-0.47*	-0.16	-0.28**	-0.14	-0.51**
PRG 7	-0.13	0.31*	-0.17**	-0.08	0.09
SE (gi)	0.69	0.47	0.10	0.33	0.63

* significant at 0.05 levels of probability
** significant at 0.01 levels of probability

The general combining ability is primarily the function of additive and additive × additive gene action. According to Gilbert (1967), the additive parental effects are of more practical use to the breeders than non-allelic interaction, if these are exploited through conventional selection methods. GCA effects would be more stable as compared to SCA effects. In general, additive effects are mainly due to polygenes producing fixable effects and indicate the capacity of variety in relation to all other varieties, it was crossed with. High GCA effects of a parent is a function of breeding value and hence due to additive gene effect and/or additive

× additive interaction effect which represents the fixable components of genetic variance. Apparently, parents with good GCA effects may be presumed to possess more favourable genes for the concerned traits. These above results are in accordance with the findings by Shaha *et al*., (1999) and Rao *et al*., (2000a) in ridge gourd. The specific combining ability (sca) effects of crosses for all characters are presented in Table 3. Analysis of sca effects for the character days to first female flower revealed that out o 28 crosses, 13 exhibited significant sca effects, where 9 were with negative values. The highest negative effect were shown by the cross PRG 131 X PRG 132 (-3.20) followed by PCPGR 7256 X PRG 131 (-2.07) and PRG 142 X PRG 132 (-2.00. 14 crosses showed significant effects for node number to first female flower out of

Table 3. Estimates of specific combining ability effects of crosses for different traits in ridge gourd

Crosses	Days to first female flower	Node number to Ist female flower	Vine length (m)	No. of primary branches	Days taken to Ist fruit harvesting
PCPGR 7256 X PRG 117	2.60**	2.17**	1.54**	0.76*	2.27**
PCPGR 7256 X PRG 142	5.80**	-4.16**	-0.30**	1.02**	6.44**
PCPGR 7256 X PRG 131	-2.07**	0.94*	1.03**	-0.61*	-0.16
PCPGR 7256 X PRG 137	-1.40*	4.54**	-0.51**	-0.88**	-1.10
PCPGR 7256 X PRG 132	-1.64*	-1.70**	0.72**	0.22	-1.13*
PCPGR 7256 X PRG 120	0.03	0.20	-0.11	-0.21	1.04
PCPGR 7256 X PRG 7	-0.97	-1.26**	0.10	0.06	-0.23
PRG 117 X PRG 142	-1.77**	0.04	-0.58**	0.62*	-0.73
PRG 117 X PRG 131	-1.30*	-3.20**	-0.58**	0.32	-0.33
PRG 117 X PRG 137	-0.64	-2.60**	0.10	0.72*	0.07
PRG 117 X PRG 132	-1.87**	-1.16**	0.00	-0.84**	-2.30**
PRG 117 X PRG 120	-0.54	0.07	0.79**	-0.28	-1.46*
PRG 117 X PRG 7	-0.54	-0.06	-0.12	-0.68*	-1.73**
PRG 142 X PRG 131	-1.77**	0.80	-0.47**	-0.74*	-2.50**
PRG 142 X PRG 137	-0.77	-1.26**	0.13	0.32	-1.43*
PRG 142 X PRG 132	-2.00**	0.84	-0.21*	-0.24	-2.46**
PRG 142 X PRG 120	-0.34	-0.26	-0.28**	-0.01	-0.96
PRG 142 X PRG 7	0.00	-0.06	0.31**	-0.08	-0.56
PRG 131 X PRG 137	-0.64	-0.83	0.55**	0.02	-0.70
PRG 131 X PRG 132	-3.20**	-1.40**	0.53**	0.79*	-3.06**
PRG 131 X PRG 120	0.46	-0.16	-0.90**	-0.31	0.77
PRG 131 X PRG 7	-0.20	0.04	0.44**	0.62*	0.84
PRG 137 X PRG 132	3.80**	2.20**	-0.64**	-0.14	3.67**
PRG 137 X PRG 120	1.80**	-0.56	-0.63**	-0.91**	0.84
PRG 137 X PRG 7	-0.87	1.64**	1.03**	0.02	-0.76
PRG 132 X PRG 120	-0.77	-0.80	0.27**	1.86**	-0.20
PRG 132 X PRG 7	1.23	0.07	-0.62**	-0.21	0.87
PRG 120 X PRG 7	0.23	1.30**	-0.71**	0.36	0.70
SE (Sij)	1.68	1.15	0.23	0.80	1.53

* significant at 0.05 levels of probability
** significant at 0.01 levels of probability

Table 4. Heterosis in ridge gourd for earliness and vegetative characters

Genotypes	Days to first female flower		Node number to first female flower		Vine length (m)		Number of primary branches		Days taken to Ist fruit harvesting	
	BP	CP	BP	CP	BP	CP	BP	CP	BP	CP
PCPGR 7256 X PRG 117	-1.59	8.77**	-7.89	29.63**	59.01**	48.50**	16.67	27.27*	5.43**	5.43**
PCPGR 7256 X PRG 142	8.73**	20.18**	-59.26**	-59.26**	-15.36**	-7.30*	40.00**	27.27*	17.83**	17.83**
PCPGR 7256 X PRG 131	-9.38**	1.75	-15.79**	18.52*	6.90**	59.66**	-23.08*	-9.09	-1.48	3.10
PCPGR 7256 X PRG 137	-8.73**	0.88	56.00**	44.44**	-11.81**	-3.86	-33.33**	-27.27*	-0.78	-0.78
PCPGR 7256 X PRG 132	-6.35**	3.51	-30.30**	-14.81*	5.16	39.91**	20.00	9.09	-4.35*	2.33
PCPGR 7256 X PRG 120	-4.76*	5.26*	0.00	0.00	-15.05**	1.72	0.00	-9.09	4.65*	4.65*
PCPGR 7256 X PRG 7	-6.35**	3.51	-11.11	-11.11	9.87**	9.87**	0.00	0.00	3.10	3.10
PRG 117 X PRG 142	-9.01**	-11.40**	-31.58**	-3.70	-22.41**	-15.02**	16.67	27.27*	-6.98**	-6.98**
PRG 117 X PRG 131	-17.97**	-7.89**	-42.11**	-18.52*	-21.26**	17.60**	7.69	27.27*	-9.63**	-5.43**
PRG 117 X PRG 137	-4.59	-8.77**	-47.37**	-25.93**	2.36	11.59**	16.67	27.27*	-3.20	-6.20**
PRG 117 X PRG 132	-15.45**	-8.77**	-28.95**	0.00	-9.03**	21.03**	-16.67	-9.09	-14.49**	-8.53**
PRG 117 X PRG 120	-3.67	-7.89**	-23.68**	7.41	3.94	24.46**	-8.33	0.00	-6.40**	-9.30**
PRG 117 X PRG 7	-7.02**	-7.02**	-21.05**	11.11	3.86	3.86	-16.67	-9.09	-8.53**	-8.53**
PRG 142 X PRG 131	-16.41**	-6.14*	-23.68**	7.41	-25.00**	12.02**	-23.08*	-9.09	-11.85**	-7.75**
PRG 142 X PRG 137	-3.60	-6.14*	-29.63**	-29.63**	-5.17	3.86	0.00	9.09	-6.98**	-6.98**
PRG 142 X PRG 132	-13.01**	-6.14*	-15.15*	3.70	-19.35**	7.30*	10.00	0.00	-12.32**	-6.20**
PRG 142 X PRG 120	-1.80	-4.39	-14.81*	-14.81*	-26.16**	-11.59**	10.00	0.00	-5.43**	-5.43**
PRG 142 X PRG 7	-2.63	-2.63	-7.41	-7.41	-2.82	6.44	0.00	0.00	-3.10	-3.10
PRG 131 X PRG 137	-14.06**	-3.51	-31.58**	-3.70	-1.44	47.21**	-7.69	9.09	-8.89**	-4.65*
PRG 131 X PRG 132	-17.19**	-7.02**	-28.95**	0.00	6.32**	58.80**	15.38	36.36**	-13.04**	-6.98**
PRG 131 X PRG 120	-10.94**	0.00	-23.68**	7.41	-29.60**	5.15	-15.38	0.00	-5.19**	-0.78
PRG 131 X PRG 7	-11.72**	-0.88	-18.42**	14.81*	-4.60	42.49**	7.69	27.27*	-3.70	0.78
PRG 137 X PRG 132	0.81	8.77**	3.03	25.93**	-20.97**	5.15	-8.33	0.00	0.00	6.98**
PRG 137 X PRG 120	5.50*	0.88	-11.11	-11.11	-26.16**	-11.59**	-33.33**	-27.27*	2.44	-2.33
PRG 137 X PRG 7	-5.26*	-5.26*	18.52*	18.52*	22.83**	33.91**	-8.33	0.00	-4.65*	-4.65*
PRG 132 X PRG 120	-9.76*	-2.63	-21.21**	-3.70	-7.10**	23.61**	70.00**	54.55**	-7.97**	-1.55
PRG 132 X PRG 7	-4.07	3.51	-9.09	11.11	-22.26**	3.43	0.00	0.00	-4.35*	2.33
PRG 120 X PRG 7	-1.75	-1.75	18.52*	18.52	-29.75**	-15.88**	9.09	9.09	-0.78	-0.78

*Significant at 0.05 level of probability
** Significant at 0.01 level of probability
CP- heterosis over check parent/ standard heterosis
BP- heterosis over better parent/ heterobeltiosis

which 8 were in desirable negative direction. The range varied between -4.16 (PCPGR 7256 X PRG 142) and 4.54 (PCPGR 7256 X PRG 137). The highest negative significant sca effect was recorded for cross PCPGR 7256 X PRG 142 (-4.16) followed by PRG 117 X PRG 131 (-3.20) and PRG 117 X PRG 137 (-2.60. Regarding days taken to first fruit harvesting among 28 crosses, 11 showed significant sca effects in which 8 were in desirable negative direction and 3 in positive direction. The highest effects were recorded by cross PRG 131 X PRG 132 (-3.06) followed by PRG 142 X PRG 131 (-2.50) and PRG 142 X PRG 132 (-2.46). 22 crosses expressed significant sca effects for vine length in which 10 were in positive direction. The highest effect was shown by PCPGR 7256 X PRG 117 (1.54) followed by PCPGR 7256 X PRG 131 (1.03), PRG 137 X PRG 7 (1.03) and PRG 117 X PRG 120 (0.79). In case of number of primary branches PRG 132 X PRG 120 (1.86) showed highest sca effect followed by PCPGR 7256 X PRG 142 (1.02). PRG 131 X PRG 132 (0.79) showed third highest effect.

Total 13 crosses exhibited the significant sca effect. Specific combining ability effect (SCA) which represents the predominance of nonadditive gene action is a major component that may be utilized in heterosis breeding. The significance of SCA effect elucidates the presence of genetic diversity among parents tested and illustrates the contribution of dominance and/ or epistatic effect which represent the non fixable components of the genetic variation related to heterosis. Specific combining ability effects mainly represent dominance, additive x dominance and dominance x dominance type of gene action. The crosses showing sca effects involving parent with good gca could be exploited as F1 hybrid breeding. however, if a cross having high sca has one of its parent as good general combiner and other as poor or average combiner, such crosses are likely to give some segregants, only if additive genetic system is present in a good general combiner and epistatic effects in the cross act in the same direction so as to maximize the desirable expression of the character in consideration (Whitehouse *et al.*, 1958, Lonnquist and Gardner 1961). Maximum F1 hybrids exhibiting significant sca effects, showed high amount of heterosis for various characters. In many of these hybrids, non additive gene action was involved for almost all the characters. These results are in conformity with the results reported by Sirohi and Choudhary (1978) in bitter gourd. In ridge gourd, Shaha and Kale (2003) found significant high sca effect for most of the characters in several cross combinations. The results of the present study are in agreement with findings reported by Rao *et al.*, (2000b), who reported that the components of variance for sca were higher than those of gca for most of the characters. In the present study, the extent of heterosis was studied in 28 F1 hybrids of ridge gourd developed by 8 parents in diallel design in open field. There was a wide variation in magnitude and direction of heterosis for all characters (Table 4). For the development of early fruiting genotypes, negative heterosis is desirable for days to first female flower, node number to first female flower and days taken to Ist fruit harvesting. The magnitude of heterobeltiosis for days to first female flower ranged from -17.97% (PRG 117 X PRG 131) to 8.73% (PCPGR 7256 X PRG 142). 19 crosses showed significant heterobeltiosis out of which 17 exhibited negative heterosis over better parent.

The maximum heterobeltiosis was found in PRG 117 X PRG 131 (-17.97%) followed by PRG 131 X PRG 132 (-17.19%) and PRG 142 X PRG 131 (-16.41%). The magnitude of standard heterosis for that trait ranged from -11.40% (PRG 117 X PRG 142) to 20.18% (PCPGR 7256 X PRG 142). For check parent 15 crosses showed significant heterosis in which 11 recorded negative heterosis over check parent. The maximum standard heterosis was found for the cross PRG 117 X PRG 142 (-11.40%) followed by PRG 117 X PRG 137 (-8.77%), PRG 117 X PRG 132 (-8.77%) and PRG 117 X PRG 131 (-7.89%), PRG 117 X PRG 120 (-7.89%). The magnitude of heterobeltiosis for node number to first female flower ranged from -59.26% (PCPGR 7256 X PRG 142) to 56.00% (PCPGR 7256 X PRG 137). 21 crosses showed significant heterobeltiosis out of which 19 exhibited negative heterosis over better parent. The maximum heterobeltiosis was found in PCPGR 7256 X PRG 142 (-59.26%) followed by

PRG 117 X PRG 137 (-47.37%) and PRG 117 X PRG 131 (-42.11%). The magnitude of standard heterosis for that trait ranged from -59.26% (PCPGR 7256 X PRG 142) to 44.44% (PCPGR 7256 X PRG 137). For check parent 12 crosses showed significant heterosis in which 6 recorded negative heterosis over check parent. The maximum standard heterosis was found for the cross PCPGR 7256 X PRG 142 (-59.26%) followed by PRG 142 X PRG 137 (-29.63%) and PRG 117 X PRG 137 (-25.93%). In case of days taken to Ist fruit harvesting the level of heterobeltiosis varied from -14.49% (PRG 117 X PRG 132) to 17.83% (PCPGR 7256 X PRG 142). 19 crosses showed significant heterobeltiosis out of which 16 exhibited desirable negative heterosis over better parent. The maximum heterobeltiosis was found in PRG 117 X PRG 132 (-14.49%) followed by PRG 131 X PRG 132 (-13.04%) and PRG 142 X PRG 132 (-12.32%). The magnitude of standard heterosis for that trait ranged from -9.30% (PRG 117 X PRG 120) to 17.83% (PCPGR 7256 X PRG 142). For check parent 17 crosses showed significant heterosis in which 13 recorded negative heterosis over check parent. The maximum standard heterosis was found for the cross PRG 117 X PRG 1420 (-9.30%) followed by PRG 117 X PRG 7 (-8.53%) and PRG 142 X PRG 131 (-7.75%). For vine length the scale of heterobeltiosis ranged from -29.75% (PRG 120 X PRG 7) to 59.01% (PCPGR 7256 X PRG 117). 20 crosses showed significant heterobeltiosis out of which 5 exhibited positive heterosis over better parent. The maximum heterobeltiosis was found in PRG PCPGR 7256 X PRG 117 (59.01%) followed by PRG 137 X PRG 7 (22.83%) and PCPGR 7256 X PRG 7 (9.87%). The degree of standard heterosis for that trait ranged from -15.88% (PRG 120 X PRG 7) to 59.66% (PCPGR 7256 X PRG 131). For check parent 20 crosses showed significant heterosis in which 15 recorded positive heterosis over check parent. The maximum standard heterosis was found for the cross PCPGR 7256 X PRG 131 (59.66%) followed by PRG 131 X PRG 132 (58.80%) and PCPGR 7256 X PRG 117 (48.50%). Regarding the trait number of primary branches the level of heterobeltiosis ranged from -33.33% (PCPGR 7256 X PRG 137 and PRG 137 X PRG 120) to 70.00% (PRG 132 X PRG 120. 6 crosses showed significant heterobeltiosis out of which 2 exhibited positive heterosis over better parent. The maximum heterobeltiosis was found in PRG 132 X PRG 120 (70.00%) followed by PCPGR 7256 X PRG 142 (40.00%). The degree of standard heterosis for that trait ranged from -27.27% (PCPGR 7256 X PRG 137) to 54.55% (PRG 132 X PRG 120. For check parent 10 crosses showed significant heterosis in which 8 recorded positive heterosis over check parent. The maximum standard heterosis was found for the cross PRG 132 X PRG 120 (54.55%) followed by PRG 131 X PRG 132 (36.36%) and PRG 117 X PRG 142, PRG 117 X PRG 131, PRG 117 X PRG 137 and PRG 131 X PRG 7 were holding the third position (27.27%). These results of present investigation are similar to the report of Singh and Pal (1949). They noticed 57.5% hybrid vigour in ridge gourd. Thakur and Singh (1968) found 4 F1 hybrids in ridge gourd were early maturing than their parents. Similar report was given by Sharma (1975) in musk melon. Early male and female flower anthesis and early maturity in musk melon has been reported by More and Seshadri (1980. Pitchaimuthu (1991) recorded significant hetrosis for vine length in bottle gourd over better and top parent. Similar results were also reported by Janakiram and Sirohi (1992). Luo *et al.*, (2000) reported that hybrids in ridge gourd were early maturing and higher yielder than their respective parents under South China condition.

Conclusion

The present study was a preliminary attempt to identify suitable parental genotypes and to develop superior early F1 hybrid having profuse vegetative growth. Keeping the results in mind it can be concluded that the gca and sca effects were highly significant for all the character studied which indicated that both additive and non additive gene actions were important in the inheritance of these characters. Therefore, in improvement of these traits, both selection and heterosis methods of breeding can be adopted. The crosses which showed high sca effects can be best utilized in heterosis breeding and the response to selection is expected to be the best in the crosses involving parents having high gca effects.

The genotypes PRG 117, PRG 142 and PRG 131can be used as suitable parent to develop commercial early hybrid having profuse vegetative growth. The hybrids PRG 117 X PRG 131, PCPGR 7256 X PRG 142, PRG 117 X PRG 132 and PRG 117 X PRG 120 can commercially be released for earliness viz. days to first female flower, node number to first female flower and days taken to Ist fruit harvesting and the hybrids PCPGR 7256 X PRG 117, PCPGR 7256 X PRG 131 and PRG 132 X PRG 120 for vegetative traits viz. vine length and number of primary branches.

Acknowledgement

Experimental facilities and assistance provided by Govind Ballav Pant University of Agriculture and Technology, Pantnagar for conducting the research is duly acknowledged.

References

Gilbert N (1967) Additive combining abilities fitted to plant breeding data. *Biometrics* **23**: 45-50. doi: http://dx.doi.org/10.2307/2528280

Griffing JB (1956a) A generalized treatment of diallel crosses in quantitative inheritance. *Heredity* **10**: 31-50. doi: http://dx.doi.org/10.1038/hdy.1956.2

Griffing JB (1956b) Concept of general and specific combining ability in relation to diallel crossing system. *Aust J Biol Sci* **9**: 463-493.

Janakiram T, Sirohi PS (1992) Studies on heterosis for quantitative characters in bottle gourd. *J Maharashtra Agric Univ* **17**(2): 204-206.

Kalloo G, Banerjee MK, Kumar S, Parkash C (2000) Hybrid Vegetable Technology in India: An overview. In: Kalloo, Gand Singh, K eds. Emerging Scenario in Vegetable Research and Development. India, Research Periodicals and Book Publishing House. pp. 11-31.

Lonnquist JH, Gardner CO (1961) Heterosis in inter-varietal crosses in maize and its implication in breeding procedure. *Crop Sci* **1**:179-183. doi: http://dx.doi.org/ 10.2135/cropsci1961.0011183X000100030007x

Luo JN, Luo SB, Gong H (2000) Breeding of new F_1 hybrid 'Yalu No.1' of *Luffa acutangula* Roxb. *China Veg* **3**: 26-28.

More TA, Seshadri VS (1980) Studies on heterosis in muskmelon. *Veg Sci* **7**(1): 27-40.

Munshi AD, Verma VK (1999) Combining ability in muskmelon (*Cucumis melo*). *Indian J Agr Sci* **69**(3): 214-220.

Phillips RL (1999) Research needs in heterosis. In: Coors, JG and Pandey, S eds. *Genetics and Exploitation of Heterosis in Crops* pp. 501-507.

Pitchaimuthu M (1991) Heterosis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. Thesis Ph D. Indian Agricultural Research Institute, Division of Vegetable Science, New Delhi, India.

Rahman AHMN, Anisuzzaman M, Ahmed F, Rafiul-Islam AKM, Naderuzzaman ATM (2008) Study of nutritive value and medicinal uses of cultivated cucurbits. *J Appl Sci Res* **4**(5): 555-558.

Rao BN, Rao PV, Reddy YN (2000a) Combining ability studies in ridge gourd (*Luffa acutangula* (L.) Roxb.). *Int J Trop Agric* **18**(2): 141-146.

Rao BN, Rao PV, Reddy YN (2000b) Heterosis in ridge gourd (*Luffa acutangula* (L.) Roxb.). *Haryana J Hort Sci* **29**(1/2): 96-98.

Shaha SR, Kale PN (2003) Diallel analysis for combining ability in ridge gourd. *J Maharashtra Agric Univ* **28**(3): 252-254.

Shaha SR, Kale PN, Narale PA (1999) Combining ability analysis in ridge gourd. *J Maharashtra Agric Univ* **24**(2): 133-135.

Sharma JC (1975) Genetical studies in muskmelon (Cucumis melo L.) Thesis PhD. Indian Agricultural Research Institute, Division of Horticulture, New Delhi, India.

Singh HB, Pal BP (1949) Some observations on the interspecific crosses between [*Luffa acutangula* (Roxb.) L. X *Luffa cylindrica* (Roem.) L.]. In Proceedings of 36th Indian Science Congress 1949. Allahabad, India.

Sirohi PS, Choudhary B (1978) Heterosis in bitter gourd (*Momordica charantia* L.). *Veg Sci* **4**(2): 107-115.

Sprague GF, Tatum LA (1942) General versus specific combining ability in single cross of corn. *J Am Soc Agron* **34**: 923-932.

Swarup V (2006) Vegetable Science and Technology in India. Kalyani Publishers, Ludhiana, India.

Thakur MR, Singh J (1968) Use of gynoecious line for production of hybrid seed in ridge gourd (*Luffa acutangula* L.). *J Res Punjab Agric Univ* **5**(1): 46-50.

Whitehouse RNH, Thompson JB, Ribiero MAM (1958) Studies on the breeding of self pollinated cereals. The use of diallel cross analysis in yield prediction. *Euphytica* **7**: 147–69. doi: http://dx.doi.org/ 10.1007/BF00729886