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Heterosis Analysis in Ridge Gourd [*Luffa acutangula* (L.) Roxb.]

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ABSTRACT: An experiment was conducted in randomized block design with three replications (*kharif*, 2023) to study the magnitude of heterosis and to assess the parents and crosses in the expression of fruit yield and its components for twelve characters in ridge gourd [*Luffa acutangula* (L.) Roxb.]. The material for the present study involved seven diverse parents and their twenty-one resultant hybrids derived from half diallel mating and one standard check (GJRGH 1), which were grown and evaluated at Horticultural Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The objective of this study were to investigate the *per se* performance and magnitude of heterosis (standard heterosis and heterobeltiosis) for different characters under study. The observations were recorded for days to first male flower, days to first female flower, primary branches per plant, node number of first male flower, node number of first female flower, days to first picking, main vine length (m), fruit weight (g), fruit length (cm), fruit girth (cm), fruits per plant and fruit yield per plant (kg). The mean of five plants was used for statistical analysis of all characters except for days to first male flower, days to first female flower, days to first picking. Analysis of variance revealed significant differences among the genotypes, parents and hybrids for all the characters excluding primary branches per plant, node number of first male flower, fruits per plant and fruit yield per plant. With respect to *per se* performance, among parent JDNRG-10, GRG-2 and JDNRG-32 was top ranking for fruit yield per plant. Mean values of cross combinations for various traits revealed that hybrids GRG-2 × JDNRG-19, GRG-2 × IC-523892 and JDNRG-19 × JDNRG-32 recorded highest fruit yield per plant. A critical analysis of parents and hybrids *per se* performance revealed that the hybrids involving GRG-2 as one of the parents recorded higher fruit yield per plant. The best heterotic cross for fruit yield per plant was GRG-2 × JDNRG-19. High magnitude of heterosis observed in this hybrid for fruit yield can be attributed to significant standard heterosis and heterobeltiosis in desirable direction for yield attributing traits *viz*., node number of first female flower and fruits per plant. This cross also exhibited significant standard heterosis for days to first male flower, days to first female flower and days to first picking. The second best hybrid GRG-2 × IC-523892 for fruit yield per plant also showed significant standard heterosis in desirable direction for node number of first female flower, fruit length, days to first picking and fruits per plant. These best performing crosses can be utilized in heterosis breeding programme for improvement of ridge gourd.

Keywords: Ridge gourd, analysis of variance (ANOVA), heterosis, heterobeltiosis, standard heterosis, *per se* performance.

INTRODUCTION

Ridge gourd [*Luffa acutangula* (L.) Roxb.] belongs to the family Cucurbitaceae and genus Luffa. It is widely grown in tropical and subtropical parts of the country. Its chromosome number is 2n=2x=26. It is also called as angled gourd, angled loofah, chinese okra, silky gourd and ribbed gourd (Muthaiah *et al*., 2017). The genus Luffa derives its name from the product 'loofah' which is used in bathing sponges, door mats, pillows and also for cleaning utensils (Srikanth *et al.*, 2021). The centre of origin and the primary gene centre of Luffa is India. *Luffa acutangula* (Ridge gourd) and *Luffa cylindrica* (Sponge gourd) are grown throughout India in tropical and subtropical climate. Ridge gourd is cultivating in 24,500 acres approximately in India with production of 3,16,925 tonnes (Bellamkonda *et al*., 2020). Ridge gourd is delicious vegetable and its tender fruits can be cooked to prepare various curries and it is also used in making chutneys in South India. Ridge gourd is grown both as spring-summer and rainy season crop.

Luffa has nine species out of which six species [*Luffa acutangula* (L.) Roxb, *L. cylindrica M. Roem*, *L. echinata* Roxb., *L. graveolens*, *L. tuberose* Roxb., *L. umbellata*] are found in India (Doijode, 2002). Ridge gourd is monoecious and cross-pollinated crop. The staminate flowers with five stamens (synandry) are borne in 10-20 flowered racemes, while pistillate flowers are solitary, short or long pedunculate and fragrant (Muthaiah *et al*., 2017). Ridge gourd is generally monoecious in nature but hermaphrodite, andromonoecious, trimonoecious and gynoecious flowering behaviour has also been reported (Swarup, 2006). Pistillate and staminate flowers are borne on the axil of the leaf. Anthers are free and pistil has three placentas with many ovules. Stigmas are three and bilobate. Anthesis starts between 5 to 7 pm and flowers remain open throughout the night.

The crop is economically and medicinally important and has immense potential for improvement. Being predominantly monoecious, ridge gourd is a cross-pollinated crop and thus provides ample scope for exploitation of the hybrid vigour. Single fruit gives many seeds and the cost of production of F_1 seeds is not high in comparison to the other vegetables. Hence, speedy improvement can be brought about by assessing and exploiting the genetic variability. Crop improvement depends upon genetic architecture of yield attributing traits. Heterosis breeding is one of the potential tools for exploitation of yield and yield contributing traits. Earlier, Abusaleha and Dutta (1994); Kadam *et al*. (1995); Niyaria and Bhalala (2001) reported that heterosis was found effective for early bearing and gave higher yields in ridge gourd. For development of promising hybrids, the identification of genetically superior plants is prerequisite.

Crop improvement depends upon genetic architecture of yield traits and magnitude of heterosis towards the yield attribute traits. Heterosis breeding is the one of potential tools for exploitation of yield and yield contributing traits. For development of an effective heterosis breeding programme in ridge gourd, one needs to elucidate the genetic variance, nature and magnitude of quantitively inherited traits and estimate of parents in hybrid combinations. The hybrid vigour is at the maximum in hybrid (F_1). The attempts of commercial production of hybrids (F_1) in vegetables in general and the cucurbits in particular was started as early as 1935 in Japan and 1940 in USA (Singh and Swarup 1971).

MATERIAL AND METHODS

The experiment was undertaken during summer and *kharif* season in the year 2022. The field experiment for evaluation was conducted at Horticultural Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar which is situated at an altitude of 152.52 meters above mean sea level on 240 – 19′N latitude and 720 – 19′E longitude. The soil of the experimental site is sandy loam, porous and poor in organic matter content with a 7.5 pH. The experimental material consisted of seven parents and their resulted twenty-one crosses by half diallel mating and one standard check (GJRGH 1). The seeds of hybrids were produced during summer 2022 at Centre for Crop Improvement, S.D. Agricultural University, Sardarkrushinagar – 385 506 by manual emasculation and crossing. The seeds of parental lines were maintained through selfing. The list of genotypes selected for crossing programme and check used is mentioned in Table 1.

Table 1: List of genotypes selected for crossing programme and check used.

Sr. No.	Genotype	Source
1.	**JDNRG-19**	Seed Spices Research Station, SDAU, Jagudan
2.	**JDNRG-32**	Seed Spices Research Station, SDAU, Jagudan
3.	**JDNRG-10**	Seed Spices Research Station, SDAU, Jagudan
4.	**JDNRG-39**	Seed Spices Research Station, SDAU, Jagudan
5.	**JDNRG-15-27**	Seed Spices Research Station, SDAU, Jagudan
6.	**IC-523892**	Seed Spices Research Station, SDAU, Jagudan
7.	**GRG 2**	Vegetable Research Station, JAU, Junagadh
8.	**GJRGH 1 (check)**	Vegetable Research Station, JAU, Junagadh

Seeds of parents were sown in February, 2022 at Centre for Crop Improvement, S.D. Agricultural University, Sardarkrushinagar, for attempting crosses in half diallel fashion. Sowing was done at a spacing of 2.0 m × 1.0 m. A total of twenty-one hybrids were developed by crossing seven genotypes. Bagging of selected male and female flowers was done in the morning with butter paper bags to avoid outcrossing and contamination. These flowers were used for crossing in the evening. Pollination was carried out from 5.00 pm to 7.00 pm by using the pollens of the desired male parent. After pollination, the female flower buds were again covered with butter paper bags to avoid contamination and tagged. The parents were also selfed simultaneously to obtain pure seeds of each variety. Crossed and selfed fruits were harvested separately at the full maturity stage. Fruits were kept for curing before the seeds were extracted. The seeds were extracted from fully dried fruits for evaluation.

A set of twenty-nine genotypes comprising of seven parents, their twenty-one F_1 hybrids and one standard check (GJRGH 1) were sown in randomized block design (RBD) with three replications, during *kharif* 2022 at Horticultural Instructional Farm, Chimanbhai

Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Each genotype was grown in single row using 2.0 m × 1.0 m spacing. In each single line, 10 plants were grown to evaluate the material for elucidate heterosis (standard heterosis and heterobeltiosis). The recommended agronomic package of practices was followed to grow the healthy crop. Observations were recorded from five randomly selected plants in each replication on twelve characters *viz.*, days to first male flower, days to first female flower, primary branches per plant, node number of first male flower, node number of first female flower, days to first picking, main vine length (m), fruit weight (g), fruit length (cm), fruit girth (cm), fruits per plant and fruit yield per plant (kg). The pooled data of all above characters were subjected to statistical analysis carried out under this experiment were done using the R statistical software, to derive the information on better parent heterosis/heterobeltiosis and standard heterosis (SH). The analysis of variance was carried out for randomized block design as per procedure described by Panse and Sukhatme (1985). Relative heterosis, heterobeltiosis and standard heterosis were calculated according to the method suggested by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

RESULTS AND DISCUSSION

Genetic variability is a vital requirement for the success of every crop improvement initiative. The mean squares for twelve different characters are presented in Table 2. The mean squares due to genotypes, parents and hybrids (F_1) were highly significant for most of the characters revealing the existence of potential variability in the parental material used in the present study. The analysis of variance revealed significant differences among the genotypes, parents and hybrids for all the characters excluding primary branches per plant, node number of first male flower, fruits per plant and fruit yield per plant. This indicated that a considerable amount of genetic variability was present in the material studied and the material was suitable for the study of the manifestation of heterosis, genetic parameters involved in the inheritance of different traits. The mean squares due to parents *vs.* hybrids were highly significant for the main vine length at 1 % which suggested the existence of differences between parents and hybrids leading to manifestation of heterosis. Whereas, mean squares due to check *vs*. hybrids are significant at only 5 % for node number of first female flower and fruit weight.

Mean data for twelve characters recorded from seven parental genotypes and their 21 F_1 hybrids were estimated. For all the characters the estimates on higher side were considered desirable while, for days to first male flower, days to first female flower, node number of first male flower, node number of first female flower, days to first picking the values on lower side were considered desirable because in this traits earliness is desirable.

The prime objective of heterosis breeding is to identify the specific cross combination capable of producing the maximum heterotic effect in F_1 generation. The measurement of heterosis over mid parental value has limited practical utility only important for academic interest. In practical plant breeding, the heterosis measured over better parent and popular hybrid is more realistic and is of more practical importance. Hence, in present investigation the extent of heterosis *i.e.*, heterobeltiosis (HB) and standard heterosis (SH) were estimated over better parent and standard check (GJRGH 1), respectively. While discussing the results of heterosis, the positive effects were considered as favourable for all the characters except days to first male flower, days to first female flower, node number for first male flower, node number for first female flower, days to first picking. Salient features of the results for each character studied are presented in Table 3-5.

Considering the importance of fruit yield per plant in the present investigation, out of 21 F_1 hybrids, heterobeltiosis ranged from -24.74 (JDNRG-39 × JDNRG-32) to 53.70 per cent (GRG-2 × JDNRG-19). Four hybrids GRG-2 × JDNRG-19 (53.70 %), IC-523892 × JDNRG-15-27 (44.26 %), GRG-2 × IC-523892 (35.77 %), GRG-2 × JDNRG-15-27 (32.75 %) showed significant positive heterosis in a desirable direction. Standard heterosis ranged from -28.03 (JDNRG-39 × JDNRG-32) to 57.52 per cent (GRG-2 × JDNRG-19). Only two hybrids, GRG-2 × JDNRG-19 (57.52 %) and GRG-2 × IC-523892 (25.51 %) showed significant positive heterosis (Fig. 1). Significant and positive heterobeltiosis and standard heterosis for fruit yield per plant was reported by Lodam *et al.* (2014); Ghuge *et al.* (2016); Tiwari *et al.* (2016); Malviya *et al.* (2017); Singh *et al.* (2017); Sarkar and Singh (2017); Chittora *et al.* (2018); Mallikarjunarao *et al.* (2018); Nandhini *et al.* (2018); Narasannavar *et al.* (2018); Wakale *et al.* (2018); Mishra *et al.* (2019); Varalakhsmi *et al.* (2019); Naik *et al.* (2020); Srikanth *et al.* (2020); Rambabu *et al.* (2021) in ridge gourd and other cucurbits.

For a successful heterosis breeding programme in any crop, there are two important pre-requisites, first, there must be ample evidence of the presence of significant heterotic effect in the hybrids that can be of practical utility and second, the production of economically feasible hybrid seed at the commercial scale. Ridge gourd is quite diverse in its character and it continues to be a choice of breeders for exploitation of heterosis due to the hardy nature of the crop, comparatively large size of flowers and more number of seeds in a single fruit enabling the production of a large number of F_1 seeds with a single act of pollination. Highly varied consumer acceptance from region to region also demands for development of a large number of high yielding F_1 hybrids.

Hybrids offer opportunities for improvement in earliness, uniformity, productivity, quality, wider adaptability and rapid deployment of dominant genes for resistance to disease and pests. Information on the magnitude of heterosis in differentcross combinations is a basic requisite to assess for identifying crosses that exhibit a high amount of exploitable heterosis. India being the centre of origin, ridge gourd has a huge genetic divergence and this offers much scope for improvement through heterosis breeding. In the present investigation, several crosses exhibited conspicuous heteroticresponses over better parent for different traits. However, apart from indicating genetic interaction, a measure of heterosis over better parent is relatively less importance than standard heterosis.

Hence, it is better to measure heterosis in terms of superiority over standard check variety, rather than over better parent. In the material studied, the degree of heterosis varied from cross to cross for all the characters. Considerable high heterosis in certain crosses and low in the other crosses suggested that the nature of gene action varied with the genetic architecture of the parents. Perusal of Table 6 showed that maximum significant standard heterosis for fruit yield per plant was observed in GRG-2 × JDNRG-19 (Fig. 2) followed by GRG-2 × IC-523892 and JDNRG-19 × JDNRG-32. The first cross also showed desirable significant heterotic effect for days to first male flower, days to first female flower, node number of first female flower, days to first picking, main vine length, fruits per plant and fruit yield per plant.

Among all the crosses, for earliness traits, IC-523892 × JDNRG-15-27 had lowest standard heterosis for days to first male flower, days to first female flower and JDNRG-39 × IC-523892 had lowest standard heterosis for days to first picking. Hybrid JDNRG-39 × JDNRG-19 manifested lowest heterosis for node number of first male flower while, JDNRG-19 × JDNRG-10 manifested lowest heterosis for node number of first female flower. For positive standard heterosis JDNRG-32 × IC-523892 had maximum heterosis for primary branches per plant, JDNRG-19 × JDNRG-32 for main vine length, JDNRG-39 × JDNRG-19 for fruit weight, JDNRG-10 × JDNRG-32 for fruit length, JDNRG-19 × JDNRG-15-27 for fruit girth, GRG-2 × JDNRG-19 had highest standard heterosis for fruit per plant and fruit yield per plant.

Table 2: Analysis of variance (mean sum of square) for twelve characters under study in ridge gourd.

Source of variation	d.f.	Days to first male flower	Days to first female flower	Primary branches per plant	Node number of first male flower	Node number of first female flower	Days to first picking
Replications	2	8.68	171.34**	0.52	4.18**	6.77**	4.17
Genotypes	28	50.62**	55.41**	0.36*	0.61**	6.22**	61.00**
Parents	6	45.66**	107.41**	0.50*	0.58	4.77**	91.87**
Hybrids	20	57.12**	44.23**	0.33	0.63**	6.96**	56.76**
Parents *vs.* Hybrids	1	0.39	3.57	0.03	0.92	2.54	3.11
Check *vs.* Hybrids	1	0.59	18.79	0.38	0.00	3.68*	18.44
Error	56	11.09	17.71	0.20	0.27	0.78	10.49

Source of variation	d.f.	Main vine length	Fruit weight	Fruit length	Fruit girth	Fruits per plant	Fruit yieldper plant
Replications	2	2.38**	268.89**	17.25	1.46*	4.95	0.25**
Genotypes	28	3.02**	1059.89**	26.02**	2.04**	7.46**	0.08
Parents	6	6.40**	409.02**	29.13**	1.00*	2.69	0.05
Hybrids	20	2.13**	1345.41**	27.21**	2.53**	9.50**	0.09*
Parents *vs.* Hybrids	1	3.40**	30.31	6.56	0.18	0.00	0.12
Check *vs.* Hybrids	1	0.13	284.24*	3.14	0.48	2.95	0.01
Error	56	1.24	51.71	6.21	0.32	1.94	0.05

*, ** Significant at 5% and 1% levels, respectively.

Table 3: Estimation of heterosis (%) over better parent (BP) and standard check (GJRGH 1) for days to first male flower, days to first female flower, primary branches per plant and node number of first male flower.

Sr. No.	Hybrids	Days to first male flower		Days to first female flower		Primary branches per plant		Node number of first male flower	
		BP	SC	BP	SC	BP	SC	BP	SC
1.	JDNRG-39 × GRG-2	41.96**	25.21**	40.36**	4.80	9.09	-0.60	13.04	-7.97
2.	JDNRG-39 × JDNRG-19	0.84	-5.51	16.51*	-13.02*	5.84	-3.56	-12.00	-22.13**
3.	JDNRG-39 × JDNRG-10	-4.83	-7.08	26.60**	-5.48	-3.28	-13.02**	7.86	-15.05
4.	JDNRG-39 × JDNRG-32	16.93**	14.19**	44.95**	8.22	-9.74	-17.76**	-7.75	-5.31
5.	JDNRG-39 × IC-523892	-0.84	-7.08	20.18**	-10.28*	14.49*	-6.51	-1.68	3.54
6.	JDNRG-39 × JDNRG-15-27	-12.90**	-14.96**	17.43*	-12.33*	-1.29	-10.06*	37.86**	25.67**
7.	GRG-2 × JDNRG-19	1.78	-10.23*	4.91	-12.33*	-5.32	-5.33	50.00**	22.13**
8.	GRG-2 × JDNRG-10	8.92	-3.93	11.47	-6.85	2.63	-7.70	28.09**	0.89
9.	GRG-2 × JDNRG-32	20.53**	6.31	22.13**	2.06	-14.10**	-20.72**	-2.17	-20.36*
10.	GRG-2 × IC-523892	1.78	-10.23*	9.01	-8.91	17.39**	-4.15	9.78	-10.62
11.	GRG-2 × JDNRG-15-27	12.50*	-0.78	12.29*	-6.17	6.49	-2.96	23.91*	0.89
12.	JDNRG-19 × JDNRG-10	-3.36	-9.45*	-3.78	-13.02*	3.28	-7.11	23.59*	-2.66
13.	JDNRG-19 × JDNRG-32	5.04	-1.57	-3.03	-12.33*	5.12	-2.96	8.50	-3.99
14.	JDNRG-19 × IC-523892	-0.84	-7.08	-0.75	-10.28*	23.18**	0.60	16.00	2.66
15.	JDNRG-19 × JDNRG-15-27	0.00	-6.30	-1.51	-10.96*	5.19	-4.15	11.00	-1.77
16.	JDNRG-10 × JDNRG-32	5.64	3.16	-0.68	0.00	13.15*	1.78	39.32**	9.74
17.	JDNRG-10 × IC-523892	19.32**	11.82*	18.24**	10.96*	10.14	-10.06*	23.59*	-2.66
18.	JDNRG-10 × JDNRG-15-27	10.48*	7.89	3.40	4.11	-1.31	-11.25*	34.83**	6.20
19.	JDNRG-32 × IC-523892	15.96**	8.67	9.48	2.74	24.63**	1.78	3.44	6.20
20.	JDNRG-32 × JDNRG-15-27	-11.42**	-2.36	-8.28	-1.37	7.79	-1.78	9.70	0.00
21.	IC-523892 × JDNRG-15-27	-9.24	-14.96**	-8.75	-14.39**	13.76*	-7.11	28.15**	16.82*
S.Em. ±		1.92	1.92	2.42	2.42	0.26	0.26	0.30	0.30
Range		-12.90 to 41.96	-14.96 to 25.21	-8.75 to 44.95	-14.39 to 10.96	-14.10 to 24.63	-20.72 to 1.78	-12.00 to 50.00	-22.13 to 25.67
Positive significant		7	3	9	1	6	0	9	3
Negative significant		2	5	0	9	1	6	0	2
Total significant		9	8	9	10	**7**	6	9	5

*, ** indicate the level of significance at 5% and 1%, respectively.

Table 4: Estimation of heterosis (%) over better parent (BP) and standard check (GJRGH 1) for node number offirst female flower, days to first picking, main vine length and fruit weight.

Sr. No.	Hybrids	Node number offirst female flower		Days to first picking		Main vine length		Fruit weight	
		BP	SC	BP	SC	BP	SC	BP	SC
1.	JDNRG-39 × GRG-2	-1.29	-19.65**	29.85**	4.82	-19.66	-51.99**	-43.17**	-41.89**
2.	JDNRG-39 × JDNRG-19	-3.88	-21.76**	9.70*	-11.45**	70.72**	2.03	38.59**	25.51**
3.	JDNRG-39 × JDNRG-10	10.77	-24.22**	17.91**	-4.82	19.80	-28.41**	44.98**	15.79**
4.	JDNRG-39 × JDNRG-32	-2.64	-22.46**	32.84**	7.23*	59.55**	-4.65	-38.28**	-50.77**
5.	JDNRG-39 × IC-523892	0.44	-19.65**	5.97	-14.46**	65.21**	-1.27	-22.20**	-24.78**
6.	JDNRG-39 × JDNRG-15-27	16.37*	-7.72	7.46	-13.26**	92.22**	14.88	-12.89**	-24.32**
7.	GRG-2 × JDNRG-19	-19.57**	-20.71**	-2.72	-13.86**	2.96	26.63**	-11.28**	-19.67**
8.	GRG-2 × JDNRG-10	38.97**	-4.92	3.36	-7.23*	-28.04**	-24.52**	4.58	-16.49**
9.	GRG-2 × JDNRG-32	51.10**	20.36**	16.11**	4.22	4.18	-0.93	32.82**	5.96
10.	GRG-2 × IC-523892	-13.16	-30.53**	0.67	-9.64**	44.38**	0.93	-11.95**	-14.87**
11.	GRG-2 × JDNRG-15-27	24.78**	-1.06	5.37	-5.43	-20.07*	-21.22*	-9.00*	-20.94**
12.	JDNRG-19 × JDNRG-10	0.51	-31.23**	-2.04	-13.26**	-23.53**	-19.79*	8.44	-13.4**
13.	JDNRG-19 × JDNRG-32	-13.66*	-31.23**	-1.36	-12.66**	33.26**	26.73**	52.18**	21.39**
14.	JDNRG-19 × IC-523892	-6.58	-25.27**	3.40	-8.44*	49.09**	4.23	0.80	-8.72*
15.	JDNRG-19 × JDNRG-15-27	38.05**	9.48	0.68	-10.85**	27.44**	25.62**	36.87**	18.92**
16.	JDNRG-10 × JDNRG-32	47.18**	0.71	0.60	1.81	-12.53	-16.83*	14.76**	-8.47*
17.	JDNRG-10 × IC-523892	41.03**	-3.51	7.36*	5.43	2.54	-28.32**	11.01*	-11.35**
18.	JDNRG-10 × JDNRG-15-27	73.85**	18.95**	5.36	6.63	2.23	0.77	12.62*	-10.07*
19.	JDNRG-32 × IC-523892	6.61	-15.09**	7.36*	5.43	8.83	-23.93**	19.53**	-4.66
20.	JDNRG-32 × JDNRG-15-27	17.70*	-6.67	-6.82*	-1.21	-29.96**	-33.39**	9.28	-12.83**
21.	IC-523892 × JDNRG-15-27	37.61**	9.13	-7.36*	-9.04**	8.95	-23.84**	13.59**	-1.32
S.Em. ±		0.51	0.51	1.87	1.87	0.32	0.32	4.15	4.15
Range		-19.57 to 73.85	-31.23 to 20.36	-7.36 to 32.84	-14.46 to 7.23	-29.96 to 92.22	-51.99 to 26.73	-43.17 to 52.18	-50.77 to 25.51
Positive significant		10	2	7	1	8	3	10	4
Negative significant		2	11	2	11	4	10	7	14
Total significant		12	13	9	12	12	13	17	18

*, ** indicate the level of significance at 5% and 1%, respectively.

Table 5: Estimation of heterosis (%) over better parent (BP) and standard check (GJRGH 1) for fruit length, fruit girth, fruits per plant and fruit yieldper plant.

Sr. No.	Hybrids	Fruit length		Fruit girth		Fruits per plant		Fruit yieldper plant	
		BP	SC	BP	SC	BP	SC	BP	SC
1.	JDNRG-39 × GRG-2	-23.86**	-12.01	-5.56*	-6.05*	14.05	14.56	-12.44	-16.26
2.	JDNRG-39 × JDNRG-19	26.66**	18.48**	10.00**	12.22**	-20.38*	-20.03*	16.30	11.23
3.	JDNRG-39 × JDNRG-10	9.79	14.17*	7.89**	10.07**	-26.00**	-25.68**	-4.97	-9.13
4.	JDNRG-39 × JDNRG-32	-0.05	-11.28	0.53	2.56	23.07*	23.61*	-24.74	-28.03*
5.	JDNRG-39 × IC-523892	-28.12**	-24.04**	4.83	3.63	8.15	7.54	6.63	-1.44
6.	JDNRG-39 × JDNRG-15-27	2.93	-12.15	-3.42	-1.48	33.21**	33.80**	23.11	-1.93
7.	GRG-2 × JDNRG-19	13.10	5.79	-4.21	-4.70	35.61**	53.76**	53.70**	57.52**
8.	GRG-2 × JDNRG-10	6.16	10.39	-6.64*	-7.12**	10.05	24.84**	4.82	18.32
9.	GRG-2 × JDNRG-32	33.64**	18.65**	-6.91*	-7.39**	-12.05	-0.23	22.52	18.61
10.	GRG-2 × IC-523892	12.52	18.91**	-4.94	-6.05*	25.11**	24.4**	35.77*	25.51*
11.	GRG-2 × JDNRG-15-27	33.06**	13.58*	3.89	3.36	30.30**	38.27**	32.75*	5.77
12.	JDNRG-19 × JDNRG-10	29.44**	21.07**	-4.79	4.17	13.10	28.23**	14.03	16.86
13.	JDNRG-19 × JDNRG-32	19.02*	5.66	2.71	6.85*	-19.61*	-8.86	26.00	21.98
14.	JDNRG-19 × IC-523892	-3.16	-9.43	7.55**	6.31*	20.74*	20.06*	22.81	13.53
15.	JDNRG-19 × JDNRG-15-27	34.21**	14.56*	16.24**	19.52**	-19.09*	-14.15	28.30	2.22
16.	JDNRG-10 × JDNRG-32	38.14**	22.64**	0.39	4.43	-4.11	11.15	9.53	6.03
17.	JDNRG-10 × IC-523892	9.75	14.12*	8.64**	7.39**	19.03*	18.36*	16.53	7.73
18.	JDNRG-10 × JDNRG-15-27	37.30**	17.20*	2.61	5.51*	-5.45	0.33	31.39	4.68
19.	JDNRG-32 × IC-523892	21.47**	7.84	5.38	4.17	-3.64	-4.19	14.03	5.41
20.	JDNRG-32 × JDNRG-15-27	14.35	-2.40	-8.36**	-5.78*	0.01	6.13	24.42	-0.88
21.	IC-523892 × JDNRG-15-27	1.02	-13.78*	14.34**	13.03**	6.19	5.59	44.26**	14.93
S.Em. ±		1.43	1.43	0.33	0.33	0.80	0.80	0.12	0.12
Range		-28.12 to 38.14	-24.04 to 22.64	-8.36 to 16.24	-7.39 to 19.52	-26.00 to 35.61	-25.68 to 53.76	-24.74 to 53.70	-28.03 to 57.52
Positive significant		9	10	6	8	7	9	4	2
Negative significant		2	2	4	5	4	2	0	1
Total significant		11	12	10	13	11	11	4	3

*, ** indicate the level of significance at 5% and 1%, respectively.

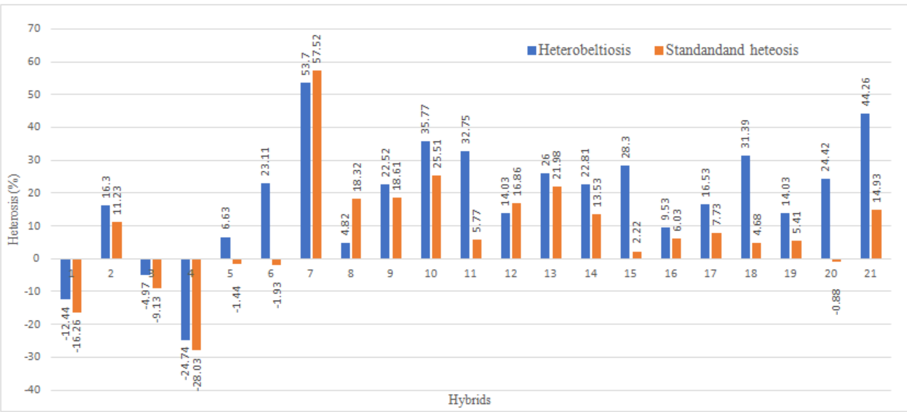
Table 6: Best heterotic crosses and their performance for fruit yield per plant and other traits in ridge gourd.

Best crosses	Fruit yield per plant (kg)	Heterobeltiosis (%)	Standard heterosis (%)	Significant standard heterosis of other traits in the desired direction
GRG-2 × JDNRG-19	1.61	53.70**	57.52**	DFMF, DFFF, NNFFF, DFP, MVL, FPP, FYPP
GRG-2 × IC-523892	1.28	35.77*	25.51*	DFMF, NNFFF, DFP, FL, FPP, FYPP
JDNRG-19 × JDNRG-32	1.25	26.00	21.98	DFFF, NFFF, DFP, MVL, FW, FG
GRG-2 × JDNRG-32	1.23	22.52	18.61	NNFMF, FL
GRG-2 × JDNRG-10	1.21	4.82	18.32	DFP, FPP

*, ** Significant at 5% and 1% levels, respectively.

Where,

DFMF : Days to first male flower
DFFF : Days to first female flower
NNFMF : Node number of first male flower
NNFFF : Node number of first female flower
DFP : Days to first picking
FW : Fruit weight
FL : Fruit length
FG : Fruit girth
MVL : Main vine length
FPP : Fruits per plant
FYPP : Fruit yield per plant



1. JDNRG-39 × GRG-2
2. JDNRG-39 × JDNRG-19
3. JDNRG-39 × JDNRG-10
4. JDNRG-39 × JDNRG-32
5. JDNRG-39 × IC-523892
6. JDNRG-39 × JDNRG-15-27
7. GRG-2 × JDNRG-19
8. GRG-2 × JDNRG-10
9. GRG-2 × JDNRG-32
10. GRG-2 × IC-523892
11. GRG-2 × JDNRG-15-27
12. JDNRG-19 × JDNRG-10
13. JDNRG-19 × JDNRG-32
14. JDNRG-19 × IC-523892
15. JDNRG-19 × JDNRG-15-27
16. JDNRG-10 × JDNRG-32
17. JDNRG-10 × IC-523892
18. JDNRG-10 × JDNRG-15-27
19. JDNRG-32 × IC-523892
20. JDNRG-32 × JDNRG-15-27
21. IC-523892 × JDNRG-15-27

Fig. 1. Estimation of heterobeltiosis and standard heterosis for fruit yield per plant.

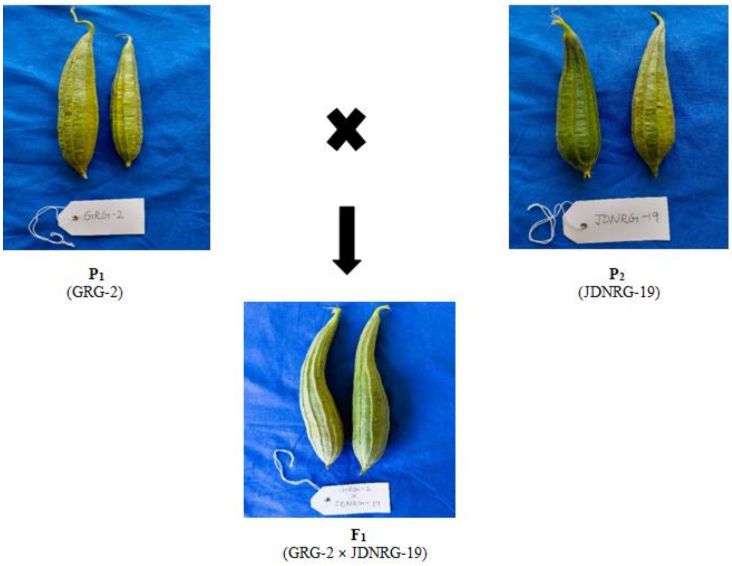


Fig. 2. Best cross based on *per se* performance and heterosis for fruit yield per plant.

CONCLUSIONS

In the present investigation of analysis of variance, it was observed that the differences due to various genotypes were highly significant for all the characters under study except for the primary branches per plant and fruit yield per plant. Highly significant differences were observed among parents for all the characters except primary branches per plant, node number of first male flower, fruit girth, fruits per plant and fruit yield per plant. This indicated the existence of considerable variability in experimental material. The study of mean values indicated that the parent JDNRG-10 exhibited the highest fruit yield per plant followed by GRG-2 and were also superior for yield contributing traits. Considering per se performance of hybrids, the superior cross combinations for fruit yield per plant were GRG-2 × JDNRG-19, GRG-2 × IC-523892 and JDNRG-19 × JDNRG-32. These cross combinations also had high per se performance for one or more yield contributing traits. The mean performance of the hybrids was found to be directly proportional to the standard heterosis observed for that hybrid. The best performing hybrids have at least one parent which showed higher per se performance among them top three hybrids for fruit yield per plant were GRG-2 × JDNRG-19, GRG-2 × IC-523892 and JDNRG-19 × JDNRG-32. The best heterotic cross for fruit yield per plant was GRG-2 × JDNRG-19. High magnitude of heterosis observed in this hybrid for fruit yield can be attributed to significant standard heterosis and heterobeltiosis in desirable direction for yield attributing traits *viz.*, days to first male flower, node number of first female flower, main vine length, fruit weight and fruits per plant. Second-best hybrid GRG-2 × IC-523892 for fruit yield per plant also showed significant heterosis in desirable direction for days to first male flower, node number of first female flower, days to first picking, fruit length and fruits per plant.

FUTURE SCOPE

The hybrids GRG-2 × JDNRG-19, GRG-2 × IC-523892 and JDNRG-19 × JDNRG-32 recorded high fruit yield per plant and reported a higher heterotic effect along for fruit yield per plant and its contributing characters. Hence, this cross was identified as potential for getting good transgressive segregants for fruit yield per plant and its contributing characters and suggested to further evaluation for generation advancement in the future breeding programme to isolate good transgressive segregants for fruit yield per plant. The present investigation suggested that non-additive genetic variances were important for most of the characters. So, suggested attempting heterosis breeding for enhancing the fruit yield potential of ridge gourd.

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Conflict of Interest. None.

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