Electronic Journal of Plant Breeding, 9(4): 1428-1435 (Dec 2018) DOI: 10.5958/0975-928X.2018.00177.1
ISSN 0975-928X

Research Article

Heterosis in ridge gourd (*Luffa acutangula* L. Roxb.) for fruit yield and quality traits

Akshay Chittora*, R. A. Kaushik, K. D. Ameta, R. B. Dubey and Rajendra Dhakar
Department of Horticulture, Rajasthan College of Agriculture, MPUA&T, Udaipur (Rajasthan)
***E-Mail:**akshaychittora@gmail.com

(Received: 22Jun2018; Revised: 12 Dec 2018; Accepted: 21 Dec 2018)

Abstract
The present investigation was conducted to investigate the extent of heterosis in 33 F_1 hybrids of ridge gourd for growth, yield and quality traits in four environments comprising of two seasons and two locations during 2017. These 33 hybrids were obtained by crossing 11 genetically diverse inbred lines with 3 testers in line x tester mating fashion. For fruit yield per vine, significant economic heterosis in positive direction against the best check "Kaveri" was reported in three crosses *viz*., $L_{11} \times T_3$ (41.64%), $L_8 \times T_3$ (31.59%) and $L_{11} \times T_2$ (11.26%). The significant estimates of heterosis for fruit yield in positive direction were recorded in 12 hybrids over mid parent with range varied from 10.07% to 68.33% and in 5 hybrids over the better parent with range varied from 15.60% to 67.45%. The hybrid $L_8 \times T_3$ exhibited maximum negative heterobeltiosis and standard heterosis for days to first harvest followed by hybrid $L_{11} \times T_2$ and $L_{11} \times T_3$. These best performing crosses can be utilized in heterosis breeding programme for improvement of ridge gourd.

Keywords
Ridge gourd, F_1 hybrids, Relative heterosis, Better parent heterosis, Standard heterosis, Fruit yield and Quality

Introduction

Ridge gourd (*Luffa acutangula w*L. Roxb.) is an important cucurbitaceous vegetable crop of India and is widely cultivated in tropical as well as subtropical regions of the world. Ridge gourd is also known as angled gourd or ribbed gourd. In India, it is grown commercially as a summer and rainy season vegetable crop. The genus *Luffa* derives its name from the product 'loofah', which is used as bathing sponges, scrubber pads, doormats and pillows and also for cleaning utensils. In addition to culinary properties, it has therapeutic properties and is also used for extraction of fibres (Swarup, 2005).A wide range of variability in fruit and vegetative characters is available in this crop but very little improvement work has been done to utilize it gainfully. Heterosis breeding is one of the most efficient tools to exploit the genetic diversity in cross pollinated crops. Ridge gourd being predominantly monoecious, is a cross pollinated crop and it provides ample scope for utilization of the hybrid vigour (Sarkar *et al.*, 2015). Single fruit of this vegetable gives large number of seeds which enables easy production of F_1 seeds at lower cost. Hence a rapid improvement can be brought about in this crop by assessing the genetic variability and exploitation of heterosis. Heterosis has contributed significantly towards increased crop production and it has become the basis of billion dollaragro-business in the world in last a few decades. 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).With these points in view, heterosis studies are prerequisite in any plant breeding programme which provides desired information regarding exploitation of heterosis for commercial purpose. Hence, an attempt was made to study the heterosis in 33 crosses of ridge gourd over mid parent (relative heterosis), better parent (heterobeltiosis) and the best commercial check (standard or economic heterosis) to develop and identify the suitable best performing hybrids.

Material and Methods

The present investigation was carried out in four environments comprising of two locations *viz.*, Horticulture farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) and Krishi Vigyan Kendra, Chittorgarh (Rajasthan) and two seasons *viz.*, summer-2017 and *kharif*- 2017. The experimental material used for the present investigation comprised of eleven genetically diverse inbred lines *viz.*, VRS-7 (L_1), VRS-24-2 (L_2), VRS-27 (L_3), VRS-25/10 (L_4), VRS-2/10 (L_5), VRS-7/10 (L_6), IC-571716 (L_7), DRG-3 (L_8), DRG-4 (L_9), DRG-5 (L_{10}), DRG-15

(L_{11}) and three testers *viz*., SwarnaManjiri (T_1), Arka Sujath (T_2), Konkan Harita (T_3) which were crossed in line × tester mating design to develop hybrids. The resulting 33 F_1hybrids along with 14 parents and 3 checks *viz.*, PusaNutan, PusaNasdar and Kaveri (total entries 50) were grown under randomized block design (RBD) with three replications in four environments. The spacing of 2.0 m between rows and 0.5m between plants was maintained. 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 twenty characters *viz.*, days to anthesis of first male flower, days to anthesis of first female flower, node to first female flower, days to first harvest, number of branches per vine, inter nodal length (cm), vine length (cm), number of male flowers per vine, number of female flowers per vine, number of fruits per vine, fruit length (cm), fruit diameter (cm), fruit weight (g), rind thickness (cm), flesh thickness (cm), number of seeds per fruit, fruit yield per vine (g), TSS (%), ascorbic acid (mg/100g) and total sugar (%). The pooled data of all four environments for above characters were subjected to statistical analysis to derive information on relative heterosis, 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 economic heterosis were calculated according to the method suggested by Shull (1908), Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

Results and Discussion

The analysis of variance for experimental design revealed that the mean squares due to genotypes, parents and crosses were significant for all the characters while mean squares due to parents v/s crosses were also significant for all the characters except node to first female flower, rind thickness, flesh thickness, number of seeds per fruit and ascorbic acid (data not presented).This indicated that enormous amount of variability was present among the genotypes studied.

In ridge gourd, earliness is a useful character for realizing the potential economic yield in a short time. The characters like days to anthesis of first male and female flower, node to first female flower and days to first harvest are considered as criteria for earliness and for these traits heterosis is desirable in negative direction. In the present study, the cross L_{11} × T_2(-10.65%) for days to anthesis of first male flower and L_8× T_3(-10.85%) for days to anthesis of first female flower, showed the highest significant negative standard heterosis. 4 hybrids exhibited significant negative standard heterosis for these two characters (Table 1). These results are in agreement with those of Narasannavar *et al.* (2014) in ridge gourd and Sonavane *et al.* (2013) in sponge gourd. For node to first female flower, the significant negative heterosis was exhibited by 4 crosses over better parent and one cross over standard check. The hybrid combination L_6 × T_2(-15.28%) exhibited maximum significant negative heterobeltiosis and L_{11} × T_3(-14.59%) showed maximum significant negative standard heterosis for this trait. In case of days to first harvest, 6 crosses showed significant negative heterosis over better parent and 4 crosses exhibited significant negative heterosis over standard check. The hybrid L_8× T_3(-9.97% and -10.93%, respectively) exhibited maximum negative standard heterosis and heterobeltiosis for days to first harvest (Table 1). The results are in conformity with those of Lodam *et al.* (2014) and Bairwa *et al.* (2017).

In the present study out of 33 crosses, 5 crosses showed significant positive heterosis over better parent with range varied from 9.85% (L_8× T_1) to 18.00% (L_7× T_1) and cross L_5× T_1(7.46%) showed significant positive heterosis over standard check for number of branches per vine (Table 1). For internodal length, heterosis is desirable in negative directionas the plant with short internodal length accommodates more number of flowers and ultimately more number of fruits even in smaller stature. Out of 33 crosses, 7 over better parent and 2 over standard check showed significant negative heterosis for internodal length (Table 2). The highest value of significant positive standard heterosis and heterobeltiosis for internodal length was shown by L_8× T_3 (-12.96% and -18.61%, respectively). For vine length, 5 crosses over better parent and 3 crosses over standard check exhibited significant estimates of heterosis in positive direction (Table 2).Maximum amount of significant positive standard heterosis and heterobeltiosis for vine length was recorded in L_8× T_3 (9.15% and 14.41%, respectively). Similar findings were also reported by Niyaria and Bhalala (2001) and Sarkar *et al.* (2015).

Presence of lesser number of male flowers and more number of female flowers per vine is advantageous for higher yield in cucurbits. For number of male flowers per vine, only one hybrid L_{11}× T_3(-5.84%) exhibited significant heterobeltiosis in negative direction while no hybrid showed significant economic heterosis in negative direction for this trait (Table 2). On the other hand, 7 hybrids exhibited significant positive heterobeltiosis and 2 hybrids exhibited significant positive economic heterosis for number of female flowers per vine. The highest value of significant positive standard heterosis and heterobeltiosis for this trait was recorded in $L_{11}\times T_3$ (8.71%) and $L_8\times T_2$ (14.12%), respectively (Table 2). Similar reports were also shown by Islam *et al.* (2012) in sponge gourd and Lodam *et al.* (2014) in ridge gourd.

In the present study, positive significant heterosis for number of fruits per vine was depicted by 14 crosses over mid parent, 8 crosses over better parent and 3 crosses over standard check.Maximum positive standard heterosis for this trait was observed in $L_{11}\times T_3$ (28.36%) (Table 2).For fruit length, 6 hybrids exhibited significant heterosis in positive directionover better parent with range varied from 10.25% ($L_{10}\times T_2$) to 15.95% ($L_{11}\times T_3$). 2 hybrids *viz.*, $L_{11}\times T_3$ (12.73%) and $L_{10}\times T_3$ (7.84%) showed significant positive heterosis over standard check for fruit length(Table 3).For fruit diameter, only hybrid $L_{11}\times T_3$(9.76%) exhibited significant standard heterosis in positive direction while significant heterobeltiosis in positive direction for this trait was depicted by 6 hybridswith range varied from 10.20% ($L_9\times T_2$) to 23.69% ($L_3\times T_2$). Fruit weight is an important character as it ultimately decides the fruit yield and positive heterosis for this character is of prime importance. The data revealed that (Table 3) positive significant heterosis for fruit weight was exhibited by 8 crosses over mid parent, 4 crosses over better parent and 3 crosses over standard check.The hybrid combination $L_{11}\times T_3$ (10.50% and 12.55%, respectively) showed the highest value of significant positive standard heterosis and heterobeltiosis for fruit weight. These results are in conformity with the findings of Karmakar *et al.* (2014),Prakash *et al.* (2015) and Poshiya *et al.* (2015).

For rind thickness, 2 hybrids *viz.*, $L_{11}\times T_3$(14.27% and 9.77%) and $L_8\times T_3$(12.44% and 8.01%) showed the positive significant heterosis over better parent and commercial check, respectively. Similarly for flesh thickness, only$L_{11}\times T_3$(6.65%) exhibited significant positive heterosis over commercial check and $L_{11}\times T_3$(8.65%) and $L_8\times T_3$ (7.41%) exhibited significant positive heterosis over better parent (Table 3). Number of seeds per fruit should be less to make it more acceptable to the consumer. In the present study out of 33 crosses, 7 crosses exhibited negative significant heterosis over better parent for this trait with range varied between -11.12% ($L_1\times T_1$) and -22.07% ($L_1\times T_2$). None of the hybrid showed significant negative heterosis over commercial check for number of seeds per fruit (Table 4). Similar results were also reported by Narasannavar *et al.* (2014) in ridge gourd.

Higher yield is the basic objective of all crop improvement programmes. Whitehouse *et al.* (1958) and Grafius (1959) indicated that the heterosis for fruit yield was through heterosis for the individual yield components or alternatively due to the multiplicative effects of partial dominance of component characters. In the present study, significant economic heterosis in positive direction for fruit yield per vine against the best check "Kaveri" was reported in 3 crosses *viz.*, $L_{11}\times T_3$ (41.64%), $L_8\times T_3$ (31.59%) and $L_{11}\times T_2$ (11.26%). The significant estimates of heterosis for fruit yield in positive direction were recorded in 12 hybrids over mid parent with range varied from 10.07% ($L_7\times T_3$) to 68.33% ($L_{11}\times T_3$) and in 5 hybrids over the better parent with range varied from 15.60% ($L_{11}\times T_2$) to 67.45% ($L_{11}\times T_3$) (Table 4). Significant amount of heterosis for fruit yield was also reported by Rao and Rao (2002), Ahmed *et al.* (2006), Bairwa *et al*. (2017) and Muthaiah *et al*. (2017) in ridge gourd Naliyadhara *et al.* (2007) in sponge gourd.

TSS, ascorbic acid and sugar content are the important quality parameters of fruit and heterosis in positive direction would be desirable for these traits. In case of TSS, the positive and significant heterobeltiosis was observed in 4 hybrids with the highest value in$L_{11}\times T_1$ (19.20%). No hybrid showed positive significant standard heterosis for TSS content. For ascorbic acid content, significant relative heterosis in positive direction exhibited by 6 hybrids with range varying from 11.69% ($L_{11}\times T_1$) to 20.58% ($L_8\times T_3$) while no hybrid showed significant heterobeltiosis and standard heterosis in positive direction (Table 4). The data in table 4 indicated that 3 hybrids showed positive significant heterosis over better parent for total sugar with the highest value in $L_{11}\times T_3$ (20.16%).

The majority of hybrids exhibited positive relative heterosis for most of the yield related traits, thereby indicating that for these traits the genes with positive effect were dominant. While for flowering characters, majority of the hybrids exhibited negative relative heterosis, thereby indicating that for these traits the genes with negative effect were dominant. For other remaining traits variable number of hybrids depicted relative heterosis in both positive and negative direction, thereby indicating that the genes with negative as well as positive effects were dominant.

Keeping in mind the results, it could be concluded that the crosses $L_{11}\times T_3$ (DRG-15 ×Konkan Harita), $L_8\times T_3$ (DRG-3 ×Konkan Harita) and $L_{11}\times T_2$ (DRG-15 ×Arka Sujath) produced the highest significant standard heterosis for fruit yield and also exhibited desirable heterosis for at least one or more yield contributing characters. These cross combinations could be recommended to be utilized in heterosis breeding programme of ridge gourd for their commercial exploitation as hybrids.

References

Ahmed, M.A., Reddy, I.P. and Neeraja, G. 2006.Combining ability and heterosis for fruit yield and yield components in ridge gourd *[Luffa acutangula* (Roxb.) L.]. *J. Res. ANGRAU*, **34**(1): 15-20.

Bairwa, S.K., Soni, A.K. and Shekhawat, A.S. 2017. Heterosis Studies in Ridge Gourd [*Luffaacutangula*(Roxb.) L.]. *Int. J. Curr. Microbiol. Appl. Sci.,* **6**(11): 1572-1576.

Fonseca, S. and Patterson, F.L. 1968. Hybrid vigour in seven-parental diallel crosses in common winter wheat (*Triticumaestvum* L.). *Crop Sci.,***8**: 85-88.

Grafius, J.E. 1959. Heterosis in barley.*Agron. J.,* **51**: 551-554.

Islam, S., Munshi, A.D. and Kumar, R. 2012.Studies on heterosis and combining ability for earliness and yield in sponge gourd.*Indian J. Hort.,* **69**(3): 348-352.

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

Karmakar, P., Munshi, A.D., Behera, T.K. and Sureja, A.K. 2014.Heterosis in ridge gourd (*Luffaacutangula*Roxb.) using hermaphrodite lines. *Indian J. Hort.,* **71**(1): 61-66.

Lodam, V.A., Patil, P.P. and Desai, D.T. 2014. Exploitation of hybrid vigour in ridge gourd (*Luffaacutangula*Roxb L.).*Electron. J. Pl. Breed.,***5**(4): 792-796.

Meredith, W.R. and Bridge, R.R. 1972. Heterosis and gene action in cotton (*Gossypiumhirsutam*).*Crop Sci.,***12**: 304-310.

Muthaiah, K., Gasti, V.D., Mallesh, S., Sunilkumar, M.K. and Mangi, V. 2017. Heterosis studies for growth and yield related parameters in ridge gourd [*Luffaacutangula*L. Roxb.]. *Int. J. Agric. Sci.,***9**: 4335-4337.

Naliyadhara, M.V., Dhaduk, L.K., Barad, A.V., Purohit, V.L. and Vachhani, J.H. 2007.Heterosis for fruit yield and its components in sponge gourd [*Luffa cylindrical* (Roem.) L.]. *Nat. J. Pl. Improv.,* **9**(2): 132-135.

Narasannavar, A., Gasti, V.D., Shantappa, T., Mulge, R., Allolli, T.B. and Thammaiah, N. 2014. Heterosis studies in ridge gourd [*Luffaacutangula*(L.) Roxb.].*Karnataka J. Agric. Sci.,* **27**(1) 47-51.

Niyaria, R. and Bhalala, M.K. 2001.Heterosis and combining ability in ridge gourd (*Luffaacutangula*(Roxb.) L.). *Indian J. Pl. Genet. Resour.,***14**: 101-102.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi.

Poshiya, S.C., Dhaduk, L.K., Raval, L. and Mehta, D.R. 2015.Heterosis study in ridge gourd (*LuffaAcutangula*(Roxb.) L.). *Electron. J. Pl. Breed.,***6**(2): 581-585.

Prakash, M., Jagadeesha, R.C., Kumara, B.R. and Savitha, H.N. 2015. Heterosis studies in ridge gourd [*Luffaacutangula* (L.) Roxb.].*Environ. Ecol.,***33**(3): 1177-1182.

Rao, B.N. and Rao, P.V. 2002.Heterosis in ridge gourd (*Luffaacutangula*(Roxb.) L.). *J. Res. ANGRAU,* **30**(1): 11-18.

Sarkar, M., Singh, D.K., Lohani, M., Das, A.K. and Ojha, S. 2015. Exploitation of heterosis and combining ability for earliness and vegetative traits in ridge gourd [*Luffaacutangula*(Roxb.) L.]. *Int. J. Agric., Environ. Biotechnol.,***8**(1): 153-161.

Shull, G.H. 1908. The composition of a field of maize.*Amer. Breeders Assoc. Rept.,* **4**: 296-301.

Sonavane, P.N., Bhalekar, M.N., Pawar, P.K. and Bawkar, S.O. 2013. Studies on heterosis and combining ability for earliness and yield in sponge gourd.*Bioinfolet,* **10**(2B): 662-666.

Swarup, V. 2005. Vegetable Science and Technology in India, Kalyani Publishers, New Delhi, pp. 426-431.

Whitehouse, R.N.H., Thompson, J.B. and Riberio, D.V. 1958. Studies on the breeding of self-pollinated cereals 2. The use of diallel crosses analysis in yield prediction. *Euphytica,* **7**: 147-169.

Electronic Journal of Plant Breeding, 9(4): 1428-1435 (Dec 2018) DOI: 10.5958/0975-928X.2018.00177.1
ISSN 0975-928X

Table 1.Extent of heterosis (%)for different characters in ridge gourd

SN	Crosses	Days to anthesis of first male flower			Days to anthesis of first female flower			Node to first female flower			Days to first harvest			Number of branches per vine		
		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	L1 × T1	0.75	-	-	0.35	-	-	-4.65	-	-	0.07	-	-	-17.93**	-	-
2	L2 × T1	-1.31	-1.26	-	0.49	-	-	8.16*	-	-	0.49	-	-	0.86	-	-
3	L3 × T1	-0.07	-	-	-0.11	0	-	2.73	-	-	0.86	-	-	-14.59**	-	-
4	L4 × T1	-1.77	-0.89	-	-0.61	-0.37	-	-1.59	-	-	-1.60	-1.18	-	-13.03**	-	-
5	L5 × T1	1.23	-	-	1.01	-	-	-6.20	-6.16	-	0.70	-	-	19.86**	11.68**	7.46*
6	L6 × T1	0.25	-	-	1.41	-	-	2.77	-	-	0.60	-	-	-7.18*	-	-
7	L7 × T1	2.08	-	-	1.75	-	-	2.24	-	-	0.43	-	-	21.35**	18.00**	3.78
8	L8 × T1	1.49	-	-	1.09	-	-	1.07	-	-	0.39	-	-	14.56**	9.85**	-
9	L9 × T1	0.74	-	-	1.31	-	-	1.68	-	-	0.77	-	-	0.36	-	-
10	L10 × T1	-0.04	-	-	0.24	-	-	-0.69	-	-	-0.97	-0.68	-	6.76*	5.85	-
11	L11 × T1	-6.82**	-5.14*	-2.39	-5.11**	-3.98	-3.17	-2.61	-	-	-4.71**	-3.58	-2.19	-20.24**	-	-
12	L1 × T2	-8.92**	-7.45**	-3.64	-7.84**	-7.72**	-5.02*	-15.08**	-8.77	-1.56	-9.05**	-8.82**	-7.15**	-1.59	-	-
13	L2 × T2	-1.19	-0.73	-	0.37	-	-	4.40	-	-	0.60	-	-	-18.30**	-	-
14	L3 × T2	-0.84	-	-	-1.20	-1.07	-	-1.39	-	-	0.71	-	-	-19.05**	-	-
15	L4 × T2	-7.83**	-6.62**	-2.20	-6.54**	-6.34**	-3.77	-7.10*	-0.61	-	-6.02**	-4.69*	-2.94	-1.60	-	-
16	L5 × T2	0.62	-	-	0.84	-	-	-10.85**	-10.19*	-	0.72	-	-	-6.83*	-	-
17	L6 × T2	-3.17	-2.34	-	-2.52	-1.85	-	-15.59**	-15.28**	-	-3.28	-1.30	-	-4.72	-	-
18	L7 × T2	-0.94	-0.54	-	0.07	-	-	9.34*	-	-	-1.68	-0.65	-	17.32**	14.63**	5.67
19	L8 × T2	-5.05**	-2.00	-1.02	-3.94*	-2.50	-2.32	-8.12*	-0.86	-	-2.55	-2.19	-1.13	-2.30	-	-
20	L9 × T2	1.69	-	-	1.73	-	-	3.80	-	-	2.79	-	-	-24.00**	-	-
21	L10 × T2	-10.96**	-10.31**	-4.99*	-6.24**	-6.17**	-3.17	-2.75	-	-	-6.61**	-5.41**	-3.67	-1.98	-	-
22	L11 × T2	-15.06**	-13.17**	-10.65**	-10.59**	-9.55**	-8.78**	-18.92**	-9.22	-9.22	-9.92**	-9.74**	-8.44**	-0.80	-	-
23	L1 × T3	1.13	-	-	0.73	-	-	5.09	-	-	1.72	-	-	-11.18**	-	-
24	L2 × T3	0.60	-	-	1.18	-	-	7.77*	-	-	-0.67	-0.19	-	-21.67**	-	-
25	L3 × T3	3.17	-	-	1.79	-	-	15.84**	-	-	1.74	-	-	-15.10**	-	-
26	L4 × T3	2.83	-	-	2.52	-	-	6.84	-	-	0.81	-	-	-8.70**	-	-
27	L5 × T3	0.38	-	-	-0.19	-	-	-8.24*	-3.64	-	-0.74	-0.12	-	-4.29	-	-
28	L6 × T3	-0.27	-	-	0.19	-	-	-1.75	-	-	-3.82*	-2.29	-	-3.53	-	-
29	L7 × T3	-0.15	-	-	0.11	-	-	7.11	-	-	-1.36	-0.77	-	-0.50	-	-
30	L8 × T3	-12.36**	-10.93**	-10.03**	-11.60**	-11.01**	-10.85**	-13.67**	-12.07**	-5.90	-11.65**	-10.93**	-9.97**	22.68**	11.84**	3.60
31	L9 × T3	-0.02	-	-	0.44	-	-	0.24	-	-	-1.73	-1.11	-	-6.08*	-	-
32	L10 × T3	-0.13	-	-	-1.30	-0.42	-	1.19	-	-	-3.28	-2.47	-	6.40*	1.75	-
33	L11 × T3	-11.52**	-10.91**	-8.33**	-9.47**	-9.17**	-8.40**	-19.03**	-14.59**	-14.59**	-9.88**	-9.31**	-8.00**	0.09	-	-

*, ** Significant at 5% and 1% level of significance respectively; MPH = Mid parent heterosis, BPH =Better parent heterosis, SH = Standard heterosis

Electronic Journal of Plant Breeding, 9(4): 1428-1435 (Dec 2018) DOI: 10.5958/0975-928X.2018.00177.1
ISSN 0975-928X

Table 2.Extent of heterosis (%) for different characters in ridge gourd

SN	Crosses	Internodal length (cm)			Vine length (cm)			Number of male flowers per vine			Number of female flowers per vine			Number of fruits per vine		
		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	L1 × T1	-16.81**	-15.61**	-5.19	-5.77	-	-	-0.22	-	-	1.03	0.12	-	-4.82	-	-
2	L2 × T1	-4.83	-4.77	-	-5.20	-	-	0.81	-	-	9.76**	7.72*	-	-1.84	-	-
3	L3 × T1	1.50	-	-	1.36	-	-	2.47	-	-	12.27**	11.07**	2.88	3.45	1.18	-
4	L4 × T1	4.15	-	-	1.45	-	-	-0.21	-	-	-3.79	-	-	11.63*	10.87*	-
5	L5 × T1	-8.26*	-4.70	-	-8.75**	-	-	0.72	-	-	-2.81	-	-	7.52	5.98	-
6	L6 × T1	-1.55	-0.60	-	-7.82**	-	-	-2.41	0	-	-1.46	-	-	1.79	-	-
7	L7 × T1	-9.09**	-8.10*	-	9.44**	7.06*	-	3.44	-	-	1.90	0.12	-	10.61*	6.84	-
8	L8 × T1	-1.69	-0.17	-	7.31*	4.67	-	4.71*	-	-	1.79	0.56	-	6.46	4.12	-
9	L9 × T1	-3.06	-2.30	-	-4.75	-	-	0.01	-	-	4.51	4.38	-	12.76**	5.83	-
10	L10 × T1	-2.17	-0.65	-	-5.83*	-	-	-4.10	-4.07	-	0.71	-	-	6.14	3.51	-
11	L11 × T1	-1.13	-	-	2.72	0.43	-	-4.06	-2.00	-1.25	3.01	-	-	22.57**	19.77**	2.96
12	L1 × T2	-14.97**	-12.61**	-4.29	-5.03	-	-	1.40	-	-	8.14**	7.59*	-	-4.55	-	-
13	L2 × T2	-3.95	-2.64	-	0.68	-	-	4.27	-	-	0.02	-	-	-10.63*	-	-
14	L3 × T2	-6.57	-5.52	-	4.88	0.67	-	5.16*	-	-	7.84**	6.27*	-	-12.79**	-	-
15	L4 × T2	-4.27	-2.75	-	12.45**	8.06*	-	-3.89	-3.02	-	6.62*	5.44	-	22.87**	12.65**	9.35*
16	L5 × T2	0.78	-	-	-1.40	-	-	-4.03	-3.20	-	-5.81*	-	-	2.87	-	-
17	L6 × T2	-3.51	-1.30	-	-5.05	-	-	-1.96	-	-	3.28	0.56	-	-8.50*	-	-
18	L7 × T2	-7.52*	-5.29	-	-6.03*	-	-	-3.32	-2.28	-	3.40	2.00	-	-15.29**	-	-
19	L8 × T2	-11.19**	-8.63*	-	-10.23**	-	-	0.64	-	-	15.05**	14.12**	2.61	10.76*	4.33	1.28
20	L9 × T2	-13.49**	-11.68**	-3.28	1.41	-	-	-1.06	-	-	2.24	1.96	-	-10.68**	-	-
21	L10 × T2	2.53	-	-	2.87	1.40	-	0.04	-	-	5.33*	3.42	-	9.72*	3.64	0.61
22	L11 × T2	-9.18*	-5.25	-4.51	6.90*	4.12	0.54	-5.29*	-3.92	-3.18	5.38*	0.07	0.07	15.81**	9.19*	5.99
23	L1 × T3	-10.25**	-6.63	-0.14	-3.80	-	-	3.12	-	-	6.09*	1.23	-	-0.20	-	-
24	L2 × T3	-2.46	-	-	-5.47	-	-	0.35	-	-	2.00	-	-	3.04	2.96	-
25	L3 × T3	3.94	-	-	2.30	-	-	3.88	-	-	2.04	-	-	-4.11	-	-
26	L4 × T3	0.22	-	-	1.44	-	-	-2.73	-0.62	-	-7.48**	-	-	13.60**	10.16	-
27	L5 × T3	-4.25	-	-	-6.71*	-	-	2.36	-	-	-1.27	-	-	13.89**	12.77*	-
28	L6 × T3	7.79*	-	-	11.94**	11.45**	6.33*	1.94	-	-	-3.82	-	-	11.22*	8.33	-
29	L7 × T3	-7.29*	-3.88	-	-7.14*	-	-	1.44	-	-	-1.63	-	-	4.33	3.21	-
30	L8 × T3	-21.85**	-18.61**	-12.96**	19.21**	14.41**	9.15**	-4.79*	-4.23	-4.23	13.55**	8.03**	5.86*	43.05**	42.77**	22.98**
31	L9 × T3	1.43	-	-	-12.63**	-	-	-5.10*	-2.21	-1.06	1.53	-	-	-0.56	-	-
32	L10 × T3	5.15	-	-	-9.30**	-	-	0.18	-	-	-2.09	-	-	19.26**	19.14**	2.83
33	L11 × T3	-14.81**	-12.21**	-11.52*	13.53**	12.85**	8.96**	-6.02**	-5.84*	-5.11	9.82**	8.71**	8.71**	49.17**	49.02**	28.36**

*, ** Significant at 5% and 1% level of significance respectively; MPH = Mid parent heterosis, BPH =Better parent heterosis, SH = Standard heterosis

Electronic Journal of Plant Breeding, 9(4): 1428-1435 (Dec 2018) DOI: 10.5958/0975-928X.2018.00177.1
ISSN 0975-928X

Table 3.Extent of heterosis (%) for different characters in ridge gourd

SN	Crosses	Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)			Rind thickness (cm)			Flesh thickness (cm)		
		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	L1 × T1	-17.40**	-	-	-17.12**	-	-	-15.21**	-	-	-14.97**	-	-	-12.42**	-	-
2	L2 × T1	2.72	-	-	-8.81*	-	-	-8.32**	-	-	-7.21*	-	-	-5.11*	-	-
3	L3 × T1	5.13	2.50	-	-1.37	-	-	-2.27	-	-	-1.76	-	-	-2.21	-	-
4	L4 × T1	-5.55	-	-	-0.70	-	-	-2.92	-	-	-2.64	-	-	-3.20	-	-
5	L5 × T1	11.32**	10.77*	-	0.69	-	-	0.23	-	-	4.14	2.28	-	4.03	2.07	-
6	L6 × T1	-2.71	-	-	-2.65	-	-	0.06	-	-	2.62	-	-	-1.15	-	-
7	L7 × T1	2.01	1.27	-	-4.15	-	-	-2.85	-	-	0.93	-	-	-0.44	-	-
8	L8 × T1	12.29**	10.36*	-	-0.51	-	-	-3.33	-	-	1.03	-	-	5.47*	4.45	1.81
9	L9 × T1	-11.29**	-	-	7.76*	-	-	-8.44**	-	-	-2.72	-	-	-2.12	-	-
10	L10 × T1	0.85	-	-	-4.83	-	-	0.53	-	-	-3.91	-	-	-3.31	-	-
11	L11 × T1	-1.12	-	-	0.96	0.74	-	1.81	1.31	-	0.39	-	-	-0.03	-	-
12	L1 × T2	-16.07**	-	-	-8.06*	-	-	-10.35**	-	-	-14.18**	-	-	-12.19**	-	-
13	L2 × T2	2.87	-	-	3.58	-	-	-4.27*	-	-	-2.93	-	-	-0.67	-	-
14	L3 × T2	5.67	-	-	25.19**	23.69**	5.29	4.86*	-	-	2.04	-	-	0.20	-	-
15	L4 × T2	-6.09	-	-	4.87	0.62	-	-6.19**	-	-	-0.92	-	-	0.29	-	-
16	L5 × T2	5.11	-	-	7.38	4.41	-	-0.17	-	-	-3.90	-	-	-1.81	-	-
17	L6 × T2	1.93	-	-	-3.36	-	-	0.34	-	-	-1.48	-	-	0.76	-	-
18	L7 × T2	-5.67	-	-	16.95**	14.48**	1.74	-2.64	-	-	8.45*	3.68	1.50	5.95*	2.20	1.93
19	L8 × T2	0.05	-	-	8.30*	6.54	-	3.19	0.59	-	7.41*	3.37	1.20	0.06	-	-
20	L9 × T2	-8.20*	-	-	14.36**	10.20*	-	-3.18	-	-	0.50	-	-	1.19	0	-
21	L10 × T2	18.01**	10.25*	7.12	13.96**	8.03	2.64	8.90**	3.21	2.46	2.99	-	-	1.01	-	-
22	L11 × T2	6.44	6.41	3.45	12.52**	6.10	1.95	6.93**	5.92*	5.14*	5.36	1.58	-	4.37	3.13	2.85
23	L1 × T3	-16.44**	-	-	-19.75**	-	-	-12.62**	-	-	-13.72**	-	-	-7.32**	-	-
24	L2 × T3	4.22	-	-	5.09	5.00	-	1.95	-	-	-0.53	-	-	2.09	1.30	-
25	L3 × T3	0.13	-	-	4.76	-	-	-1.42	-	-	-6.65	-	-	-4.84	-	-
26	L4 × T3	4.96	-	-	16.26**	16.23**	7.67	0	-	-	1.32	-	-	-5.14*	-	-
27	L5 × T3	9.82**	4.89	0.99	-0.15	-	-	0.55	-	-	-4.23	-	-	-3.48	-	-
28	L6 × T3	15.50**	4.77	0.88	7.93*	6.96	-	5.13*	-	-	3.62	0.80	-	4.25	0.85	-
29	L7 × T3	6.77	0.80	-	2.03	-	-	5.47*	2.24	0.39	9.06*	5.22	1.07	7.11**	4.11	2.20
30	L8 × T3	14.75**	10.92**	6.80	17.44**	14.52**	6.03	11.22**	9.00**	7.02**	15.77**	12.44**	8.01*	8.84**	7.41**	5.43
31	L9 × T3	-8.51*	-	-	8.33*	0.34	-	-0.54	-	-	1.30	-	-	1.85	1.45	-
32	L10 × T3	19.37**	11.99**	7.84*	5.98	4.62	-	10.39**	5.17*	3.26	8.75*	6.11	1.93	3.67	3.24	1.34
33	L11 × T3	16.51**	15.95**	12.73**	16.35**	14.23**	9.76*	13.00**	12.55**	10.50**	17.44**	14.27**	9.77*	9.09**	8.65**	6.65*

*, ** Significant at 5% and 1% level of significance respectively; MPH = Mid parent heterosis, BPH =Better parent heterosis, SH = Standard heterosis

Table 4.Extent of heterosis (%) for different characters in ridge gourd

SN	Crosses	Number of seeds per fruit			Fruit yield per vine (g)			TSS (%)			Ascorbic acid (mg/100g)			Total sugar (%)		
		MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH	MPH	BPH	SH
1	L1 × T1	-20.80**	-11.12*	-7.72	-18.60**	-	-	-13.85**	-	-	-27.32**	-	-	-20.33**	-	-
2	L2 × T1	0.51	-	-	-9.09	-	-	-0.66	-	-	-6.93	-	-	-11.06**	-	-
3	L3 × T1	0.87	-	-	1.68	-	-	-14.93**	-	-	-2.50	-	-	-20.02**	-	-
4	L4 × T1	-0.85	-	-	8.63	5.99	-	-8.83**	-	-	-2.76	-	-	-13.38**	-	-
5	L5 × T1	13.33**	-	-	8.88	6.29	-	-3.97	-	-	-9.92*	-	-	-8.71**	-	-
6	L6 × T1	6.63	-	-	2.70	-	-	-17.22**	-	-	-16.27**	-	-	-24.87**	-	-
7	L7 × T1	8.00*	-	-	8.24	7.50	-	-6.60**	-	-	-5.37	-	-	-18.81**	-	-
8	L8 × T1	21.61**	-	-	3.47	3.11	-	3.68	-	-	13.27**	-	-	-0.83	-	-
9	L9 × T1	-24.36**	-13.40**	-10.09	3.41	-	-	2.71	-	-	1.52	-	-	-3.75	-	-
10	L10 × T1	18.88**	-	-	6.34	4.05	-	-5.31**	-	-	-20.71**	-	-	-6.89**	-	-
11	L11 × T1	-14.58**	-7.65	-4.12	24.68**	22.10**	2.20	19.21**	19.20**	1.77	11.69**	7.06	-	17.47**	9.46**	-
12	L1 × T2	-24.97**	-22.07**	-6.54	-14.36**	-	-	-3.58	-	-	-15.30**	-	-	-7.09**	-	-
13	L2 × T2	-0.16	-	-	-14.51**	-	-	-7.24**	-	-	-12.27**	-	-	-10.36**	-	-
14	L3 × T2	12.77**	-	-	-9.02	-	-	-14.97**	-	-	-12.95**	-	-	-19.97**	-	-
15	L4 × T2	0.20	-	-	14.80**	2.93	-	-5.06*	-	-	-1.00	-	-	-9.98**	-	-
16	L5 × T2	11.03**	-	-	2.53	-	-	7.18**	0.64	-	-4.72	-	-	-10.58**	-	-
17	L6 × T2	7.41	-	-	-8.36	-	-	-7.29**	-	-	-10.48*	-	-	-15.87**	-	-
18	L7 × T2	1.02	-	-	-18.10**	-	-	-8.01**	-	-	-2.01	-	-	-13.72**	-	-
19	L8 × T2	21.57**	-	-	14.91**	5.68	1.72	3.44	-	-	13.54**	-	-	-6.22*	-	-
20	L9 × T2	-5.43	-	-	-12.80**	-	-	8.41**	-	-	-9.84*	-	-	0.58	-	-
21	L10 × T2	-2.20	-	-	18.63**	6.63	2.62	-7.98**	-	-	-20.91**	-	-	-19.44**	-	-
22	L11 × T2	-12.11**	-11.84**	-	23.66**	15.60**	11.26*	-1.40	-	-	-1.57	-	-	-1.61	-	-
23	L1 × T3	-23.67**	-20.25**	-5.44	-12.69*	-	-	-6.05**	-	-	-20.88**	-	-	-13.30**	-	-
24	L2 × T3	2.43	-	-	5.52	1.07	-	6.44**	-	-	-2.45	-	-	4.10	-	-
25	L3 × T3	5.44	-	-	-5.27	-	-	-12.90**	-	-	-19.05**	-	-	-14.46**	-	-
26	L4 × T3	12.17**	-	-	14.50**	8.92	-	2.43	2.20	-	-5.90	-	-	-2.41	-	-
27	L5 × T3	11.89**	-	-	14.41**	8.88	-	-14.57**	-	-	-3.54	-	-	-20.35**	-	-
28	L6 × T3	17.45**	-	-	16.83**	9.76	-	3.61	2.24	-	-8.05	-	-	-4.59	-	-
29	L7 × T3	9.30*	-	-	10.07*	7.97	-	12.84**	6.81**	-	13.18**	-	-	7.31*	0.80	-
30	L8 × T3	-5.52	-	-	59.14**	55.57**	31.59**	21.12**	16.32**	-	20.58**	1.14	-	13.82**	7.40*	-
31	L9 × T3	-23.07**	-18.09**	-2.89	-0.89	-	-	5.03*	-	-	-22.19**	-	-	1.34	-	-
32	L10 × T3	16.37**	-	-	31.68**	25.60**	6.24	-0.28	-	-	-12.51**	-	-	-1.56	-	-
33	L11 × T3	-12.71**	-11.94**	-	68.33**	67.45**	41.64**	20.56**	16.56**	-	16.31**	8.52	-	22.84**	20.16**	-

*, ** Significant at 5% and 1% level of significance respectively; MPH = Mid parent heterosis, BPH =Better parent heterosis, SH = Standard heterosis