HETEROSIS IN RIDGE GOURD
(*Luffa acutangula* (Robx.) L.)

By

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THESIS

Submitted in partial fulfilment of the
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DECLARATION

I hereby declare that this thesis entitled "**Heterosis in ridgegourd (*Luffa acutangula* (Roxb) L.)** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
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CERTIFICATE

Certified that this thesis, entitled "**Heterosis in ridgegourd (*Luffa acutangula* (Roxb.) L.)** is a record of research work done independently by **Miss. Thankachan Julie Mole** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

India is the second largest producer of vegetables in the world producing about 72 million tonnes of vegetables annually from an area of 5.3 million hectares (Yadav, 1999). Our country has made significant strides during the last 3-4 decades in developing high yielding varieties/hybrids of vegetable crops with improved qualities. Adequate infrastructural support, good market potential, open seed policy, less price fluctuation and increasing demand for improved seed have contributed significantly in bringing awareness among producers, consumers, marketers and policy makers about vegetable production.

The development of high yielding open-pollinated varieties in almost all the popular vegetable crops with higher yield potential and resistance to biotic and abiotic stress, has made it possible to produce vegetable for extended periods and in different seasons.

Despite such progress made in the field of vegetable crops, India is still far behind of several countries in productivity and per capita consumption of vegetables. Our country needs 2.13 lakh tonnes of vegetables per day or 78.07 million tonnes annually to meet the requirement of 230 g vegetables per day per person. The deficit is approximately 7 million tonnes year^{-1}. The area under vegetable is likely to increase by 3 per cent annually. If the productivity is increased to 15 tonnes ha^{-1}, the expected production would be 91.84 million tonnes. Thus we expect to be self sufficient in vegetable production (Yadav, 1999). The cultivable area being limited, we have to increase the productivity by developing F_1 hybrids with high yield potential and standardising their agrotechniques.

The unique geographical location of Kerala presents a diversity of agro-climatic conditions suitable for a large crop cafetaria. It is estimated that the present area under vegetables including drumstick and minor tubers in the state is only 2.04 lakh ha producing 5.78 lakh tonnes (Devadas, 1999). Kerala has a unique system of homestead farming consisting of small operational holding wherein vegetable cultivation has become an integral part. The vegetables of the family cucurbitaceae consitute the largest group of summer vegetables. Of these bitter gourd, bottle gourd, ash gourd, snake gourd, pumpkin, cucumber, watermelon, ivy gourd and ridge gourd are cultivated in Kerala. Ridge gourd [*Luffa acutangula* (Roxb.) L] is an underexploited vegetable crop in the state. Every 100 g of the edible portion contain 0.5 g fibre, 0.5 g protein, 5.0 mg vitamin C, 18 mg calcium and 0.5 mg Fe. Earlier attempts to popularise the cultivation of this crop has resulted in the identification of superior genotypes PIL-LA-1 (KAU, 1994) and LA-7 (Anitha, 1998) as suitable for Kerala.

Being a cross pollinated crop, heterosis has long been known to offer good potentialities for increasing yield. The F_1 hybrids provide higher productivity with more uniformity in size, shape and other quality parameters. Hence the present investigation is undertaken with a view of crop improvement in ridge gourd with the following objectives.

- To study the general combining ability and specific combining ability.
- To study the heterosis in terms of relative heterosis, heterobeltiosis and standard heterosis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Since the information available on crop improvement in ridge gourd is very little, the work done in sponge gourd, bottle gourd, snake gourd, bitter gourd and pointed gourd are also reviewed and presented under the following heads.

2.1 Combining ability

In heterosis breeding programme, the concept of combining ability is very important. Combining ability is the ability to produce superior hybrids in combination with other inbreds. General combining ability is the average performance of a strain in a series of crosses. Specific combining ability is the deviation from performance predicted on the basis of general combining ability.

Sirohi and Chaudhary (1977) conducted detailed investigation in genetically diverse lines of bitter gourd. The parent Pusa Do Mousmi had the highest gca effects for weight, length and diameter of fruits, vine length, seeds/fruit and seed weight/fruit. The 28 hybrids showed significant sca effects for vine length, fruit weight, fruit diameter, flesh thickness, fruit/plant, fruit weight, seed/fruit, seed weight/fruit and total yield. It was observed that when either 1 or 2 of these parental lines having high gca effects for yield and its component characters were involved in the crosses, the F_1 hybrids gave the best performance. In Line x Tester analysis with five lines and two testers in bitter gourd conducted by Pal *et al*. (1983), the phenotypically superior parent Monsoon Miracle was the best general combiner for fruit yield, fruit weight, fruit size and fruit cavity size. In a few combinations like Monsoon Miracle x Holly Green, The Largest x Indian Prime and China x Indian Prime, the absolute value of sca effects were negative indicating that the hybrids can be exploited for earliness. Inspite of high sca effects some of the hybrids were not heterotic, whereas heterosis was exhibited by three other hybrids having no marked sca effects.

In another study conducted by Srivastava and Nath (1983) in bittergourd, the breeding lines showed significant gca and sca effects for days to flowering, fruits per plant, fruit weight per plant and total yield per plant. Chaudhary (1987) reported that the variances due to gca were consistently greater than the sca variance for all the characters. The parents Coimbatore Long, Hissar Selection and Khandesh Mali were the best combiners since they made significant contributions towards yield contributing characters as evidenced by their high gca effect. In another study by Lawande and Patil (1989), the crosses Green Long x Co-2 White Long, Co-1 Green x Hissar Selection, Hissar Selection x Green Long, Co-1 Green x Green Long and Green Long x Delhi Local were heterotic and produced higher yield than that of better parent, Green Long. They also reported that when the observations on heterosis and sca effects of hybrids were considered the crosses with high heterosis displayed high sca effects and nearly 80.0 per cent crosses which were having better F_1 mean, involves at least one parent with high gca. The highly significant gca and sca variances for days to first female flower opening in bittergourd in three seasons have been observed by Vahab (1989). MC-79 had the highest gca effects for female flowers per plant in three seasons Priya ranked first in gca effect in yield per plant, followed by MC-66 and MC-79. For fruits per plant, MC-79 had the highest and consistent values of gca effects followed by MC-82 and MC-66. The cross Arka Harit x MC-79 had highest sca effects in the first season. Other crosses with high sca effects were MC-49 x MC-34, MC-78 x MC-66, MC-78 x MC-49 in the first season, MC-78 x MC-79, Arka Harit x MC-79, Arka Harit x MC-69 and MC-49 x MC-34 in the second season and MC-82 x MC-79 and Arka Harit x MC-34 in the third season.

Chaudhari and Kale (1991) evaluated growth and yield attributes in the parental and F_1 generation in genetically diverse lines of bittergourd. The best combiners were Coimbatore Long and Hissar Selection. There were indications of epistatic additive gene action. In a study conducted by Maurya *et al.* (1993) in bottlegourd, P4 was the best general combiner as it showed high general combining ability effect in desirable direction for most of the traits out of the nine parents. The data also revealed that the crosses having high specific combining ability effect and *per se* performance were not necessarily the products of parents having high gca effect and high *per se* performance respectively.

Hissar Local - 2 Sel recorded high gca effects for fruits per plant, fruit length, vine length, branches per plant and yield per plant. PSPL Sel-1 (Pocha seeds) also showed good gca effects for fruit number and yield. Summer Long Green was noted as the best general combiner for days to first female flower. The cross Summer Long Green Sel-2 x Faizabadi Long showed highest sca effects for number of fruits per plant and yield followed by PSPL Sel-1 (Pocha seed x PSPL). For first female flowering node, No 64 Sel x Faizabadi Long was noted best cross combination. The cross combination showing highest sca effects for number of fruits and yield involved one of the parents having high gca effect (Sharma *et al.*, 1993). Kharitra *et al.* (1994) reported that PDM was the best combiner for fruit length, average fruit weight and total yield in bittergourd. ACC-32 had maximum gca effects for fruit diameter, fruit number, anthesis for first female flower and marketable yield. PDM x Priya was the best specific combiner for anthesis of first female flower, days to first harvest. BG-14 x ACC-32 was best for fruit number and total yield.

The estimated component of variance of sca were higher than gca for all the characters, except vine length and fruit length indicating the predominance of non additive gene action for most of the characters in bittergourd (Munshi and Sirohi, 1994). The parents P1, P2, P3, P6 and P8 were observed to be good combiners for number of characters including yield per plant. The crosses P2 x P3, P1 x P2, P1 x P6, P1 x P8 and P4 x P5 were observed to be the most promising combinations for earliness and other desirable characters including yield per plant. Singh *et al.* (1995) reported that in bottlegourd Rajendra Chamatkar, Dholi Safed and Pusa Naveen are the best general combiners and were suitable for rainy season. Hybrids, Rajendra Chamatkar x Pusa Naveen, Rajendra Chamatkar x

Faizabadi and Dholi Safed x Faizabadi had good sca for several characters during both seasons

Karale and Sawant (1998) reported highly significant gca and sca variances for almost all the characters in bittergourd. The combination AB x N-10 was the best, as it recorded significantly highest sca effects (0.752) for yield per vine. In most of the crosses, the heterosis appeared to be due to better mean performance of the parents and their high gca effects as evident from the fact that in the heterotic crosses, at least one parent possessed high gca value. The sca variances were of greater magnitude than gca variances for all the characters except for length of fruit and fruit weight. Dominance gene action played the role in expression of yield and yield contributing character in bittergourd.

Sharma *et al.* (1998) revealed that in bottlegourd, among the female parents, KBG-16 has been rated as the best general combiner for fruit length, fruit weight, vine length, early yield, fruits per plant and total yield per plant. Among the male parents, Pusa Naveen is rated as best general combiner for number of branches and total yield per plant. The estimates of sca showed that the best cross combinations for early yield were GH-13 x G-2 (1020.77 g $plant^{-1}$), GH-9 x PSPL (1180.42 g $plant^{-1}$), GH-13 x G-2 (1145.44 g $plant^{-1}$), GH-16 x Pusa Naveen (1122.85 g $plant^{-1}$) and KBG-16 x Pusa Naveen (1119.71 g $plant^{-1}$). Based on ranking and *per se* performance of a particular cross, combination which showed a significant responsiveness towards more number of desirable traits are GH-13 x G-2 for fruit diameter, fruit weight, vine length, number of branches, internodal length, early yield and total yield; GH-10 x G-2 for fruit weight, vine length, number of branches and number of fruits per plant; GH-9 x PSPL for fruit weight, early yield and number of fruits per plant and KBG-16 x Pusa Naveen for early yield, number of fruits per plant and total yield per plant. These cross combinations involved at least one poor general combiner namely G-2, PSPL or GH-9.

Significant differences were observed in the variances due to males and females indicating the presence of enough variability among the inbred lines as female parents and improved varieties as male testers used in the investigation in bottlegourd. Predominance of non-additive as well as additive genetic components was observed (Chaudhari *et al.*, 1998). From general combining ability analysis, it was revealed that parents with high mean value showed high gca effects. Crosses between good x good, poor x average and poor x poor combiners recorded high sca effects which appeared due to the dominance gene effects. The increased superiority in the different characters of the hybrids may be due to genetic diversity among the uniting gametes. This situation can be conveniently used to exploit hybrid vigour. Low to average heritability revealed predominance of additive as well as dominance genetic components.

Matoria and Khandelwal (1999) revealed that non-additive gene action was predominant for all the traits, except girth of fruit and number of seeds per fruit in bittergourd. BG-14 was observed to be the best general combiner for yield per vine. Singh *et al.* (1999) reported that variances due to general and specific combining abilities were significant for most of the characters in long fruited type of bottlegourd. Parents, PSPL, LC_{2-1}, PBOG-40, NDBG-56 and PBOG-61 were good general combiners for days to early female flowering; PBOG-40, Pusa Naveen and LC_{2-1} for early harvest. ARBGH-7 for number of fruits, PSPL and NDBG-56 for vine length PBOG-40, ARBGH-7 and PBOG-61 for yield per vine. Cross ARBGH-7 x LC_{2-1} showed best sca for yield per vine and days to first female flowering; ARBGH-7 x NDBG-56 for fruit number, NDBG-56 x Pusa Naveen for vine length and PSPL x LC_{2-1} for first harvest. Ram *et al.* (1999) reported significant differences for all the charactersunder study. The variance due to sca were higher than the gca for all the charactersindicating the predominance of non-additive gene effect Narendra and VRBT-46 were good combiners for marketable fruit yield. VRBT-46 was a good general combiner for leaf length, fruit length, fruit girth and number of seed per fruit. The crosses Faisabad x VRBT-46, IC4441013 x VRBT-46, IC50516 x VRBT-77, MC-48 x VRBT-78 and Narendra x VRBT-78 combined well for earliness. For marketable yield, the good cross combinations were Narendra x VRBT-46, Arka Harit x VRBT-78, MC-63 x VRBT-77.

2.2 Heterosis

Ridgegourd being a cross-pollinated crop, heterosis breeding is one of the important tools of crop improvement. The term heterosis refers to the phenomenon in which the F_1 obtained, by crossing two genetically dissimilar gametes or individual, shows increased or decreased vigour over the better parent or over the mid parental value. Heterosis was first noted in cucurbits by Hayes and Jones (1916) in cucumber. Later, several workers reported heterosis for different traits in cucurbits.

Pal and Singh (1946) studied the heterotic behaviour of five diverse lines of bittergourd. Hybrids between small fruited varieties gave more number of fruits per plant than hybrids between long fruited varieties. In the cross between Delhi Local and Panipat Local, heterobeltiosis observed was even to the tune of 191.3 per cent. Performance of these hybrids was better in hot season than in rainy season. The hybrid between Panipat Local x Ambala Local showed consistently higher yields than other hybrids. Reciprocal crosses showed distinct differences for all character. Aiyadurai (1951) noticed heterosis for earliness, fruits per plant, fruit size, fruit flesh thickness and total yield. The F_1s were intermediate for vine length.

Similarly Aggrawal *et al.* (1957) studied several crosses between wild bittergourd types and cultivated types and noticed intermediate performance for earliness, vine length, female flowers, fruits and yield per plant. Thakur and Choudhary (1965) reported that the F_1 was intermediate in respect of the number of fruits, the weight of fruit and length of fruit in *Luffa acutangula.* The yield per plant and girth of fruit in the F_1 were more than the better parent. This indicated over dominance and heterosis in these two characters. Heterosis in yield was owing to the increased girth of fruit, Since the girth of fruit was found to be highly heritable. Srivastava (1970) analysed the perofmrnace of 90 F_1 hybrids in bittergourd and found that 45 hybrids showed significant earliness for female flower production compared to the better parent. He also observed 64.0 per cent heterobeltiosis for yield and significant increase for fruit length, fruit girth, fruit weight and fruits per plant in the hybrids. Kolhe (1972) studied the performance with respect to yield in the hybrids of bottlegourd, ridgegourd and bittergourd. It was found that only one cross combination in bottlegourd (Kalyanpur 9 x Malkopur 26), one in ridgegourd (Baroda-24 x Mulsi-33) and one in smoothgourd (Indore-6 x M.P.-7) showed heterosis of considerable magnitude worth of practical exploitation. In bittergourd none of the cross combinations possessed standard heterosis.

Tyagi (1973) examined the hybrid behaviour in bottlegourd. He observed maximum heterobeltiosis for number of female flower (69.06%) in the cross 5415 x 6106 and for number of fruits, the maximum relative heterosis (33.33%) was in the cross Type 1 x 6022. For weight of fruit, maximum relative heterosis (38.29%) and maximum heterobeltiosis (13.64%) was manifested by the cross Type 1 x 6022. The number of seeds in hybrids showed a heterobeltiosis ranging from 1.10 to 2.10 per cent. In another study in bittergourd hybrid Green Local x White Local and Green Local x Bundel Khand Local exhibited heterosis for vegetative characters like internodal length, leaf size, leaf length, number of primary branches, length of main shoot, floral characters like days to flower (negative heterosis), number of internode at which male flower emerged, sex ratio (negative heterosis) and fruit characters like number of fruits, fruit length, average fruit weight etc. In total yield, Green Local x White Local exhibited 139.1 per cent heterobeltiosis while Green Local x Bundel Khand Local showed 35.2 per cent heterobeltiosis (Lal *et al.*, 1976).

When either one or two of the parental lines have got high gca effects for yield and its component characters, the F_1 hybrids also showed high amount of positive heterosis in bittergourd (Sirohi and Chaudhary, 1978). For yield and its component characters, heterobeltiosis was shown by the hybrid, Pusa Do Mausmi x S-144 (84.10%), Pusa Do Mausmi x S-63 (72.00%) and Coimbatore Long x S-63 (45.46%). Singh and Joshi (1979) in a 5 x 5 diallel cross in bittergourd, observed heterobeltiosis for vine length and for primary branches per plant. For number of fruits per plant, heterobeltiosis was shown by the hybrids BWMI x BWLI (13.7%) and BWLI x BSI (34.4%).

Pal *et al.* (1984) crossed a line from South Africa, 45-1-1 with the Indian lines 7 and 52 of bittergourd. Analysis of parental and F_1 data revealed that, compared with the parents, the hybrids showed more rapid germination (2-4 vs 5-6 days) and earlier fruit maturity (10-11 days earlier than the better parent), bore the female flowers on lower nodes and had 17-28 per cent thicker flesh, 20 per cent higher early yields and a longer harvesting period (65-71 vs 55-65 days); fruit shape was intermediate between that of the parents. Natrajan *et al.* (1984) reported that hybrids from crosses between the high yielding strains of snake gourd (fruits 100-150 cm long) and the local low yielding Pauni Pudal (fruits 40-45 cm) had a significantly higher yield per plant and mean weight of fruit than the parents. The fruits were intermediate in length.

Significant heterosis was recorded over the respective parental line for vine lenth, fruit number and yield in bottlegourd. For yield the F_1s, P_4 x P_{10}, P_3 x P_9 and P_2 x P_{12} proved the best and manifested 48.01, 34.61 and 29.03 per cent heterosis, respectively over the best check P_{11}. The high yield recorded in the three F_1 hybrids has been directly attributed to increased number of fruits per plant. The cross P_4 x P_{10} was identified as the best for number of fruits and yield (Sirohi *et al.*, 1987). Chaudhary (1987) observed heterosis for vine length (26.32%), early female flower production (22.00-98.00%), early harvest (19.25%), fruit length (11.57%), flesh thickness (16.18%), fruits per plant (18.11%), total yield per plant (25.32%)

and T.S.S. (11.87%). Relative heterosis was also observed for yield per plant (276.43%), fruits per plant (127.44%), fruit weight (121.45%) and flesh thickness (118.74%). Heterobeltiosis was also noted for characters like yield per plant (235.94%), fruit weight (85.7%), flesh thickness (74.24%) etc. The hybrid C-96 x Green bittergourd recorded a heterobeltiosis of 53.03 per cent for yield.

Janakiram and Sirohi (1987) reported heterotic performance for characters like vine length, days to first harvest, fruits per plant, fruit weight and yield per plant in bottlegourd. They suggested that the presence of dominant genes for most of the characters studied in parents can be exploited by developing F_1 hybrids for commercial cultivation. However, in bittergourd maximum and significant heterosis was observed for yield and fruit number per plant. Heterosis for fruit length was of low magnitude. Crosses between CO-1 Green x Hissar Selection, Green Long x CO-2 White long, CO-1 Green x Delhi Local, CO-1 Green x Priya White and Hissar Selection x Green Long were found to be promising for characters like yield per plant, number of fruits, fruit weight etc. (Lawande and Patel, 1989).

Vahab (1989) investigated the heterosis in bittergourd in a 10 x 10 diallel test and reported significant standard heterosis for earliness in crosses MC-66 x MC-49, MC-49 x MC-34 and Arka Harit x MC-82 to the tune of -11.97 per cent, 13.28 per cent and -11.67 per cent respectively. For percentage of female flowers Priya x MC-49 (7.91%) and MC-49 x MC-69 (7.1%) showed standard heterosis. Arka Harit x MC-79 showed high heterobeltiosis in first (117.7%) and second (43.09%) season. For the character fruit per plant, in first season, heterobeltiosis was shown by MC-78 x MC-49 (40.76%) and MC-49 x MC-34 (17.07%). In the second season it was MC-49 x MC-69 (37.83%) and Arka Harit x MC-79 (37.6%).

In another study Varghese and Rajan (1993) reported that the F_1 hybrids exhibited high heterosis for yield ranging from 86.4 per cent to 113.68 per cent. High heterosis was also exhibited for number of fruits. High and negative heterosis was manifested for fruit length ranging from 13.29 to 136.45 per cent. Heterosis for seeds per fruit ranged from 43.4 to 74.47 per cent and for average fruit weight from 28.2 to 74.3 per cent.

In bottlegourd highest yielding parents were S 9-1 (8.13 kg plant^{-1}) and NC 59812-1 (7.69 kg plant^{-1}). Significant heterobeltiosis for yield was reported in the best performing hybrids, S 36-1 x NC 59812-1 (76.4%) and S 39-1 x S 1-3 (58.1%) (Janakiram and Sirohi, 1992). Ranpise *et al.* (1992) observed heterosis for yield per plant (93.69%), flesh thickness (43.18%), number of fruits per plant (37.3%), fruit weight (36.09%), fruit length (26.02%), number of node at which first female flower appeared (-24.72%), vine length (24.63%), days to first female flower appeared (-24.72%), vine length (24.63%), days to first female flowering (-5.4%) and days to first harvest (-4.32%). The mean of F_1 hybrids was greater than that of parents in all the characters except days to first harvest, days to first female flower opening and fruit length. In heterotic hybrids, heterobeltiosis for yield ranged from 19.21 per cent to 93.69 per cent.

Abusaleha and Dutta (1993) recorded heterosis over better parent in spongegourd for all the characters, except days to first female flower and fruit girth. The crosses IIHR-9 x IIHR-23, IIHR-44 x IIHR-36 and IIHR-9 x IIHR-82 recorded 72.78, 63.75 and 49.80 per cent increased yield respectively over the better parent IIHR-76 (a high yielding selection). The higher yields recorded in these three F_1 hybrids were attributed to direct effect of fruit length, fruit weight and total number of fruits on yield.

Hybrids were evaluated under low temperature condition in bottlegourd (Maurya *et al.*, 1993). It was reported that the highest yielding cross took only 83.33 days for its first picking compared to 111.33 days needed by commercial cultivar. Heterosis over the top parent for yield per plant was 80.15 per cent. Abusaleha and Dutta (1993) undertook a study involving forty five F_1 hybrids of ridgegourd in a diallel set (excluding reciprocals) of 10 inbred parents. High degree of heterosis was observed over better parent in all the cross combinations except days to first female flower and first harvest. The four best F_1 hybrid combination P_2 x P_6, P_3 x P_8 and P_2 x P_8 showed 85.50, 80.70, 65.07 and 48.08 per cent higher yield respectively than the top parent P_2 (IIHR-6, a high yielding early maturiting variety). The best parental combination was P_2 x P_4 (IIHR-6 x Coimbatore Long) which gave 85.50 per cent high yield over best parent and can be utilized for exploitation of hybrid vigour for commercial cultivation.

Pitchaimuthu and Sirohi (1994) made a detailed study on heterosis in bottlegourd. They observed heterosis for all the characters under study except days to first fruit harvest. The F_1 hybrid Pusa Naveen x S-10 and Pusa Naveen x Pusa Summer Prolific Long were observed to be the best performing for yield and they showed 64.60 and 60.38 per cent heterosis for yield over top parent S-10. Heterobeltiosis for the characters like days to first male flower opening and first female flower opening ranged from -0.18 to -20.77 and from 0.77 to 019.81 respectively. The best performing hybrid was Pusa Naveen x S-10, which recorded 64.62 per cent heterosis over the top parent and 78.30 per cent over Pusa Naveen, the commercial cultivar for total yield per plant. Kadam *et al.* (1995) evaluated nine diverse lines and the resulting 36 F_1 hybrids from one way diallel in ridgegourd. The highest mean heterosis over better parent was for fruit per plant (19.91%) followed by yield (17.02%) and fruiting nodes per vine (14.1%). Increase in *per se* yield was shown by hybrids P_1 x P_2, P_5 x P_9, P_2 x P_4 and P_5 x P_6 indicating strong tendency of the parents to transmit higher gain to the offsprings. Amongst these four crosses, P_1 x P_2 (Kawlapur x RG-105) with 1.93 kg per vine exceeded the yield performance of the top parent Kawlapur (1.79 kg vine^{-1}). This hybrid gave 60.8 per cent higher yield over Pusa Nasdar, the standard check.

According to Singh *et al.* (1995) among the round fruited genotypes of bottlegourd, the highest heterosis over the better parent was expressed by the hybrid LC-4-5-4 x Punjab Komal for yield and weight per fruit, P-11 x P-10 for fruit size, LC-25-8-1 x Punjab Round for early female flowering and LC-19-4 x P-10 for the earliest harvesting. Range of heterosis was the widest for fruit size, followed by weight per fruit and yield per plant. Hybrid LC-4-5-4 x Punjab Komal expressed 6.23 per cent heterosis of the standard variety and was the best among all the crosses. Another hybridization work involving 15 lines and 4 testers of diverse geographical origin of bittergourd was undertaken by Kennedy and Arumugam (1995). Heterosis was observed for all the characters under study. The F_1 hybrid Pusa Vishesh x MC-13, MC-84 x MDU-1 and DFM-21 x MC-13 gave the highest fruit yield per vine and they showed 65.74, 61.92 and 48.04 per cent heterosis for yield over the standard variety MC-84. The best performing F_1 hybrids of the study, Pusa Vishesh x MC-13 recorded 65.74 per cent heterosis over the standard variety (MC-84) and 49.00 per cent heterosis over the better parent MC-13.

A new early bittergourd F_1 hybrid 'Xiang Kugua 1' derived from the crosses 8901-1-4 x 003-2-3 was reported by Xue Da Yu and Huang Yan Wa (1996). It could be harvested 45 days after transplanting in the spring or after 42 days in summer and autumn and yielded about 45 t ha^{-1} in in the field in spring and about 97.5 t ha^{-1} from spring to autumn. The negative heterosis which is desirable for days to male flowers anthesis, days to female flower anthesis and plant height was common in most of the crosses of bittergourd (Ram et al. 1997). The fruit per plant and yield per plant were the most heterotic characters. High positive heterosis over better parent was observed in the crosses IC-50516 x VRBT-77 for fruits per plant and in crosses Narendra x VRBT-46 and IC-50516 x VRBT-77 for yield per plant.

Karale and Sawant (1998) reported high amount of significant heterosis in desirable direction for all characters of bottlegourd. Seventeen crosses exhibited significant heterosis over better parent, of which AB x N-10, AB x PK, N-5B x Sel.P-2-1, AB x BT4-2, AB x Sel.P-2-1, BTG-2 x PK, BTG-2 x Sel.P-2-1, PK x Sel.P-2-1 produced more than 10 per cent heterosis for yield per vine. In case of superior parent, only two combinations viz. SAMT x TAB and AB x N-10 showed significant positive heterosis for yield per vine and all other crosses were magnitudinally negative. Appreciable heterosis was recorded over best parental lines of bottlegourd for all character under study (Sharma and Malik, 1998). Maximum and significant heterosis was observed for node to first female flower (-27.13%), early yield (63.34%), total yield (52.16%) and number of fruits per vine (50.00%) over better parent. The three best performing F_1 hybrid KBG-16 x Pusa Naveen, GH-16 x Pusa Naveen and GH-13 x G-2 showed 72.81, 68.95 and 47.94 per cent heterosis, respectively for yield over Arka Bahar, the best parental line. The higher yield recorded in these three F_1 hybrids has been attributed to increase in number of fruits per vine. The best F_1 hybrid KBF-16 x Pusa Naveen gave 78.76 per cent higher yield over the standard check Pusa Summer Prolific Long and 72.81 per cent higher yield over the best parental line (Arka Bahar) and has been identified as commercial cultivar.

Sixty six F_1 hybrids were evaluated alongwith 12 parents and 2 hybrids from the private sector during summer. The observation on different characters indicated that heterosis for the yield was obtained from -35.36 to 66.23 per cent over better parent and -59.34 to 8.45 per cent over top parent (Kanade *et al.*, 1998). The maximum per cent superiority over to commercial hybrid was observed from -81.40 to 100.24 per cent. Among the two commercial hybrids the hybrid MBTH-101 showed higher yield (192.33 q ha^{-1}). Among the 66 F_1 hybrids the yield ranged from 129.99 q ha^{-1} (Co-White Long x PBTG-3) to 346.55 g ha^{-1} (PBTG-2 x DPLBG-2). Kumar *et al.* (1999) reported heterosis for yield and its component traits in the 20 F_1 hybrids of bottlegourd. Significant and positive heterotic effects over the better parent and a standard check was observed for fruit yield per plant in the hybrids PBOG-22 x Punjab Komal, PBOG-62 x Punjab Komal followed by PSPL x Punjab Komal and PBOG-62 x BGL2-1.

Tewari and Ram (1999) reported heterosis for yield and other associated characters in bittergourd using three F_1 hybrids from 3 promising genotype of diverse nature namely PBIG-1, PBIG-2 and PBIG-3. Ample amount of heterosis was found for yield over local check and better parent. The best performing hybrid was PBIG-1 x PBIG-2 which showed 25.75 per cent heterosis over better parent.

In a Line x Tester analysis in bottlegourd Kumar *et al.* (1999) crossed 13 promising lines with 3 testers which were selected on the basis of good adoption and desirable traits. The highest heterosis over mid parent for yield per plant was recorded in L_{13} x T_1 (117.26%) while the yield per plant of F1 hybrids L_{12} x T_2 (13.80%) and L_9 x T_1 (8.08%) manifested heterosis over top parent.

MATERIALS AND METHODS

MATERIALS AND METHODS

The research work was conducted in the vegetable research farm of the Department of Olericulture, College of Horticulture, Vellanikkara. The experimental site is located at an altitude of 23 M above M.S.L. and between 10°32" and 76°16" E longitude. The experiment was conducted in two seasons, February 1999 to May 1999 and November 1999 to February 2000. The whole experiment consisted of the following parts

A. Selection of parents, followed by crossing and production of hybrid seeds

B. Evaluation of F_1 hybrids along with their parents, and estimation of heterosis and combining ability

3.1 Experimental materials

Five ridge gourd genotypes viz. LA 81, LA 43, LA 44, LA 87, LA 86 (Plate 1) were selected from the genetically divergent clusters which were identified by Anitha in 1998 and were crossed in a diallel pattern without reciprocals to produce ten F_1 hybrids (Table 1). The seeds were collected and these F_1 hybrids were grown along with the parents in the field during November 1999 to January 2000.

These 10 F_1 hybrids along with their parents were grown in a randomised block design with three replications. The spacing adopted was 2 m x 2 m. There were two plants per pit and 4 pits per genotype per replication. The cultural practices and plant protection measures were adopted according to the Package of Practices recommended by Kerala Agricultural University (1996). The fertilizer was given at a dose of 150:100:100 kg NPK ha^{-1}.

3.2 Observations recorded

The following observations were recorded for all the genotypes.

Table 1. Parents and F_1 hybrids

Sl.No.	Parents	F_1 hybrids
1	LA 81	LA 81 x LA 43
2	LA 43	LA 81 x LA 44
3	LA 44	LA 81 x LA 87
4	LA 87	LA 81 x LA 86
5	LA 86	LA 43 x LA 44
6		LA 43 x LA 87
7		LA 43 x LA 86
8		LA 44 x LA 87
9		LA 44 x LA 86
10		LA 87 x LA 86

Plate 1. PARENTS

LA 43

LA 44

LA 81

LA 86

LA 87

Vine length

The plants were pulled out after harvesting and the length was measured from the collar region to the tip of the main vine.

Number of primary branches

The number of branches originating from the main vine were recorded.

Days to first female flower

The number of days were counted from the date of sowing to the date of opening of the first female flower.

Nodes to first female flower

The nodes were counted from the lowest to the one at which the first female flower appeared.

Days to first harvest

The number of days were counted from the date of sowing to the date of first harvest.

Days to vegetable maturity

The number of days were counted from the date of fruit set to the day when they attained vegetable maturity.

Number of fruits per plant

The total number of fruits harvested from a plot was divided by the number of plants in the plot (8) to get the number of fruits per plant.

Yield per plant

The total weight of fruits (g) collected from a plot was divided by the number of plants in the plot (8) to get the yield per plant.

Average fruit weight

The total weight of fruits (g) from a plot was divided by the total number of fruits to get the average fruit weight.

Length of fruit

The length of five fruits selected at random from each plot was recorded and the average was worked out.

Girth of fruit

The girth at the middle of five fruits selected at random from each plot was recorded and average was worked out.

Duration of the crop

The number of days were counted from the date of sowing to the date of final harvest and recorded as the duration of the crop.

Seeds per fruit

Number of seeds were counted from five fruits selected at random from each plot and the average was worked out.

3.3 Statistical analysis

3.3.1 Analysis for combining ability

The mean value of F_1 hybrids and parents for all the characters were analysed for combining ability using the method suggested by Griffing (1956).

3.3.2 Heterosis

The mean values of parents and hybrids of the three replications for each characters was taken for the estimation of heterosis in terms of three parameters, heterosis over mid parent (Relative heterosis, RH), heterosis over the better parent (Heterobeltiosis, HB) and heterosis over standard parent (Standard Heterosis, SH) and these were worked out as suggested by Briggle (1963) and Hayes *et al.* (1965). For calculation of the standard heterosis, the genotype LA-86 (Arka Sumeet) was taken as the standard parent (SP).

Relative heterosis is the deviation of hybrid mean from the mid parental (MP) value

$$RH = \frac{\bar{F}1 - \bar{MP}}{\bar{MP}} \times 100$$

Heterobeltiosis is the deviation of hybrid mean from the better parent (BP) values,

$$HB = \frac{\bar{F}1 - \bar{BP}}{\bar{BP}} \times 100$$

Heterosis over the standard variety (SP),

$$SH = \frac{\bar{F}1 - \bar{SP}}{\bar{SP}} \times 100$$

For each character the average value of the two parents in each cross was taken as the mid parental value (MP) and that of the superior parent as the better parent value (BP).

To test the significance of difference of F_1 mean over mid and better parents, critical difference (CD) was worked out. Critical difference (CD) was calculated from the standard error of difference as given below (Briggle, 1963).

To test the significance over mid parent

$$CD\ (0.05) = te'\ (0.05) \times \sqrt{\frac{3\ MSE}{2r}}$$

$$= te'\ (0.05) \times SE$$

To test the significance over better parent and standard parent.

$$CD\ (0.05) = te'\ (0.05) \times \sqrt{\frac{2\ MSE}{2r}}$$

$$= te'\ (0.05) \times SE$$

Where te = critical value of t statistic at 5% level of significance
MSE = error mean square
r = number of replications
SE = standard error of difference between two means

RESULTS

RESULTS

The resultsof the study entitled "Heterosis in ridge gourd" are presented under the following heads.

4.1 Combining ability analysis

The analysis of variance for combining ability in a 5 x 5 diallel cross was conducted according to Griffings Method 2. Analysis of variance for 13 characters in 15 genotypes showed significant variability among the tested genotype (Appendix I). The general combining ability effects were significant for vine length, days to first female flower, nodes to first female flower, days to vegetable maturity, number of fruits per plant, yield per plant, average fruit weight, length of fruit, duration of crop and sca effects were significant for days to vegetable maturity, days to first harvest, number of fruits per plant, yield per plant, length of fruit, duration of crop (Table 2). The gca and sca effects of the parents and F_1 hybrids were estimated (Table 3 and 4).

Vine length

Highest gca effect for vine length was observed for LA 87 (47.40). This was followed by LA 44 (15.35). All the other genotypes had negative gca effects. The cross LA 43 x LA 86 showed the highest value for sca effect (53.71) followed by the cross LA 87 x LA 86 (43.37).

Primary branches per plant

The genotype LA 44 (0.25) exhibited the highest gca effect for primary branches per plant followed by LA 43 (0.23). Highest sca effect was shown by the cross LA 44 x LA 86 (1.10). This was followed by the combination LA 81 x LA 43 (0.73) and LA 43 x LA 44 (0.70).

Table 2. Analysis of variance for combining ability in a 5 x 5 diallel in ridgegourd

Source of variation	df	Vine length	No. of primary branches	Days to first female flower	Nodes to first female flower	Days to vegetable maturity	Days to first harvest	No. of fruits per plant
GCA	4	7624.13**	0.43	13.27**	2.07*	0.11**	1.35	21.01**
SCA	10	1988.53	0.53	2.69	1.01	0.09**	5.25**	4.84*
Error	28	1426.06	0.32	2.69	0.76	0.02	1.25	1.85

Source of variation	df	Yield per plant	Average fruit weight (g)	Length of fruit (cm)	Girth of fruit	Duration of crop	Seeds per fruit
GCA	4	282351.04	1552.79**	137.22**	0.43	7.65**	116.60
SCA	10	138606.85**	446.60	10.95*	1.07	5.75**	625.55
Error	28	25863.47	304.12	4.13	0.56	1.66	305.97

** Significant at 1% level
* Significant at 5% level

Table 3. Estimate of gca effect of five ridgegourd genotypes for 13 characters

Characters	LA 81	LA 43	LA 44	LA 87	LA 86	Var (GI)	Var (GI-GI)
Vine length	-16.23	-39.53	15.35	47.40	-6.99	162.97	407.44
No. of primary branches	-0.28	0.23	0.25	0.03	-0.23	0.03	0.09
Days to first female flower	-0.59	-0.73	-1.35	2.07	0.70	0.30	0.76
Nodes to first female flower	0.14	-0.52	-0.60	0.32	0.66	0.08	0.21
Days to vegetable maturity	-0.06	-0.03	-0.11	0.22	-0.02	0.002	0.007
Days to first harvest	-0.52	0.00	0.65	0.11	-0.24	0.143	0.35
No. of fruits per plant	-0.02	-0.05	0.51	2.24	-2.59	0.21	0.52
Yield per plant	160.98	-199.08	-9.24	241.15	-193.81	2955.82	7389.56
Average fruit weight	7.08	-18.37	-12.15	5.50	17.94	34.75	86.89
Length of fruit	+0.09	-3.47	-4.81	1.89	6.30	0.47	0.11
Girth of fruit	0.14	-0.01	0.81	0.11	-0.43	0.06	0.16
Duration of crop	-1.53	-0.45	0.69	1.16	0.13	0.19	0.47
Seeds per fruit	5.58	-3.49	0.60	-4.45	1.76	34.96	87.42

Table 4. Estimate of sca effect of 10 F_1 hybrids for 13 characters

F_1 hybrids	Vine length	No. of primary branches	Days to first female flower	Nodes to first female flower	Days to vegetable maturity	Days to first harvest	No. of fruits per plant
LA 81 x LA 43	28.09	0.73	2.00	0.66	0.04	-0.97	-1.11
LA 81 x LA 44	-48.02	-0.11	1.35	0.99	0.21	-0.51	5.14
LA 81 x LA 87	8.267	-0.23	0.01	-0.43	0.21	0.31	0.69
LA 81 x LA 86	-46.80	-0.55	-1.28	-1.77	0.04	0.94	-0.79
LA 43 x LA 44	34.01	0.70	0.72	0.32	-0.08	-2.42	1.45
LA 43 x LA 87	-35.54	-0.66	0.58	-1.69	0.01	-1.88	0.32
LA 43 x LA 86	53.71	-0.54	-1.24	-0.03	-0.33	0.70	-0.84
LA 44 x LA 87	35.12	0.60	2.43	0.52	0.26	-2.53	-0.07
LA 44 x LA 86	28.07	1.10	0.05	0.23	0.56	-1.62	0.46
LA 87 x LA 86	43.47	0.47	0.13	0.64	0.01	-1.91	0.04
Var (SIJ)	1086.52	0.24	2.05	0.58	0.01	0.95	1.40
Var (SIJ-SIK)	2444.68	0.55	4.01	1.31	0.04	2.15	3.17
Var (SIJ-SLK)	2037.24	0.46	3.84	1.09	0.03	1.79	2.64

Table 4. Continued

F1 hybrids	Yield per plant	Average fruit weight	Length of fruit	Girth of fruit	Duration of crop	Seeds per fruit
LA 81 x LA 43	-3.22	16.10	1.23	0.63	3.38	28.58
LA 81 x LA 44	788.56	24.73	-0.05	1.64	-3.25	-22.76
LA 81 x LA 87	56.07	-31.10	-5.54	0.03	0.94	31.39
LA 81 x LA 86	-165.57	-6.04	-4.87	0.18	-3.85	-25.25
LA 43 x LA 44	318.82	22.00	2.63	1.03	0.09	-2.89
LA 43 x LA 87	47.93	0.61	-1.06	0.90	1.61	9.34
LA 43 x LA 86	-146.01	-3.50	0.39	-0.67	-0.69	7.32
LA 44 x LA 87	-192.65	3.13	0.11	0.27	0.40	-10.44
LA 44 x LA 86	150.77	-32.22	-2.30	0.11	0.02	42.32
LA 87 x LA 86	339.21	26.38	3.20	0.21	-0.46	-27.50
Var (SIJ)	19705.50	231.71	3.14	0.43	1.27	233.12
Var (SIJ-SIK)	44337.38	521.35	7.08	0.97	2.86	524.53
Var (SIJ-SLK)	36497.82	434.46	5.90	0.81	2.38	437.11

Days to first female flower

The highest negative gca effect was shown by the genotype LA 44 (-1.35) followed by LA 43 (-0.73). The combination LA 81 x LA 86 showed highest negative sca effect (-1.28) followed by LA 43 x LA 86 (-1.24).

Nodes to first female flower

The genotype LA 44 showed the highest negative gca effect (-0.60) followed by LA 43 (-0.52). The cross LA 81 x LA 86 exhibited the highest negative sca effect (-1.77). This was followed by LA 43 x LA 87 (-1.69).

Days to vegetable maturity

The highest negative gca effect was exhibited by the genotype LA 44 (-0.11) followed by LA 81 (-0.06). The combination LA 43 x LA 86 showed the highest negative sca effect (-0.33) followed by LA 43 x LA 44 (-0.08).

Days to first harvest

Highest negative gca effects were observed for LA 81 (-0.52) followed by LA 86 (-0.24). The cross which exhibited maximum negative sca effect was LA 44 x LA 87 (-2.53) followed by LA 43 x LA 44 (-2.42).

Fruits per plant

The genotype LA 87 showed the highest gca effect (2.24) followed by LA 44 (0.51). The combination which exhibited the highest sca effect was LA 81 x LA 44 (5.14) whereas the combination LA 81 x LA 43 showed the lowest sca effect (-1.11).

Yield per plant

The genotype which exhibited the maximum gca effect was LA 87 (241.15) followed by LA 81 (160.94) while the other genotypes showed negative gca effect. The highest sca effect was exhibited by the combination LA 81 x LA 44

(788.56) followed by LA 87 x LA 86 (339.21). LA 44 x LA 87 showed the highest negative sca effect (-192.65).

Average fruit weight

The genotype LA 86 showed the highest gca effect (17.94) followed by LA 81 (7.08). The combination showing highest sca effect is LA 87 x LA 86 (26.38).

Length of fruit

The genotype which exhibited the highest gca effect was LA 86 (6.30). The cross which showed maximum sca effect was LA 87 x LA 86 followed by LA 43 x LA 44 (2.63).

Girth of fruit

The genotype LA 44 showed the highest gca effect (0.81) for girth of fruit followed by LA 81 (0.14). All the other genotypes showed negative gca effect. The combination which exhibited the maximum sca effect was LA 81 x LA 44 (1.64) whereas LA 43 x LA 86 showed the lowest sca effect (0.90).

Duration of crop

The highest gca effect was shown by the genotype LA 87 (1.16) followed by LA 44 (0.69). The combination LA 81 x LA 43 showed the highest sca effect (3.38). This was followed by LA 43 x LA 87 (1.61).

Seeds per fruit

The genotype LA 87 showed maximum negative gca effect (-4.45) followed by LA 43 (-3.49). The cross LA 87 x LA 56 showed the highest negative sca effect (-27.50) followed by LA 81 x LA 56 (-25.25).

4.2 Analysis of heterosis

Analysis of variance for 13 characters among the five parents and 10 hybrids of ridgegourd showed significant differences among the genotypes (Table 5). Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for all the characters were calculated. Arka Sumeet (LA 86) was taken as the standard variety for estimation of standard heterosis.

Table 5. Mean values of parents and F1 hybrids and percentage heterosis

Parents / crosses	Vine length				No. of primary branches			
	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
LA 81	466.50				4.00			
LA 43	350.54				4.83			
LA 44	475.83				3.83			
LA 87	538.87				4.44			
LA 86	416.53				3.78			
LA 81 x LA 43	442.07	8.21	-5.24	6.13	5.17	17.03	6.90	36.77
LA 81 x LA 44	420.83	-10.68	-11.56	1.03	4.33	10.69	8.42	14.55
LA 81 x LA 87	509.17	1.29	-5.51	22.24	4.00	-5.21	-9.98	5.82
LA 81 x LA 86	399.72	-9.47	-14.32	-4.03	3.42	-12.21	-14.51	-9.52
LA 43 x LA 44	479.57	16.06	0.78	15.13	5.67	30.77	17.24	50.00*
LA 43 x LA 87	442.07	-0.59	-17.96	6.13	4.08	-11.97	-15.52	7.94
LA 43 x LA 86	476.93	24.35	14.50	14.50	3.94	-8.51	-18.41	4.23
LA 44 x LA 87	567.60	11.88	5.33	36.27**	5.36	29.52	20.63	41.80
LA 44 x LA 86	506.17	13.44	6.37	21.52	5.61	47.16	46.26*	48.41*
LA 87 x LA 86	553.61	15.89	2.74	32.91*	4.75	15.43	6.90	25.66
SE		46.86	52.76	52.76		0.70	0.82	
CD(0.05)		96.06	108.15	108.15		1.43	1.68	
CD(0.01)		129.33	145.61	145.61		1.93	2.26	

* Significant at 5% level
** Significant at 1% level

Table 5. Continued

Parents / crosses	Days to first female flower				Nodes to first female flower			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
LA 81	35.28				7.44			
LA 43	35.19				6.22			
LA 44	32.72				5.17			
LA 87	40.25				8.53			
LA 86	40.25				8.67			
LA 81 x LA 43	38.28	8.63	8.50	-4.89	7.17	4.90	-3.72	-17.30
LA 81 x LA 44	37.00	8.83	4.89	-8.07	7.42	17.63	-0.36	-14.42
LA 81 x LA 87	39.09	3.50	-2.90	-2.90	6.92	-13.38	-18.88	-20.18
LA 81 x LA 86	36.42	-3.57	-9.52	-9.52	5.92	-26.55	-31.73*	-31.72*
LA 43 x LA 44	36.33	7.00	3.24	-9.74	6.08	6.85	-2.20	-29.79*
LA 43 x LA 87	39.61	5.01	-1.59	-1.59	5.00	-32.19*	-41.36**	-42.26**
LA 43 x LA 86	36.42	-3.46	-9.52	-9.52	7.00	-5.96	-19.23	-19.17
LA 44 x LA 87	40.83	11.92*	1.45	1.44	6.08	-11.15	-28.66*	-29.80*
LA 44 x LA 86	37.08	1.64	-7.87	-7.87	7.17	3.61	-17.31	-17.30
LA 87 x LA 86	40.58	0.83	0.83	0.82	8.50	-1.12	-1.92	-1.85
SE		1.88	2.36			1.00	1.14	
CD(0.05)		3.85	4.83			2.05	2.34	
CD(0.01)		5.18	6.51			2.76	3.15	

* Significant at 5% level

** Significant at 1% level

Table 5. Continued

Parents / crosses	Days to vegetable maturity				Days to first harvest			
	Mean	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
LA 81	8.08				52.05			
LA 43	8.58				55.28			
LA 44	8.33				57.83			
LA 87	8.33				56.22			
LA 86	8.83				53.44			
LA 81 x LA 43	8.42	1.00	-1.94	-4.64	51.50	-4.04	-6.84*	-3.63
LA 81 x LA 44	8.50	3.55	2.00	-3.74	52.61	-4.25	-9.04**	-1.55
LA 81 x LA 87	8.83	5.47*	1.92	0.00	52.89	-2.31	-5.93*	-1.03
LA 81 x LA 86	8.42	-0.49	-4.72	-4.64	53.16	0.79	-0.52	-0.52
LA 43 x LA 44	8.25	-2.46	-3.88	-6.57**	51.22	-9.43**	-11.44**	-4.15
LA 43 x LA 87	8.67	0.48	0.00	-1.11	51.22	-8.12**	-8.89**	-4.15
LA 43 x LA 86	8.08	-7.18**	-8.49**	-8.50*	53.44	-1.69	-3.32	0.00
LA 44 x LA 87	8.83	3.92	1.92	0.00	51.22	-10.19**	-11.44**	-4.15
LA 44 x LA 86	7.77	-9.44**	-12.00*	-12.00**	51.78	-6.94**	-10.47**	-3.11
LA 87 x LA 86	8.67	-0.95	-1.89	-1.81	50.94	-7.10**	-9.39**	-4.69
SE		0.18	00.21			1.39	1.61	
CD(0.05)		0.37	0.43			2.85	3.30	
CD(0.01)		0.50	0.58			3.84	4.44	

* Significant at 5% level

** Significant at 1% level

Table 5. continued

Parents / crosses	No. of fruits per plant				Yield per plant			
	Mean	RH (%)	HB (%)	SH (%)	Mean (g)	RH (%)	HB (%)	SH (%)
LA 81	10.26				1882.07			
LA 43	12.46				1391.11			
LA 44	10.00				1346.80			
LA 87	16.47				2255.05			
LA 86	7.86				1421.22			
LA 81 x LA 43	11.19	-1.48	-10.17	42.37	1856.72	13.45	-1.35	30.64
LA 81 x LA 44	18.00	77.69**	75.44**	129.01**	2838.33	75.81**	50.81**	99.71**
LA 81 x LA 87	15.28	14.29	-7.26	94.41**	2356.23	13.91	4.49	65.79**
LA 81 x LA 86	8.97	-0.94	-12.54	14.12	1699.64	2.91	-9.96	19.59
LA 43 x LA 44	14.38	28.10	15.47	83.05**	2008.53	46.72**	44.38**	41.32*
LA 43 x LA 87	14.98	3.58	-9.04	90.59**	1988.03	9.05	-11.84	39.88*
LA 43 x LA 86	9.00	-11.42	-27.78*	14.50	1359.14	-3.34	-4.37	-2.26
LA 44 x LA 87	15.15	14.45	-8.03	92.75**	1937.29	7.57	-14.09	36.31*
LA 44 x LA 86	10.86	21.60	8.57	38.17	1845.76	33.36*	29.87	29.87
LA 87 x LA 86	12.16	-0.01	26.16*	54.71*	2284.58	24.29*	1.31	60.75**
SE		1.65	1.84			195.48	222.12	
CD(0.05)		3.38	3.77			400.73	455.34	
CD(0.01)		4.55	5.08			539.52	613.05	

* Significant at 5% level
** Significant at 1% level

Table 5. Continued

Parents / crosses	Average fruit weight				Length of the fruit			
	Mean (g)	RH (%)	HB (%)	SH (%)	Mean (cm)	RH (%)	HB (%)	SH (%)
LA 81	168.75				31.98			
LA 43	102.08				18.63			
LA 44	123.31				17.37			
LA 87	167.92				32.60			
LA 86	200.00				41.57			
LA 81 x LA 43	161.25	19.08	-4.44	-19.36	25.03	-1.09	-21.73*	-39.79**
LA 81 x LA 44	176.10	20.59	4.36	-11.95	22.42	-9.14	-29.90**	-46.06**
LA 81 x LA 87	137.92	-18.07	-18.27	-31.05**	23.62	-26.86*	-27.56**	-43.18**
LA 81 x LA 86	175.42	-4.86	-12.29	-12.30	28.70	-21.96*	-30.95**	-30.96**
LA 43 x LA 44	147.92	31.25	19.96	-26.05	21.53	19.63	15.56	-48.21**
LA 43 x LA 87	144.17	6.79	-14.14	-27.92*	24.54	-4.20	-24.72**	-40.98**
LA 43 x LA 86	152.50	0.97	-23.75	-23.75	30.40	1.00	-26.86**	-26.87**
LA 44 x LA 87	152.92	5.02	-8.93	-23.55	24.37	-2.47	-25.26**	-41.38**
LA 44 x LA 86	130.00	-19.58	-35.00	-35.00	26.37	-10.52	-36.57**	-36.57**
LA 87 x LA 86	206.25	12.12	3.12	3.13	38.57	4.00	-7.22	-7.22
SE		21.85	26.60			2.57	3:19	
CD(0.05)		44.80	54.53			5.27	6.54	
CD(0.01)		60.30	73.41			7.09	8.80	

* Significant at 5% level

** Significant at 1% level

Table 5. Continued

Parents / crosses	Girth of the fruit				Duration of the crop			
	Mean (cm)	RH (%)	HB (%)	SH (%)	Mean	RH (%)	HB (%)	SH (%)
LA 81	13.79				71.08			
LA 43	13.77				69.67			
LA 44	13.58				75.50			
LA 87	14.27				73.83			
LA 86	13.97				75.50			
LA 81 x LA 43	15.50	12.50	12.50	11.95	74.17	5.39*	4.34	-1.76
LA 81 x LA 44	16.70	22.50**	21.10**	19.54*	68.67	-6.31**	-9.05**	-9.05**
LA 81 x LA 87	15.02	7.09	5.30	7.52	73.33	-1.21	-0.68	-2.87
LA 81 x LA 86	14.63	5.44	4.77	4.72	67.50	-7.90**	-10.60**	-10.60**
LA 43 x LA 44	15.94	16.59*	15.79*	14.10	73.08	6.69	-3.20	-3.20
LA 43 x LA 87	15.74	12.29	10.33	12.67	75.09	4.65*	1.69	-0.56
LA 43 x LA 86	13.63	-1.68	-2.39	-2.43	71.75	-1.15	-4.97*	-4.97*
LA 44 x LA 87	15.30	9.90	7.24	9.52	75.00	0.45	-0.66	-0.66
LA 44 x LA 86	14.60	6.01	4.53	4.51	73.58	-2.54	-2.54	-2.54
LA 87 x LA 86	14.63	3.66	2.57	4.72	73.58	-1.45	-2.54	-2.54
SE		0.91	1.04			1.61	1.79	
CD(0.05)		1.87	2.13			3.30	3.67	
CD(0.01)		2.51	2.87			4.44	4.94	

* Significant at 5% level

** Significant at 1% level

Table 5. Contd.

Parents / crosses	Seeds per fruit			
	Mean	RH (%)	HB (%)	SH (%)
LA 81	151.47			
LA 43	118.08			
LA 44	144.33			
LA 87	136.00			
LA 86	151.33			
LA 81 x LA 43	176.92	31.27	16.80	16.91
LA 81 x LA 44	129.67	-12.33	-14.39	-14.31
LA 81 x LA 87	178.67	24.30	17.96	18.07
LA 81 x LA 86	128.33	-15.24	-15.27	-15.20
LA 43 x LA 44	140.47	7.06	-2.68	-7.18
LA 43 x LA 87	147.64	16.21	8.56	-2.44
LA 43 x LA 86	151.83	12.70	0.33	0.33
LA 44 x LA 87	131.95	-5.86	-8.58	-12.87
LA 44 x LA 86	190.93	29.15	26.17	26.17
LA 87 x LA 86	116.05	- 19.22	-23.13	-23.31
SE		21.82	24.83	
CD(0.05)		47.731	50.90	
CD(0.01)		60.22	68.53	

* Significant at 5% level

** Significant at 1% level

Vine length

Mean vine length for the hybrids ranged from 399.72 to 567.60 cm. Maximum relative heterosis was observed for the cross LA 43 x LA 86 (24.35%). This cross also exhibited maximum heterobeltiosis (14.50%). The combination LA 44 x LA 87 exhibited maximum and significant standard heterosis of 36.27 per cent followed by LA 87 x LA 86 (36.91%). The cross LA 81 x LA 86 was the only combination which showed negative standard heterosis of -4.03 per cent. The *per se* performance also was highest in LA 44 x LA 87.

Primary branches per plant

Number of primary branches per plant ranged from 3.42 to 5.67 in the F_1's. The maximum relative heterosis was shown by the cross LA 44 x LA 86 (47.16%). This cross also exhibited maximum significant heterobeltiosis of 46.26 per cent and a significant standard heterosis of 48.41 per cent. But the maximum and significant standard heterosis was exhibited by the combination LA 43 x LA 44 (50.00%) which also had the highest mean value of 5.67.

Days to first female flower

The F_1 means ranged from 36.33 (LA 43 x LA 44) to 40.83 (LA 44 x LA 87) for days to first female flower opening. The maximum and significant negative relative heterosis was observed for LA 81 x LA 86 (-3.57%). The highest negative heterobeltiosis was observed for the cross LA 43 x LA 86 (-9.52%) whereas the cross LA 43 x LA 44 showed the highest negative standard heterosis of -9.74 per cent.

Nodes to first female flower

The nodes to first female flower in the F_1 hybrids ranged from 5.00 (LA 43 x LA 87) to 8.50 (LA 87 x LA 86). The cross LA 43 x LA 87 exhibited the highest negative and significant value for relative heterosis (-32.19%), heterobeltiosis (-41.36%) and standard heterosis (-42.26%). This was followed by the cross LA 81 x LA 86 with relative heterosis of -26.25 per cent, heterobeltiosis of -31.73 per cent and standard heterosis of -31.72 per cent. The cross LA 43 x LA 44 (-29.79%) and LA 44 x LA 87 (-29.80%) showed negative and significant standard heterosis.

Days to vegetable maturity

Number of days to vegetable maturity in the F_1 hybrids ranged from 7.77 in LA 44 x LA 86 to 8.83 in LA 44 x LA 87. But none of the F_1 hybrids showed a significant decrease in the number of days to vegetable maturity than their parents. The combination LA 44 x LA 86 showed the highest negative and significant relative heterosis (-9.44%), heterobeltiosis (-12.00%) and standard heterosis (-12.00%). The combination LA 43 x LA 86 also showed significant negative heterosis for relative heterosis (-7.18%), heterobeltiosis (-8.49%) and standard heterosis (-8.5%).

Days to first harvest

The mean values for number of days to first harvest in F_1 hybrids ranged from 50.94 (LA 87 x LA 86) to 53.44 (LA 43 x LA 86). All the crosses exhibited negative heterosis for this character. The highest negative and significant relative heterosis of -10.19 per cent and heterobeltiosis of -11.44 per cent was exhibited by the cross LA 44 x LA 87. The cross LA 43 x LA 44 also showed a heterobeltiosis of -11.44 per cent. The highest negative standard heterosis was exhibited by the cross LA 87 x LA 86 (-4.69%).

Fruits per plant

The number of fruits per plant in the F_1 hybrids ranged from 8.97 (LA 81 x LA 86) to 18.00 (LA 81 x LA 44). The maximum positive and significant relative heterosis of 77.69 per cent was exhibited by the cross LA 81 x LA 44. This cross also showed a heterobeltiosis of 75.44 per cent and standard heterosis value of 129.01 per cent. The next highest significant heterobeltiosis was shown by the cross LA 43 x LA 86 (-27.78%) and standard heterosis of 94.41 per cent by the cross LA 81 x LA 87.

Yield per plant

The yield per plant of F_1 hybrids ranged from 1359.14 (g) in LA 43 x LA 86 to 2838.33 (g) in LA 81 x LA 44. The cross LA 81 x LA 44 exhibited the highest yield per plant. This cross also showed the highest positive and significant relative heterosis (75.81%), heterobeltiosis (50.81%) and standard heterosis (99.71%). The next highest relative heterosis of 46.72 per cent and heterobeltiosis of 44.38 per cent was exhibited by the cross LA 43 x LA 44. The next highest and significant standard heterosis value of 65.79 per cent was observed in the cross LA 81 x LA 87.

Average fruit weight

The average fruit weight per plant in the F_1 hybrid ranged from 130.00 (g) (LA 44 x LA 86) to 206.25 (g) (LA 87 x LA 86). The cross LA 87 x LA 86 exhibited the highest average fruit weight than the parents. The highest relative heterosis of 31.25 per cent was shown by the cross LA 43 x LA 44. This cross also exhibited highest positive heterobeltiosis of 19.96 per cent but these were not significant. Only LA 87 x LA 86 exhibited highest positive standard heterosis of 3.13 per cent. All the other crosses showed negative standard heterosis.

Length of fruit

The mean values of the F_1 hybrids for length of fruit ranged from 21.53 cm in LA 43 x LA 44 to 38.57 cm in LA 87 x LA 86. The highest positve and significant relative heterosis was shown by the cross LA 43 x LA 44 (19.63). This cross also showed positive and significant heterobeltiosis of 15.56 per cent and the maximum was in LA 43 x LA 44 (-48.21).

Girth of fruit

All the F_1 hybrids exhibited positive heterosis for girth of fruit. The highest mean value was shown by the cross LA 81x LA 44 (16.70 cm). This cross showed the highest positive and significant relative heterosis of 22.5 per cent, heterobeltiosis of 21.1 per cent and standard heterosis of 19.54 per cent. This was followed by the cross LA 43 x LA 44 with relative heterosis of 16.59 per cent and heterobeltiosis of 15.79 per cent, but the standard heterosis of 14.1 per cent was not found significant.

Duration of the crop

The duration of the crop ranged from 67.50 days (LA 81 x LA 86) to 75.08 days (LA 43 x LA 44) days. The maximum value was shown by the cross LA 43 x LA 87 and the minimum was in LA 81 x LA 86. The cross LA 81 x LA 43 recorded the maximum relative heterosis (5.39%), heterobeltiosis (4.34%). All the F_1 hybrids exhibited negative standard heterosis. The maximum negative relative heterosis (-15.24), heterobeltiosis (-15.27) and standard heterosis (-15.20) was observed in LA 81 x LA 86.

Seeds per fruit

Number of seeds per fruit ranged from 116.05 to 190.93 in the hybrids. The number of seeds per fruit was highest in LA 87 x LA 86. The values were statistically nonsignificant in the case of relative heterosis, heterobeltiosis and standard heterosis.

DISCUSSION

DISCUSSION

Ridgegourd is a commercially important vegetable crop grown all over India. It is mainly grown for its immature and tender fruits. Ridgegourd is also seen in the homesteads throughout Kerala. Improvement work on this crop was initiated in the year 1988 at various centres such as IARI, New Delhi; NBPGR, New Delhi; PAU, Ludhiana; CCSHAU, Hisar and NDUAT, Faizabad co-ordinated by the Project Directorate of Vegetable Research under Indian Council of Agricultural Research.

The combining ability analysis helps the breeder in identifying suitable parents which can be hybridized to exploit heterosis. Heterosis breeding is one of the handy tools for the speedy development of better genotypes, whose performance can be judged in the very first generation after crossing. It would rather facilitate to combine favourable attributes of parents involved in the programme, especially when the character is controlled by dominant genes. Hence the present study is aimed at utilizing the available variability to produce F_1 hybrids in ridgegourd. The major findings are discussed under the following headings.

5.1 Combining ability

In a heterosis breeding programme, the selection of parents is a very important step for getting good results. The selection of parents based on the *per se* performance need not necessarily lead to production of best F_1 hybrids. Therefore, the parents will have to be identified based on complete genetic information and knowledge of their combining abilities. In the present study five parents belonging to five different genetic clusters identified by the earlier work were crossed in a diallel pattern without reciprocals to obtain ten F_1 hybrids. The F_1 hybrids along with their parents were evaluated to obtain information on combining ability and heterosis.

There was significant variance due to gca effect for vine length, days to first female flower, days to vegetable maturity, number of fruits per plant, yield per plant, average fruit weight, length of fruit and duration of the crop. The sca effects were significant for days to vegetable maturity, days to first harvest, yield per plant and duration of the crop. The significance of gca and sca indicated the possible role of additive and non additive gene action in the control of these characters. The magnitude of gca variance was higher than that of sca variance for vine length, number of primary branches, days to first female flower, nodes to first female flower, days to vegetable maturity, number of fruits per plant, yield per plant, average fruit weight, length of fruit and duration of crop indicating the preponderance of additive gene action in controlling these characters. However, sca variance was higher for days to first harvest, girth of fruit and seeds per fruit indicating the preponderance of non-additive gene action. Choudhury *et al.* (1998) and Matoria and Khandelwal (1999) also have reported preponderance of additive and non additive gene action in the control of most of the vegetative and reproductive characters in bottlegourd and in bittergourd respectively. According to Griffing (1956) the gca variance per effects include both additive and additive x additive component. Since there is indication of additiveness (i.e., high gca effects) in all the characters by selection, the response to selection is expected to be the best in the F_1s involving parents having high gca effects.

Though the gca effect for vine length was maximum in LA 87, the sca effect was the highest in the cross LA 43 x LA 86 where the parents had negative gca effects. The best general combiner with high positive gca effect for the number of primary branches was LA 44. The cross LA 44 x LA 86 also showed the best sca effect. Similar results were reported by Kharitra *et al.* (1994) in bittergourd.

The genotype LA 44 had the maximum negative gca effect for days to first female flower followed by LA 43 indicating that these are good combiners for earliness. But the sca effect was negative and maximum in the cross LA 81 x LA 86 (-1.28) eventhough the parents had the lowest negative and positive gca effects respectively. The cross LA 43 x LA 86 had sca effect of -1.24 which was significantly different from that of LA 81 x LA 86. The gca effect for days to vegetable maturity was the highest in LA 43 and sca effect was the highest in LA 43 x LA 86. Though LA 81 had the maximum negative gca effect for days to first harvest, the sca effect was maximum in LA 44 x LA 87 indicating that LA 81 is not a good combiner for days to first harvest.

For the character number of fruits per plant and yield per plant LA 87 had the highest gca effect indicating it to be the best combiner. The maximum sca effect for these characters were exhibited by LA 81 x LA 44 wherein the genotype LA 81 had minimum negative and positive gca effects for fruits per plant and yield per plant respectively. LA 44 had minimum positive and negative gca effects for fruits per plant and yield per plant respectively. It appears that the non-additive genetic components were of greater importance. Sharma *et al.* (1998) also had reported high gca and sca effect for these characters in bottlegourd.

The maximum gca effects for average fruit weight and length of fruit was in LA 86. The combination LA 87 x LA 86 had maximum sca effects for these characters probably because LA 86 was a good general combiner. The genotype LA 81 had maximum gca effects for girth of fruit and the combination LA 81 x LA 44 had maximum sca effect indicating dominance gene action. High gca and sca effect for average fruit weight and length of fruit in bittergourd had been reported by Matoria and Khandelwal (1999).

The gca effect for duration of crop was the highest in LA 87 but the sca effects was the highest in LA 81 x LA 43 where both the parents had negative gca effect indicating the preponderance of non-additive gene action for this character. The genotype LA 87 had maximum negative gca effect for seeds per fruit and the cross LA 87 x LA 86 had maximum negative sca effect indicating that LA 87 is a good general combiner for less number of seeds in ridgegourd.

5.2 Heterosis

The relative heterosis, heterobeltiosis and standard heterosis for 13 characters including yield were estimated in the diallel experiment. Significant differences were observed for all the characters among the genotypes.

Vine length exhibited relative heterosis, heterobeltiosis and standard heterosis in the different F_1's studied. When compared to the standard variety LA 86, the combination LA 44 x LA 87 had the maximum, standard heterosis for vine length which also exhibited high *per se* performance. This is because of the highest gca effects of the parents. But in the F_1 hybrid LA 81 x LA 86, vine length had negative heterosis. This is probably due to negative gca effect of the parents. Sirohi *et al.* (1987) reported significant heterosis only for vine length, number of fruits per plant and yield in bottlegourd.

Maximum and significant relative heterosis and heterobeltiosis was exhibited by the cross LA 44 x LA 86 and significant standard heterosis was exhibited by LA 43 x LA 44 for the character number of primary branches probably due to the high positive gca effect of the parent LA 44. The results are in agreement with Ram *et al.* (1997) who also observed high positive heterosis over better parent for branches per plant in bittergourd. The cross LA 43 x LA 44 showed good *per se* performance.

The number of days to first female flower opening exhibited maximum negative relative heterosis and heterobeltiosis in LA 81 x LA 86 and standard heterosis was maximum in LA 43 x LA 44 probably due to the negative gca effect of the parents. Maurya *et al.* (1993) also had reported high magnitudes of combining ability for days to anthesis of female flower. The relative heterosis, heterobeltiosis and standard heterosis were significant, negative and maximum in LA 43 x LA 87 for nodes to first female flower. The same combination also had negative sca effect and good *per se* performance. The negative standard heterosis in all the F_1 hybrids indicated that they were early when compared to the standard variety. Pal *et al.* (1984) and Sharma and Malik (1998) also had reported the tendency of the hybrids to produce first female flower at lower nodes in bittergourd and bottlegourd respectively.

The F_1 hybrids LA 44 x LA 86 exhibited maximum, negative and significant relative heterosis, heterobeltiosis and standard heterosis for the days to vegetable maturity probably due to negative gca effects of the parents. The negative standard heterosis of the hybrid indicated that they require minimum days to vegetable maturity when compared to the standard variety. LA 44 x LA 86 also exhibited good *per se* performance. Maximum, negative and significant relative heterosis and heterobeltiosis was exhibited by the combination LA 44 x LA 87 for days to first harvest. The same cross also had high sca. However, the standard heterosis was maximum in LA 87 x LA 86 probably due to negative gca effect of LA 86. Similar findings were reported by Maurya *et al.* (1993) in bottlegourd.

The maximum significant relative heterosis, heterobeltiosis and standard heterosis for fruits per plant and yield per plant were in LA 81 x LA 44 even though the parents had low gca values. The cross also exhibited good *per se* performance. However, the sca effect was the highest in this cross. The F_1 hybrid LA 43 x LA 44 exhibited maximum relative heterosis and heterobeltiosis for average fruit weight and length of fruit eventhough the parents were not good general combiners. The standard heterosis was very low in all the crosses indicating that none of the F_1 hybrids were better than the standard variety for these characters. Similarly Maurya *et al.* (1993) had reported in bottlegourd that the crosses having highest sca effect are not necessarily the products of parents having high gca effect and there is no direct relationship between the *per se* performance of the parents and their resultant crosses. The girth of fruit exhibited maximum relative heterosis, heterobeltiosis and standard heterosis in LA 81 x LA 44 probably due to high gca effects of the parent. The same combination had high sca effect for the character and also *per se* performance was also good.

The cross LA 81 x LA 43 exhibited maximum relative heterosis and heterobeltiosis for the duration of the crop. The sca effect was also maximum in this cross though both the parents were poor general combiners. The negative standard heterosis indicated that none of the F_1 hybrids had longer duration than the standard variety. The maximum negative relative heterosis, heterobeltiosis and standard heterosis observed in LA 81 x LA 86 is probably because it was early in producing female flowers and LA 81 was a good combiner for shorter duration of the crop.

The maximum negative relative heterosis, heterobeltiosis and standard heterosis for seeds per fruit was in LA 87 x LA 86 probably because LA 87 was a good general combiner. The combination also exhibited lowest specific combining ability but the *per se* performance was good.

It is apparent from the foregoing discussion that in almost all the hybrids which showed the best results, at least one of the outstanding parental lines namely, LA 87, LA 81 or LA 44 were involved. These lines had high gca effects for one or more of the characters contributing towards yield. This indicated that there was a strong tendency for higher gain to be transmitted from the parents to the offspring. These results suggest that from the economic point of view, it is necessary to utilize the best performing parental lines for one or more character associated with yield in order to achieve higher gains in the F_1 hybrids through exploitation of heterosis.

SUMMARY

SUMMARY

The present investigation on "Heterosis in ridgegourd [*Luffa acutangula* (Roxb.) L] was conducted at the Vegetable Research Farm of the Department of Olericulture, Vellanikkara during the period 1999-2000. The major objectives of the study were estimation of combining ability, evaluation of the F_1 hybrids based on relative heterosis, heterobeltiosis and standard heterosis and identification of promising F_1 hybrids in ridgegourd.

In a heterosis breeding programme, theselection of parents based on *per se* performance need not lead to production of superior F_1 hybrids.

During the course of the present study, five diverse parents were selected from five genetic clusters were crossed in all possible combinations to develop 10 hybrids (excluding reciprocal). These F_1 hybrids were evaluated along with their parents for estimating combining ability and heterosis.

There was significant differences among the 15 genotypes for both gca and sca of different characters. The magnitude of gca variance was higher than sca variance for vine length, number of primary branches, days to first female flower, nodes to first female flower, days to vegetable maturity, number of fruits per plant, yield per plant, average fruit weight, length of fruit and duration of crop indicating the preponderance of additive gene action on controlling these characters. However, sca variance was higher for days to first harvest, girth of fruit and seeds per fruit indicating the preponderance of non-additive gene action. It was observed that the genotype having high gca for yield per plant and other character also gave good *per se* performance. The vine length was the highest in the cross LA 44 x LA 87 which also exhibited longer duration of 75 days. The F_1 hybrid LA 43 x LA 44 produced female flower earlier (36.33 days) hence it came to harvesting also earlier (51.22 days). It was also noticed that parental line LA 81 and LA 87 were good combiners for yield. The best combination for yield was LA 81 x LA 44

(2838.33 g) which also had higher number of fruits per plant (18.00). But the best combination for average fruit weight (206.25 g) and fruit length (38.57 cm) was LA 87 x LA 86.

The heterobeltiosis, relative heterosis and standard heterosis for 13 characters including yield was estimated in the diallel experiment.

The hybrid LA 44 x LA 87 had the maximum standard heterosis for vine length and come to harvest at an early date. This hybrid had the maximum fruiting period. The *per se* performance for this character was also good. Similarly the hybrid LA 81 x LA 86 showing maximum negative heterosis was the earliest to flower in the lowest nodes.

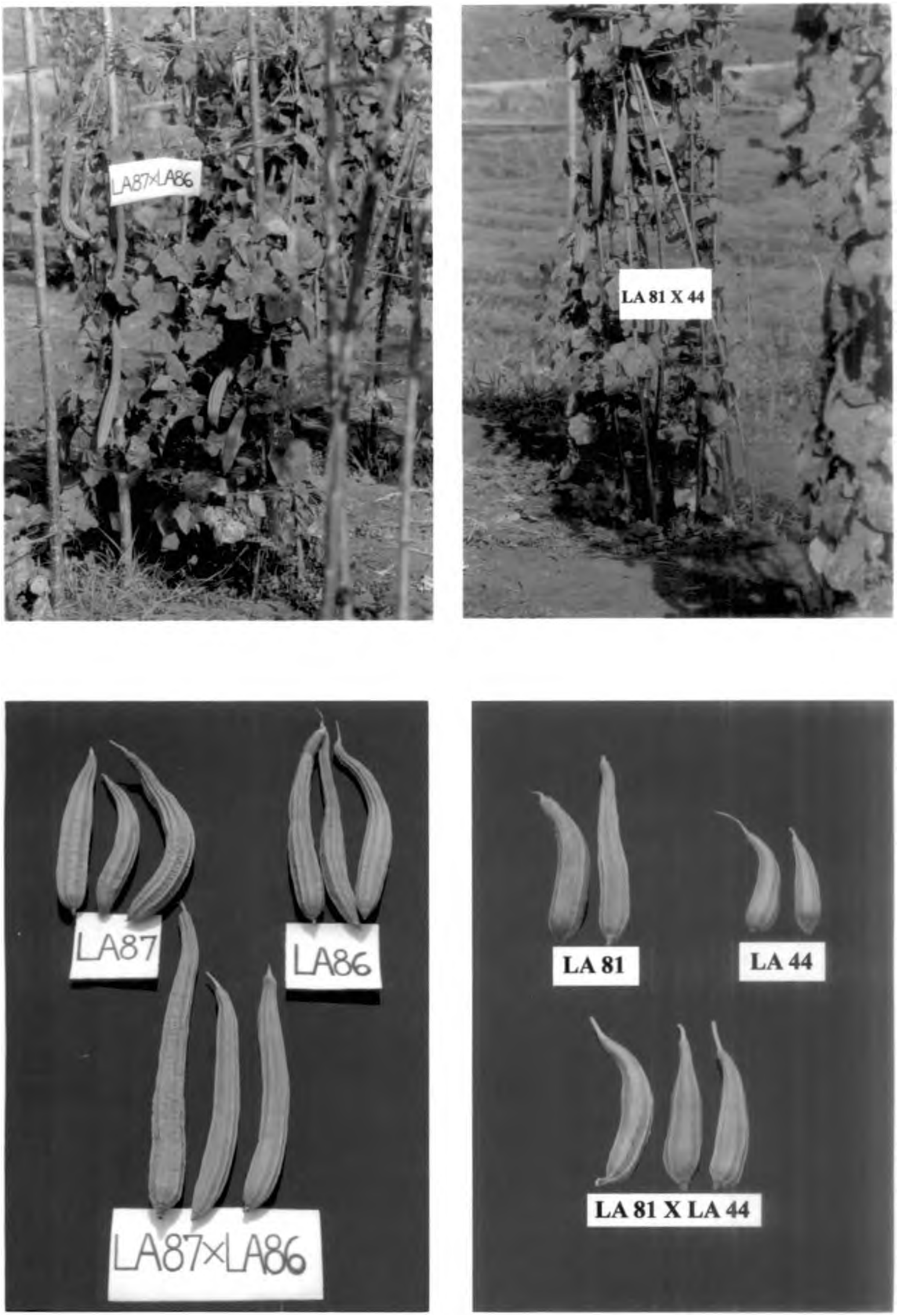
The maximum heterosis for yield and fruits per plant was exhibited by the combination LA 81 x LA 44. The hybrid LA 87 x LA 86 showed the highest standard heterosis for average fruit weight indicating that none of the other crosses had increased average fruit weight than the standard variety. The F_1 hybrid LA 81 x LA 44 exhibited relative heterosis, heterobeltiosis and standard heterosis for fruit girth.

The results of the study indicate that use of parental lines like LA 87, LA 81 and LA 44 with good gca for yield and its components could lead to the production of promising F_1 hybrids (Table 6). The promising hybrids showing superiority in most of the economic characters were LA 81 x LA 44, LA 87 x LA 86 and LA 43 x LA 44(Plate 2) Such F_1's can also be carried to advanced generation for further selection of promising segregants.

Table 6. *Per se* performance of the promising hybrids

Character	Hybrids	Mean ~~(cm)~~	sca	RH (%)	HB (%)	SH (%)
Vine length	LA 44 x LA 87	567.60	35.12	11.88	5.33	36.27
Number of primary branches	LA 43 x LA 44	5.67	0.70	30.77	17.24	50.00
Days to first female flower	LA 43 x LA 44	36.33	0.72	7.00	3.24	-9.74
Nodes to first female flower	LA 43 x LA 87	5.00	-1.69	-32.19	-41.36	-42.26
Days to vegetable maturity	LA 44 x LA 86	7.77	0.56	-9.44	-12.00	-12.00
Days to first harvest	LA 87 x LA 86	50.97	-1.91	-7.10	-9.39	-4.69
Number of fruits per plant	LA 81 x LA 44	18.00	5.14	77.69	75.44	129.01
Yield per plant	LA 81 x LA 44	2838.33 (g)	788.56	75.81	50.81	99.71
Average fruit weight	LA 87 x LA 86	206.25 (g)	26.38	12.12	3.12	3.13
Length of fruit	LA 87 x LA 86	38.57 (cm)	3.20	4.00	-7.22	-7.22
Girth of fruit	LA 81 x LA 44	16.70 (cm)	1.64	22.55	21.10	19.54
Duration of the crop	LA 44 x LA 87	75.00	0.40	0.45	-0.66	-0.66
Seeds per fruit	LA 87 x LA 86	116.05	-27.50	-19.22	-23.13	-23.31

Plate 2. Promising F_1 Hybrids



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APPENDIX

APPENDIX-I

Analysis of variance for 13 characters in five genotypes of ridgegourd and their 10 hybrids

Source of variation	df	Vine length	No. of primary branches	Days to first female flower	Nodes to first female flower	Days to vegetable maturity	Days to first harvest	No. of fruits per plant
Replication	2	6883.830	3.44	38.69	0.56	0.01	5.56	10.05
Genotype	14	10785.250	1.81	17.14	3.94	0.29**	12.41**	28.40**
Error	28	4278.206	0.97	8.07	2.29	0.07	3.77	5.55

Source of variation	df	Yield per plant	Average fruit weight (g)	Length of fruit (cm)	Girth of fruit	Duration of crop	Seeds per fruit
Replication	2	62873.23	2510.68	18.66	1.29	16.84	612.41
Genotype	14	539034.74**	2309.39	141.10**	2.68	18.89**	1440.41
Error	28	77590.41	912.37	12.39	1.70	5.00	197.93

** Significant at 1% level

HETEROSIS IN RIDGE GOURD
(*Luffa acutangula* (Robx.) L.)

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

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ABSTRACT

The present investigation on Heterosis in Ridge gourd [*Luffa acutangula* (Roxb.) L] was conducted at the Vegetable Research Farm, College of Horticulture, Thrissur during 1999-2000. From the germplasm available in the Department of Olericulture, five parents belonging to different genetic clusters were selected. They were crossed in a diallel fashion to produce F_1 hybrids. The F_1's without reciprocals were grown in a randomised block design. These F_1 hybrids were evaluated along with their parents to derive information on general and specific combining ability.

From combining ability analysis, it was noticed that the parental lines LA 81 and LA 87 were good combiners for yield. The best comination for yield was LA 81 x LA 44 and that for earliness was LA 43 x LA 44. The best combination for average fruit weight and fruit length was LA 87 x LA 86.

The combination LA 44 x LA 87 had maximum duration which also exhibited maximum vine length. The standard heterosis was highest for LA 43 x LA 44 for earliness. The maximum heterosis for yield was exhibited by the combination LA 81 x LA 44 which also showed increased fruit number per plant. The combination LA 81 x LA 44 showed increased fruit girth which also showed more number of fruits per plant hence increased yield. But length of fruit was maximum for the combination LA 87 x LA 86 but fruits produced by this cross was less. The study revealed that the three hybrids viz. LA 81 x LA 44, LA 87 x LA 86 and LA 43 x LA 44 are promising hybrids showing superiority in yield and its component characters considered in the study.