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Original Research Paper

GENERAL AND SPECIFIC COMBINING ABILITY FOR FRUIT YIELD USING DIALLEL POPULATION OF RIDGE GOURD (*Luffa acutangula* (Roxb.) L.)

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An experiment was conducted using 7 × 7 diallel population of ridge gourd (*Luffa acutangula* (Roxb. L.) to study the general and specific combining ability (GCA and SCA) of parents and their hybrids for 17 yield traits in a randomized complete block design with three replications. Data on 17 characters were subjected to analysis of GCA and SCA variances and their effects. The GCA and SCA variance were found highly significant for all the characters except days to first female flowering. Low magnitude of σ^2g/σ^2s ratio was observed for all the traits other than days to first male flowering, days to first female flowering, fruit length , fruit width, individual fruit weight. On the other hand, σ^2g/σ^2s ratio was more than 1.0 for days to first male flowering, days to first female flowering, fruit length, fruit width and individual fruit weight. The general combining effects (GCA) of the parents revealed that none of the parent was found to be good general combiner for all the characters. However, in the present investigation, parent P3 was observed to be one of the best general combiner as it has shown significant GCA effects in desirable direction for number of fruits per plant and fruit yield per plant. It also observed significant GCA effects for parameters related to earliness viz., days to first male flowering, node number of first female flower and days to first harvest. Similarly, parent P5 was also good general combiners for fruit length, fruit width and individual weight of fruit, parent P6 and P7 were also good general combiners for fruit length, individual weight of fruit except fruit width. The parent P2 and P4 were also good general combiners for number of fruits per plant. The estimate of SCA effects revealed that none of the crosses was consistently superior for all the characters. The highest yielding hybrid (P3 × P4) had registered the highest SCA effect for fruit yield per plant. Similarly, the cross combinations P6 × P7, P3 × P6, P3 × P7, P1 × P5, P2 × P6, P4 × P5 were observed as good specific combinations for fruit yield per plant. The hybrid P2 × P6 was good specific combiner for days to first male flowering, hybrid P3 × P4 for sex ratio followed by P4 × P5 and P5 × P7. Hybrid P1 × P4, P6 × P7, P3 × P6 and P2 × P4 were found as good specific combinations for fruit length, P4 × P6 and P3 × P4 for fruit width. The hybrids P3 × P6, P6 × P7, P3 × P4, P2 × P4 and P1 × P5 were observed as good specific combinations for individual fruit weight.

Keywords: Ridge gourd (*Luffa acutangula*), hybrids, σ^2g/σ^2s ratio, GCA, SCA, fruit yield

Introduction

Ridge gourd is an important cucurbitaceous vegetable (Kalloo and Bergh, 1993) cultivated in tropical and subtropical countries like Bangladesh, China and different region of India such as Asam, West Bengal, and Uttar Pradesh and in some other countries (Bose and Som, 1986). In Bangladesh, ridge gourd is known as 'Jhinga' or 'Tarui'. There are 24827 acres of land used for ridge gourd cultivation in Bangladesh and total production was 50240 MT (BBS, 2018). Ridge gourd is mostly used as vegetable with good nutritive value and high yield potential. Edible portion of fruit (100 g) contains carbohydrate (0.2 g), protein (9.6 mg·g^{-1}), dietary fiber (3.3 g), organic acid (0.11-0.6 g), vitamin E (0.01 mg·g^{-1}), vitamin C (2.05 mg·g^{-1}), free fatty acid (43.9 mg·g^{-1}), P (4.86%), S (2.22%), Ca (14 mg), K (160 mg), Mg (14 mg), Zn (0.2 mg), thiamine (0.05 mg), riboflavin (0.01 mg) and niacin (0.20 mg) (Dandge *et al.,* 2010, Manikandaselvi and Brindha, 2014). It also provides a comparable source of various components of antioxidants like ascorbic acid (8.64-14.13 mg·100 g^{-1}), flavonoid (0.77-1.59 mg·g^{-1}) and phenolics (0.416-0.742 mg·100 g^{-1}) with variable amount of nutritional compounds like soluble sugar (1.21-1.58%), protein (0.175-0.253%), carotenoid (14.5-36.1 mg·100 g^{-1}) and chlorophyll (1.59-1.85 mg·g^{-1}) content on fresh weight basis (Kandoliya *et al.,* 2016).

Though ridge gourd is a popular vegetable but less attention has been paid for the improvement the high yielding or hybrid varieties. The efforts of crop improvement have been constrained mainly by a lack of adequate information on the genetic control of characteristics of the earliness and yield traits in ridge gourd. In Bangladesh, there is also lack of high yielding hybrid variety of ridge gourd and are not adequate to fulfil our requirement. So, it is essential to develop more hybrid varieties to increase yield of ridge gourd. Earliness and yield related traits are crucial for increasing the total yield of ridge gourd. Being predominantly monoecious in sex expression and cross-pollination can be the most effective tools to exploit the genetic diversity in ridge gourd hybrid development (Muthaiah *et al.,* 2017). The identification of genetically superior plants is an important pre-requisite for development of promis-

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ing F_1 hybrids. A wrong choice of parents at this stage is considered as obstacle for successful breeding program. But this problem can be solved by the use of combining ability test.

The exploitation of hybrid vigor and selection of potential parents depends on their combining ability (Sprague and Tatum, 1942). Diallel analysis is widely used to estimate combining ability effects of the parents and the crosses. Diallel analyses are important tools for identifying superior parents in order to development of new varieties in plant breeding programs. Combining ability is used for breaking yield related barriers and evolving crosses having high yielding potential. Selection of parents on the basis of phenotypic performance alone is not an appropriate technique, since phenotypically superior lines or crosses may not lead to expected degree of heterosis. Griffing (1956) approach (all four methods) has been widely used to estimate genetic parameters (Biabani et al., 2012). This analysis is focused on partitioning the total variation of the data into GCA and SCA of parents and crosses, respectively. It also explains the potential of parents to produce superior progenies, associated with the magnitude of additive and non-additive gene action (Rainey and Griffiths, 2005; Bidhendi et al., 2011). Combining ability is one of the potential tools for identifying appropriate parents for hybridization and shifting productive hybrids from a set of crosses in F_1 generation (Griffing, 1956). The success of combining desirable traits would depend upon the extent of gene effects and combining ability of parents for yield and yield attributing traits. Thus, considering the importance of work, the present investigation was undertaken to assess the combining ability of parents and hybrids for earliness and fruit yield of ridge gourd.

Materials and Methods

The present research was conducted at the experimental field of the Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the period from April 2018 to August 2018 for crossing of parents and April 2019 to August 2019 for evaluation of parents and their F_1's for heterosis in yield and related traits.

Soil and climate

The experimental site is situated in the subtropical climate zone, characterized by heavy rainfall during the months from May to September and scanty in water with gradual fall of temperature from the month of September. The soil type of experimental field is terrace soil, which is nearly equivalent to Ochrept sub order of USDA soil taxonomy and belongs to the locally termed Salna series of Shallow Red Brown Terrace type soil. The soil is silt loam in texture having acidic (pH 5.5) in nature, poor fertility status and impeded internal drainage (Brammer, 1971).

Experimental materials

Seven genetically diverse parental genotypes of ridge gourd (Tab. 1; Islam et al. 2024) along with their 21 F_1's developed by crossing through diallel fashion was used as experimental materials to study combining ability and heterosis for fruit

Table 1

Sources and salient features of seven ridge gourd parental genotypes

Name	Sources / Origin	Salient Features
RG001 (P_1)	Local Seed Market, Gazipur, Bangladesh	Fruit borne in cluster, small size
RG002 (P_2)	Local Seed Market, Gazipur, Bangladesh	Fruit borne in solitary, medium size
RG003 (P_3)	Local Seed Market, Gazipur, Bangladesh	Fruit borne in cluster, medium size
RG004 (P_4)	Siddique Bazar, Dhaka, Bangladesh	Fruit borne in solitary, medium size
RG005 (P_5)	Siddique Bazar, Dhaka, Bangladesh	Fruit borne in solitary, large size
RG006 (P_6)	Siddique Bazar, Dhaka, Bangladesh	Fruit borne in solitary, medium size
RG007 (P_7)	3S Seed Company, Dhaka, Bangladesh	Fruit borne in solitary, large size

Raising and transplanting of seedlings

Seeds of seven parents and their 21 F_1's were first allowed to soak water for 24 hours. The soaked seeds were then sown in polythene bag (size 15 cm × 15 cm) containing a mixture of soil and well decomposed cowdung (1:1) in 21 April, 2019. Half part of polythene bag was watered for moisturizing and intensive care was taken for production of healthy seedlings. After 15 days of sowing, the seedlings were transplanted in the main field. After one week, gap filling was done whenever death of previously transplanted seedling occurred.

Land preparation and application of manures and fertilizers

The experimental plot was prepared by ploughing with tractor followed by harrowing and laddering to bring the desired tilth. Beds of entry containing 14 pits were raised with 1.5 m made by spade and developed properly. Drains with 1m between beds and between replications were maintained. Final land and bed preparation was done about one week before the pit preparation. Recommended doses of manure and fertilizer at the following rates were applied in the experimental field (BARI, 2019).

Design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was divided into three blocks where genotypes were assigned randomly.

Data collection

Data were collected on each of seven parents and their F_1·s for the characters viz. days to first male flowering, days to first female flowering, node number of first male flower, node number of first female flower, sex ratio, percent fruit set, days to first harvesting, days to last harvesting, fruit length (cm), fruit width (mm), individual fruit weight (g),ridge number per fruit, number of fruits per plant, fruit yield per plant (g), fruit yield per plant (kg), seed number per fruit, 100 seed weight (g).

Statistical analysis

Analysis of variance (ANOVA), mean, standard error (SE), coefficient of variation (CV) was done from the replicated data of different characters by using computer software STAR (Statistical Tools for Agricultural Research). Method II of Griffing (1956) was followed for combining ability analysis. The analytical methods and procedures were often quoted with worked out examples, could be found in reference literature (Mather and Jinks, 1982; Singh and Chaudhary, 1985; Dabholkar, 1992; Sharma, 1998). The combining ability analysis of the present study was mainly done by following Sharma (1998).

Results and Discussion

Combining ability analysis (Griffing's approach)

The analysis of variance for combining ability have been presented in (Tab. 2) for 17 agronomic traits under this study. The mean squares of GCA were found to be highly significant in all the characters except node number of first male flowering, days to last harvest, fruit width (mm), ridge number per fruit, hundred seed weight which revealed the importance of both additive and non-additive gene action as the cause of observed variation for these traits (Tab. 2). The mean squares due to SCA was found to be highly significant in all the characters except days to first male flowering, days to first female flowering, node number of first male flower, fruit set (%), days to first harvest, days to last harvest, fruit width (mm), ridge number per fruit, 100-seed weight.

The characters which exhibited non-additive gene action can be improved by the heterosis breeding. The significance of SCA effect elucidates the presence of genetic diversity among parents tested and illustrates the contribution of dominance and/or epistatic effect which represent the non-fixable components of the genetic variation related to heterosis. Combining ability analysis is an important tool in the hands of the plant breeders to identify good lines in their breeding material and further to select promising hybrid combinations to develop suitable hybrid from them. The relative amount of GCA and SCA effects can play a vital role in establishing a successful breeding program. GCA is attributed to additive genetic effects and additive x additive epistasis and is, theoretically, fixable. On the other hand, specific combing ability attributable to non-additive gene action may be due to either dominance or epistasis or both and is unfixable. The presence of non-additive genetic variance is the primary justification for initial the hybrid program (Cockerham, 1961).

Specific combining ability variance (σ^2s) was higher than the general combining ability variance (σ^2g) for all the traits other than days to first male flowering, days to first female flowering, fruit length, fruit width, individual fruit weight, indicating the predominance of non-additive type of gene action and possibility of exploiting heterosis for yield enhancement. This was further confirmed by σ^2g/σ^2s ratio. The low magnitude of σ^2g/σ^2s ratio for all the traits other than days to first male flowering, days to first female flowering, fruit length, fruit width, individual fruit weight, confirmed the non-additive gene effects were appeared to be predominant for all other characters. On the other hand, the high magnitude of σ^2g/σ^2s ratio is more than 1 for days to first male flowering (1.16), days to first female flowering (5.66), fruit length (1.98 cm), fruit width (2.85 mm) and individual fruit weight (1.17 g) for confirmed the additive gene effects were appeared to be predominant (Tab. 2). The predominance of non-additive gene action for fruit yield and its component traits were also reported by Kadam (1989), Rao et al., (2000), Purohit et al., (2005), Prabhakar (2008), Lodam et al., (2009), Deshpande (2010), Naransaver et al., (2014) in ridge gourd.

General combining ability (GCA) effects of parental genotypes

The estimation of GCA of a parent in the diallel population is an important indicator of its potential for generating superior breeding populations. The GCA effect represents the additive gene action. Besides, performance of the parents, nature of gene action for controlling the concerned characters may also be considered as a guide to select the parent. Depending on a character apparent with higher positive or negative significant effects is considered as good combiner. The general combining ability effects of the selected parents for earliness and yield and yield contributing characters are discussed character wise in (Tab. 3).

GCA of the parents revealed that none of the parent was found to be good general combiner for all the characters. However, in the present investigation, parent P3 was observed to be one of the

Table 2

Analysis of variance (ANOVA) of combining ability for 17 agronomic traits in 7 × 7 diallel population of ridge gourd

Source of variation	df	Mean sum of squares																
		DMF	DFF	NMF	NFF	SXR	PFS	DFH	DLH	FLT (cm)	FWT (mm)	AWF (g)	RNF	NFP	FYP (g)	FYP (kg)	NSF	SWT
gca	6	3.57*	5.68**	1.53	2.92**	5.56**	0.50*	0.65*	0.46	59.68**	8.89	710.79**	0.19	89.24**	64424.82*	0.11**	1068.67**	1.84
sca	21	0.96	1.08	1.43	2.39**	2.27*	0.28	0.28	0.25	4.92**	7.11	124.07*	0.16	25.96**	205991.40*	0.27**	1235.91**	2.79
Error	54	1.21	1.17	0.90	0.67	1.19	0.20	0.24	0.55	1.87	7.18	68.42	0.14	7.83	104611.09	0.03	208.72	1.75
		Components																
$\sigma^2 g$		0.29	0.51	0.01	0.06	0.36	0.02	0.04	0.02	6.08	0.20	65.19	0.00	7.03	–15729.6	-0.02	–18.58	–0.11
$\sigma^2 s$		–0.25	–0.09	0.53	1.72	1.08	0.09	0.04	–0.31	3.06	–0.07	55.65	0.02	18.13	101380.3	0.25	1027.19	1.04
$\sigma^2 g/\sigma^2 s$		1.16	5.66	0.018	0.034	0.33	0.22	1.00	0.064	1.98	2.85	1.17	0.00	0.387	0.15	0.08	0.018	0.10
SE (±)		0.24	0.28	0.23	0.30	0.33	0.11	0.12	0.10	0.78	0.52	3.01	0.07	1.19	78.95	0.093	6.54	0.30
CV (%)		3.69	4.01	12.31	8.69	9.09	1.01	3.86	0.745	43.22	45.72	632.50	5.24	15.17	0.15	24.12	35.56	17.16
F-value		**	**	*	**	*	**	**	*	**	**	**	*	**	**	**	**	**

* and ** indicate significant at 5% and 1% levels respectively, df – Degrees of freedom
DMF – Days to first male flower, DFF – Days to first female flower, NMF – Node number of first male flower, NFF – Node number of first female flower, SXR – Sex ratio, PFS – Percent fruit set, DFH – Days to first harvest, DLH – Days to last harvest, FLT (cm) – Fruit length, FWT (mm) – Fruit width,, AWF (g) – Average weight of fruit, RNF – Ridge number per fruit, NFP – Number of fruit per plant, FYP (g) – Fruit yield per plant, FYP (kg) – Fruit yield per plant, NSF – Number of seed per fruit, SWT (g) – Seed weight.

Table 3

General combining ability (GCA) effects for seventeen agronomic traits in 7 × 7 diallel population of ridge gourd

Parent	DMF	DFF	NMF	NFF	SXR	PFS	DFH	DLH	FLT (cm)	FWT (mm)	AWF (g)	RNF	NFP	FYP (g)	FYP (kg)	NSF	SWT
P1	0.01	0.00	–0.84**	–0.80**	–1.31**	0.18	–0.20	0.03	–0.95*	–1.54*	–6.77**	0.11	0.43	–160.50*	–0.16**	–17.07**	–0.28
P2	–0.20	–0.07	0.46	–0.21	–0.37	–0.13	0.13	0.34	–2.60**	–0.68	–7.87**	–0.02	2.58**	–19.71	–0.09*	–6.94	–0.23
P3	–0.84*	–1.04	–0.10	–0.58**	0.20	–0.27*	–0.40**	–0.16	–0.93*	0.93	–3.50	0.16	2.59**	103.08	0.17**	5.23	–0.65*
P4	–0.75*	–1.04	0.05	0.31	0.38	–0.24*	0.02	–0.25	–2.73**	0.50	–9.16**	–0.11	3.56**	38.36	0.02	–4.79	0.74*
P5	0.60*	0.92	0.20	0.16	1.29**	–0.02	–0.11	–0.12	4.47**	1.35*	11.11**	–0.17	–3.62**	20.34	–0.02	17.38**	0.30
P6	0.66*	0.50	0.01	0.84**	–0.09	0.09	0.43**	0.27	1.17**	–0.18	5.30*	0.17	–1.22	54.60	0.09*	2.17	–0.04
P7	0.53	0.72	0.23	0.29	–0.10	0.38**	0.13	–0.12	1.58**	–0.37	10.89**	–0.13	–4.33**	–36.17	–0.02	4.01	0.17
SE(gi)	0.27	1.03	0.23	0.20	0.27	0.11	0.12	0.18	0.34	0.66	2.05	0.09	0.69	80.03	0.04	3.57	0.33

* and ** indicate significant at 5% and 1% levels respectively
DMF – Days to first male flower, DFF – Days to first female flower, NMF – Node number of first male flower, NFF – Node number of first female flower, SXR – Sex ratio, PFS – Percent fruit set, DFH – Days to first harvest, DLH – Days to last harvest, FLT (cm) – Fruit length, FWT (mm) – Fruit width,, AWF (g) – Average weight of fruit, RNF – Ridge number per fruit, NFP – Number of fruit per plant, FYP (g) – Fruit yield per plant, FYP (kg) – Fruit yield per plant, NSF – Number of seed per fruit, SWT (g) – Seed weight.

best general combiners as it has shown significant GCA effects in desirable direction for number of fruits per plant and fruit yield per plant. It also observed significant GCA effects for parameters related to earliness viz., days to first male flowering, node number of first female flower and days to first harvest. Two parental lines exhibited significant GCA effects in negative direction, which is desirable. Maximum negative GCA effects was observed in the parent P3 (–0.84) and P4 (–0.75). The parents P3 and P4 can be identified as good combiner for earliness and could be utilized in breeding program to improve earliness. For nodes to first male flower, one parent exhibited negative and significant GCA effects which is desirable. The parent P1 (–0.84) exhibited maximum negative GCA effects (Tab. 3). For nodes to first female flower, two parents exhibited negative and significant GCA effects which is desirable. The parents P1 (–0.80) and P3 (–0.58) exhibited maximum negative GCA effects (Tab. 3). The parents P1 and P3 can be selected for developing earliness parameter.

Days to first harvest is the earliness parameter which helps to get fruit earlier. The GCA effects varied from –0.40 to 0.43. The maximum positive significant GCA effects was observed in P6 (0.43) and P3 (–0.40) exhibited negative significant GCA effects (Tab. 3). It indicates that the parent P3 can be selected as good combiner to get fruit early. Parent P3 was found as good general combiner as it has shown significant GCA effects in desirable direction (negative) for days to first harvest. The GCA effects for sex ratio ranged from –1.31 to 1.29. The parent P1 (–1.31) exhibited maximum negative GCA effects which is desirable. The parent P5 (1.29) exhibited maximum positive GCA effects (Tab. 2). Parent P1 were observed as good general combiner as it has shown significant GCA effects in desirable direction for sex ratio. Percentage of fruit helps to increase the number of fruits per plant and ultimately the yield. For per cent fruit set, one parent exhibited positive and two parents negative exhibited significant GCA effects. It ranged from –0.27 to 0.38 (Tab. 3). The highest significant positive GCA effects was observed in P7 (0.38). The parents P3 (–0.27), P4 (–0.24) showed the highest and significant negative GCA effects for this trait.

Fruit length is an important parameter to develop the quality of fruit. Three parents showed maximum positive significant GCA effects which is desirable and four parents showed maximum negative significant GCA effects (Tab. 3). The parents P5 (4.47), P7 (1.58), P6 (1.17) exhibited the highest significant positive GCA effects which indicates that these can be selected as good combiner to get longer size fruits. Maximum negative GCA effects were observed in P4, P2, P1and P3. It reveals that these can be identified as good combiner to get shorter size fruit in cluster. The parental line P5 (1.35) showed maximum positive significant GCA effects (Tab. 3). Parent P5 exhibited as good general combiners for fruit length and fruit width. Similarly, parent P6 and P7 were also good general combiners for fruit length. These parents can be selected as good combiner for getting long size fruit with maximum weight. The parent P5 can be selected as good combiner for developing quality diameter of this fruit.

Individual fruit weight is an important trait which is related to total fruit yield per plant. Three parents showed maximum positive significant GCA effects such as P5 (11.11), P7 (10.39), and P6 (5.30). The parent P4 (–9.16), P2 (–7.87), P1 (–6.77) showed the highest negative significant GCA effects which reveals that these can be selected as good combiner for developing light size of fruit. On the other hand, number of fruits per plant is an important trait for increasing yield per plant. Three parental genotypes P4 (3.56), P3 (2.59), P2 (2.58) showed significant positive GCA effects (Tab. 3), and these genotypes can be selected as a good combiner to get more fruits per plant. Two parents exhibited significant positive GCA effects and the highest significant positive GCA effects was observed in parents P3 (0.17) which indicates that these can be selected as good combiner to increase yield per plant. The parental line P5 (17.38) exhibited the highest significant positive GCA effects and the parent P1 (–17.07) showed maximum negative significant GCA effects (Tab. 3). The parental genotype P4 (0.74) exhibited maximum positive significant GCA effects and P3 (–0.65) showed maximum negative significant GCA effects.

Specific combining ability (SCA) effects of parents in hybrid combinations

The performance of a parent in specific cross in relation to general combining ability is termed as specific combining ability. SCA effects are indicative of heterosis and both dominant and epistatic components of genetic variation which are non-fixable and associated with hybrid vigor (Sharma et al., 2016). It represents the performance of specific cross combination. High SCA effects may arise not only in crosses involving high general combiners but also in those involving low combiners. Estimation on SCA effects of the crosses in F1 generation revealed that there are a good number of crosses having significant positive and negative SCA effects on different traits of ridge gourd. The SCA effects of promising F1 hybrids for yield and related traits are presented in (Tab. 4).

Table 4

Specific combining ability (SCA) effects for seventeen agronomic traits in 7×7 diallel population of ridge gourd

Crosses	DMF	DFF	NMF	NFF	SXR	PFS (%)	DFH	DLH	FLT (cm)	FWT (mm)	AWF (g)	RNF	NFP	FYP (g)	FYP (kg)	NSF	SWT
P1 × P2	1.51*	1.07	–1.44	0.53	1.12	–0.47*	–0.032	0.389	0.595	–2.249	1.087	0.037	–0.131	–10.194	–0.016	8.324	–0.245
P1 × P3	–0.84	–0.29	0.12	1.90**	1.58*	–0.05	0.171	–0.111	0.225	–0.068	–3.932	–0.537*	–2.601	–252.234	–0.379**	19.491*	0.425
P1 × P4	–0.94	–1.96	0.97	–1.66**	0.17	0.51*	0.745*	–0.019	2.772**	1.423	–0.960	0.230	–3.688*	–272.085	–0.259**	–11.491	2.133**
P1 × P5	–1.29	–1.25	–0.18	0.49	3.12**	–0.23	0.208	0.519	0.067	–2.333	12.737*	0.541*	–2.765	176.247	0.407**	23.343**	2.024*
P1 × P6	0.66	0.67	–0.66	–0.36	–1.73	0.29	0.005	–0.204	–0.671	–1.235	–7.048	0.100	0.044	–149.033	–0.174*	3.880	–1.136
P1 × P7	0.29	0.44	0.12	–1.14	–0.88	0.04	–0.366	0.019	–0.521	0.287	0.021	–0.200	1.762	83.560	–0.001	–11.787	–0.900
P2 × P3	–1.31	–1.55	0.49	–0.03	0.16	–0.25	0.171	0.241	0.910	2.124	1.543	0.387	0.123	5.979	0.014	–24.306**	3.180**
P2 × P4	–0.73	–0.89	2.34*	0.08	0.23	0.10	0.079	–0.333	2.322**	1.678	14.297**	–0.746**	–4.089*	168.942	–0.086	8.713	–1.811*
P2 × P5	0.92	0.82	–0.14	–1.44**	–0.10	–0.61*	0.875**	0.537	–3.827**	1.160	–8.196	0.015	2.375	–0.166	–0.031	–70.454**	0.980
P2 × P6	–1.81**	–1.09	0.38	–0.45	–0.48	–0.35	–0.662*	–0.852*	–0.697	1.650	4.456	–0.059	3.936*	443.958*	0.371**	1.083	–0.381
P2 × P7	–0.01	0.02	–1.51	–0.56	–0.39	1.32**	–0.366	–0.130	–3.386	–0.143	–11.416*	0.441*	–1.482	–360.277*	–0.439**	23.583**	–1.745*
P3 × P4	0.92	1.08	0.23	–0.55	–1.89**	–0.27	0.616*	0.167	0.362	3.462*	15.680**	0.280	11.280**	1187.142**	1.362**	26.213**	0.208
P3 × P5	0.40	0.07	–0.92	–1.06	–0.79	0.43	–0.088	–0.463	0.611	–1.321	–5.461	–0.159	–1.266	–260.474	–0.360**	–1.787	–1.946
P3 × P6	–0.82	–0.79	2.27*	–0.75	1.90**	–0.14	–0.792	0.648	2.453**	0.793	26.412**	–0.400	–3.080*	508.575**	0.583**	63.250**	1.089
P3 × P7	–0.36	–0.68	1.05	1.14*	0.25	–0.54*	–0.162	–0.630	–0.687	0.609	–2.964	0.200	2.328	183.039	0.436**	–21.917*	1.925*
P4 × P5	1.47*	1.45	–0.06	3.05**	–1.50*	–0.41	–0.681*	0.796*	–4.075**	–0.322	–2.915	–0.192	5.317**	317.351	0.267**	–23.935**	1.058
P4 × P6	–0.25	–0.13	–0.55	1.36**	–0.03	–0.77**	0.116	0.074	–3.145**	5.691**	–11.964*	–0.733**	11.918**	256.899	0.143	–59.731**	–0.953
P4 × P7	–0.12	0.31	–0.44	0.58	1.17*	–0.34	0.745*	–0.537	0.415	–1.416	–3.327	0.067	–2.434	–182.670	–0.377**	52.435**	0.733
P5 × P6	–0.27	–0.75	1.31	–0.16	2.58**	0.18	–0.088	0.278	–0.304	0.514	–3.431	0.528*	–5.578**	–484.732*	–0.559**	–4.898	1.563*
P5 × P7	–0.81	–1.31	0.42	2.73**	–1.34*	–0.27	0.208	0.333	1.213	1.989	–2.167	0.128	0.195	–78.357	0.058	23.935**	–0.776
P6 × P7	0.47	0.78	0.94	2.05**	1.33*	–0.50*	0.671*	0.278	2.579**	1.703	17.864**	–0.013	–0.035	444.205*	0.750**	–50.861**	2.064**
SE(sij)	0.68	2.57	0.58	0.50	0.67	0.27	0.30	0.46	0.84	1.65	5.08	0.23	198.74	0.10	*1.72*	0.81	8.88

* and ** indicate significance at 5% and 1% levels respectively.
DMF – Days to first male flower, DFF– Days to first female flower, NMF– Node number of first male flower, NFF – Node number of first female flower, SXR – Sex ratio, PFS – Percent fruit set, DFH – Days to first harvest, DLH – Days to last harvest, FLT (cm) – Fruit length, FWT (mm) – Fruit width,, AWF (g) – Average weight of fruit, RNF – Ridge number per fruit, NFP – Number of fruit per plant, FYP (g) – Fruit yield per plant, FYP (kg) – Fruit yield per plant, NSF – Number of seed per fruit, SWT (g) – Seed weight.

The estimate of SCA effects revealed that none of the crosses was consistently superior for all the characters. The highest yielding hybrid (P3 × P4) had registered the highest SCA effect for fruit yield per plant. Similarly, the cross combinations P6 × P7, P3 × P6, P3 × P7, P1 × P5, P2 × P6, P4 × P5 were observed as good specific combinations for fruit yield per plant. These can be selected as good specific combiner for commercial exploitation of heterosis to increase yield.

The hybrid P2 × P6 (–1.81) showed significant negative SCA effects (Tab. 3) and was designated as good specific combiner for days to first male flowering. Similar results were also observed by Kamble et al., (2018). The hybrids P1 × P4, P2 × P5 were found as good specific combinations for nodes to first female flower. The hybrid P3 × P4 was the good combiner for sex ratio followed by P4 × P5 and P5 × P7. The crosses P4 × P5, P2 × P6 were good specific combinations for days to first harvest. The hybrid P4 × P5 was found as good combination for days to last harvest. So, the crosses P1 × P4, P2 × P5, P2 × P6, P3 × P4, P4 × P5, and P5 × P7 can be selected for improving the earliness in ridge gourd. Among the crosses, two exhibited negative and significant SCA effects. The crosses P1 × P4 (–1.66) exhibited maximum negative SCA effects followed by P2 × P5 (–1.44). It reveals that these were good combiner for getting flower in lesser node number. Similar results were also observed by Sarker et al. (2015). Sex ratio is an important trait because it indicates which parents or hybrids provide appropriate male and female flowers that helps to increase the yield. Among the crosses, six showed positive significant SCA effects and three hybrids showed negative significant SCA effects. The magnitude of SCA effects varied from –1.89 to 3.12 (Tab. 4). The maximum positive significant SCA effect was observed in P1 × P5 cross (3.12) followed by P5 × P6 (2.58), P3 × P6 (1.90), and the maximum negative significant SCA effects was observed in P3 × P4 (–1.89) followed by P4 × P5 (–1.50), P5 × P7 (–1.34). The hybrid P3 × P4, P4 × P5 and P5 × P7 were good combiner for sex ratio in desirable direction. This results accordance with the findings of Muthaiah et al. (2017).

The hybrid P1 × P4, P6 × P7, P3 × P6 and P2 × P4 were found as good specific combinations for fruit length. The crosses P4 × P6, P3 × P4 were good specific combiners for fruit width. The hybrids P3 × P6, P6 × P7, P3 × P4, P2 × P4 and P1 × P5 were observed as good specific combinations for individual fruit weight. The hybrids P1 × P4, P1 × P5, P2 × P4, P3 × P4, P3 × P6, P6 × P7 and P4 × P6 can be identified for getting quality fruit with proper size and weight through breeding program. Percentage of fruit set is influenced yield by increasing the number of fruits per plant. Among the crosses, two exhibited positive and five crosses exhibited negative and significant SCA effects. SCA effects varied from –0.77 to 1.32. The highest positive and significant SCA effects were observed in crosses P2 × P7 (1.32) followed by P1 × P4 (0.51). The crosses P4 × P6 (–0.77), P2 × P5 (–0.61), P3 × P7 (–0.54), P6 × P7 (–0.50) showed the highest and significant negative SCA effects for this trait (Tab. 4). The hybrids P1 × P4 and P2 × P7 were good combiner for percent of fruit set in desirable direction. Four crosses among 21 exhibited maximum positive significant SCA effects (Tab. 4) and the highest positive significant SCA effects were observed in crosses P1 × P4 (2.77) followed by P6 × P7 (2.57), P3 × P6 (2.45), P2 × P4 (2.32). The three crosses showed maximum negative significant SCA effects (P4 × P5, P2 × P5, P4 × P6). It reveals that these can be identified as good combiner to get shorter size fruit with cluster. The hybrids P1 × P4, P6 × P7, P3 × P6 and P2 × P4 can be identified as good combiner to get longer size fruit because exhibited maximum positive significant SCA effects. This result accordance with the findings of Jadav and Sapovadiya (2018). The cross P4 × P6 (5.69) exhibited maximum positive significant SCA effect followed by P3 × P4 (3.46) (Tab. 4). The hybrids P4 × P6, P3 × P4 can be selected as good combiner for developing quality diameter of this fruit.

Five crosses out of 21 exhibited significant positive SCA effects and two crosses exhibited significant negative SCA effects (Tab. 4). The highest positive significant SCA effects were founded in cross P3 × P6 (26.41), P6 × P7 (17.86), P3 × P4 (15.68), P2 × P4 (14.29), P1 × P5 (12.74). The hybrids P4 × P6 (–11.96), P2 × P7 (–11.41) exhibited the highest negative significant SCA effects which reveals that these can be selected as good combiner for developing light size of this fruit. The parents P5, P7, P6 can be selected as good combiner for developing heavy size of this fruit because these showed the highest positive significant GCA effects. The hybrids P3 × P6, P6 × P7, P3 × P4, P2 × P4 and P1 × P5 can be identified as good combiner for heavy fruits. This result accordance with the findings of Muthaiah et al., (2017). Four crosses showed maximum positive significant SCA effects and the four crosses showed maximum negative significant SCA effects for number of fruits per plant (Tab. 4). The highest and positive significant SCA effects were observed in P4 × P6 (11.918) followed by the cross P3 × P4 (11.280), P4 × P5 (5.31), P2 × P6 (3.93). Among 21 crosses, four exhibited significant positive SCA effects and two crosses showed significant negative SCA effects for fruit yield per plant in gram (Tab. 4). The highest and positive significant SCA effects were found in the cross P3 × P4 (1187.142), P3 × P6 (508.575) and the cross P5 × P6 (–484.732) showed maximum negative effects. Seven crosses exhibited significant positive SCA effects and seven crosses showed significant negative SCA effects for fruit yield per kg (Tab. 4). The highest positive significant SCA effects were found in the crosses P3 × P4 (1.362) followed by P6 × P7 (0.750), P3 × P6 (0.583), P3 × P7 (0.376), P1 × P5 (0.407), P2 × P6 (0.371), P4 × P5 (0.267). It indicates that these can be selected as good combiner to increase yield per plant. Six crosses showed maximum negative significant SCA effects for seeds per fruit (Tab. 4). The crosses P2 × P5 (–70.754), P4 × P6 (–59.731), P6 × P7 (–50.861) showed the highest and negative SCA effects.

Conclusions

Sufficient variability revealed among the parents and hybrids used in the present research which helps to select the best parents and promising hybrids with high yield and yield related traits. The GCA and SCA variance were found highly significant for all the characters except days to first female flowering, days to last harvesting which revealed the importance of both additive and non-additive gene action controlling the inheritance of these traits. GCA effects revealed that the parent P3 was the best general combiners and SCA effects revealed that the hybrids P3 × P4, P6 × P7, P3 × P6, P3 × P7, P1 × P5, P2 × P6, P4 x P5 were the best specific combinations for fruit yield per plant and related traits. The crosses P1 × P4, P2 × P5, P2 × P6, P3 × P4, P4 × P5, and P5 × P7 can be selected as good specific combinations for improving earliness in ridge gourd.

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References

BARI, 2019. Krishi projukti hatboi (Handbook on Agro-Technology), 8th edition, 168.

BBS, 2020. Statistical year book (2019). Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh. Dhaka, Bangladesh.

Biabani, A, Rafii, M. Y., Saleh, G., Shabanimofrad, M., Latif, M. A., 2012. Combining ability analysis and evaluation of heterosis in *Jatropha c*urcas L. F1-hybrids. Australian Journal of Crop Science, 6, 1030-1036.

Bidhendi, M.Z., Choukan, R., Darvish, F., Mostafavi, K., Hervan, E.M., 2011. Determination of combining abilities and heterotic patterns of fourteen medium to late maturing Iranian maize inbred lines using diallel mating design. African Journal of Biotechnology, 10, 16854-16865.

Brammer, H., 1971. Soil resources soil survey project, Bangladesh. AGL: SF\Pac.6. Technical report 3.

Cockerham, C. C., 1961. Implications of genetic variances in a hybrid breeding program. Crop Science, 1(1), 47-52.

Dabholkar, A. R., 1992. Elements of biometrical genetics. Concept Publishing Company, New Delhi, India, 138-140.

Dandge, V.S., Rothe, S.P., Pethe, A.S., 2010. Antimicrobial activity and pharmacognostic study of *Luffa acutangula* Roxb var amara on some deuteromycetes fungi. International Journal of Science Innovations and Discoveries, 2 (1), 191-196.

Deshpande, M.R., 2010. Genetic studies of fruit yield and its components by line x tester analysis in ridge gourd (*Luffa acutangula* (Roxb.) L.). Unpublished M.Sc. (Agri.) thesis submitted to Anand Agriculture University, Anand.

Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Sciences, 9, 463-493.

Islam, S., Era, F.M., Biswas, M.S., Islam, A.K.M.A., 2024. Parental diversity and hybrids performance for yield related traits in ridge gourd [*Luffa acutangula* (L.) Roxb.]. Vegetos (2024). https://doi.org/10.1007/s42535-024-00911-6.

Jadav, K., Sapovadiya, M.H., 2018. Combining ability for fruit yield and its component traits in ridge gourd (*Luffa acutangula* (Roxb.) L.). The Pharma Innovation Journal, 7(9), 62-66.

Kadam, P.Y., 1989. Heterosis studies in ridge gourd (*Luffa acutangula* (Roxb.) L.). Ph.D. Thesis, Mahtma Phule Krishi Vidyapeeth, Rahuri, India.

Kalloo, G., Bergh, B.O., 1993. Loofah-Luffa spp. In: Genetic improvement of vegetable crops (eds.), Pergamon Press, 265-266.

Kamble, D.S., Gasti, S.D.V., Evoor, S., Masuthi, D.K.A., Koulagi, S., 2018. Combining ability in ridge gourd (*Luffa acutangula* (Roxb.) L.). International Journal of Current Microbiology and Applied Sciences, 7(12), 567-577.

Kandoliya, U.K., Marviya, G.V., Bodar, N.P., Bhadja, N.V., Golakiya, B.A., 2016. Nutritional and antioxidant components of ridge gourd (*Luffa acutangula* (Roxb.) L.) fruits of promising genotypes and varieties. Scholars Journal of Agriculture and Veterinary Sciences, 3(5), 397-401.

Lodam, V.A., Desai, D.T., Khandelwal, V., Patil, P.P., 2009. Combining ability analysis in ridge gourd (*Luffa acutangula* (Roxb.) L.). Vegetable Science, 36(1), 113-115.

Manikandaselvi, S., Brindha, P., 2014. Quality control studies on *Luffa acutangula* L. International Journal of Pharm acy and Pharmaceutical Sciences, 6 (1), 55-62.

Mather, K., Zinks, J.L., 1982. "Biometrical Genetics" (3rd Edn). Chapman and Hall Ltd., London.

Muthaiah, K., Gasti V.D., Mallesh, S., Das, A., Mangi V., 2017. Combining ability studies for early and yield traits in ridge gourd (*Luffa acutangula* (Roxb) L.). International Journal of Agriculture Sciences, 9(26), 4319-4321.

Naransaver, A.R., Gasti, V.D., Shantappa, T., Mulge, R., Allolli, T.B., Thammaiah, N., 2014. Heterosis studies in ridge gourd (*Luffa acutangula* (Roxb.) L.). Karnataka Journal of Agricultural Science, 27(1), 47-51.

Prabhakar, B.N., 2008. Combining ability and heterosis for fruit yield and yield components in ridge gourd (*Luffa acutangula* (Roxb) L.). Journal Research of ANGRAU (Acharya N.G. Ranga Agricultural University), 36, 24-32.

Purohit, V.L., Mehta, D.R., Dhaduk, L.K., Gajipara, N.N. 2005. Combining ability for fruit yield and its attributes in ridge gourd (*Luffa acutangula* (Roxb.) L.). Vegetable Science, 34(1), 84-85.

Rainey, K.M., Griffiths, P.D., 2005. Diallel analysis of yield components of snap beans exposed to two temperature stress environments. Euphytica, 142, 43-53.

Rao, B.N., Venkata Rao, P., Reddy, Y.N., 2000. Combining ability studies in ridge gourd (*Luffa acutangula* (Roxb.) L.). Indian Journal of Tropical Agriculture, 18(2), 141-146.

Sarkar, M., Singh, D.K., Lohani, M., Das, A.K., Ojha, S. 2015. Exploitation of heterosis and combining ability for earliness and vegetative traits in ridge gourd (*Luffa acutangula* (Roxb.) L.). International Journal of Agriculture, Environment and Biotechnology, 8(1), 153.

Sharma, J.R., 1998. Statistical and biometrical techniques in plant breeding. Pune, India: New Age International (pvt.) Limited.

Sharma, M., Sharma, A., Muthukumar, P., 2016. Genetic combining ability, gene action and heterosis for biochemical and antioxidant content in chili pepper. The Bioscan, 11(3), 1963-1968.

Singh, A.K., Chaudhary, B.D., 1985. Biometrical Methods in Quantitative Genetic Analysis. New Delhi, India: Kalyani Publishers.

Sprague, G.F., Tatum, L.A. 1942. General vs. specific combining ability in single crosses of corn 1. Agronomy Journal, 34(10), 923-932.