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LINE × TESTER ANALYSIS OF PHYSIOLOGICAL TRAITS FOR FRUIT YIELD AND RELATED CHARACTERS IN *LUFFA ACUTANGULA* (ROXB.) L.

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ABSTRACT

The present study was carried out to know the influence of physiological traits on the total fruit yield per vine in *Luffa acutangula* during 2012 -2014. The genotype L_4 and T_4 were found to be good general combiners. The crosses L_4 x T_2 (1581.69g), L_5 x T_4 (1365.00g), L_6 x T_4 (1359.65g) and L_2 x T_4 (1224.48g) have been identified as good specific combiners for fruit yield per vine. The best performing parents can be used for further breeding programmes and hybrids could be exploited for cultivation.

INTRODUCTION

The concept of Line x Tester was developed by Kempthorne (1957). It is a modified form of a top cross scheme. In case of top cross only one tester is used, while in case of Line x Tester several testers are used. The first step in evaluating the potential of new inbred lines is to cross them to a common parent and compare the performance of their hybrids. The common parent referred to as the tester and the hybrids produced are known as test crosses or top crosses. The tester is the same for all the inbred lines under evaluation (Singh and Narayanam, 2006). Ridge gourd (*Luffa acutangula* (Roxb.) L.) offers greater scope for exploitation of hybrid vigour on commercial scale to increase the productivity and production; otherwise it is the least exploited cucurbit vegetable. Niyaria and Bhalala (2001) reported that, the hybrids were early and gave higher yields in ridge gourd which helps to bridge the gap between the availability and requirement hence the crop is selected. The concept of combining ability helps in the identification of parents with good general and specific combing ability and also to determine the gene action involved in the expression of important quantitative traits. Reddy *et al.* (2013) reported that the possible exploitation of hybrid vigour in ridge gourd has been taken up at several research centers. However, very little systematic attention has been paid by plant breeders to study per se performance for earliness, yield and its components Reddy *et al.* (2013) as well as to physiological parameters. As such, so for there is no public sector or institutional commercial hybrids in ridge gourd in India, though few private hybrids from leading seed production companies are being cultivated by growers. The investigation on heterosis with regard to physiological growth parameters in cucurbits like ridge gourd as well as in most of the important vegetables *viz*., okra, onion, potato *etc*. is meager. Hence, the present investigation was undertaken to its precision and versatility with an objective to select elite parental lines which can be utilized for future hybridization programmes, combining ability of selected ridge gourd local cultivars for fruit and the best performing hybrids for commercial cultivation.

MATERIALS AND METHODS

The present investigation was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka. The experimental material consists of ten parents *viz*; Deepthi (L_1), Mudigere Local (L_2), Dalasanur Local (L_3), Arabhavi Local (L_4), Kolar Local (L_5), Arka Sumeet (L_6) used as lines (females) and Jaipur Long (T_1), Gadag Local (T_2), Ghataprabha Local (T_3) and Arka Sujata (T_4) as testers (males) and mated as per Line x Tester mating model of Kempthorne (1957) and Thus a total of 24 hybrids were synthesized by making crosses between lines and the testers during kharif 2012. All the 24 hybrids along with their corresponding ten parents and one commercial check variety viz; Naga were evaluated in a randomized block design in three replications during summer 2014. The data was subjected to the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978). Observations on five randomly selected plants were recorded for various yield attributing traits to see the performance of parents and hybrids over the checks. Variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of crosses (hybrids) were worked out on the Line x Tester analysis procedure developed by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance using Line x Tester analysis showed significant treatment difference for all the characters studied are presented in Table 1. The mean sum of squares due to gca and sca were significant for all characters, indicated the importance of both additive and non-additive genetic components for traits under study. Similar results were reported by Singh *et al.* (2013), Singh *et al.* (2014) and Reddy *et al.* (2013). Tyagi *et al.* (2010) also found significant gca and sca for the traits like fruits per vine, fruit length and fruit girth. The ratio of variance gca to variance sca suggested the preponderance of non additive gene action for all the characters suggested by Lodam *et al.* (2009).

Absolute growth rate at 45-90 DAS of vine and leaf were observed lowest in L_5 (2.21 and 3.71 g/day respectively) and highest in L_2 (10.92 and 4.63 g/day respectively) among the lines. Among the testers, with respect to vine, highest was observed in T_2 (8.69 g/day) and lowest was expressed in T_4 (7.54 g/day) and with respect to leaf, highest was observed in T_4 (8.55 g/day) and lowest was expressed in T_3 (4.18 g/day). L_1 x T_3 (13.47 g/day) exhibited the highest AGR with respect to vine and L_4 x T_3 was with highest AGR with respect to the leaf at 45-90 DAS. The commercial check, NAGA possessed the 10.68 g/day (for vine) and 4.46 g/day (for leaf). This work is first time in ridge gourd. The parents which possess the higher value of AGR resulted in higher yield per vine and findings were in consonance with Meena *et al.* (2013) in mustard, Sharma *et al.* (1996) in cauliflower and Chavan *et al.* (2010) in tomato.

CGR of vine and leaf (45-90 DAS) were observed highest in L_2 (20.22 and 8.58 g. $m^{-2}.day^{-1}$ respectively) and lowest in L_5 (4.08 and 6.88 g. $m^{-2}.day^{-1}$respectively) among the lines. Among the testers, with respect to vine, highest was observed in T_2 (16.09 g. $m^{-2}.day^{-1}$) and lowest was expressed in T_4 (13.97 g. $m^{-2}.day^{-1}$) and with respect to leaf, highest was observed in T_4 (15.83 g. $m^{-2}.day^{-1}$) and lowest was expressed in T_3 (7.74 g. $m^{-2}.day^{-1}$). The commercial check, NAGA possessed the 19.78 g. $m^{-2}.day^{-1}$ (for vine) and 8.27 g. $m^{-2}.day^{-1}$ (for leaf). These results were conformity with the results of Sharma *et al.* (1996) in cauliflower, Ninganur (2002) in cotton and Chavan *et al.* (2010) in tomato and they reported that is the rate of increase of dry weight per unit land area per unit time. CGR is also the product of leaf area index and net assimilation rate. CGR increases as LAI increases to an optimum because of greater light interception the variation in the biomass is further supported by growth analysis studies.

Relative growth rate at 45-90 DAS of vine varied from 0.15 mg. $m^{-2}.day^{-1}$ (L_5) to 0.77 mg. $m^{-2}.day^{-1}$ (L_2) among the lines, 0.53 mg. $m^{-2}.day^{-1}$ (T_1) to 0.64 mg. $m^{-2}.day^{-1}$ (T_2) among the testers and 0.29 mg. $m^{-2}.day^{-1}$ (L_4 x T_1) to 0.79 mg. $m^{-2}.day^{-1}$ (L_1x T_4) among the crosses. Relative growth rate at 45-90 DAS of leaf varied from 0.16 mg. $m^{-2}.day^{-1}$ (L_4) to 0.23 mg. $m^{-2}.day^{-1}$ (L_1) among the lines, 0.22 mg. $m^{-2}.day^{-1}$ (T_1) to 0.45 mg. $m^{-2}.day^{-1}$ (T_4) among the testers and 0.02 mg. $m^{-2}.day^{-1}$ (L_3x T_4) to 0.39 mg. $m^{-2}.day^{-1}$ (L_4 x T_3) among the crosses. The commercial

Table 1: Analysis of variance (mean sum of squares) of line × tester analysis for various characters in ridge gourd

Sl. No.	Character		Replication	Genotypes	Parents	Parents v/s Crosses	Crosses	Lines	Testers	Line × Tester	Error
	Degree of freedom		1	33	9	1	23	5	3	15	34
1	AGR 45 -90 DAS ($g.day^{-1}$)	Vine	2.97	16.06**	15.04**	165.05**	9.97**	27.79**	4.98	5.03	3.51
		Leaf	2.75	15.03**	4.37	80.97**	16.67**	42.57**	14.70	8.42	4.86
2	CGR 45 - 90 DAS(g. $m^{-2}.day^{-1}$)	Vine	10.19	55.07**	51.60**	566.03**	34.22**	95.33**	17.08	17.27	12.04
		Leaf	9.41	52.33**	14.98	277.66**	57.15**	145.99**	50.43	28.88	16.65
3	RGR 45-90 DAS (mg. $m^{-2}.day^{-1}$)	Vine	0.008	0.046**	0.079**	0.017	0.034**	0.085*	0.020	0.021	0.012
		Leaf	0.004	0.015*	0.014	0.002	0.016*	0.040**	0.015	0.008	0.008
4	NAR 45-90 DAS (g.$m^{-2}.day^{-1}$)	Vine	0.018	0.046*	0.088**	0.003	0.030	0.058	0.036	0.020	0.020
		Leaf	0.002	0.024	0.032	0.0004	0.020	0.035	0.014	0.019	0.015
5	LA (cm^2)	45 DAS	1454.49	1340.59**	3173.04**	277.06	699.79*	506.88	512.19	755.61*	306.87
		90 DAS	381.63	2639.28**	81.08	44950.10**	1800.71**	528.42**	709.00	857.44	111.67
7	SLA ($cm^2.g^{-1}$)	45 DAS	18.39	31.05**	66.69**	210.85**	6.19	5.63	5.80	6.45	7.81
		90 DAS	1.38	5.079**	0.904	21.97**	5.63**	12.314	1.53	4.28**	0.92
8	Total chlorophyll (mg/g fresh weight)	45 DAS	0.001	0.05**	0.069**	0.023	0.040**	0.028	0.024	0.047**	0.014
		90 DAS	0.058	0.064**	0.147**	0.077**	0.030**	0.016	0.013	0.039**	0.005
9	Number of fruits per vine		0.18	0.71*	0.56	13.53**	0.21	0.13	0.07	0.26	0.36
10	Average fruit weight (g)		1742.25	1314.59**	1040.10**	1985.64**	1392**	2842.69*	1387.00	910.61**	248.74
11	Fruit length (cm)		33.67	30.85**	2.97	492.96**	21.68**	41.75	21.15	15.09**	0.02
12	Fruit diameter (mm)		80.52	29.87**	19.66**	50.60*	3296.00**	66..83*	40.69	20.12*	8.13
13	Fruit yield per vine (g)		132225.04	76581.05**	32535.43	709197.44**	66311.24**	117729.46	83885.19	45657.04	25062.53

*and ** indicate significance of values at C.D. 5 % and at C.D. 1 % respectively; NS: Non significant DAS: Days after sowing LA: Leaf area, SLA: Specific Leaf Area, SLW: Specific leaf weight. AGR: Absolute growth rate, CGR: Crop growth rate, RGR: Relative growth rate, NAR: Nett assimilation rate

Table 2: ***per se*** **performance of parents and crosses for physiological and yield parameters in ridge gourd**

Sl. No.	Crosses	AGR 45 – 90 DAS g.day^{-1} x 10^2		CGR 45 – 90 DAS m^{-2}.day^{-1} x 10^2		RGR 45 – 90 DAS g.m^{-2}day^{-1} x 10^2		NAR 45 – 90DAS mg.m^{-2}.day^{-1} x 10^2		Leaf area		Specific leaf area		Total chlorophyll (mg/g fresh weight)		No. of fruits/ vine	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (mm)	Total yield (g)
		Vine	Leaf	Vine	Leaf	Vine	Leaf	Vine	Leaf	45	90	45	90	45	90					
1	$L_1 x T_1$	13.17	6.91	24.39	12.80	0.72	0.23	0.65	0.34	78.21	99.64	6.71	6.73	0.98	0.74	7.50	128.88	22.23	31.21	964.88
2	$L_1 x T_2$	12.11	8.53	22.42	15.80	0.57	0.27	0.48	0.34	96.85	124.41	8.18	7.95	0.97	0.99	7.50	118.30	25.72	25.12	887.65
3	$L_1 x T_3$	13.47	5.92	24.94	10.97	0.62	0.20	0.51	0.22	109.33	127.92	9.41	8.92	0.92	0.80	7.25	159.20	28.35	30.37	1180.20
4	$L_1 x T_4$	14.06	5.52	26.03	10.22	0.79	0.17	0.84	0.33	52.22	99.38	4.04	6.45	1.21	0.98	6.75	125.02	24.43	31.17	847.13
5	$L_2 x T_1$	12.56	10.72	23.25	19.85	0.69	0.33	0.43	0.37	97.55	160.37	8.32	9.66	1.03	0.66	6.75	160.22	28.30	28.12	1081.45
6	$L_2 x T_2$	11.30	7.42	20.92	13.73	0.57	0.23	0.55	0.37	55.16	133.25	4.43	8.46	1.12	0.91	7.00	167.50	23.95	30.41	1174.35
7	$L_2 x T_3$	10.71	11.87	19.83	21.98	0.55	0.39	0.48	0.53	57.92	153.28	5.33	9.45	1.24	0.98	6.50	147.65	26.18	28.86	958.72
8	$L_2 x T_4$	12.52	8.19	23.19	15.16	0.71	0.27	0.58	0.39	83.12	104.25	7.10	6.79	0.72	0.77	7.50	160.93	27.28	29.15	1224.48
9	$L_3 x T_1$	8.89	9.14	16.47	16.93	0.43	0.29	0.44	0.45	79.16	98.47	6.84	6.31	1.15	0.89	7.50	107.83	24.65	32.35	808.40
10	$L_3 x T_2$	8.51	5.03	15.75	9.32	0.51	0.17	0.40	0.24	96.72	86.68	8.09	6.08	1.21	0.86	7.25	143.25	23.70	27.07	1038.70
11	$L_3 x T_3$	8.02	4.12	14.86	7.63	0.43	0.14	0.44	0.22	77.30	82.71	6.61	6.10	1.06	0.84	7.50	98.85	22.07	20.14	741.95
12	$L_3 x T_4$	7.91	1.44	14.65	2.66	0.41	0.02	0.37	0.05	86.36	104.90	7.19	8.56	0.78	0.92	6.75	139.10	21.85	25.67	938.70
13	$L_4 x T_1$	6.59	11.56	12.21	21.42	0.29	0.35	0.28	0.49	73.61	151.61	6.30	8.88	1.17	0.99	7.25	155.75	26.70	33.84	1125.50
14	$L_4 x T_2$	11.76	11.73	21.77	21.72	0.59	0.38	0.36	0.45	92.08	211.02	8.36	12.98	1.20	0.96	8.25	191.72	27.80	34.02	1581.69
15	$L_4 x T_3$	8.62	12.32	15.97	22.81	0.40	0.39	0.31	0.44	112.49	134.63	10.01	8.03	1.16	0.64	7.00	164.75	26.88	32.06	1159.25
16	$L_4 x T_4$	12.56	5.84	23.25	10.81	0.62	0.17	0.57	0.26	62.22	141.25	4.54	8.59	1.12	0.70	7.00	169.20	34.90	31.28	1186.70
17	$L_5 x T_1$	7.50	5.48	13.89	10.14	0.34	0.18	0.30	0.22	103.53	114.11	8.41	7.73	0.95	0.82	6.50	188.50	25.70	23.06	1222.00
18	$L_5 x T_2$	11.11	3.90	20.57	7.22	0.53	0.12	0.53	0.19	69.60	116.08	5.15	7.59	1.15	0.98	7.25	151.38	24.70	27.06	1099.08
19	$L_5 x T_3$	11.98	6.93	22.18	12.84	0.60	0.22	0.57	0.32	78.29	107.71	6.57	7.15	1.04	0.95	7.25	120.45	33.42	20.60	876.15
20	$L_5 x T_4$	10.22	7.19	18.93	13.32	0.54	0.22	0.57	0.41	65.93	90.31	5.26	5.74	1.14	0.89	7.50	182.00	31.68	30.23	1365.00
21	$L_6 x T_1$	8.43	5.20	15.61	9.64	0.45	0.16	0.47	0.29	64.72	94.37	4.91	6.08	1.18	1.04	7.00	128.68	25.00	28.39	900.17
22	$L_6 x T_2$	6.82	4.23	12.62	7.83	0.31	0.12	0.46	0.27	42.58	94.09	3.05	5.92	0.93	0.67	6.75	168.45	25.60	22.75	1136.60
23	$L_6 x T_3$	10.07	5.42	18.64	10.03	0.51	0.17	0.54	0.29	76.75	86.08	5.92	5.59	0.88	0.68	7.00	140.00	24.75	22.01	980.10
24	$L_6 x T_4$	9.24	5.93	17.12	10.98	0.43	0.19	0.42	0.27	77.11	115.78	6.42	7.87	0.99	0.75	7.25	187.68	28.18	30.0	1359.65

Table 2: Continued...

Sl. No.		Genotypes	AGR 45 – 90 DAS g.day^{-1} x 10^2 Vine	Leaf	CGR 45 – 90 DAS m^{-2}.day^{-1} x 10^2 day^{-1} x 10^2 Vine	Leaf	RGR 45 – 90 DAS g.m^{-2} day^{-1} x 10^2 Vine	Leaf	NAR 45 – 90 DAS mg.m^{-2}. leaf area Vine	Leaf	Leaf area Specific weight) 45	90	Total chlorophyll (mg/g fresh 45	90	No. of fruits per vine weight (g) 45	(cm) 90	Average fruit (mm)	Fruit length	Fruit diameter	Total yield (g)
	Lines																			
1	L_1	2.83	4.00	5.25	7.41	0.27	0.23	0.21	0.21	114.97	52.71	17.67	6.30	1.01	0.92	5.25	118.06	18.35	23.9	628.00
2	L_2	10.92	4.63	20.22	8.58	0.77	0.22	0.77	0.32	56.28	67.94	7.06	6.74	0.87	0.35	6.25	123.78	20.35	27.1	777.27
3	L_3	8.67	3.99	16.05	7.39	0.61	0.21	0.32	0.15	176.17	74.03	23.25	7.70	0.83	0.58	6.75	123.30	20.28	28.0	836.85
4	L_4	4.97	3.81	9.21	7.06	0.26	0.16	0.33	0.24	70.04	62.88	7.19	5.44	1.18	0.42	5.25	189.75	22.73	33.1	996.18
5	L_5	2.21	3.71	4.08	6.88	0.15	0.17	0.19	0.31	41.42	63.31	4.62	5.92	1.22	1.00	6.00	141.18	19.28	21.6	848.45
6	L_6	8.15	3.99	15.09	7.39	0.57	0.19	0.52	0.26	76.56	60.40	9.23	5.98	1.19	0.99	6.75	161.98	20.95	25.3	1085.82
	Testers																			
7	T_1	7.63	4.43	14.13	8.20	0.53	0.22	0.59	0.34	63.77	62.49	6.78	6.34	1.08	0.98	6.50	131.75	20.23	25.9	848.5
8	T_2	8.69	5.82	16.09	10.77	0.64	0.31	0.78	0.52	106.46	53.09	9.07	5.48	0.89	0.99	6.00	148.40	20.35	23.8	886.6
9	T_3	7.58	4.18	14.03	7.74	0.57	0.22	0.45	0.27	72.39	58.23	14.17	6.34	0.68	0.53	6.25	117.43	20.70	25.4	729.67
10	T_4	7.54	8.55	13.97	15.83	0.54	0.45	0.49	0.55	176.17	60.77	11.11	5.69	1.17	1.01	6.25	141.94	21.88	28.2	887.12
CC		10.68	4.46	19.78	8.27	0.75	0.22	1.20	0.50	64.18	21.29	8.10	2.14	1.01	0.60	7.00	157.00	20.25	29.7	1088.25
S.Em±		0.01	0.02	0.71	2.84	0.08	0.06	0.10	0.09	12.20	7.37	1.95	0.67	0.07	0.06	0.43	11.00	1.56	2.0	110.33
C.D. @ 5%		0.04	0.04	2.04	8.17	0.22	0.18	0.29	0.25	35.07	21.18	5.60	1.92	0.20	0.18	1.22	31.62	4.49	5.7	317.08

Table 3: Variances due to general and specific combining ability for different characters in ridge gourd

Sl. No.	Particulars		GCA	SCA	GCA : SCA
	LA (cm^2)	45 DAS	44.17	1549.66	0.03
		90 DAS	6.87	1293.44	0.01
	SLA ($cm^2.g^{-1}$)	45 DAS	0.58	11.31	0.05
		90 DAS	0.01	6.22	0.002
	AGR 45-90 DAS ($g.day^{-1}$ x 10^2)	Vine	0.02	7.97	0.002
		Leaf	0.43	9.05	0.05
	CGR 45-90 DAS ($g.m^{-2}$. Day^{-1} x 10^2)	Vine	0.07	27.32	0.002
		Leaf	1.48	31.16	0.05
	RGR 45-90 DAS ($mg.cm^{-2}.day^{-1}$ x 10^2)	Vine	0.000064	0.032	0.002
		Leaf	0.001	0.01	0.07
	NAR 45-90 DAS ($mg.m^{-2}.day^{-1}$ x 10^2)	Vine	0.0006	0.3	0.002
		Leaf	0.001	0.01	0.06
	Total chlorophyll (mg/g fresh weight)	45 DAS	0.001	0.07	0.001
		90 DAS	0.01	0.07	0.02
14	Number of fruits per vine		0.001	0.27	0.004
15	Average fruit weight (g)		147.17	2535.61	0.06
16	Fruit length (cm)		0.28	36.23	0.008
17	Fruit diameter (mm)		6.00	39.31	0.15
18	Fruit yield per vine (g)		7528.09	133226.70	0.05

DAS: Days after sowing;GCA: Variances due to general combining ability; SCA: Variances due to specific combining ability; LA: Leaf area ; LAI: Leaf area index ; SLA: Specific leaf area ; SLW: Specific leaf weight ; AGR: Absolute growth rate; CGR: Crop growth rate ; RGR: Relative growth rate

check, NAGA possessed the 0.75 mg. $m^{-2}.day^{-1}$ (for vine) and 0.22 mg. $m^{-2}.day^{-1}$ (for leaf). Chavan *et al.* (2010) reported that RGR is the rate of increase of dry weight per unit weight already present per unit time and it decreases as the stress level increases. These results were conformity with the results of Sharma *et al.* (1996) in cauliflower and Ninganur (2002) in cotton.

NAR at 45-90 DAS of vine varied from 0.19 $mg.m^{-2}.day^{-1}$ (L_5) to 0.77 $mg.m^{-2}day^{-1}$ (L_2) among the lines, 0.45 $mg.m^{-2}.day^{-1}$ (T_3) to 0.78 $mg.m^{-2}day^{-1}$ (T_2) among the testers and 0.28 $mg.m^{-2}.day^{-1}$ (L_4 x T_1) to 0.84 $mg.m^{-2}.day^{-1}$ (L_1x T_4) among the crosses. NAR at 45-90 DAS of leaf varied from 0.15 $mg.m^{-2}day^{-1}$ (L_3) to 0.32 $mg.m^{-2}.day^{-1}$ (L_2) among the lines, 0.27 $mg.m^{-2}.day^{-1}$ (T_3) to 0.55 $mg.m^{-2}day^{-1}$ (T_4) among the testers and 0.05 $mg.m^{-2}.day^{-1}$(L_3x T_4) to 0.53 $mg.m^{-2}.day^{-1}$ (L_2x T_3) among the crosses. The commercial check, NAGA possessed the 1.20 mg. $m^{-2}.day^{-1}$ (for vine) and 0.50 mg. $m^{-2}.day^{-1}$ (for leaf). AGR, CGR, RGR and NAR indicate better growth and development which in turn depends on the leaf area. Net assimilation rate is the rate of increase of dry weight per unit area of leaf per unit time. These results were conformity with the results of Ninganur (2002) in cotton and Chavan *et al.* (2010) in tomato.

Leaf area on 45 DAS varied from 41.42 cm^2 (L_5) to 176.17 cm^2 (L_3) among the lines, 63.77 cm^2 (T_1) to 176.17 cm^2 (T_4) among the testers and 42.58 cm^2 (L_6 x T_2) to 112.49 cm^2 (L_4 x T_3) among the crosses. Whereas, Leaf area at 90 DAS ranged from 52.71 cm^2 (L_1) to 74.03 cm^2 (L_3) among the lines, 53.09 cm^2 (T_2) to 62.49 cm^2 (T_1) among the testers and 86.08 cm^2 (L_6 x T_3) to 211.02 cm^2 (L_4 x T_2) among the crosses. The commercial check, NAGA possessed the 64.18 cm^2 (45 DAS) and 21.29 cm^2 (90 DAS). Leaf area being the photosynthetic surface area, which plays an important role in determining total biomass accumulation and quality of photosynthates available for yield production. The highest leaf area was observed in L_4 x T_1 (211.02 cm^2) that might have lead to more assimilation of photosynthates and contributed to highest fruit yield. This was akin with the results of Kore *et al.* (2003) in bitter gourd and Reddy *et al.* (2013) in ridge gourd.

Specific Leaf area on 45 DAS varied from 4.62 cm^2 /g (L_5) to 23.25 cm^2 /g (L_3) among the lines, 6.78 cm^2 /g (T_1) to 14.17 cm^2 /g (T_3) among the testers and 3.05 cm^2 /g (L_5x T_2) to 10.01 cm^2 /g (L_4 x T3) among the crosses. Specific Leaf area at 90 DAS ranged from 5.44 cm^2 /g (L_4) to 7.70 cm^2 /g (L_3) among the lines, 5.48 cm^2 /g (T_2) to 6.34 cm^2 /g (T_3) among the testers and 5.48 cm^2 /g (L_6 x T_3) to 12.98 cm^2 /g (L_4 x T_2) among the crosses. The commercial check, NAGA possessed the 8.10 cm^2/g (45 DAS) and 2.14 cm^2/g (90 DAS). Specific leaf area is the ratio of assimilating area to its dry weight. SLA is maximum in open area crops because of high photosynthetic surface area (Radford, 1962). The highest specific leaf area was observed in L_4 x T_2 (12.98 cm^2/g) that might have lead to more assimilation of photosynthates and contributed to highest fruit yield. This was akin with the results of Kore *et al.* (2003) in bitter gourd and Reddy *et al.* (2013) in ridge gourd.

Number of fruits per vine varied significantly among the genotypes, which ranged from 6 (T_2) to 6.5 (T_1) among testers, 5.25 (L_4) to 6.75 (L_2) among lines and 6.5 (L_5X T_1) to 7.5 (L_5x T_4) among crosses. The commercial check, NAGA possessed the 7.00 fruits per vine. Anand (2012) in ridge gourd and Rathod (2007) in bitter gourd reported that number of fruits per vine had a high relationship to the total yield. For the trait, average fruit weight, the genotypes ranged from 117.43 g (T_3) to 148.4 g (T_2) among testers, 118.06 g (L_1) to 189.75 g (L_4) among lines and 98.85 (L_3x T_3) to 194.73 g (L_4 x T_2) among crosses. The commercial check, NAGA possessed the 157.00 g fruit weight. The trait fruit weight had a high relationship to the total yield per vine. The results were consonance with the scientists Anand (2012) and Rathod (2007) in bitter gourd.

Lines, testers and hybrid combinations used in investigation differed significantly for the character fruit length and it varied from 20.23 cm (T_1) to 21.88 cm (T_4) among testers, 18.35 (L_1) to 22.73 cm (L_4) among lines and 21.85 (L_3X T_4) to 34.90 cm (L_4 X T_4) among crosses. The commercial check, NAGA had

Table 4: General combining ability effects for physiological parameters in ridge gourd

S.No.	Parents	AGR Vine	AGR Leaf	CGR Vine	CGR Leaf	RGR Vine	RGR Leaf	NAR Vine	NAR Leaf	Leaf area 45	Leaf area 90	SLA 45	SLA 90	Total Chlorophyll 45	Total Chlorophyll 90	No. of fruits per vine	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (mm)	Total yield (g)
Lines																				
1	L_1	2.86**	-0.39	5.30**	-0.71	0.15**	-0.01	0.14*	-0.01	5.45	-5.17	0.539	-0.14	-0.035	0.027	0.15	-17.76**	-1.24	1.34	-99.53
2	L_2	1.43*	2.44**	2.65*	4.52**	0.11*	0.08*	0.03	0.10*	-5.27	19.77**	-0.255	0.94*	-0.027	-0.02	-17.0	8.46	0.01	1.05	40.26
3	L_3	-2.00**	-2.17*	-3.71**	-4.02*	-0.08	-0.06	-0.07	-0.08	6.18	-24.82**	0.632	-0.89*	-0.003	0.027	0.15	-28.39**	-3.35**	-1.82	-187.56**
4	L_4	-0.46	3.28**	-0.84	6.03**	-0.05	0.10**	-0.11*	0.06	6.39	41.61**	0.755	1.97**	0.109*	-0.028	-0.04	20.49**	2.65**	4.67**	139.24*
5	L_5	-0.14	-1.23	-0.25	-2.28	-0.02	-0.04	0.01	-0.03	0.64	-10.96**	-0.201	-0.59	0.017	0.060*	0.02	11.59*	2.49**	-2.88**	82.95
6	L_6	-1.69*	-1.91*	-3.14*	-3.54*	-0.10*	-0.07	-0.01	-0.04	-13.41**	-20.43**	-1.469	-1.28**	-0.061	-0.065*	-0.10	5.80	-0.535	-2.33	24.63
SEm±		0.46	0.55	0.86	1.01	0.03	0.02	0.04	0.04	4.35	2.62	0.69	0.23	0.04	0.02	0.21	5.57	0.79	1.00	55.97
C.D. at 5%		1.37	1.61	2.53	2.98	0.08	0.06	0.1	0.09	12.81	7.72	2.04	0.7	0.08	0.05	0.44	11.53	1.63	2.08	115.78
C.D. at 1%		1.86	2.18	3.44	4.05	0.11	0.09	0.14	0.12	17.38	10.48	2.77	0.95	0.12	0.07	0.59	15.65	2.21	2.83	157.13
Testers																				
7	T_1	-0.81	1.06	-1.51	1.97	-0.04	0.03	-0.05	0.04	4.1	1.75	0.367	-0.08	0.02	0.005	-0.21	-5.64	-0.98	1.37	-52.43
8	T_2	-0.07	-0.29	-0.14	-0.55	-0.01	-0.01	-0.02	-0.02	-3.2	9.57**	-0.339	0.51	0.04	0.044*	0.021	6.65	-1.17	-0.39	47.15
9	T_3	0.14	0.65	0.26	1.22	-0.01	0.02	-0.01	0.02	6.64	-2.62	0.761	-0.108	-0.01	-0.034	-0.021	-12.13*	0.52	-2.45**	-86.76
10	T_4	0.75	-1.42**	1.38	-2.63*	0.06	-0.05	0.08	-0.03	-7.54	-8.70**	-0.789	-0.32	-0.06	-0.015	0.021	11.12*	1.63*	1.46	92.04
SEm±		0.38	1.09	0.7	0.83	0.02	0.02	0.03	0.03	3.55	2.14	0.58	0.0123	0.035	0.02	0.12	3.19	0.60	0.58	32.17
C.D. at 5%		1.11	3.22	2.07	2.43	0.07	0.05	0.09	0.08	10.46	6.31	1.67	0.57	0.07	0.04	0.36	9.41	1.33	1.70	94.54
C.D. at 1%		1.52	4.37	2.81	3.3	0.09	0.07	0.12	0.1	14.19	8.56	2.27	0.77	0.099	0.06	0.49	12.78	1.80	2.31	128.3

20.25 cm fruit length. For fruit diameter, among the lines, L5 was having 21.61mm and L_4 was with 33.1 mm. the genotype T_2 was with 23.8 mm of fruit diameter whereas, T_4 was having the 28.2 mm among testers and 20.1mm (L_3x T_3) to 34.02 mm (L_4 x T_2) was a range among crosses. The commercial check, NAGA had 29.70 mm fruit diameter. Tyagi *et al.* (2010) also reported that number of fruits per vine, fruit length and girth had a high relationship to the total yield. These results are conformity with the Anand (2012) and Reddy *et al.* (2013) in ridge gourd.

The parameters like per cent fruit set, fruit length, fruit girth, number of fruits per vine and average fruit weight are important for contributing to the total yield. For the trait fruit yield per vine which ranged from 729.67 g (T_3) to 886.5 g (T_2) among testers, 628 g (L_1) to 1085 g (L_6) among lines and the minimum, 741.95 g fruits were with the hybrid (L_3x T_3) and high heterotic hybrid was (1581.69 g) L_4x T_2 among crosses. The commercial check, NAGA had 1088.25 g fruit yield per vine.

The hybrid L_4 x T_2 showed maximum number of fruits per vine and leaf area might have contributed to highest yield per vine (1581.69 g). The hybrid L_5 x T_4 also showed significantly superior performance for yield per vine (1365.00 g) which might due to highest number of female flowers, fruit girth, average fruit weight and least sex ratio. The mean yield per vine was highest (1088.25 g) in hybrids compared to check variety (Table 2). The high yielding hybrids in the order of merit are L_4 x T_2, L_5 x T_4 and L_6 x T_4 has surpassed the yield of parents and the commercial check. The high yield in these F_1 hybrids has been attributed due to early maturity, increased number of fruits per vine and increase in fruit length and fruit weight. These results were in confirmation with Kadam *et al.* (1995), Narayanankutty *et al.* (2006) in snake gourd, Bharathi *et al.* (2006) Gayen and Hossain (2006), Kumar *et al.* (2007), Rathod (2007) in bottle gourd, Anand (2012) in ridge gourd, Islam *et al.* (2009) in bitter gourd and Singh *et al.* (2013) in bitter gourd. The parents differ significantly for all the characters except AGR and NAR of leaf 45 - 90 DAS, CGR, leaf area, leaf area index, specific leaf area and specific leaf weight at 90 DAS. The crosses differed significantly for all the characters studied except diameter of vine at 45 and 90 DAS and NAR of leaf and vine, number of fruits per vine and fruit length. Mean sum of square for the parents vs. crosses differed significantly for all the characters except NAR of leaf and vine, which indicated that heterosis for other traits considered. There was greater diversity among lines than testers based on the significant mean sum of squares for majority of the traits. The interaction of lines and testers differed significantly for all the traits. Singh *et al.* (2013) reported that the data revealed to contain higher magnitude of SCA variance as compared to GCA variances for all the characters which indicated the predominance of non additive gene action (Table 3).

General combing ability effects

The gca effects of lines and testers (Table 4) revealed significant differences among the lines and testers. Line L_4 was a good general combiner and appeared to transmit additive genes for important yield attributes *viz.*, leaf area at 90 DAS (41.61), specific leaf area at 90 DAS (1.97), AGR of leaf (3.28), CGR of leaf (6.03) and RGR of leaf (0.10) at period of 45-90 DAS, average fruit weight (20.49), fruit length (2.65), fruit diameter

Table 5: Specific combining ability effects for physiological parameters in ridge gourd

Sl. No.	Crosses	AGR 45 – 90 DAS g.day^{-1} x 10^2		CGR 45 – 90 DAS m^{-2}.day^{-1} x 10^2		RGR 45 – 90 DAS g.m^{-2}day^{-1} x 10^2		NAR 45 – 90 DAS mg.m^{-2}.day^{-1} x 10^2		Leaf area		Specific leaf area (mg/g fresh weight)		Total chlorophyll	fruits/vine	No. of fruit	Average f length weight (g)	Fruit diameter (cm)	Fruit (g) (mm)	Total yield
		Vine	Leaf	Vine	Leaf	Vine	Leaf	Vine	Leaf	45	90	45	90	45	90					
1	$L_1 x T_1$	0.79	-0.87	1.45	-1.62	0.08	-0.02	0.10	-0.01	-10.04	-14.95	-0.74	-0.69	-0.06	-0.15**	0.27	1.67	-1.97	0.37	47.34
2	$L_1 x T_2$	-1.02	2.11	-1.89	3.91	-0.10	0.06	-0.13	0.05	15.90	1.99	1.43	-0.07	-0.09	0.07	0.23	-21.20	1.72	-3.96	-129.45
3	$L_1 x T_3$	0.13	-1.45	0.24	-2.69	-0.04	-0.04	-0.10	-0.11	18.53	17.71*	1.57	1.52*	-0.10	-0.04	0.20	38.48**	2.64	3.35	-2297.00*
4	$L_1 x T_4$	0.11	0.22	0.20	0.41	0.1	0.01	0.14	0.05	-24.40	-4.76	-2.54	-0.74	0.25**	0.12*	-0.52	-18.94	-2.39	0.24	-214.87
5	$L_2 x T_1$	1.60	0.11	2.96	0.21	0.10	-0.01	-0.03	-0.08	20.02	20.83*	1.66	1.15	-0.02	-0.17**	-0.17	6.79	2.86	-2.39	24.13
6	$L_2 x T_2$	-0.40	-1.83	-0.74	-3.39	-0.04	-0.06	0.06	-0.02	-15.10	-14.12	-1.53	-0.64	0.05	0.03	0.04	1.77	-1.30	1.66	17.45
7	$L_2 x T_3$	1.21	1.67	-2.23	3.08	-0.10	0.06	-0.03	0.10	-22.16	18.12*	-1.73	0.97	0.22*	0.18**	-0.41	0.71	-0.77	2.18	-64.26
8	$L_2 x T_4$	0.01	0.06	0.01	0.11	0.02	0.01	-0.001	0.01	17.22	-24.84**	1.60	-1.49*	-0.25**	-0.04	0.54	-9.27	-0.78	-1.45	22.69
9	$L_3 x T_1$	1.38	3.24*	2.55	6.03*	0.02	0.14*	-0.10	0.19*	-9.82	3.53	-0.71	-0.37	0.07	0.001	0.27	-8.79	2.57	4.67*	-21.41
10	$L_3 x T_2$	0.25	0.40	0.45	0.74	0.07	0.02	0.01	0.02	15.03	-16.08*	1.23	-1.19	0.11	-0.06	-0.02	14.34	1.80	1.15	109.61
11	$L_3 x T_3$	-0.45	-1.47	-0.84	-2.73	-0.01	-0.05	0.03	-0.03	-14.23	-7.86	-1.34	-0.55	0.02	-0.01	0.27	-11.27	-1.52	-3.72	-53.22
12	$L_3 x T_4$	-1.17	-2.07	-2.17	-3.85	-0.10	-0.05	-0.12	-0.16	9.01	20.41*	0.80	2.11**	-0.21*	0.06	-0.52	5.73	-2.86	-2.10	-35.27
13	$L_4 x T_1$	-2.87*	0.14	-5.58*	0.25	-0.17*	-0.01	-0.05	0.05	-15.60	-19.77*	-1.37	-0.65	-0.02	0.16**	0.21	-9.71	-1.38	-0.33	-30.81
14	$L_4 x T_2$	1.95	1.67	3.60	3.01	0.13	0.07	-0.001	-0.001	10.18	41.82**	1.40	2.84**	0.001	0.9	-0.08	16.98	-0.09	1.60	107.61
15	$L_4 x T_3$	-1.40	1.30	-2.59	2.40	-0.10	0.04	-0.06	0.04	20.74	-22.37**	1.95	-1.48*	0.003	-0.15**	-0.04	5.77	-2.72	1.71	37.27
16	$L_4 x T_4$	1.93	-3.10	3.57	-5.74	0.10	-0.11	0.11	-0.08	-15.40	-9.68	-1.98	-0.72	0.019	-0.11*	-0.08	-13.03	4.19*	-2.98	-114.27
17	$L_5 x T_1$	-1.89	-1.46	-3.49	-2.71	-0.12	-0.04	-0.14	-0.10	20.09	5.31	1.70	0.76	-0.14	-0.09	-0.60	31.94**	-2.18	-3.55	121.98
18	$L_5 x T_2$	0.98	-1.68	1.81	-3.10	0.04	-0.10	0.05	-0.08	-6.53	-0.55	-0.86	0.03	0.04	0.03	0.10	-17.47	-3.01	2.21	-100.52
19	$L_5 x T_3$	1.64	0.40	3.03	0.74	0.10	0.01	0.08	0.02	-7.69	3.23	-0.58	0.20	-0.03	0.08	0.14	-29.62*	4.03*	-2.19	-189.53
20	$L_5 x T_4$	-0.73	2.74	-1.35	5.07	-0.02	0.08	0.001	0.16	-5.85	-8.04	-0.30	-0.99	0.13	-0.01	0.35	15.11	1.17	3.53	168.07
21	$L_6 x T_1$	0.61	-1.10	1.16	-1.96	0.10	-0.03	0.05	-0.03	-4.67	-4.95	-0.53	-0.18	0.17	0.25**	0.02	-21.88	0.11	1.22	-141.53
22	$L_6 x T_2$	-1.75	-0.67	-3.29	-1.23	-0.10	-0.03	0.05	0.02	-19.51	-13.06	-1.69	-0.96	-0.11	-0.16**	-0.27	5.59	0.89	-2.66	-4.68
23	$L_6 x T_3$	1.29	-0.44	2.39	-0.81	0.10	-0.02	0.08	-0.01	4.8	-8.87	0.08	-0.66	-0.11	-0.07	0.02	-4.06	-1.66	-1.33	-27.27
24	$L_6 x T_4$	-0.14	2.16	-0.26	3.99	-0.05	0.10	-0.13	0.02	19.36	26.90**	2.13	1.82*	0.05	-0.02	0.23	20.35	0.66	2.76	173.48
S.Em±		0.93	1.09	1.72	2.03	0.05	0.04	0.07	0.06	8.70	6.99	1.39	0.48	0.09	0.03	0.40	7.82	1.10	1.42	78.56
CD at 5%		2.74	3.22	5.08	5.97	0.16	0.13	0.21	0.18	25.62	15.46	4.08	1.40	0.18	0.10	0.88	23.07	3.26	4.17	231.57
CD at 1 %		3.73	4.38	6.89	8.11	0.22	0.18	0.29	0.25	34.78	20.98	5.55	1.90	0.27	0.14	1.20	31.31	4.43	5.66	314.26

(4.67) and fruit yield per vine (139.24). The line L_1 seemed to possess additive genes for AGR of vine (1.43), CGR of vine (2.65), RGR of vine (0.11) and NAR of vine (0.14). The line L_2 appeared to possess additive genes for yield attributes such as leaf area (19.77) and specific leaf area (0.94) at 90 DAS, AGR of leaf (2.44), CGR of leaf (4.52), RGR of leaf (0.08) and NAR of leaf (0.10) at 45-90 DAS, CGR of vine (2.65) and RGR of vine (0.11) at 45-90 DAS. Among the testers, T_2 was a good general combiner and appeared to transmit additive genes for important yield attributes *viz.*, leaf area (9.57) and specific leaf weight at 45 DAS (0.019). The method followed by Arunachalam and Bandopadyaya, (1979) was followed to designate the lines and testers as high (H) and low (L) overall general combiners (Table.6). The results of gca effects are similar with Anand (2012) in ridge gourd and Rathod (2007) in bitter gourd Accordingly, nearly 50 per cent of them were good general combiners and among the testers, except T_4, all expressed average overall gca status which suggested its ability to transmit additive genes for the traits.

Specific combining ability effects

High specific combining ability (sca) results mostly from dominance and interaction effects existing between the hybridizing parents. The cross L_4 x T_2 exhibited sca effect in positive desirable direction for three characters namely leaf area at 90 DAS (41.82) and specific leaf area (SLA) at 90 DAS (2.84) (Table 5). As the leaf area increases the photosynthetic capacity of the plant also increases and directly proportional to the average yield per vine (Ahmad, 2005). SLA is maximum in open area condition because of high photosynthetic surface area (Radford, 1962). The crosses L_1x T_3 and L_5x T_1 exhibited positive significant sca effect for average fruit weight whereas L_6 x T_4 was with higher amount of sca effect for total yield per vine. The final yield and yield attributing characters are basically governed by the vegetative growth as dry matter production and its distribution. Yield is the function of many yield contributing characters like number of fruits and average fruit weight (Islam *et al.,* 2009 in bitter gourd). Among the 24 F_1 hybrids, 4 hybrids are highly heterotic than parents and commercial check. The hybrid, L_4 x T_2 was high heterotic than rest of all. Nearly 50 per cent of the F_1 hybrids had high (H) overall status (Table 6). The cross L_4 x T_2 had a high overall status and had positive sca effects for important traits such as average fruit weight and fruit yield per vine. It was seen that the best crosses for majority of the characters involved at least one high general combining parent. Therefore, it is desirable to select one parent with high general combining ability and other with low general combining ability for obtaining crosses with high sca effects. The above results have an important bearing on future breeding strategies. The presence of non additive gene action can be exploited to

Table 6: Analysis of general combining ability status of parent's and specific combining ability status for hybrids for physiological, biochemical and yield traits in ridge gourd

Sl. No.	Parents	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total		gca status
1	L1	0	0	0	0	+1	0	+1	0	+1	0	+1	0	0	-1	0	0	-1	-1	0	4	2	H
2	L2	+1	+1	+1	0	+1	+1	+1	+1	+1	+1	0	+1	0	0	-1	0	0	0	0	10	0	H
3	L3	-1	-1	-1	0	-1	-1	-1	-1	0	0	0	0	0	-1	0	0	-1	-1	-1	0	10	L
4	L4	+1	+1	+1	-1	0	+1	0	+1	0	+1	-1	0	+1	+1	+1	0	+1	+1	+1	13	2	H
5	L5	0	-1	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	+1	0	2	3	H
6	L6	-1	-1	-1	0	-1	-1	-1	-1	-1	0	0	0	-1	+1	+1	-1	0	0	0	0	11	L
1	T_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	A
2	T_2	+1	+1	0	0	0	0	0	0	0	0	0	0	+1	0	+1	+1	0	0	0	3	0	A
3	T_3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	-1	0	0	1	A
4	T_4	-1	-1	0	0	0	-1	0	-1	0	0	0	0	0	0	+1	0	0	+1	0	1	4	L

Analysis of specific combining ability status for hybrids

Sl. No.	Cross	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total + ve	Total - ve	Status of CH	Status of PG
1	L4 x T2	+1	+1	+1	-1	+1	+1	+1	+1	+1	+1	-1	-1	+1	-1	-1	-1	+1	+1	0	12	6	H	H x A
2	L5 x T4	+1	+1	+1	-1	0	-1	+1	-1	-1	+1	-1	-1	-1	-1	-1	-1	+1	0	0	6	10	L	H x L
3	L6 x T4	+1	+1	+1	-1	-1	-1	+1	-1	-1	+1	+1	-1	-1	-1	-1	-1	-1	+1	0	7	11	L	L x L

1. Leaf area at 45 DAS
2. Leaf area at 90 DAS
3. Specific leaf area at 45 DAS
4. Specific leaf weight at 90 DAS
5. Absolute growth rate of vine
6. Absolute growth rate of leaf
7. Crop growth rate of vine
8. Crop growth rate of leaf
9. Relative growth rate of vine
10. Relative growth rate of leaf
11. Net assimilation rate of vine
12. Net assimilation rate of leaf
13. Total Chlorophyll content at 45 DAS
14. Total Chlorophyll content at 90 DAS
15. Number of fruits per vine
16. Average fruit weight
17. Fruit length
18. Fruit diameter
19. Total yield/ vine

CH – Crosses
PG – Parental status
0 – Non-significant gca effects
+1 – gca effects in desirable direction
-1 – gca effects in undesirable direction
H – High combiner
L – Low combiner
A – Average combiner

produce hybrids with high yield. In this study the parents L_6, L_4, were good general combiners for various characters taken under study, in this perspective they could be exploited further in different breeding programmes. The promising hybrids like L_4 x T_2, L_5 x T_4, L_6 x T_4 and L_3 x T_4 which are superior yielders than the checks can be further subjected to selection to isolate desirable transgressive segregants.

REFERENCES

Anand, N. 2012. Heterosis and combining ability in ridge gourd. *M. Sc. (Hort.) Thesis*, Univ. Hortil. Sci. Bagalkot.

Arunachalam, V. and Bandyopadhyay, A. 1979. *Multiple cross-multiple pollen hybrids an answer for productive populations in Brassica campestris var. Brown sarson: Methods for studying Mucromphs. Theoretical and Applied Genetics*. **54(5)**: 203-207.

Bharathi, L. K. Naik, G. and Dora, D. K. 2006. Correlation and path analysis in spine gourd (*Momordica dioca* Roxb.). *The Orissa J. Hort.* **33(2):** 105-108.

Blackman, V. H. 1919. The compound interest law and plant growth. *Annals Bot*. **33:** 353 360.

Chavan, M. L., Janagoudar, B. S., Dharmatti, P. R. and Koti, R. V. 2010. Effect of drought attributes of tomato (Lycopersicon esculentum Mill.,) genotypes. *Indian J. Plant Physiol.* **15(1):** 11-18.

Gayen, N. and Hossain, M. 2006. Study of heritability and genetic advance in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. *J. Inter. Academicia*. **10(4):** 463-466.

Islam, M. R., Hossain, M. S., Bhuiyan, M. S. R., Husna A. and Syed, M. A. 2009. Genetic variability and Path-coefficient analysis of bitter gourd (*Momordica charantia* L.). *Int. J. Sustainable Agric*. **1(3):** 53-57.

Kadam, P. Y., Desai, U. T. and Kale, P. N. 1995. Heterosis studies in ridge gourd. *J. Maharastra Agril. Univ*. **20(1):** 119-120.

Kempthorne, O. 1957. An Introduction to genetic statistics. *J. Wiley and Sons*, New York. pp. 408-711.

Kore, V. N., Dhanawate, K. P., Bendale, V. W., Patil, R. S. and Mane, A. V. 2003. Genetic variation in leaf area production and yield potential of bitter gourd (Momordica charantia L.) cultivars. *Res. Crops*. **4(2):** 284-286.

Kumar, S., Singh, R. and Pal, A. K. 2007. Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in bottle gourd. *Indian J. Hort*. **64(2):** 163-168.

Lodam, V. A., Desai, D. T., Khandelwal, V. and Patil, P. P. 2009. Combining ability analysis in ridge gourd. *Veg. Sci*. **36(1):** 113-115.

Meena, D. R., Chauhan, J. S., Singh, M., Singh, R. H. and Meena, M. L. 2013. Genetic variation and correlation among physiological characters in Indian mustard (Brassica juncea L.) under high temperature stress. *Indian J. Genet*. **73(1):** 101-104.

Narayanankutty, C., Sunanda, C. K. and Jaikumaran, U. 2006. Genetic variability and character association analysis in snake gourd. *Indian J. Hort*. **63(4):** 402-406.

Ninganur, B. T. 2002. Screening cotton genotypes (Gossypium spp.) for tolerance to drought using line source sprinkler irrigation technique. *Ph. D. Thesis*, University of Agril., Sci., Dharwad.

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

Panse, V. G and Sukhatme, P. V. 1978. Statistical methods for agricultural workers. *Indian Council of Agricultural Research, New Delhi,* p. 145.

Rathod, V. 2007. Studies on genetic variability and molecular characterization of bitter gourd (*Momordica charantia* L) genotypes. *M.Sc (Hort.) Thesis,* Univ. Agril. Sci., Bangalore.

Reddy, K. P., Reddy, V. S. K. and Padma, S. S. V. 2013. Performance of parents and hybrids for yield and yield attributing characters in Ridge Gourd (*Luffa acutangula* (Roxb.) L.). *The Bioscan*. **8(4):** 1373-1377.

Sharma, S. R., Mohan, J. and Gill, H. S. 1996. Genetic analysis of growth, photosynthesis and yield attributes in late cauliflower (*Brassica olarecea*). *Indian J. Hort*. **53(3):** 213-216.

Singh, A. K., Pan, R. S. and Bhavana, P. 2013. Heterosis and combining ability analysis in bittergourd (Momordica charantia L.). *The Bioscan*. **8(4):** 1533-1536.

Singh, P. and Narayanam, S. S. 2006. Biometrical Techniques in Plant Breeding. pp. 99-107.

Singh, M. K., Bhardwaj, D. R. and Upadhyay, D. K. 2014. Genetic Architecture And Association Analysis In Bitter Gourd (*Momordica Charantia* L.) Landraces. *The Bioscan*. **9(2):** 707-711.

Tyagi, S. V. S., Sharma, P., Siddiqui, S. A. and Khandelwal, R. C. 2010. Combining Ability for Yield and Fruit Quality in *Luffa*. *Int. J. Veg. Sci*. **16:** 267-277.