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Studies on combining ability in ridge gourd (*Luffa acutangula* (L.) Roxb.) in summer season

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Abstract
Combining ability effects revealed that, the mean of square due to general combining ability and specific combining ability were highly significant for all characters except days to 50% flowering and days required for first harvest. The estimates for general combining ability effects revealed that none of the parents showed good general combiners for all characters. The parents RHR RG-2, RHR RG-6 and RHR RG-8 were the good general combiners as they displayed significant GCA effects in desirable direction for most of the characters like earliness and yield attributing characters. Estimates on specific combining ability effects indicated that, the cross combinations 1 x 8 (RHR RG-1 x RHR RG-8), 2 x 7 (RHR RG-2 x RHR RG-7), 2 x 8 (RHR RG-2 x RHR RG-8), 5 x 8 (RHR RG-5 x RHR RG-8), 6 x 7 (RHR RG-6 x RHR RG-7) and 6 x 8 (RHR RG-6 x RHR RG-8) displayed significant and positive specific combining ability for weight of fruits per vine and number of fruits per vine and also showed significant negative SCA effects for desirable traits.

Keywords: *Luffa acutangula,* combining ability, gene action, diallel analysis

Introduction

Ridge gourd (*Luffa acutangula* (L.) Roxb.) is an important vegetable in India and South East Asia. Belongs to genus *Luffa* of cucurbitaceae family having a chromosome number of 2n= 26. It is an annual climbing herb; tender fruits are green in colour which is used in soups and curries or as a cooked vegetable. Altogether there are two well-defined sub-families, 8 tribes, 118 genera and 825 species. Ridge gourd has good nutritive value, rich in carbohydrates and contains the minerals Ca. P and Fe. It is also a good source of vitamin A, vitamin B and a fair source of ascorbic acid. Exploitation of hybrid vigour in recent years has led to remarkable yield advances in many crops. However, the possibility in exploitation of hybrid vigour in ridge gourd as a result of inter-varietal crossing was shown by Richharia (1952) [8]. Owing to existence of wide variability, monoecious nature, conspicuous and convenient flower and quite large number of seeds per fruit. Combining ability analysis is important to the plant breeder as it helps in understanding the nature of gene action governing the expression of the character help in deciding upon the future breeding strategy. Development of the concept of combining which can exhibit maximum hybrid vigour in F_1. General combining ability is the average performance of the lines in hybrid combinations while the specific combining ability refers to the deviation of certain cross from expectations on the basis of the average performance of the lines involved. General combining ability include additive variance and variance arising due to additive x additive interaction, while specific combining ability includes non-additive genetic variances arising from dominance and epistatis. Though so information about combining ability of ridge gourd is available. However, to substantiate this information and to derive additional information on all the characters and also for locating all the possible combinations. More use of the available variability is required so that maximum exploitation of this phenomenon is affected. Besides, for rational improvement of yield and its components. As yield is highly complex character and many factors are responsible for the expression it is necessary to understand the mode of inheritance in governing such characters.

Material and Methods

The experiment was laid out during summer-2017 and summer-2018 at All India Coordinated Research Project on Vegetable crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri in Randomized Block Design (RBD) with two replications. The experiment consists of eight parents (RHR RG-1, RHR RG-2, RHR RG-3, RHR RG-4, RHR RG-5, RHR RG-6, RHR RG-7 and RHR RG-8), twenty eight F_1 hybrids and one standard check; each entry was planted in rows of five vines each. A spacing of 1.5 x 1.0 m was followed and the crop was raised as per the recommended package and practices.

The all parents, hybrids and standard check were randomized completely among themselves and grown in continues block. Recorded parameters *viz*., length of vine (cm), number of nodes per vine, length of internode (cm), number of female flowers, days to 50% flowering, days required for first harvest, length of fruit (cm), diameter of fruit (cm), length of pedicel (cm), weight of fruit (g), number of fruits per vine, weight of fruits per vine (kg), weight of fruits per plot (kg), fruit yield (q/ha). The analysis of variance, for all traits under study, was carried out the method suggested by Panse and Sukhatme (1985) [5]. Data analysed for combining ability following Model I and Method II of Griffing (1956) [1].

Results and Discussion

The analysis of variance for combining ability revealed that mean square due to GCA and SCA were significant for all the characters which indicated variation in parents and crosses, except days to 50% flowering and days required for first harvest in summer season. Similar result found by Shaha *et al*. (1999) [11] and Rao *et al.* (2000) [7]. The parents RHR RG-2, RHR RG-6 and RHR RG-8 exhibited good general combining ability for most of the characters but none of the parent showed the good general combiner for all characters under study. Which were desirable for earliness as well as yield contributing traits. GCA effects and *per se* performance of parents are related to each other. The parents showing highest GCA effects for a particular trait were also displayed high mean with respect to the character. The parent RHR RG-4 result significantly positive GCA effect for length of vine. For vine length, observed earlier by Shaha *et al*. (1999) [11] and Rao *et al.* (2000) [7]. None of the parent showed negative GCA effect for length of internode while for days to 50% flowering and days required for first harvest. The result was in correspondence with Mole *et al.* (2001) [3] and Sarkar *et al.* (2015) [9] in ridge gourd. Only parent RHR RG-7 exhibited significantly GCA effects for number of nodes per vine. The parental line RHR RG-8 significantly positive GCA effects were displayed for number of female flowers. Similar findings for positive GCA effects recorded by Shaha and Kale (2003) [11] and Ram *et al*. (2004) [16]. Significantly negative GCA effects reported for length of pedicel in the parent RHR RG-6. The parents RHR RG-4 and RHR RG-8 significantly positive GCA effects recorded in length of fruit. The parent RHR RG-2 found to be with highly significant positive GCA effects for diameter of fruit. Among the eight parents significantly highest and positive GCA effects exhibited by the parent RHR RG-8 for number of fruits per vine. Similar findings for positive GCA effects recorded by Hedau and Sirohi (2004) [2] and Neeraja (2008) [4] for number of female flowers, length of fruit, diameter of fruit and number of fruits pr vine. The data from Table 2. revealed that, parents RHR RG-1 and RHR RG-4 expressed significantly highest and positive GCA effect for weight of fruit. The parent RHR RG-7 and RHR RG-8 positive GCA effects for weight of fruits per vine. Among the different parents, RHR RG-8 displayed significantly GCA effect for weight of fruits per plot. The parent RHR RG-8 showed positive GCA effects for fruit yield (q/ha). Similar result of positively significant GCA effects for weight of fruit, weight of fruits per vine and fruit yiel (q/ha) were reported earlier by Rao *et al.* (2000) [7] and Mole *et al.* (2001) [3]. The estimates of SCA effects are given in Table 3. For length of vine, 6 crosses showed positive SCA effects and the cross combinations 1 x 6, 2 x 7, 3 x 5, 3 x 7, 4 x 5 and 6 x 8 recorded highest significant effects. Similar result in conformity with the findings of Shaha *et al*. (1999) [11] and Rao *et al.* (2000) [7]. The significant and negative SCA effects for length of internode was recorded 4 crosses. The data displayed significant SCA effects for number of nodes per vine revealed that the cross combinations 2 x 7, 3 x 5, 3 x 7 and 4 x 5. Among 28 F_1 hybrids the negatively significant SCA effects for Days to 50% flowering expressed in only one cross 2 x 6. Among all the hybrids cross combinations *viz.*, 3 x 4, 5 x 8, 6 x 7, 6 x 8 and 7 x 8 showed significantly negative SCA effects for days required for first harvest. Sarkar *et al.* (2015) [9] in ridge gourd narrated similar significant negative SCA effects. The 6 crosses recorded significantly SCA effects for number of flowers and the crosses 1 x 8, 2 x 7, 3 x 4, 3 x 5, 6 x 7 and 6 x 8. These results were in concordance to the findings of Shaha and Kale (2003) [11] and Ram *et al*. (2004) [16]. Data for length of pedicel presented in Table 3. and described that, among 28 F_1 hybrids the negatively significant SCA effect expressed in cross combinations 1 x 2, 1 x 5, 1 x 6, 2 x 7, 2 x 8, 3 x 4, 4 x 7, 4 x 8 and 6 x 7. For the length of fruit, 11 crosses recorded significantly positive SCA effects and the crosses 1 x 2, 1 x 4, 1 x 8, 2 x 5, 2 x 6, 3 x 6, 3 x 7, 4 x 6, 4 x 7, 4 x 8 and 7 x 8. The 4 crosses showed significantly SCA effects for diameter of fruit and the cross combinations 1 x 3, 2 x 3, 4 x 7 and 5 x 7 displayed highly significantly effect. Among all 28 F_1 hybrids, 10 crosses indicated highest positive value and significantly SCA effects for number of fruits per vine. The data Table 3. on average weight of fruit represented, 10 crosses expressed significant and highest positive SCA effects for crosses 1 x 2, 1 x 3, 1 x 6, 2 x 4, 2 x 8, 3 x 5, 4 x 6, 4 x 8, 5 x 7 and 5 x 8 respectively. The result of significantly positive SCA effects for length of fruit, diameter of fruit, number of fruits per vine and weight of fruit in consonance with Hedau and Sirohi (2004) [2] and Ram *et al*. (2004) [16]. Significant and highest positive SCA effects was manifested 11 crosses for weight of fruits per vine. Among that, 9 cross combinations 1 x 8, 2 x 4, 2 x 7, 2 x 8, 3 x 4, 3 x 5, 5 x 8, 6 x 7 and 6 x 8 respectively revealed significant positive SCA effects for weight of fruits per plot. According to the presented data Table 3., it was revealed that, the crosses 1 x 8, 2 x 4, 3 x 4, 3 x 5, 5 x 8 and 6 x 7 respectively. Among all 28 crosses, the data like yield per hectare 9 crosses showed significant and positive SCA effects. In previous studies Shaha and Kale (2003) [11] and Neeraja (2008) [4] also recorded significant SCA effects for weight of fruits per vine and fruit yield (q/ha).

Table 1: Analysis of variance for combining ability in 8 x 8 half diallel of ridge gourd

Sr. No.	Characters	GCA		SCA		Error	
		D.F.	M.S.S.	D.F.	M.S.S.	D.F.	M.S.S.
1.	Length of vine (cm)	7	3269.19**	28	5146.43**	35	2020.24
2.	Length of internode (cm)	7	0.58**	28	1.25**	35	0.48
3.	Number of nodes per vine	7	11.57*	28	9.51*	35	4.40
4.	Days to 50% flowering	7	8.41	28	7.84	35	7.56
5.	Days required for first harvest	7	5.14	28	12.88**	35	2.83
6.	Number of female flowers	7	60.85**	28	55.36**	35	6.02

7.	Length of pedicel (cm)	7	0.39**	28	0.98**	35	0.02
8.	Length of fruit (cm)	7	17.33**	28	20.91**	35	1.54
9.	Diameter of fruit (cm)	7	0.06*	28	0.08**	35	0.03
10.	Number of fruits per vine	7	65.76**	28	27.03**	35	1.57
11.	Weight of fruit (g)	7	56.14**	28	96.52**	35	16.99
12.	Weight of fruits per vine (kg)	7	0.73**	28	0.37**	35	0.01
13.	Weight of fruits per plot (kg)	7	17.99**	28	9.02**	35	0.51
14.	Fruit yield (q/ha)	7	3197.09**	28	1603.64**	35	91.67

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

Table 2: Estimates of general combining ability effects for different characters in 8 x 8 half diallel of ridge gourd

Sources	Length of vine (cm)	Length of internode (cm)	Number of nodes per vine	Days to 50% flowering	Days required for first harvest	No. of female flowers	Length of pedicel (cm)
P_1	-9.41	-0.20	-0.08	-1.10	-0.34	-0.52	0.00
P_2	-12.62	0.26	-1.44*	0.32	-0.31	-1.35	0.10*
P_3	-17.83	-0.27	-0.44	-1.18	-0.26	-2.31**	0.13*
P_4	27.21*	0.28	0.96	1.50	1.30*	0.11	0.11*
P_5	-20.20	0.08	-1.44*	0.02	-0.19	-0.61	-0.05
P_6	-0.91	-0.13	0.38	0.46	-0.04	-1.42	-0.46**
P_7	15.77	-0.24	1.52*	-0.58	0.81	0.39	0.05
P_8	17.99	0.13	0.56	0.56	-0.97	5.70**	0.10*
S.E.(gi) ±	13.29	0.20	0.62	0.81	0.49	0.72	0.05
C.D. at 5%	26.99	0.41	1.25	1.65	1.01	1.47	0.10
C.D. at 1%	36.22	0.54	1.68	2.20	1.33	1.95	0.13

Sources	Length of fruit (cm)	Diameter of fruit (cm)	No. of fruits per vine	Weight of fruit (g)	Weight of fruits per vine (kg)	Weight of fruits per plot (kg)	Fruit yield (q/ha)
P_1	0.33	0.01	-1.35**	3.22*	-0.11**	-0.56*	-7.53*
P_2	-1.82**	0.13*	-0.54	-1.79	-0.07	-0.33	-4.52
P_3	1.02**	-0.07	-3.09**	1.89	-0.31**	-1.50**	-20.01**
P_4	1.11**	0.06	-1.25**	2.61*	-0.11**	-0.50*	-6.75*
P_5	-1.54**	-0.00	-0.33	-2.64*	-0.04	-0.27	-3.62
P_6	-0.40	-0.11*	0.18	-2.84*	-0.04	-0.25	-3.39
P_7	-0.57	-0.01	0.73	-0.37	0.10*	0.37	5.08
P_8	1.87**	-0.01	5.66**	-0.06	0.60**	3.06**	40.79**
S.E.(gi) ±	0.36	0.05	0.37	1.21	0.03	0.21	2.83
C.D. at 5%	0.74	0.10	0.75	2.47	0.07	0.43	5.74
C.D. at 1%	0.97	0.13	1.00	3.29	0.08	0.57	7.69

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

Table 3: Estimates of specific combining ability effects for different characters in 8 x 8 half diallel of ridge gourd

Sr. No.	Crosses	Length of vine (cm)	Length of internode (cm)	Number of nodes per vine	Days to 50% flowering	Days required for first harvest	No. of female flowers	Length of pedicel (cm)
1.	1 x 2	28.71	-0.21	2.40	-5.78*	-2.55	-0.26	-1.20**
2.	1 x 3	-54.58	-1.51*	0.40	1.17	-3.00	-6.20**	0.73**
3.	1 x 4	-46.26	0.49	-4.00*	2.63	-0.06	1.06	0.65**
4.	1 x 5	-40.81	-0.50	-1.39	-2.68	-1.27	-10.20**	-0.37*
5.	1 x 6	91.70*	2.09**	0.37	0.82	-1.72	-5.69*	-0.86**
6.	1 x 7	55.75	1.50*	-0.26	2.42	1.33	1.28	1.03**
7.	1 x 8	50.66	0.35	2.19	-1.77	-0.89	11.97**	-0.19
8.	2 x 3	-80.78	-1.56*	-1.43	-0.50	1.37	-5.77*	0.86**
9.	2 x 4	60.94	0.42	2.55	3.94	-0.89	1.89	1.42**
10.	2 x 5	-40.33	0.15	-2.83	-1.76	0.00	-10.27**	-0.10
11.	2 x 6	6.92	0.01	0.33	-0.91	0.25	-5.86*	2.35**
12.	2 x 7	130.08**	0.77	5.99**	1.03	-0.40	14.31**	-1.60**
13.	2 x 8	40.66	-0.07	2.65	4.14	2.18	2.40	-0.40*
14.	3 x 4	5.08	0.41	-0.64	-4.18	-3.34*	4.95*	-0.79**
15.	3 x 5	92.59*	0.46	4.56*	-1.90	-0.65	7.58**	0.74**
16.	3 x 6	-71.74	-2.25**	1.33	0.35	-2.80	-5.20*	-0.09
17.	3 x 7	131.58**	1.55*	4.09*	0.50	-0.75	0.07	0.60**
18.	3 x 8	49.33	0.82	0.95	1.65	-2.27	-4.83*	0.40*
19.	4 x 5	98.59*	0.6	4.35*	0.20	0.49	-0.44	-0.06
20.	4 x 6	-30.11	-0.22	-1.37	0.95	0.54	-4.63*	1.15**
21.	4 x 7	6.70	0.47	-0.71	-0.84	1.79	-6.65**	-1.17**
22.	4 x 8	7.28	-0.26	1.14	3.16	3.47*	-6.06**	-0.62**
23.	5 x 6	-43.33	-1.63*	1.33	3.69	3.53*	3.49	0.12
24.	5 x 7	-78.99	-1.20	-2.00	-0.30	-0.02	3.97	-0.02
25.	5 x 8	-26.04	-0.63	-0.14	-3.50	-4.04*	3.26	-0.29

26.	6 x 7	-16.17	-0.65	1.06	-4.35	-5.97**	8.28**	-0.49**
27.	6 x 8	83.40*	1.01	2.52	-3.74	-5.19**	13.57**	0.06
28.	7 x 8	-18.40	-0.68	0.58	-0.84	-6.54**	1.15	1.84**
S.E. (sij) ±		40.75	0.63	1.90	2.49	1.52	2.22	0.15
C.D. at 5%		82.73	1.28	3.86	5.06	3.10	4.52	0.31
C.D. at 1%		110.84	1.72	5.17	6.78	4.15	6.05	0.41

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

Sr. No.	Crosses	Length of fruit (cm)	Diameter of fruit (cm)	No. of fruits per vine	Weight of fruit (g)	Weight of fruits per vine (kg)	Weight of fruits per plot (kg)	Fruit yield (q/ha)
1.	1 x 2	5.27**	0.12	-1.01	11.65**	0.12	0.20	2.76
2.	1 x 3	1.22	0.50**	0.26	13.38**	-0.01	0.93	12.52
3.	1 x 4	2.46*	-0.32*	-1.79	4.74	-0.03	-0.65	-8.66
4.	1 x 5	-4.88**	-0.18	-4.46**	-5.13	-0.58**	-2.78**	-37.05**
5.	1 x 6	1.05	0.02	-3.64**	8.13*	-0.29*	-1.33*	-17.72*
6.	1 x 7	0.44	-0.29	-0.18	4.05	0.16	0.27	3.74
7.	1 x 8	3.55**	-0.02	9.47**	-4.70	0.95**	4.82**	64.02**
8.	2 x 3	1.58	0.34*	-4.07**	-7.87*	-0.54**	-2.73**	-36.83**
9.	2 x 4	-1.90	0.24	1.08	13.77**	0.31*	1.61*	21.57*
10.	2 x 5	7.03**	0.11	-6.48**	-12.46**	-0.86**	-4.25**	-56.66**
11.	2 x 6	8.63**	-0.18	-4.45**	-6.36	-0.54**	-2.67**	-35.66**
12.	2 x 7	-1.79	-0.28	9.62**	2.94	1.04**	5.39**	71.85**
13.	2 x 8	-4.45**	0.29	3.98**	8.26*	0.59**	3.01**	40.26**
14.	3 x 4	1.54	-0.56**	4.28**	7.20	0.58**	2.94**	39.35**
15.	3 x 5	-0.03	0.17	4.06**	11.35**	0.58**	3.02**	40.38**
16.	3 x 6	3.45**	0.11	-3.50**	1.20	-0.363**	-1.72*	-23.05*
17.	3 x 7	3.76**	0.28	2.68*	-5.74	0.39**	0.93	12.43
18.	3 x 8	1.49	-0.09	-4.28**	2.36	-0.42**	-2.11**	-28.07**
19.	4 x 5	-0.00	-0.22	2.81*	-10.64**	0.07	0.46	6.17
20.	4 x 6	2.54*	-0.11	-3.84**	9.66*	-0.29*	-1.35*	-17.98*
21.	4 x 7	3.22**	0.43**	-4.79**	-3.15	-0.59**	-2.85**	-38.09**
22.	4 x 8	6.43**	0.24	-1.14	7.72*	0.03	0.22	2.96
23.	5 x 6	-0.77	-0.12	1.71	3.21	0.37**	1.16	15.51
24.	5 x 7	-0.57	0.50**	0.64	9.36*	0.23	1.03	13.84
25.	5 x 8	-1.35	0.08	3.55**	15.26**	0.71**	3.65**	48.77**
26.	6 x 7	1.07	-0.18	7.97**	0.91	0.79**	4.42**	59.05**
27.	6 x 8	-1.55	-0.08	9.04**	-9.59*	0.79**	3.37**	44.91**
28.	7 x 8	3.22**	-0.25	-1.00	1.09	-0.13	-0.45	-6.08
S.E. (sij) ±		1.12	0.16	1.13	3.73	0.11	0.65	8.68
C.D. at 5%		2.28	0.32	2.30	7.58	0.24	1.32	17.62
C.D. at 1%		3.06	0.43	3.08	10.16	0.32	1.78	23.61

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

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