Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 7 [9] August 2018 : 84-90

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Combining Ability Analysis for Biochemical Traits in Chilli (*Capsicum annuum* L.)

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ABSTRACT
Fifty four F_1 hybrids were developed in chilli using Line x Tester mating design with nine lines and six testers at Horticultural Research Station, Lam farm, Guntur, Andhra Pradesh during kharif, 2013-14 and 2014-15 to estimate the combining ability effects for seven biochemical traits. The analysis of variance revealed significant differences among the parents, crosses and parents vs. hybrids for all the traits studied indicating that the existence of wide variability among the material studied. All the characters exhibited low gca to sca ratio indicated predominance of non-additive gene action in inheritance of all traits studied and improvement can be made through heterosis breeding. Among the parents, the lines LCA 504, LCA 446, LCA 466, LCA 654 and LCA 355 and the testers G4, LCA 678, LCA 453 and LCA 705-2 were found to be good general combiners and among the 54 hybrids, the hybrids LCA 504 x LCA 678, LCA 615 x G4, LCA 655 x LCA 315, LCA 355 x LCA 678, LCA 504 x G4, LCA 504 x LCA 453 and LCA 607 x LCA 703-2 were found to be promising hybrids as they have exhibited significant gca and sca effects in desirable direction for most of the quality traits. The resulted promising hybrids may be further tested over locations or seasons and recommended for commercial release and identified good general combiners could be utilized in future chilli breeding programmes.
Key words: Chilli, *Capsicum annuum*, Combining ability, bio chemical, trait, additive

Received 09.04.2018 Revised 21.06.2018 Accepted 31.07. 2018

INTRODUCTION

Chilli (*Capsicum annuum* L.) has its unique place in the diet as a spice, condiment, culinary supplement, vegetable, medicine and ornamental plant. It belongs to Solanaceae family (2n=24), originated in South and Central America. India is the largest producer, consumer and exporter of chilli in the world with productivity of 1.9 metric t/ha [11]. Andhra Pradesh leads the country in its production, productivity and export followed by Telangana, Karnataka and West Bengal *etc.*

Chilli is increasingly recognized as a rich source of health-related metabolites, such as ascorbic acid (vitamin C), carotenoids, flavonoids and capsaicinoids [5]. Capsicinoids and carotenoids are the major chemicals in chilli fruits which add commercial value to the crop. The carotenoids contributing to fruit colour act as dietary precursors of vitamin A. Pungency (heat) is an important quality attribute of hot pepper besides colour (carotenoids) and it has been established due to presence of capsaicinoids. The 'capsaicin' is an alkaloid present in the placenta of the fruit, which can directly scavenge various free radicals [9]. The capsaicinoids also have antioxidant, anticancer, antiarthritic and analgesic properties [12]. Chilli has also acquired a great importance because of the presence of 'oleoresin', which permits better color distribution and flavor in foods.

In view of the changing of food habits and health consciousness, food quality particularly perishables like fruits and vegetables is gaining importance since improved quality not only facilitates remunerative market price for the producer and also improves consumer's health. Thus, attempts towards improvement of quality characters in crop plants have lot of significance which can increase the income of the farmer through premium price. For effective implementation of the desired objectives, the plant breeder should have knowledge on the relative importance of additive and non-additive gene action [2] and combining ability of genotypes for proper choice of parents to gain better heterotic promising hybrids.

Combining ability is the capacity or ability of a genotype to transmit superior performance to its progeny. The concept of combining ability was originally developed in maize by Richey and Meyar [15]. Sprauge and Tatum [18] defined the terms 'general combining ability' (GCA) and 'specific combining ability' (SCA) as a measure of gene action while working with maize. Griffing [3], showed the relationship between GCA and SCA variances. The GCA variance is due to additive whereas SCA variance is due to non-additive gene action. Hence, both are important diagnostic tools in selection of suitable parents. Among all the crossing techniques, the Line x Tester (L x T) mating design provides more precise estimate of GCA, SCA and other parameters [7]. Therefore, the present investigation was carried out to estimate the combining ability effects for biochemical traits in chilli using Line x Tester mating design. Similar type of research works have also been conducted by Prasath and Ponnuswami, [13]; Khalil and Hatem [8]; Suryakumari *et al*., [19]; Jindal *et al.*[6] and Kranthi Rekha [10].

MATERIAL AND METHODS

The present investigation was conducted at Horticulture Research Station, Dr.Y.S.R.H.U. Lam farm, Guntur. The experimental material and their salient features were presented in Table 1. The experimental material has identified in chillies improvement scheme at HRS, Lam farm, Guntur and comprised of nine lines (LCA 504, LCA 615, LCA 446, LCA 466, LCA 442, LCA 654, LCA 607, LCA 655 and LCA 355) and six testers (G4, LCA 678, LCA 453, LCA 703-2, LCA 705-2 and LCA 315) and these parents were crossed in Line x Tester fashion during *Kharif*, 2013-14 and 54 F_1 hybrids were generated. The resulting 54 F_1 hybrids along with their 15 parents and 2 commercial checks (Tejaswini and Indam-5) were evaluated during *Kharif,* 2014-15 in a Randomized Block Design with three replications. Each genotype was sown in two rows (one row of 4 m length) of at spacing of 75 cm x 30 cm. The crop was raised as per the recommended package of practices. Each row consisted of 12 plants, of which five competitive plants were selected at random for collecting the fruit samples to estimate qualitative traits *viz*. ascorbic acid (mg/100g), oleoresin (%), capsaicin (%), red carotenoids (%), yellow carotenoids (%), total carotenoids (%) and total color value (ASTA units).

The red ripe fruits were sun dried and ground in an electronic grinder and passed through a 0.5 mm sieve and the dry chilli powder was used to measure biochemical constituents whereas mature green fruits were used for estimating the Vitamin 'C' content. Ascorbic acid content of mature green fruits was estimated by volumetric (2, 6- dichlorophenol indophenol dye) method described by Sadasivam and Balasubramanian [17]. The oleoresin content was estimated as per the procedure described by Ranganna [14]. The capsaicin content was estimated by colorimetric method described by Balasubramanian *et al.* [1]. Total red (C^R; capsanthin, capsorubin and capsanthin-5, 6-epoxide) and yellow (C^Y; zeaxanthin, violaxanthin, antheraxanthin, â-cryptoxanthin, â-carotene and cucurbitaxanthin A) carotenoid isochromic fractions were estimated following the protocol of spectrophotometric method [4]. Total colour value (ASTA- American Spice Trade Association units) was estimated as per the procedure given by Rosebrook *et al.* [16]. The collected data were analyzed for combining ability according to the standard procedure given by Kempthorne [7].

RESULTS AND DISCUSSION

The analysis of variance (Table 2) revealed significant differences among the parents, crosses and parents vs. hybrids for all the seven traits studied. All genotypes were partitioned into lines, testers and lines x testers and the significant differences were observed among lines, testers and lines x testers for all the characters studied. This indicated the existence of wide variability in the material studied and there is a good scope to identify the promising hybrid combinations for quality parameters. These results were in accordance with the earlier findings of Kranthi Rekha [10] who concluded existence of wide variability in chilli.

The estimates of *gca* and *sca* variances, their ratios and gene action were presented in Table 3. Variances due to general combining ability (*gca*) and specific combining ability (*sca*) were found to be significant for all the characters studied *viz.* ascorbic acid, oleoresin, capsaicin, red carotenoids, yellow carotenoids, total carotenoids and total colour value. General combining ability is genetically associated with additive gene action while specific combining ability is due to non-additive gene action *i.e.* dominance and epistasis. The ratio of *gca* to *sca* variances is an index of additive / non-additive gene action. If the ratio of *gca* to *sca* variances less than unity, it indicates predominance of non-additive gene action whereas the ratio of more than unity indicates predominance of additive gene action. In the present investigation, all characters exhibited higher *sca* variances than *gca* variances and recorded low ratio of *gca* to *sca* variances (<1) which indicated predominance of non-additive gene action in inheritance of all traits studied and genetic improvement can be made through heterosis breeding. The results of this kind of gene action were in conformity with earlier findings of Jindal *et al.* [6] in chilli.

The estimates of general combining ability (*gca)* effects of nine lines and six testers for seven quality traits were presented in Table 4. The general combining ability (*gca)* effects revealed that two lines LCA 504 (17.14), LCA 446 (5.04) and three testers G4 (4.46), LCA 678 (7.83), LCA 703-2 (9.15) for ascorbic acid content; two lines LCA 615 (3.88), LCA 446 (1.24) and one tester G4 (2.08) for oleoresin content; two lines LCA 504 (0.02), LCA 654 (0.19) and three testers G4 (0.03), LCA 678 (0.02), LCA 453 (0.03) for capsaicin content; three lines LCA 466 (23.23), LCA 654 (20.38), LCA 355 (17.01) and two testers LCA 453 (5.23), LCA 705-2 (16.62) for red carotenoids; four lines LCA 446 (11.85), LCA 466 (80.38), LCA 654 (10.07), LCA 355 (25.65) and three testers LCA 678 (17.34), LCA 453 (14.11), LCA 705-2 (14.17) for total carotenoids and five lines LCA 446 (8.71), LCA 466 (18.92), LCA 442 (6.20), LCA 654 (4.30), LCA 355 (19.66) and three testers LCA 678 (5.97), LCA 453 (2.95), LCA 705-2 (5.82) for total colour value were considered as good general combiners as they have registered significant *gca* effects in desirable direction (positive) due to contribution of large number of favorable alleles. Suryakumari *et al.* [19] have also been reported the similar results for respective characters in chilli.

With respect to yellow carotenoids, negative direction is desirable. For this trait, five lines *viz.* LCA 504 (-14.43), LCA 615 (-19.92), LCA 442 (-13.84), LCA 654 (-10.31), LCA 607 (-12.87) and two testers G4 (-10.89), LCA 703-2 (-15.70) were considered as good general combiners as they have registered significant negative *gca* effects.

The estimates of specific combining ability (*sca)* effects of 54 hybrids for seven quality characters were furnished in Table 5. Among the 54 crosses, 21 crosses for ascorbic acid, nine crosses for oleoresin, 12 crosses for capsaicin, 13 crosses each for red and yellow carotenoids, 17 crosses for total carotenoids and 16 crosses for total colour value were considered as good specific cross combinations as they have manifested significant *sca* effects in desirable direction. Among the 54 crosses, the crosses LCA 504 x LCA 315 (38.79), LCA 615 x LCA 705-2 (36.09) and LCA 355 x LCA 678 (34.18) for ascorbic acid; LCA 504 x G4 (7.04), LCA 466 x LCA 453 (5.06) and LCA 615 x LCA 678 (4.42) for oleoresin; LCA 615 x LCA 315 (0.16), LCA 504 x LCA 678 (0.11), LCA 504 x LCA 453 (0.11) and LCA 654 x G4 (0.11) for capsaicin; LCA 607 x LCA 703-2 (65.38), LCA 607 x LCA 705-2 (59.67) and LCA 615 x G4 (39.80) for red carotenoids; LCA 442 x LCA 705-2 (-54.10), LCA 654 x G4 (-52.21) and LCA 607 x LCA 703-2 (-32.88) for yellow carotenoids; LCA 607 x LCA 705-2 (84.61), LCA 615 x G4 (69.06) and LCA 355 x LCA 678 (67.07) for total carotenoids and LCA 442 x LCA 315 (27.88), LCA 615 x G4 (25.27) and LCA 655 x LCA 315 (22.51) for total colour value were found to be best three specific cross combinations as they showed higher magnitude of significant *sca* effects in desirable direction.

The findings of earlier works have also reported the significant *gca* and *sca* effects in desirable direction for ascorbic acid [8], oleoresin [13], capsaicin [20], red carotenoids, yellow carotenoids, total carotenoids [10] and total colour value [19, 6].

Based on the estimates of *gca* effects, the parents were classified as good, average and poor combiners (Table 6). The crosses which had both parents as good general combiners may be advanced through pedigree method of selection. The crosses which had only one parent as good general combiner would be improved through recurrent selection. The crosses which had both parents as poor general combiners would be difficult to improve the trait by selection. Hence, improvement of this character is possible through heterosis breeding only.

The estimates of *sca* effects revealed that none of the crosses were constantly superior for all the traits. This indicated that the specific combining ability of the crosses was not always dependent on the *gca* of the parents involved. The good general combining parents when crossed do not always produce high *sca* effects, while poor general combining parents do not always produce low *sca* effects. So, any parental combination either good x good, average x good, average x average or poor x poor may result into high *sca* effects. These results are supported by earlier findings of Suryakumari *et al.* [19], Jindal *et al.* [6] and Kranthi Rekha [10] in chilli.

Among 15 parents, the lines LCA 504, LCA 446, LCA 466, LCA 654 and LCA 355 and the testers G4, LCA 678, LCA 453 and LCA 705-2 were found to be good general combiners and among the 54 hybrids, the hybrids LCA 504 x LCA 678, LCA 615 x G4, LCA 655 x LCA 315, LCA 355 x LCA 678, LCA 504 x G4, LCA 504 x LCA 453 and LCA 607 x LCA 703-2 were found to be best specific cross combinations as they have exhibited significant *gca* and *sca* effects in desirable direction for most of the quality traits. The resulted promising hybrids may be further tested over locations or seasons and recommended for commercial release and identified good general combiners could be utilized in future chilli breeding programmes.

Table 1: Salient features of parents used in Line x Tester analysis of chilli

S.No	Parents	Features
Lines		
1	LCA-504	Drought resistant, highly pungent
2	LCA-615	High yielding line with parrot green fruits
3	LCA-446	Bold pod, high colour and oleoresin
4	LCA-466	Bold and long pod, high colour and oleoresin
5	LCA-442	Bold and long pod, high colour and mild pungent
6	LCA-654	Medium bold, shiny fruit surface, light green in colour
7	LCA-607	Light green pod, profuse branching
8	LCA-655	Dual purpose variety, bold light green pod
9	LCA-355	High colour with wrinkled surface
Testers		
1	G4	Dark green (olive green) fruits, virus resistant
2	LCA-678	More primary branches, semi erect plant habit
3	LCA-453	Bold pod, erect growth habit
4	LCA-703-2	Virus resistant, dark green fruits
5	LCA-705-2	More no. of fruits, shiny dry pod
6	LCA-315	Virus resistant, fruits are long and dark green
Checks		
1	Indam-5	Indo-American Hybrid Seeds (India) Pvt.Ltd. (IAHS)
2	Tejaswini	Maharashta Hybrid Seeds Co.Ltd. (MAHYCO)

Table 2: Analysis of variance for L x T in respect of biochemical characters in chilli

	Df	Ascorbic acid (mg/100g)	Oleoresin (%)	Capsaicin (%)	Red carotenoids (mg/100g)	Yellow carotinoids (mg/100g)	Total carotenoids (mg/100g)	Total colour (ASTA units)
Replications	2	14.92	0.00	0.06	7.95	22.72	5.92	23.40
Treatments	68	2417.40**	0.05**	33.70**	3998.56**	3139.88**	10595.07**	1659.34**
Parents	14	3597.82**	0.13**	51.35**	5302.04**	2697.75**	13994.68**	2209.20**
Lines	8	2779.55**	0.18**	44.09**	8709.48**	4484.69**	23066.37**	3448.91**
Testers	5	3515.78**	0.05**	5.42*	737.85*	210.62*	1598.45**	322.66**
Line x Tester	1	10554.25**	0.10**	339.05**	863.46*	837.83**	3402.25**	1724.30**
Parents *vs* Crosses	1	10059.97**	0.02**	67.09**	23579.70**	9601.24**	63274.96**	5490.19**
Crosses	53	1961.39**	0.03**	28.41**	3284.78**	3134.75**	8703.10**	1441.81**
Error	136	38.45	0.00	1.80	141.50	68.83	278.48	50.22

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

Table 3: Estimates of general and specific combining ability variances and proportionate gene action for seven quality traits in chilli.

Source of variation	Ascorbic Acid (mg/100g)	Oleoresin (%)	Capsaicin (%)	Red carotenoids (mg/100g)	Yellow carotenoids (mg/100g)	Total carotenoids (mg/100g)	Total colour value (ASTA units)
σ^2gca	113.69*	2.12**	0.003**	228.68**	328.46**	806.88**	130.67**
σ^2sca	601.22**	6.34**	0.004**	760.69**	489.49**	1502.44**	244.09**
σ^2gca/σ^2sca	0.19	0.33	0.75	0.30	0.67	0.54	0.54

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

Table 4: Estimates of general combining ability effects for seven quality characters in chilli

Parents	Ascorbic acid (mg/100g)	Oleoresin (%)	Capsaicin (%)	Red carotenoids (mg/100g)	Yellow carotenoids (mg/100g)	Total carotenoids (mg/100g)	Total colour value (ASTA units)
Lines							
LCA-504	17.14**	-0.22	0.02**	-0.79	-14.43**	-15.22**	2.90
LCA-615	0.20	3.88**	-0.05**	-29.05**	-19.92**	-48.97**	-21.08**
LCA-446	5.04**	1.24**	-0.06**	5.34	6.51**	11.85**	8.71**
LCA-466	1.49	-0.87**	-0.03**	23.23**	57.15**	80.38**	18.92**
LCA-442	-15.06**	-2.64**	-0.04**	5.29	-13.84**	-8.55*	6.20**
LCA-654	-9.02**	-0.32	0.19**	20.38**	-10.31**	10.07*	4.30*
LCA-607	-1.53	0.35	0.01	-37.95**	-12.87**	-50.83**	-28.15**
LCA-655	-0.58	-1.35**	-0.04**	-3.45	-0.94	-4.38	-11.45**
LCA-355	2.32	-0.06	0.00	17.01**	8.64**	25.65**	19.66**
SE (gi)	**1.46**	**0.32**	**0.01**	**2.80**	**1.96**	**3.93**	**1.67**
Testers							
G4	4.46**	2.08**	0.03**	-1.43	-10.89**	-12.32**	-1.53
LCA-678	7.83**	0.46	0.02**	-4.01	21.35**	17.34**	5.97**
LCA-453	0.61	-0.62*	0.03**	5.23*	8.88**	14.11**	2.95*
LCA-703-2	9.15**	-0.55*	-0.01*	-9.39**	-15.70**	-25.09**	-7.15**
LCA-705-2	0.96	0.08	0.00	16.62**	-2.45	14.17**	5.82**
LCA-315	-23.01**	-1.44**	-0.05**	-7.02**	-1.19	-8.21*	-6.06**
SE (gj)	**1.19**	**0.26**	**0.01**	**2.29**	**1.60**	**3.21**	**1.36**

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

Table 5: Estimates of specific combining ability effects for seven quality traits in chilli

Crosses	Ascorbic acid (mg/100g)	Oleoresin (%)	Capsaicin (%)	Red carotenoids (mg/100g)	Yellow carotenoids (mg/100g)	Total carotenoids (mg/100g)	Total colour value (ASTA units)
Crosses							
LCA-504 x G4	-27.46**	7.04**	0.00	29.34**	-6.10	23.24*	16.67**
LCA-504 x LCA-678	8.32*	-1.83*	0.11**	25.80**	20.33**	46.14**	9.47*
LCA-504 x LCA-453	9.96**	-2.02*	0.11**	23.15**	-5.77	17.38	11.23**
LCA-504 x LCA-703-2	3.20	-0.42	-0.04*	0.48	7.16	7.64	6.11
LCA-504 x LCA-705-2	-32.82**	-1.94*	-0.09**	-51.06**	-9.12	-60.19**	-28.12**
LCA-504 x LCA-315	38.79**	-0.82	-0.10**	-27.71**	-6.51	-34.22**	-15.36**
LCA-615 x G4	-13.97**	1.55*	-0.02	39.80**	29.26**	69.06**	25.27**
LCA-615 x LCA-678	-10.17**	4.42**	-0.03	-12.81	-22.40**	-35.21**	-11.34**
LCA-615 x LCA-453	2.66	1.50	-0.05**	-3.54	-12.14*	-15.68	-11.66**
LCA-615 x LCA-703-2	-14.88**	-3.42**	-0.06**	16.08*	18.28**	34.36**	12.70**
LCA-615 x LCA-705-2	36.09**	0.64	0.00	-31.29**	-3.00	-34.29**	-12.59**
LCA-615 x LCA-315	0.26	-4.70**	0.16**	-8.24	-10.01*	-18.24	-2.37
LCA-446 x G4	22.82**	1.31	-0.09**	-21.95**	-8.68	-30.63**	-18.88**
LCA-446 x LCA-678	15.92**	4.19**	-0.01	-18.98**	-8.54	-27.52**	5.60
LCA-446 x LCA-453	7.97*	-4.17**	0.03	11.42	15.07**	26.49**	19.47**
LCA-446 x LCA-703-2	-28.27**	-2.95**	0.07**	6.82	-3.45	3.37	-5.06
LCA-446 x LCA-705-2	-10.27**	-2.53**	0.02	0.79	1.76	2.56	-3.76
LCA-446 x LCA-315	-8.17*	4.16**	-0.02	21.90**	3.85	25.74**	2.64
LCA-466 x G4	22.27**	-2.85**	-0.01	12.05	29.04**	41.09**	13.97**
LCA-466 x LCA-678	-25.72**	-3.06**	0.01	9.89	-10.30*	-0.41	12.28**
LCA-466 x LCA-453	-13.30**	5.06**	0.00	12.39	10.08*	22.47*	20.02**
LCA-466 x LCA-703-2	5.05	0.38	0.02	-13.87*	-25.85**	-39.72**	-7.10
LCA-466 x LCA-705-2	23.64**	0.46	-0.07**	-18.27**	-5.62	-23.88*	-3.25
LCA-466 x LCA-315	-11.94**	0.02	0.06**	-2.19	2.64	0.45	-35.91**
LCA-442 x G4	-22.11**	-1.92*	0.04*	-37.76**	9.33	-28.44**	-24.40**
LCA-442 xLCA-678	8.32*	0.07	0.00	10.84	-4.61	6.23	-9.24*

LCA-442 x LCA-453	32.46**	-2.01*	-0.09**	10.02	26.39**	36.41**	3.23
LCA-442 x LCA-703-2	-3.85	2.21**	0.00	4.28	22.58**	26.85**	-2.41
LCA-442 x LCA-705-2	11.46**	1.21	0.05*	14.25*	-54.10**	-39.84**	4.93
LCA-442 x LCA-315	-26.27**	0.44	0.00	-1.63	0.41	-1.21	27.88**
LCA-654 x G4	32.10**	-2.31**	0.11**	-6.96	-52.21**	-59.17**	-11.46**
LCA-654 x LCA-678	-26.30**	-1.25	-0.11**	-0.31	-2.31	-2.62	-1.52
LCA-654 x LCA-453	17.19**	0.95	-0.02	-7.19	-10.32*	-17.52	-4.96
LCA-654 x LCA-703-2	-7.58*	2.68**	0.03	11.00	34.95**	45.96**	14.47**
LCA-654 x LCA-705-2	-23.35**	0.12	0.08**	4.03	35.33**	39.36**	7.80
LCA-654 x LCA-315	7.94*	-0.18	-0.09**	-0.58	-5.44	-6.02	-4.33
LCA-607 x G4	31.93**	-1.50	0.01	-31.05**	0.33	-30.71**	1.58
LCA-607 x LCA-678	20.60**	-1.35	-0.02	-38.54**	-13.01**	-51.55**	-10.56*
LCA-607 x LCA-453	-49.94**	1.05	-0.02	-56.46**	6.21	-50.25**	-17.68**
LCA-607 x LCA-703-2	-9.86**	1.67*	0.06**	65.38**	-32.88**	32.50**	-1.27
LCA-607 x LCA-705-2	6.37	-0.50	0.00	59.67**	24.94**	84.61**	12.57**
LCA-607 x LCA-315	0.89	0.63	-0.03	1.00	14.40**	15.40	15.35**
LCA-655 x G4	-0.50	-0.82	0.00	1.22	2.45	3.67	-4.62
LCA-655 x LCA-678	-25.16**	-0.43	-0.02	6.14	-8.27	-2.13	-11.69**
LCA-655 x LCA-453	4.57	-0.91	0.04*	3.70	1.88	5.58	-7.56
LCA-655 x LCA-703-2	24.66**	0.50	-0.04*	-53.29**	-7.19	-60.48**	-17.88**
LCA-655 x LCA-705-2	-15.13**	1.11	0.03	25.80**	0.39	26.19**	19.23**
LCA-655 x LCA-315	11.55**	0.56	0.00	16.44*	10.73*	27.17**	22.51**
LCA-355 x G4	-45.09**	-0.50	-0.04*	15.31*	-3.42	11.89	1.87
LCA-355 x LCA-678	34.18**	-0.74	0.07**	17.97*	49.10**	67.07**	17.00**
LCA-355 x LCA-453	-11.57**	0.55	-0.01	6.52	-31.40**	-24.88*	-12.09**
LCA-355 x LCA-703-2	31.52**	-0.64	-0.03	-36.88**	-13.61**	-50.49**	0.44
LCA-355 x LCA-705-2	4.01	1.45	-0.01	-3.92	9.40	5.49	3.19
LCA-355 x LCA-315	-13.05**	-0.11	0.02	1.00	-10.07*	-9.07	-10.41*
SE (gij)	**3.58**	**0.77**	**0.02**	**6.87**	**4.79**	**9.63**	**4.09**

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

Table 6: Summary of *gca* effects of the parents for quality traits in chilli

S.No.	Parents	Ascorbic acid (mg/100g)	Oleoresin (%)	Capsaicin (%)	Red carotenoids (mg/100g)	Yellow carotenoids (mg/100g)	Total carotenoids (mg/100g)	Total colour value (ASTA units)
Lines								
1	LCA-504	G	P	G	P	G	P	A
2	LCA-615	A	G	P	P	G	P	P
3	LCA-446	G	G	P	A	P	G	G
4	LCA-466	A	P	P	G	P	G	G
5	LCA-442	P	P	P	A	G	P	G
6	LCA-654	P	P	G	G	G	G	G
7	LCA-607	P	A	A	P	G	P	P
8	LCA-655	P	P	P	P	G	P	P
9	LCA-355	A	P	A	G	P	G	G
Testers								
1	G4	G	G	G	P	G	P	P
2	LCA-678	G	A	G	P	P	G	G
3	LCA-453	A	P	G	G	P	G	G
4	LCA-703-2	G	P	P	P	G	P	P
5	LCA-705-2	A	A	A	G	A	G	G
6	LCA-315	P	P	P	P	A	P	P

Where,
G: Good combiner (Significant in desired direction)
A: Average combiner (Non-significant but in desired direction)
P: Poor combiner (Undesired direction)

ACKNOWLEDGEMENT

I extend my deep sense of reverence and gratitude to Associate Dean, Horticultural College and Research Institute, Venkataramannagudem, Dr. Y.S.R.H.U for allotting me to HRS, Lam to take up my research work. I am highly thankful to Dr. Y.S.R. Horticultural University, Venkataramannagudem for providing financial assistance in the form of stipend to complete this endeavour.

REFERENCES

1. Balasubramaniam, T., D. Raj, R. Kasthuri and P. Rengaswami, (1982). Capsaicin and plant characters in chillies. Indian J. Hort., 39(3-4): 239-242.
2. Dudley, J.W. and R.H. Moll, (1969). Interpretation and use of estimates of heritability and genetic variances in plant breeding. *Crop Sci.,* 9: 257-263.
3. Griffing, B., (1956). Concept of general and specific combining ability in relation to diallel crossing system. *Austral. J. Biol. Sci.,* 9: 463-493.
4. Hornero-Mendez, D. and I.M. Minguez-Mosquera, (2001). Rapid spectrophotometric determination of red and yellow isochromic carotenoid fractions in paprika and red pepper oleoresins. *J. Agr. Fd. Chem.,* 49: 3584-3588.
5. Howard, L. R. and R. E. C. Wildman, 2007. Antioxidant vitamin and phytochemical content of fresh and processed pepper fruit (Capsicum annuum). In R. E. C. Wildman (Ed.), Handbook of nutraceuticals and functional foods (2nd ed.,Boca Raton: CRC Press. pp. 165-191.
6. Jindal, S.K., D. Kaur, M.S. Dhaliwal and N. Chawla, (2015). Combining ability and heterosis for qualitative traits in chili pepper (*Capsicum annuum*L.). *Intl. J. Hort.,* 5 (5): 1-13.
7. Kempthorne, O. (1957). An introduction to Genetic Statistics, John Wiley and Sons, New York, pp. 408-711.
8. Khalil, M.R., and M.K. Hatem, 2014. Study on combining ability and heterosis of yield and its components in pepper (*Capsicum annum*, L.). *Alexandria J. Agr. Res.,* 59 (1): 61-71.
9. Kogure, K., S. Goto, M. Nishimura, M. Yasumoto, K. Abe and L. Ohiwa, (2002). Mechanism of potent antiperoxidative effect of capsaicin. *Biochimica et Biophysica Acta*, 157: 84-92.
10. Kranthi Rekha, G. 2015. Development of hybrids and their stability in chilli (*Capsicum annuum* L.). *Ph.D Thesis (Hort.)*, Dr. Y.S.R. Horticultural University, Venkataramannagudem, Andhra Pradesh, India.
11. National Horticulture Board (NHB). 2014. Data Base of Horticulture crops, Gurgaon, New Delhi.
12. Prasad, N.B.C., H.B. Gururaj, V. Kumar, P. Giridhar, R. Parimalan, A. Sharma, G.A. Ravishankar, 2006. Influence of 8-methyl nonenoic acid on capsaicin biosynthesis in vivo and in vitro cell cultures of Capsicum spp. *J. Agr. Fd. Chem.,* 54: 1854-1859.
13. Prasath, D. and V. Ponnuswami, (2008). Heterosis and combining ability for morphological, yield and quality characters in paprika type chilli hybrids. *Indian J. Hort.,* 65(4): 441-445.
14. Ranganna, S. (1986). Handbook of analysis and quality control for fruits and vegetable products. 2nd edition. p: 259. Tata McGraw Hill Publ.Com., New Delhi, India.
15. Richey, F.D. and L.A. Meyar, (1925). Effect of selection on yield of crosses between varieties of corn: USDA Bulletin. 135: 18.
16. Roserbrook, D.D., C.C. Proize and J.E. Barney, (1968). Improved method for determination of extractable colour in capsicum spices. *J. Assn. Offic. Anal. Chem.,* 51: 637-643.
17. Sadasivam, S. and T. Balasubramanian, (1987). Practical manual in Biochemistry. TNAU, Coimbatore. pp: 14.
18. Sprague, G.F. and L.A. Tatum, 1942. General versus specific combining ability in single crosses of corn. *J. Amer. Soc. Agron.,* 34: 923-932.
19. Suryakumari, S., D. Srihari, C. Ravishankar, V. Chengareddy and A. Sivashankar, (2014). Genetic divergence and combining ability studies for exploitation of heterosis in paprika (*Capsicum annuum* L.). *Intl. J. Agr. Sci. Res.*, 4(2): 59-66.
20. Zewdie, Y., P.W. Bosland and R. Steiner, (2001). Combining ability and heterosis for capsaicinoids in *Capsicum pubescens. Hort. Sci.,* 36(7): 1315-1317.

CITATION OF THIS ARTICLE

M. Janaki, J. Dilip Babu, L. Naram Naidu, C. Venkata Ramana. Combining Ability Analysis for Biochemical Traits in Chilli (*Capsicum annuum* L.). Bull. Env. Pharmacol. Life Sci., Vol 7 [9] August 2018: 84-90