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Combining ability analysis for growth and yield characters in chilli (*Capsicum annuum* L)

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ABSTRACT

In the present study the experimental material consisted of six parents and 15 F_1s produced in half-diallel mating design. Analysis of variance for combining ability exhibited the significance for gca and sca effects for all the characters studied. The non-additive effects played a more important role than additive effects. CA-32 was good general combiner for green fruit yield per plant. CA-8 was good general combiner for number of fruits per plant which can be exploited in breeding programme. The maximum sca effect for green fruit yield per plant in F_1 generation was recorded in the cross of CA-23 x CA-32. The hybrids CA-23 x CA-32, CA-8 x CA-23, CA-8 x CA-32 and CA-6 x CA-23 were best specific crosses for several characters on the basis of specific combining ability effect. The results suggested exploitation of hybrid vigour in chilli.

Keywords: Chilli; additive; non-additive; half-diallel; gca; sca

INTRODUCTION

Chilli (*Capsicum annuum* L) is one of the most important commercially grown spices cum vegetables in the world. It belongs to family Solanaceae and has a chromosome number 2n= 24. Many food industries have extracted the oleoresin from chilli and used in preparation of processed products and pharmaceutical preparations. Chillies have two important qualities viz biting pungency attributes due to capsaicin and captivating red colour due to pigment capsanthin. In any breeding programme the proper choice of parents based on their combining ability is a prerequisite which not only provides necessary information regarding the choice of parents but also simultaneously illustrates the nature and magnitude of gene action involved in the expression of desirable traits. Accordingly the present investigation was undertaken to have an idea of the nature of gene action for fruit yield and other important attributes in chilli. Several biometrical methods are available for studying the combining ability and gene action. The diallel cross gives a fairly good idea of both general (gca) and specific (sca) combining abilities of parents and hybrid combinations respectively.

Study of combining ability is important for selecting parents for hybridization. Sprague and Tatum (1942) first time proposed the concepts of gca and sca. According to them gca variance is due to additive variance and sca variance due to non-additive variance both of whom act as an important diagnostic tool in selection of suitable parents and cross combination. The study reported was designed to gather information on the genetics of the characters studied and on the extent of combining ability for yield and its yield attributing traits in chilli.

MATERIAL and METHODS

Six genetically diverse parental lines viz CA 3 (P_1), CA 5 (P_2), CA 6 (P_3), CA 8 (P_4), CA 23 (P_5) and CA 32 (P_6) were crossed in diallel mating design excluding reciprocal to get 15 cross combinations. All the 15 hybrids along with their parents were raised in a randomized block design with three replications during 2014-15. The experiment was conducted at College of Agriculture, Vellayani, Kerala Agricultural University, Thiruvananthapurum, Kerala. The plot size for each treatment was 3.6 x 1.8 m wherein both row to row and plant to plant spacing was 45 x 45 cm. The crop was raised as per the standard package of practices. Timely management practices were followed to grow a good crop. Five plants were randomly selected per plot for recording data on plant height (cm), days to first flowering, fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g), seeds per fruit and green fruit yield per plant (g). Combining ability analysis was performed with the data obtained for parents and hybrids according to Model-I, Method-II proposed by Griffing (1956).

RESULTS and DISCUSSION

The knowledge of combining ability is necessary for selection of appropriate parents in hybridization since it gives an idea whether a particular parent combines well in a cross and also denotes the specific performance of a cross combination against the expectations from the gca of the parents. Sprague and Tatum (1942) used the term combining ability to describe the average performance of a line in a series of cross combinations. The analysis of variance for combining ability was carried out for all eight characters of F_1 diallel crosses (Table 1). The analysis of variance for combining ability showed that gca and sca variances were significant for all the traits. The non-additive effects played a more important role than additive effects. The magnitudes of gca and sca effects are indicative of the relative importance of additive and non-additive gene actions in the inheritance of a trait respectively. The lower $\sigma 2gca/\sigma 2sca$ ratio indicates that the predominance of non-additive (dominance or epistasis) gene action is important for all the traits except fruit girth and fruit weight. The results suggested the possibility of the hybrid vigour exploitation because of the significant non-additive effects for all the traits except fruit

Table 1. Analysis of variance for combining ability in chilli

Character	GCA	SCA	Error	σ^2gca	σ^2sca	σ^2gca/ σ^2sca
Plant height (cm)	70.12**	27.49**	3.14	8.37	24.35	0.34
Days to first flowering	3.86**	7.28**	0.63	0.40	6.64	0.06
Fruits/plant	1422.12**	759.61**	17.35	175.59	742.25	0.23
Fruit length (cm)	7.83**	2.02**	0.32	0.93	1.69	0.55
Fruit girth (cm)	5.63**	0.21**	0.03	0.70	0.17	3.96
Fruit weight (g)	13.72**	1.06**	0.30	1.67	0.76	2.20
Seeds/fruit	270.91**	167.37*	66.55	25.54	100.82	0.25
Green fruit yield/plant (g)	28757.39**	57010.50**	479.62	3534.72	56530.88	0.06

*Significant at 5 per cent level, **Significant at 1 per cent level

girth and fruit weight. These effects could be important in maximizing these traits. However both additive and non-additive gene actions with the latter predominating for days to 50 per cent flowering, days from fruit set to fruit maturity, fruit length and girth, fresh fruit, dry fruit weight and seed weights have also been reported (Bhagyalakshmi et al 1991).

GCA effects of the paprents

The gca effects calculated for each parent are presented in Table 2. It was found that some of the parents were good general combiners for yield characters. Among the six parents the highest and significant gca effect for green fruit yield and yield attributing traits per plant were observed in parent CA 32 (P_6). Good general combiners for yield and yield attributing traits related to chilli were reported by Bhagyalakshmi et al (1991). The estimation of gca effects showed that the parent CA 23 (P_5) showed significant positive general combing ability for fruit girth and fruit weight whereas the parent CA 8 (P_4) was found to be good general combiner for the days to first flowering and number of fruits per plant. Based on gca estimates it was revealed that parent CA 3 (P_1) was a good combiner for number of fruits per plant and fruit length and CA 6 (P_3) for seeds per fruit. Similar kind of results were also reported by Gandhi et al (2000) and Jagadeesha and Wali (2005). Mohite Patil (2011) identified best general combiners for days to first flowering and yield per plant which confirms the results of the present research. The good gca for number of fruits per plant, fruit length and fruit girth was reported by Lippert (1974) and significant gca effect for all characters by Gandhi et al (2000). All these reports confirm the findings of the present investigation.

Although significant gca was observed in all the traits but no parent was found having significant gca in all the traits studied. Considering the situation CA 32 (P_6) and CA 8 (P_4) were indicated as the

Table 2. Estimates of general combining ability effects of parents

Character	P_1 (CA 3)	P_2 (CA 5)	P_3 (CA 6)	P_4 (CA 8)	P_5 (CA 23)	P_6 (CA 32)
Plant height (cm)	-3.54**	0.55	1.28*	-0.79	-2.31**	4.82**
Days to first flowering	1.01**	0.094	0.21	-0.81**	0.27	-0.78**
Fruits/plant	-11.30**	1.94	5.61**	19.90**	-18.05**	1.90
Fruit length (cm)	1.15**	-0.18	-0.18	-0.20	-1.56**	0.99**
Fruit girth (cm)	-0.22**	-0.42**	-0.52**	-0.54**	1.64**	0.06
Fruit weight (g)	0.22	-0.66**	-0.92**	-1.63**	1.66**	1.33**
Seeds/fruit	-0.98	0.76	5.47*	-10.73**	0.80	4.68
Green fruit yield/plant (g)	-77.94**	-14.28*	0.70	13.91	-26.34**	103.95**

*Significant at 5 per cent level, **Significant at 1 per cent level

best general combiners for yield characters. Similar results have also been reported by Jagadeesha and Wali (2008). As none of the parents was a good general combiner for all the traits simultaneously the parents with desirable gca for maximum traits could be selected for use in further breeding programmes.

SCA effect of the crosses

Specific combing ability effects of the crosses in F_1 generation are given in Table 3. The data show that there was a good number of crosses with significant sca effects in desirable direction for growth, yield and yield contributing characters.

The highest sca effect for green fruit yield per plant in F_1 generation was noticed in the cross of CA-23 x CA-32. This cross also showed significant sca effects for other component characters in F_1 like number of fruits per plant, fruit weight, plant height and days to first flowering. Estimated sca values showed that the combinations CA-23 x CA-32 and CA-5 x CA-32 have highly negative significant values for days to first flowering and these crosses were projected as the best hybrids for earliness.

The maximum sca effect was noticed in CA-6 x CA-23 followed by CA-8 x CA-23 for number of fruits per plant. The crosses CA-5 x CA-23 and CA-6 x CA-23 showed significant and desirable sca effects for fruit length. For fruit girth the hybrids CA-3 x CA-8 and CA-6 x CA-23 had significant negative sca effects. Among the hybrids for fruit weight CA-23 x CA-32 had positive and significant sca effects and CA-3 x CA-8 showed negative and significant effects. For seeds per fruit among the hybrids CA-3 x CA-32 had significant and positive sca effect and CA-3 x CA-23 had negative and significant effect. The cross exhibiting significant desirable sca effects for green fruit yield per plant was CA-6 x CA-23 followed by CA-23 x CA-32, CA-5 x CA-23, CA-8 x CA-23, CA-3 x CA-5, CA-6 x CA-32,

Table 3. Specific combining ability effects of hybrids

Character	Plant height (cm)	Days to first flowering	Fruits /plant	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g)	Seeds/fruit	Green fruit yield /plant (g)
P_1 x P_2, CA 3 x CA 5	3.81*	1.03	16.96**	-0.09	-0.17	-0.51	6.90	187.54**
P_1 x P_3, CA 3 x CA 6	-0.54	-1.55*	4.96	0.30	-0.02	0.59	0.53	82.09**
P_1 x P_4, CA 3 x CA 8	4.10*	-0.06	6.00	-0.40	-0.78**	-1.88**	1.73	8.17
P_1 x P_5, CA 3 x CA 23	-9.99**	4.64**	-51.70**	-0.95	0.32	0.005	-15.80*	-402.59**
P_1 x P_6, CA 3 x CA 32	-0.76	-0.02	4.67	-0.01	-0.07	-0.01	27.98**	33.59
P_2 x P_3, CA 5 x CA 6	0.69	1.36	-11.61**	-0.86	0.06	-0.49	-8.22	-112.18**
P_2 x P_4, CA 5 x CA 8	-0.78	-1.81*	-4.24	0.48	0.12	0.56	8.98	0.74
P_2 x P_5, CA 5 x CA 23	2.66	-2.03*	16.71**	2.53**	-0.28	0.99	13.78	217.48**
P_2 x P_6, CA 5 x CA 32	0.96	-2.97**	11.42**	-0.32	0.15	0.20	-5.09	48.44*
P_3 x P_4 CA 6 x CA 8	5.23**	-2.33**	20.08**	-0.37	0.18	-0.05	5.28	54.97*
P_3 x P_5, CA 6 x CA 23	7.87**	-0.81	47.71**	2.71**	-1.23**	0.78	4.40	334.69**
P_3 x P_6, CA 6 x CA 32	-2.74	-1.56*	5.42	0.39	0.29	-0.16	3.19	121.72**
P_4 x P_5, CA 8 x CA 23	2.99	-2.13**	25.08**	0.42	0.07	-0.06	-6.72	205.67**
P_4 x P_6, CA 8 x CA 32	-1.70	0.12	18.13**	0.86	0.01	0.63	11.73	115.05**
P_5 x P_6, CA 23 x CA 32	7.70**	-3.22**	14.75**	1.06	0.01	1.79**	6.19	286.05**

*Significant at 5 per cent level, **Significant at 1 per cent level

CA-8 x CA-32, CA-3 x CA-6 CA-6 x CA-8 and CA-5 x CA-32. Similar kind of results were also reported by Shekhawat et al (2007) and Prasath and Ponnuswami (2008). Similarly many other crosses showed desirable sca effects for more than one component character along with yield per plant in F_1 generation. The crosses which exhibited high desirable sca effects for component characters excluding yield per plant are practically of no use in general plant breeding programme but can be used for the improvement of these characters. Thus it appears that the selection of crosses merely on the basis of per se performance and sca effects may not be helpful but gca effects of the parents should be considered. An ideal combination to be exploited is one with higher degree of sca with higher per se performance and at least one parent with good general combining ability.

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