Vegetable Science (2015) 42 (2) : 116-118

Short Communication

Combining ability analysis for green fruit yield and its component traits in chilli (*Capsicum annuum* L.)

Bhaumik R Patel, B R Patel, J I Nanavati and K B Kathiriya

Received: August, 2014 / Accepted: May, 2015

Chilli is classified under self pollinated crop, natural cross pollination takes place up to the extent of 7 to 60 % (Aiyadurai, 1996). Patel *et al.* (2001) reported that with natural out crossing the average fruit set with male sterile plants varied from 30.22 to 35.99 per cent and on an average it was 32.79 per cent, which was about 118.60 per cent higher than per cent fruit set on GMS lines with hand pollination (14.44 %). Therefore, greater amount of variability is observed in this crop. Combining ability analysis is used in crop plants for identifying the superior parents for obtaining superior hybrid combinations. Besides, it also helps in characterization of nature and magnitude of gene action for various characters of economic importance. The concept of general and specific combining ability is an especially useful testing procedure that involves the study and comparison of the performance of homozygous inbred lines in cross combinations. The knowledge of gene action for characters helps in employing suitable breeding methodology for their improvement.

The present study was conducted at Vegetable Research Station, Anand Agricultural University, Anand (Gujarat) during *Kharif-Rabi* 2011-2012 season with the objective of getting information on combining ability and nature of gene action for fruit yield and its component characters in chilli. Five females having 2 CGMS and 3 GMS *viz.,* [9907-9611 (B line), PBC-483 (B line), ACMS 4, ACMS 6 and ACMS 8] and 8 males *viz.,* (PBC 142, ACG 12, 9955-15R, LCA-206, LCA-436, RHRC PENDT, JCA 283 and G 4) were crossed in line x tester fashion. The experimental materials with 40 F_1s and 13 parents (5 maintainer lines + 8 testers) were planted in RBD with three replications. Each experimental unit was represented by single row accommodating 15 plants with intra and inter row spacing 60 cm. However, experimental unit of GMS lines were planted with two seedlings at every dibble and sterile plants were removed immediately after emergence of crown flower. For recording observations, 5 competitive plants were randomly selected from each treatment in each replication and the average value per plant was computed for various quantitative traits *viz.,* days to flower initiation, plant height, primary branches per plant, secondary branches per plant, fruits per plant, fruit length, fruit girth, fruit weight, pericarp thickness and green fruit yield per plant. Analysis of variance and estimation of combining ability effects were made as per Kempthorne (1957).

Analysis of variance for combining ability (Table 1) revealed that the gca variances and sca variances were highly significant for all the characters except pericarp thickness. This indicates that sufficient variability exists for gca effect in the parents and that for the sca effect in the crosses. This also suggests that both additive and non-additive gene actions were important for the inheritance of all the traits and all the traits used in the study could be improved by proper choice of the parents, their hybridization and by adopting suitable selection methods. The higher magnitude of sca variance was observed for all the characters. High sca variance for yield and other characters have been also reported in chilli by Patel (2004), Reddy *et al.* (2008) and Karthik *et al.* (2009). The variance ratio for general combining ability to specific combining ability (?^{2}gca/?^{2}sca) indicating the role of both additive and non-additive gene action in the inheritance of characters used in present study. This suggested that improvement of these traits could be possible by simultaneous exploitation of both additive and non-additive components.

The information regarding gca effect of the parents is of prime importance as this would help in identification

Anand Agricultural University,
Anand (Gujarat)

of suitable parents. The estimates of gca effect revealed that the female parent ACMS 4 was found good general combiner for green fruit yield per plant as well as for fruits per plant, fruit length, fruit girth and fruit weight. While female parent 9907-9611 (B line) was found good general combiner for green fruit yield per plant as well as for days to flower initiation, secondary branches per plant, fruit girth and fruit weight. Among the male parents, LCA 206 was a good general combiner for green fruit yield per plant as well as for days to flower initiation, plant height, secondary branches per plant and fruits per plant. Another male parent, ACG 12 was appeared to be a good general combiner for green fruit yield per plant as well as for days to flower initiation, plant height, primary branches per plant, fruit length, fruit girth and fruit weight. Other male parent, RHRC PENDT was also good general combiner for fruit yield per plant as well as for primary branches per plant, secondary branches per plant, fruits per plant and fruit weight.

Among the hybrids, ACMS-4 x 9955-15R, CCA-4759 x LCA 206 and ACMS-8 x RHRC PENDT exhibited significant SCA effect for green fruit yield per plant and its important component characters. The estimates of specific combining ability effect revealed that CCA-4758 x 9955-15R for days to flower initiation, CCA-4759 x LCA 206 for plant height, ACMS-4 x PBC for primary branches per plant, CCA-4758 x JCA 283 for secondary branches per plant, CCA-4759 x LCA 206 for fruits per plant, ACMS-8 x PBC 142 for fruit length, CCA-4759 x 9955-15R for fruit girth, ACMS-4 x 9955-15R for fruit weight and ACMS-8 x ACG 12 for pericarp thickness were the best specific cross combinations. The results are in conformity with those obtained earlier by Reddy *et al.* (2008) and Karthik *et al.* (2009). The knowledge of combining ability of parents and hybrids can be of much help in further breeding programmes.

Table 1: Analysis of variance for combining ability for different characters

Sources	Day to flower initiation	Plant height	Primary branches per plant	Secondary branches per plant	Fruits per plant	Fruit length	Fruit girth	Fruit weight	Pericarp thickness	Green fruit yield per plant
σ^2gca	8.31**	12.22**	0.006**	0.03**	90.18**	0.13**	0.03**	-0.01**	0.0003	1176.46**
σ^2sca	13.92**	24.86**	0.03**	0.18**	300.27**	0.36**	0.06**	0.90**	0.0004	117886.30**
Error	4.41	22.79	0.06	0.09	87.14	0.30	0.02	0.34	0.03	2084.30
σ^2gca/ σ^2sca	0.6	0.5	0.2	0.17	0.30	0.36	0.5	-0.01	0.75	0.009

Table 2: General combining ability effect of parents for different characters

Parents	Day to flower initiation	Plant height	Primary branches per plant	Secondary branches per plant	Fruits per plant	Fruit length	Fruit girth	Fruit weight	Pericarp thickness	Green fruit yield per plant
Female parents										
9907-9611 (B line)	-4.27 **	1.33	0.05	0.18 **	2.11	-0.03	0.04 *	0.43 **	0.04	42.47 **
PBC-483 (B line)	-4.27 **	-7.22 **	-0.01	-0.18 **	-17.44 **	-0.78 **	-0.10 **	-0.09	0.01	-78.30 **
ACMS 4	3.82 **	1.39	0.00	-0.21 **	11.67 **	0.59 **	0.14 **	0.23 *	0.03	75.14 **
ACMS 6	4.36 **	4.25 **	0.07	0.15 **	4.85 **	0.09	-0.10 **	-0.39 **	-0.08 *	-16.41 *
ACMS 8	0.36	0.26	-0.11 **	0.06 *	-1.20	0.13	0.01	-0.19 *	0.00	-22.91 **
SE (g_i) female	0.33	0.76	0.04	0.05	1.48	0.09	0.02	0.09	0.03	7.24
Male parents										
PBC 142	-0.71 *	-2.80 **	0.00	-0.09	6.98 **	0.22 *	-0.07 *	-0.42 **	-0.04	-14.15
ACG 12	-2.17 **	3.32 **	0.10 *	-0.17 **	-3.21	0.59 **	0.19 **	0.61 **	0.06	42.63 **
9955 – 15R	4.42 **	-5.02 **	-0.09 *	-0.17 **	-9.91 **	0.29 **	0.49 **	0.17	0.07	-6.48
LCA 206	-2.78 **	7.66 **	0.00	0.22 **	24.61 **	-0.21 *	-0.06 *	0.03	-0.03	107.67 **
LCA 436	2.03 **	-3.95 **	0.00	-0.45 **	-13.81 **	-0.07	0.01	-0.48 **	-0.02	-98.38 **
RHRC PENDT	2.16 **	-0.15	0.15 **	0.30 **	8.25 **	0.08	-0.09 **	0.34 **	0.01	67.83 **
JCA 283	-3.04 **	-0.84	0.08 *	0.39 **	-11.09 **	-0.02	-0.26 **	0.34 **	-0.04	-26.87 **
G 4	0.09	1.78	-0.24 **	-0.04	-1.84	-0.89 **	-0.21 **	-0.58 **	0.00	-72.25 **
SE (g_j) male	0.44	1.00	0.05	0.06	1.96	0.11	0.03	0.12	0.04	9.58

*, ** significant at 5 and 1 % levels of significance, respectively.

Table 3: Specific combining ability effect of crosses for different characters

Hybrids	Day to flower initiation	Plant height	Primary branches per plant	Secondary branches per plant	Fruits per plant	Fruit length	Fruit girth	Fruit weight	Pericarp thickness	Green fruit yield per plant
CCA-4759 X PBC 142	0.67	-6.67**	-0.08	-0.07	-0.23	-0.33	-0.01	-0.34	0.01	-31.38
CCA-4759 X ACG 12	-1.87*	-1.18	0.30**	0.34**	-13.55**	0.00	-0.19**	0.37	-0.12	-34.67
CCA-4759 X 9955-15R	-3.13**	-5.01*	0.02	0.41**	-4.10	-0.22	0.92**	-1.28**	-0.02	-141.13**
CCA-4759 X LCA 206	-0.93	9.08**	-0.01	0.16	41.43**	0.57*	-0.08	-0.21	0.03	151.70**
CCA-4759 X LCA 436	3.93**	-11.58**	-0.21*	-0.71**	0.47	-0.02	-0.31**	0.22	0.01	15.32
CCA-4759 X RHRC PENDT	1.13	8.29**	0.18	0.21	11.91**	0.13	-0.18**	0.62*	0.18*	128.82**
CCA-4759 X JCA 283	1.33	0.81	-0.16	-0.02	-16.50**	0.46*	-0.08	0.59*	0.00	-28.56
CCA-4759 X G-4	-1.13	6.25**	-0.04	-0.32**	-19.45**	-0.59*	-0.08	0.02	-0.10	-60.10**
CCA-4758 X PBC 142	1.33	1.98	-0.02	0.16	-5.76	-0.57*	0.06	0.08	0.01	-3.08
CCA-4758 X ACG 12	1.13	-0.33	-0.05	-0.76**	4.34	0.06	-0.02	-0.68**	-0.16*	-46.03*
CCA-4758 X 9955-15R	-6.13**	6.74**	0.27**	0.10	14.37**	0.00	-0.31**	0.13	0.11	47.94*
CCA-4758 X LCA 206	2.73**	-1.21	-0.09	0.12	-26.64**	-0.30	-0.08	-0.13	0.05	-122.76**
CCA-4758 X LCA 436	-4.40**	-2.03	-0.09	-0.22	14.61**	-0.17	0.07	0.23	-0.01	81.42**
CCA-4758 X RHRC PENDT	4.13**	0.43	-0.03	0.10	-13.28**	0.04	0.07	-0.08	-0.04	-65.87**
CCA-4758 X JCA 283	3.67**	-0.47	0.10	0.94**	12.89**	0.56*	0.10	-0.49*	0.10	21.59
CCA-4758 X G-4	-2.47**	-5.10*	-0.11	-0.43**	-0.53	0.38	0.10	0.93**	-0.05	86.78**
ACMS 4 X PBC 142	-4.42**	4.80*	0.37**	0.11	5.71	-0.74**	0.00	0.47	-0.04	65.68**
ACMS 4 X ACG 12	1.72*	6.46**	-0.25*	0.06	-0.02	0.57*	-0.09	0.79**	0.10	78.66**
ACMS 4 X 9955-15	3.12**	-7.80**	0.00	-0.01	15.01**	1.23**	0.18**	2.82**	0.01	345.99**
ACMS 4 X LCA 206	-3.02**	-0.92	-0.23*	-0.39**	-4.17	-0.36	0.00	0.90**	0.09	80.28**
ACMS 4 X LCA 436	6.85**	5.39**	-0.03	0.87**	-4.26	-0.35	0.09	-0.48	-0.04	-72.01**
ACMS 4 X RHRC PENDT	-2.95**	-4.41*	0.23*	-0.21	-16.48**	-0.94**	0.11	-1.88**	-0.08	-257.49**
ACMS 4 X JCA 283	-5.42**	-3.42	-0.11	-0.63**	1.53	0.04	-0.13*	-1.91**	-0.05	-173.72**
ACMS 4 X G-4	4.12**	-0.11	0.01	0.19	2.69	0.56*	-0.17**	-0.71**	-0.01	-67.40**
ACMS 6 X PBC 142	-1.96*	0.85	-0.03	-0.64**	4.70	-0.27	0.13**	0.38	-0.03	43.64*
ACMS 6 X ACG 12	2.51**	-1.27	0.35**	0.44**	-9.78**	-0.40	0.19**	-0.66**	-0.03	-98.03**
ACMS 6 X 9955-15R	5.91**	4.57*	-0.27**	-0.30*	-13.42**	-0.04	-0.55**	-0.78**	0.02	-127.05**
ACMS 6 X LCA 206	-0.56	0.89	0.24*	-0.08	29.94**	0.24	0.12*	0.26	-0.03	117.66**
ACMS 6 X LCA 436	-2.69**	6.83**	0.04	0.32**	-6.93	-0.18	-0.02	-0.5	-0.01	-54.42**
ACMS 6 X RHRC PENDT	1.17	-5.5**	-0.31**	0.30*	-5.45	0.67**	-0.05	0.87**	-0.05	57.49**
ACMS 6 X JCA 283	-3.96**	-1.41	-0.04	-0.39**	3.52	0.00	0.03	0.73**	0.08	90.74**
ACMS 6 X G-4	-0.42	-4.97*	0.01	0.37**	-2.57	-0.02	0.15*	-0.3	0.05	-30.03
ACMS 8 X PBC 142	4.38**	-0.96	-0.25*	0.45**	-4.42	1.90**	-0.19**	-0.59*	0.05	-74.86**
ACMS 8 X ACG 12	-3.49**	-3.68	-0.35**	-0.07	19.01**	-0.24	0.11	0.17	0.21**	100.08**
ACMS 8 X 9955-15R	0.24	1.5	-0.03	-0.21	-11.87**	-0.97**	-0.24**	-0.89**	-0.12	-125.75**
ACMS 8 X LCA 206	1.78*	-7.85**	0.08	0.21	-40.55**	-0.14	0.04	-0.81**	-0.14*	-226.88**
ACMS 8 X LCA 436	-3.69**	1.39	0.28**	-0.26*	-3.89	0.73**	0.17**	0.53*	0.05	29.69
ACMS 8 X RHRC PENDT	-3.49**	1.19	-0.07	-0.41**	23.30**	0.10	0.05	0.46	-0.02	137.04**
ACMS 8 X JCA 283	4.38**	4.48*	0.20*	0.10	-1.44	-1.05**	0.07	1.07**	-0.13*	89.95**
ACMS 8 X G-4	-0.09	3.92*	0.12	0.19	19.86**	-0.33	0.00	0.05	0.10	70.75**
Range Min.	-6.13	-11.58	-0.35	-0.76	-40.55	-1.05	-0.55	-1.91	-0.16	-257.49
Max.	6.85	9.08	0.37	0.94	41.43	1.90	0.92	2.82	0.21	345.99
SE (S_{ij})±	0.88	2.00	0.10	0.12	3.92	0.23	0.06	0.25	0.07	19.16

*, ** significant at 5 and 1 % levels of significance, respectively.

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