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COMBINING ABILITY ANALYSIS IN THE INTERSPECIFIC CROSSES OF CHILLI

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ABSTRACT

The combining ability of fifteen interspecific hybrids (Capsicum annuum x Capsicum frutescens) produced by crossing the parents in line x tester fashion along with their eight parentals, were tested for disease resistance and yield parameters. Combining ability analysis showed that the line Nenmara Local (60.80) and Thavanur Local (58.28) were alone good general combiners for fruit yield. Four hybrids *viz*., Mavelikkara Local x Jwalasakhi (165.79), Nenmara Local x Vellayani Athulya (135.61), Kayamkulam Local x Jwalamukhi (53.07) and Thavanur Local x Jwalamukhi (50.56) exhibited significant specific combining ability for fruit yield and except kayamkulam local x jwalamukhi all other three hybrids *viz*., Mavelikkara Local x Jwalasakhi (31.85), Nenmara Local x Vellayani Athulya (30.25) and Thavanur Local x Jwalamukhi (17.83)exhibited significant specific combining ability for number of fruits per plant. Nenmara local and jwalasakhi showed both significant general and specific combining ability for fruit yield. There is predominance of non-additive gene action for yield and yield components indicating that multiple parents having good GCA effects might prove to be useful.

INTRODUCTION

Capsicum is an important vegetable species among solanaceous crops. Generally pepper fruits (Capsicum spp.) are among the most consumed vegetables as fresh green or red and dried whole or ground forms in the world. Analysis of genetic diversity is useful in selecting diverse parental combinations, reliable classification of accessions and for exact identification of variety (Bahurupe *et al*., 2013). The success of any crop improvement programme depends upon the nature and magnitude of genetic variability existing in breeding material with which plant breeder is working, choice of parents for hybridization and selection procedure (Meena and Bahadur, 2014). In any breeding programme the proper choice of parents based on their combining ability is a prerequisite. This not only provides necessary information regarding the choice of parents but also simultaneously illustrate 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 combining ability between Capsicum frutescens with multiple resistance and Capsicum annuum with desirable fruit characters. The compatibility between Capsicum frutescens and Capsicum annuum had been reported variably by different workers. Both compatible and incompatible crosses have been obtained and it had been found that the compatibility mainly depends on the variation in genotypes. Hence screening of crosses and selection of desirable hybrids is to be attempted with line x tester analysis in this study.

MATERIALS AND METHODS

Five Capsicum frutescens local accession lines named as Mangalapuram Local (L1), Thavanur Local (L2), Kayankulam Local (L3), Mavelikkara Local (L4) and Nenmara Local (L5) and three Capsicum annuum testers which were commercial cultivars namely Jwalamukhi (T1), Jwalasakhi (T2) and Vellayani Athulya (T3) were crossed in line x tester design to obtain fifteen hybrids.

The experiment was conducted in Randomized Block Design (RBD) with three replications. Plot size was 5 x 0.75 m^2 with a spacing of 50 cm between plants and 75 cm between rows. Ten plants were maintained in each plot.

During the experiment, pepper plants were grown according to the regular recommendations for the pepper crop such as weeding, fertilization and irrigation. Pesticide application was avoided to build up white fly population. Five harvests were made and the following sixteen agronomic characteristics were assessed: plant height (PH) (measured in centimeters when 50% of the plants in the plot produced ripe fruits); number of branches (PB) (number of primary branches arising from main stem was counted at final harvest); number of days to first flowering (DF)(number of days from transplant to production of first flower); plant spread (PS) (measured in centimeters, when 50% of the plants in the plot produced ripe fruits); duration of flowering or fruiting span(FS)(number of days from first flowering to final harvest); number of fruits per plant (NFP) (sum of the number of fruits obtained in the five harvests); fruit length (FL) (measured in centimeters considering ten fruits per plant); fruit width (FW)((measured in centimeters considering

Table 1: Mean values of 16 characters in chilli (Capsicum spp)

Sl.No	Treatments	PH	PB	DF	PS	FS	NFP	FL	FW	PFR	DC	AFW	NS	SW	VS	VP	YP
1.	L1	57.67	5.8	98.2	46.6	121.1	62.42	6.16	0.82	0.43	0.83	28.33	0.49	215.97	0.81(5.16)	0.27(2.99)	107.51
2.	L2-	65.4	4.93	96.87	50.73	115.4	42.53	6.33	1.21	0.41	1.95	41.2	0.62	208.93	0.81(5.16)	0.38(3.54)	136.8
3.	L3	66.23	7.1	101.77	45.48	126.5	63.13	7.04	0.99	0.48	1.57	47.81	0.47	221.6	3.56(10.88)	0.44(3.82)	127
4.	L4	41.73	8	94.93	45	129.57	37	3.52	1.57	0.5	2.13	62.27	0.49	217.83	0.81(5.16)	0.23(2.76)	123.53
5.	L5	57	6	101.97	54.07	129.3	65.53	6.73	1.31	0.4	1.95	55.3	0.67	224.6	0.81(5.16)	0.30(3.12)	139.25
6.	T1	39.47	4.83	54	33.07	78.07	15.13	12.62	1.73	0.26	6.18	50.46	0.58	132.07	66.83(54.83)	5.65(13.76)	89.2
7.	T2	40.27	5.07	51.17	31.73	80.83	14.77	12.41	1.59	0.26	5.45	51.9	0.53	132	58.40(49.83)	6.01(14.19)	67.37
8.	T3	35.55	4.95	51.53	19.42	83.13	12.99	12.34	1.76	0.22	6.32	94.2	0.47	134.67	63.41(52.78)	6.79(15.11)	83.1
9.	L1 x T1	51.23	6.67	65.37	36.27	63.67	75.6	5.67	0.81	0.48	1.02	29.74	0.37	129.03	23.25(28.83)	3.12(10.18)	39.97
10.	L1 x T2	59.58	7.9	62	52.05	84.57	91.06	6.13	0.88	0.44	0.81	29.73	0.55	146.57	7.62(16.02)	1.12(6.09)	70.27
11.	L1 x T3	62.17	7.07	66.3	45.6	78.37	53.97	6.06	0.77	0.48	0.74	20.79	0.43	144.67	3.54(10.85)	0.77(5.03)	38.43
12.	L2 x T1	48	6.43	63.93	52.35	109.33	86.33	9.49	1.54	0.32	2.37	68.68	0.59	173.27	32.58(34.81)	3.73(11.13)	219.3
13.	L2 x T2	52.6	6.47	57.2	43.33	101.67	62.53	9.46	1.5	0.32	3.13	65	0.58	158.87	26.02(30.67)	3.05(10.06)	187.97
14.	L2 x T3	52.52	7.87	67.5	45.3	105.83	59.67	10.46	1.67	0.25	4.07	69.73	0.57	173.33	39.36(38.86)	4.27(11.92)	226.33
15.	L3 x T1	54.56	6.4	65.9	41.47	104.23	58.8	10.29	1.48	0.35	2.47	75.73	0.46	170.13	34.48(35.96)	4.01(11.56)	146.07
16.	L3 x T2	58.79	8.17	68.53	47.54	106.73	63.13	11.01	1.3	0.34	3.15	62.4	0.51	175.27	28.22(32.09)	3.47(10.73)	197.2
17.	L3 x T3	49.93	7.73	68.77	35.47	102.6	25.6	11.47	1.52	0.29	2.67	57.33	0.51	171.37	21.46(27.60)	2.60(9.29)	63.1
18.	L4 x T1	38.77	9.25	62	30.06	91.87	28.78	4.13	1.61	0.45	2.55	67.53	0.46	153.87	25.00(30.00)	3.12(10.17)	31.83
19.	L4 x T2	52.07	8.8	68.37	53.17	103.2	91.8	7.63	1.94	0.41	4.08	90.17	0.5	171.57	8.16(16.60)	1.11(6.05)	368.97
20.	L4 x T3	24.1	9.03	50.97	21.67	91.6	20.77	6.88	2.61	0.35	3.08	93.47	0.63	142.57	33.26(35.22)	3.96(11.48)	63.2
21.	L5 x T1	47.49	7.9	59.73	50.85	114.3	49.33	7.07	1.48	0.34	2.18	76.13	0.47	174.03	26.02(30.67)	2.99(9.96)	115.12
22.	L5 x T2	52.27	7.67	67.4	54.55	104.1	57.27	10.63	1.46	0.31	3.1	61.6	0.47	171.5	36.37(37.09)	4.35(12.05)	182.77
23.	L5 x T3	55.6	8.33	66.6	49.87	108.97	80.27	10.59	1.68	0.24	4.4	76.92	0.58	175.57	8.16(16.60)	1.09(5.99)	343.27
	CD (0.05)	8.3	1.72	5.37	9.73	9.28	14.12	1.29	0.15	0.05	0.62	9.57	0.05	9.16	11.56	2.83	38.84
	SE	4.92	1.02	3.18	5.76	5.5	8.44	0.77	0.09	0.03	0.37	5.67	0.03	5.42	6.85	1.68	23.01

Transformed values in brackets

ten fruits per plant); pedicel - fruit ratio (PFR) (the ratio between length of the pedicel and fruit length including pedicel considering ten fruits per plant); average fruit weight (AFW) (average weight in grams of ten fruits per plant during second harvest); number of seeds per fruit (NS) (average number seeds in ten dried ripe fruits) hundred seed weight (SW) (average weight of hundred seeds in g considering ten dried ripe fruits); duration of crop (DC)(number of days from sowing to final harvest)green fruit yield per plant (YP) (sum of the yield obtained in each harvest measured in g) vector population (VP) and virus disease scoring (VS).

Analysis of variance was performed for each character as per the procedure suggested by Panse and Sukhatme (1985). Combining ability analysis was performed according to Kempthorne (1957) to estimate the general and specific combining abilities of the parents and hybrids.

RESULTS AND DISCUSSION

Significant variation was observed among yield and yield component traits for majority of the characters (Table 1). The analysis of variance for combining ability for yield and yield component traits is presented in Table 2. Lines varied significantly for number of branches, duration of flowering, fruit length, fruit width, pedicel - fruit ratio, average fruit weight, number of seeds per fruit and duration of crop while testers exhibited significant variation for fruit length and pedicel - fruit ratio alone. Line x Tester interaction mean square was significant for all the characters except number of branches, pedicel - fruit ratio and average fruit weight. The general combining ability (GCA) were significant in all the characters studied and specific combining ability (SCA) for all the characters except number of branches. In GCA vs SCA significant differences were observed for majority of the characters except plant height, plant spread, fruit length and pedicel - fruit ratio.

The GCA effects calculated for each parent are presented in Table 3. Among the 14 parents, the highest positive and significant GCA effects for green fruit yield per plant was observed in Nenmara Local (60.80) and Thavanur Local (58.28). The parent Thavanur Local was good combiner for fruit length and hundred seed weight while the parent Nenmara Local exhibited high GCA for number of seeds per fruit and plant spread.

Mangalapuram local had high GCA for plant height, duration of flowering, number of fruits per plant, duration of crop and along with Mavelikkara local for pedicel - fruit ratio. Mavelikkara local was found to have good GCA for number of seeds per fruit, number of branches and fruit width. Four hybrids viz., Mavelikkara Local x Jwalasakhi, Nenmara Local x VellayaniAthulya, Kayamkulam Local x Jwalamukhi and Thavanur Local x Jwalamukhi exhibited significant SCA effects (Table 4) for fruit yield and except kayamkulam local x jwalamukhi all other three exhibited significant specific combining ability for number of fruits per plant. Nenmara local and jwalasakhi showed both significant general and specific combining ability for fruit yield.

Significant differences were noted for all characters among GCA and for SCA except number of branches. Navhale *et al.*,

Table 2: MSE for combining ability for various characters in chilli (*Capsicum spp*)

Source	PH	PB	DF	PS	FS	NFP	FL	FW	PFR	DC	AFW	NS	SW	VS	VP	YP
Replication	509.2**	19.5**	53.8	415.5**	9.8	188.2	2.33	0.003	0.0003	1842.78	0.04	69.28	0	11.96	581.45**	9.51
Treatments	311.5**	5.5**	818.3**	308.3**	936.3**	1801.4**	22.4**	0.524**	0.0229**	24098.64**	7.68**	1271.75**	0.02**	2699.66**	714.30**	45.89**
GCA	467.1**	4.1*	74.1**	405.8**	559.9**	1579.0**	37.4**	0.365**	0.0353**	2151.83*	15.48**	1100.62**	0.02**	680.29**	1730.07**	99.86**
GCA vs SCA	0.91	55.1**	1756.8**	160.8	1602.8**	6693.4**	0.1	0.185**	0.0034	29890.88**	6.48**	1297.71**	0.01**	5851.94**	317.45*	64.76**
SCA	255.9**	2.7	4666.4**	270.1**	1539.8**	1541.7**	16.5**	0.628**	0.0181**	34658.31**	3.87**	1355.46**	0.02**	8904.87**	234.76**	17.56**
Lines	488.5	6.2*	64.1	354.3	1653.5**	1263.8	45.4**	1.754**	0.0511**	40692	9.47**	4148.80**	0.02	1800.41**	338.58	20.81
Tester	222.2	1.9	6.5	452.5	46.7	2367	14.5*	0.315	0.0159**	31449.82	3.33	16.7	0.02	86.35	175.45	15.27
Lines x Tester	148.1**	1.1	96.1**	182.4**	141.5**	1474.4**	2.6*	0.143**	0.0022	32443.58**	1.21	293.48**	0.01**	268.72**	197.68*	16.51**
Error	36.24	1.56	15.13	49.82	45.34	106.83	0.88	0.013	0.0012	794.38	0.21	48.27	0	44.14	63.67	4.21

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

Table 3: General combining ability (GCA) effect of lines and testers for 14 characters

Treatments	PH	PB	DF	PS	FS	NFP	FL	FW	PFR	DC	AFW	NS	SW	YP
L1	7.02*	-0.5	0.52	0.67	-22.54**	13.22**	-2.51**	-0.66**	0.11**	-22.02**	-1.80**	-36.24**	-6.05**	-103.36**
L2	0.39	-0.79	-1.16	3.03	7.54*	9.18	1.34**	0.08	-0.06**	6.38	0.53	4.8	0.07**	58.28**
L3	3.78	-0.28	3.7	-2.48	6.45*	-11.15*	2.46**	-0.04	-0.03**	10.15	0.11	2.16	-0.02	-17.46
L4	-12.33**	1.32*	-3.59	-9.01**	-2.51	-13.21**	-2.25**	0.57**	0.04**	-6.11	0.58	20.72**	0.02	1.75
L5	1.14	0.25	0.54	7.79*	11.05**	1.96	0.96	0.05	-0.06**	11.59	0.57	8.55**	-0.01	60.80**
CD	7.66	1.59	7.21	8.98	8.57	13.16	1.2	0.15	0.04	8.46	0.96	8.84	0.05	35.87
SE	2.84	0.59	2.67	3.33	3.17	4.87	0.44	0.05	0.02	3.13	0.36	3.28	0.02	13.29
T1	-2.64	-0.38	-0.65	-1.77	-1.39	-0.56	-1.13**	-0.09*	0.03**	-2.04	-0.54	0.57	-0.04**	-42.46**
T2	4.42	0.09	0.66	6.16*	1.98	12.83**	0.51	-0.06	0.01	2.65	0.2	-1.22	0.01	48.51**
T3	-1.78	0.29	-0.01	-4.39	-0.6	-12.27**	0.63	0.16**	-0.04**	-0.61	0.34	0.65	0.03*	-6.05
CD	5.94	1.23	5.59	6.96	6.64	10.19	0.93	0.11	0.03	6.55	0.74	6.85	0.04	27.79
SE	2.2	0.46	2.07	2.58	2.46	3.77	0.34	0.04	0.01	2.43	0.28	2.54	0.01	10.29

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

Table 4: Specific combining ability (SCA) effect of lines x tester hybrids for 14 characters

Treatments	PH	PB	DF	PS	FS	NFP	FL	FW	PFR	DC	AFW	NS	SW	YP
L1 x T1	-3.79	-0.16	1.46	-6.6	-10.48	2.62	0.85	0.0864	-0.01	-9.02	0.7	-1	-0.04	32.87
L1 x T2	-2.49	0.6	-3.22	1.25	7.05	4.69	-0.33	0.1264	-0.04	3.83	-0.25	0.33	0.09**	-27.8
L1 x T3	6.29	-0.44	1.76	5.35	3.43	-7.3	-0.52	-0.2129*	0.05	5.18	-0.45	0.67	-0.06	-5.07
L2 x T1	-0.4	-0.11	1.71	7.13	5.11	38*	0.82	0.0687	-0.01	6.82	-0.28	5.67	0.05	50.56*
L2 x T2	-2.86	-0.54	-6.34	-9.82	-5.93	-19.81*	-0.85	-0.0047	0.02	-12.27*	-0.26	-4.67	-0.01	-71.75**
L2 x T3	3.26	0.65	4.63	2.69	0.82	2.43	0.03	-0.064	-0.01	5.45	0.54	-1	-0.04	21.19
L3 x T1	2.77	-0.65	-1.18	1.75	1.1	10.18	0.5	0.1487	-0.01	-0.08	0.24	0.11	0.01	53.07*
L3 x T2	-0.05	0.65	0.14	-0.11	0.23	1.12	-0.42	-0.0647	0.01	0.36	0.19	1.44	0.01	13.23
L3 x T3	-2.71	0.01	1.04	-1.64	-1.33	-11.3	-0.08	-0.084	0	-0.28	-0.43	-1.56	-0.02	-66.30**
L4 x T1	3.09	0.6	2.21	-3.14	-2.3	-17.78*	-0.95	-0.3413*	0.02	-0.09	-0.15	-7.11	-0.03	-80.37**
L4 x T2	9.34	-0.32	7.26*	12.04*	5.66	31.85**	0.91	-0.0447	0	12.92*	0.64	-5.78	-0.04	165.79**
L4 x T3	-12.43*	-0.29	-9.47**	-8.91	-3.36	-14.07	0.04	0.3860**	-0.02	-12.83*	-0.49	12.89**	0.07*	-85.42**
L5 x T1	-1.66	0.32	-4.19	0.86	6.57	-12.4	-1.23	0.0376	0.01	2.37	-0.51	2.33	0.01	-56.14**
L5 x T2	-3.94	-0.39	2.16	-3.36	-7.01	-17.85*	0.7	-0.0124	0.01	-4.85	-0.33	8.67	-0.05	-79.47**
L5 x T3	-3.79	-0.16	1.46	-6.6	-10.48	30.25**	0.85	-0.0251	-0.01	2.47	0.7	-11	0.04	135.61**
CD	13.27	2.75	12.49	15.56	14.84	22.79	2.08	0.25	0.08	62.13	1.67	15.32	0.08	14.65
SE	4.92	1.02	4.63	5.76	5.5	8.44	0.77	0.09	0.03	23.01	0.62	5.67	0.03	5.42

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

2014 reported that analysis of variance for combining ability exhibited the significance for GCA and SCA effects for all the characters studied and Tembhurne and Rao 2012 for most of the characters whereas Gawande *et al*., 2015 reported that variance due to lines was non significant for all the characters under study except average fruit weight and 1000 seed weight while variance due to testers was non significant for all the traits. In accordance with Payakhapaab *et al*., 2012 in this study also there was no parental lines which showed a good appearance in all but some parents show a high general combining ability value in some characteristics. The SCA variance was greater than GCA variance for all the characters indicating that non-additive gene action is predominant than additive gene action. Khalil and Hatem 2014 also reported that the high ratio of GCA: SCA mean squares showed that GCA effect was more important than SCA effect. These results are in conformity with the findings of Reddy *et al*. (2008) and Hasanuzzaman and Faruq (2011). Combining ability study revealed higher SCA variance than GCA variance for all the traits except plant spread, fruit length, fruit diameter, average dry fruit weight, dry fruit recovery and seed weight indicating the prevalence of non-additive gene action (Rekha *et al*., 2016).There is predominance of non-additive gene action for yield and yield components. Hence it is difficult to bring together desirable genes by pedigree method. Under these circumstances, multiple parents having good GCA effects as suggested by Jensen (1970) might prove to be useful.

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