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Heterosis and combining ability for morphological, yield and quality characters in paprika type chilli hybrids

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ABSTRACT

Hybrids, utilizing six diverse genotypes Arka Lohit, MDU Y, S 1, Arka Abir, Bydagi Kaddi and Co 4 were evaluated for general and specific combining ability, variance components and standard heterosis. Among the lines Bydagi Kaddi, MDUY and Arka Abir were found to be good general combiners for yield and quality characters. The estimates of *gca* and *sca* variance for all the characters except for leaf area index, dry yield per hectare and capsaicin suggested preponderance of additive gene action than non additive. The cross combination MDU Y × Co 4 had desirable significant *sca* effects for yield and quality characters namely fresh yield, dry yield, total extractable colour and capsaicin. The estimates of heterosis over best parent ranged from 40.35 to 126.32 percent for the character dry yield per hectare. In the present study based on *per se* performance, heterosis and *sca* effects, the hybrids Bydagi Kaddi × Arka Abir and MDU Y × Co 4 were found superior in respect of total extractable colour, low capsaicin besides dry yield and contributing characters.

Key words: Chilli, combining ability, heterosis, capsaicin, extractable colour.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is commonly cultivated for use as spice (red ripe fm) or vegetables (green fruits) in many countries. India is the leading producer, consumer and exporter of chillies. It is used as an essential condiment in foods for its pungency and red colour. Some varieties are famous for colour because of the pigment capsanthin, others are known for pungency attributed by capsaicin. The fluctuation in the market price and export, due to strong competition from other producing countries over the years, has become less remunerative for hot chilli production. Whereas market for less pungent paprika types has been growing steadily and mainly used as natural food colourant in the form of oleoresin. In India, paprika types are not suitable for all the chilli growing areas and this necessitated the development of less pungent paprika type chilli hybrids to tap the paprika oleoresin market. Chilli has been classified under self-pollinated crop, but the extent of natural out crossing has been reported upto 66. 4 percent (Singh *et al*., 12) and it has a substantial amount of non-additive genetic variance, hybrid vigour for yield (Gopalakrishnan *et al*., 4; Doshi and Shukla, 3) and quality (Sharma and Saini, 9), which can be exploited profitably through heterosis breeding. It is very much essential to find out the combining ability of the desirable genotypes to involve in breeding programme, for effective transfer of desirable genes controlling both quantitative and qualitative traits in the resultant progenies. The main objective of this investigation was to identify good general and specific combiners and heterotic cross combinations for yield, its component traits and quality in paprika type chilli.

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MATERIALS AND METHODS

Six genetically diverse parental lines Arka Lohit (P1), MDU Y (P2), S 1 (P3), Arka Abir (P4), Bydagi Kaddi (P5) and Co 4 (P6) were crossed with each other in diallel mating design, both as direct and reciprocal to get 30 cross combinations. All the 30 hybrids along with their parents were raised in a randomized block design with three replications during 2004-05. The experiment was conducted at Tamil Nadu Agricultural University, Horticulture College and Research Institute, Coimbatore, Tamil Nadu and each plot consisted of 2 rows of 4 m length spaced at 60 cm x 45 cm. The observations were recorded on 13 morphological, yield and 3 quality characters from five competitive plants selected randomly from each plot. The colour value of chilli pod was estimated as per the standard procedure (Woodbury, 13) and expressed in ASTA units. The capsaicin content in dry fruit was estimated by adopting the procedure given by Sadasivam and Manikam (8). The dried fruit samples were finely ground and sieved through No. 40 sieve. Two grams of the ground powder was taken in 100-ml volumetric flask. The volume was made up to 100 ml with 0.01 percent ethyl acetate and it was kept as such for 24 hours. Then one ml of extract was taken and diluted to five ml with ethyl acetate. To that 0.5 ml of vanadium oxychloride solution was added and shaken well. The samples were then read at 720 nm in spectrophotometer. The standard curve was drawn using 0.5, 1.0, 1.5, 2.0 and

2.5 ml of standard solution containing 50, 100, 150, 200 and 250 mg capsaicin respectively. The capsaicin content of chilli fruit was estimated using the following formula and expressed in percent.

$$\% \text{ capsaicin} = \frac{\mu\text{g capsaicin}}{1000 \times 1000} \quad \frac{100}{1} \quad \frac{100}{2}$$

Five grams of finely ground paprika chilli powder was taken. The oleoresin content was estimated by solvent extraction method using acetone and expressed in percent. Heterosis in F_1 hybrids was estimated for each trait based on all the criteria using best parent mean values (Gowen, 5). The mean values of each genotype were subjected to combining ability analysis by diallel method of Griffing's approach (Griffing, 6).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) revealed significant differences among the genotypes for all the characters studied except for capsaicin content indicating wider genetic difference among them. The magnitude of gca variances for all the characters studied except for leaf area index, dry yield per hectare and capsaicin, was higher than their corresponding sca variances in all crosses suggesting preponderance of additive gene action than non-additive. Similar results have also been reported in chilli (Ahmed *et al*., 1). The magnitude of sca was high for leaf area index, dry yield per hectare and capsaicin indicating the preponderance of non additive genetic effects. High *sca* variances for yield per plant was also reported by Singh (10). The general combining ability (*gca*) effects (Table 2) revealed that none of the parents were found to be good general combiner for all the characters. However, among the parents P5 (Bydagi Kaddi) and P2 (MDUY) were good general combiner for as many as five characters on the strength of the magnitude of *gca* effects for various traits. The parent P4 (Arka Abir) was good general combiner for quality characters like total extractable colour, capsaicin and oleoresin content. The results are in agreement with Bhagyalakshmi *et al*. (2).

The specific combining ability effects (Table 3) showed that the cross combination P1 × P3 (Arka Lohit × S1) exhibited highly significant *sca* effects for seven characters, followed by the cross combination P4 × P5 (Arka Abir × Bydagi Kaddi) for six characters and P4 × P5 was the only hybrid with significant *sca* for leaf area index. The desirable significant sca effects for yield and quality characters namely fresh yield, dry yield, total extractable colour and capsaicin was recorded in the cross P2 × P6 (MDU Y × Co 4), whereas, P2 × P4 (MDU Y × Arka Abir) exhibited significant high *sca* effects for four fruit characters (fruit length, fruit girth, individual green and dry fruit weight). These crosses exhibited significant *sca* effects indicating the presence of dominance and epistatic (non-additive) gene action. Similar results were reported by Bhagyalakshmi *et al*. (2), and Singh and Hundal (11). The estimate of heterosis over best parent is presented in Table 4 and several crosses were promising with highly significant and positive heterosis for different characters studied. Heterosis over best

Table 1. Analysis of variance for combining ability for 18 characters in paprika type chillies.

Character	Genotypes	Error	GCA	SCA
Plant height	1085.16**	37.89	2012.69**	492.36**
Branches per plant	566.57**	15.91	1043.57**	288.65**
Days to first flowering	22.85**	0.55	27.40**	4.92**
Days to 50 percent flowering	24.68**	1.10	44.29**	5.08**
Leaf area index	0.03**	0.01	4.14**	4.74**
Fruits per plant	1127.49**	37.58	1578.36**	756.04**
Fruit length	9.32 **	0.55	11.43**	6.83**
Fruit girth	1.73 **	0.08	2.48**	1.66**
Seeds per fruit	737.42**	121.27	886.04**	289.96**
Individual green fruit weight	33.47 **	0.80	58.59**	18.80**
Individual dry fruit weight	1.59**	0.02	2.73**	0.90**
Fresh yield per plant	123157.0**	8223.63	104071.0**	97704.65**
Dry yield per hectare	6.78**	0.24	3.62**	6.60**
Total extractable colour	3643.78**	64.94	8483.90**	1372.79**
Capsaicin	0.32	0.05	0.16**	0.33**
Oleoresin	3.34**	0.27	2.87**	2.74**

*Significant at 5 % level, ** significant at 1 % level.

Table 2. General combining ability effects of parents for yield and other characters.

Character	P1	P2	P3	P4	P5	P6
Plant height	19.29**	-12.85**	-0.03	9.99**	-14.00**	-2.40*
Branches per plant	8.79**	-17.63**	4.20**	4.98**	-1.58*	1.24
Days to first flowering	1.18**	-1.08**	1.02**	1.84**	-1.33**	-1.62**
Days to 50 percent flowering	1.20**	-0.65*	1.79**	1.60**	-1.81**	-2.12**
Leaf area index	-0.05*	0.00	-0.01	-0.05*	0.07**	0.04*
Fruits per plant	15.81**	-19.61**	-2.61*	1.18	3.43**	1.81
Fruit length	-1.39**	1.40**	-0.33*	0.14	0.70**	-0.51**
Fruit girth	-0.66**	0.66**	-0.08	-0.25**	0.31**	0.03
Seeds per fruit	1.19	9.61**	-3.35	-1.14	7.86**	-14.18**
Individual green fruit weight	-2.97**	3.70**	-0.32	-0.27	0.87**	-1.02**
Individual dry fruit weight	-0.59**	0.82**	-0.20**	0.15**	0.06	-0.24**
Fresh yield per plant	-79.68**	-23.97	-109.99**	-8.45	144.37**	77.72**
Dry yield per hectare	-0.27**	-0.37**	-0.71**	0.11	0.71**	0.53**
Total extractable colour	-33.38**	19.33**	-27.76**	16.52**	31.14**	-5.85**
Capsaicin	0.28**	-0.11**	0.36**	-0.16**	-0.25**	-0.12**
Oleoresin	0.19	-0.09	-0.45**	0.74**	-0.60**	0.20*

* significant at 5 % level, ** significant at 1 % level.

Table 3. Hybrid combinations with desired significant *sca* effects together with type of *gca* combination.

Character	Significant crosses	*sca* effect	Ranking on *gca* basis
Plant height	P4 × P6, P1 × P3, P6 × P4	21.50, 18.63, 15.50	GXP, GXP, PXG
Branches per plant	P3 × P5, P1 × P2, P1 × P6	23.08, 19.06, 13.61	GXP, GXP, GXA
Days to first flowering	P4 × P2, P3 × P2, P1 × P5	-3.35, -3.00, -2.83	PXG, PXG, PXG
Days to 50 percent flowering	P4 × P2, P3 × P4, P3 × P2	-4.35, -2.88, -2.85	PXG, PXP, PXG
Leaf area index	P4 × P5	0.14	PXG
Fruits per plant	P1 × P3, P4 × P5, P1 × P2	28.36, 24.94, 21.11	GXP, AXG, GXP
Fruit length	P2 × P4, P3 × P6, P2 × P3	2.79, 2.36, 2.00	GXA, PXP, GXP
Fruit girth	P2 × P4, P1 × P5, P1 × P6	1.29, 1.16, 1.05	GXP, PXG, PXA
Seeds per fruit	P4 × P5, P3 × P6, P1 × P2	17.06, 14.06, 11.97	GXP, AXP, AXG
Individual green fruit weight	P2 × P4, P3 × P5, P1 × P5	7.21, 2.17, 1.72	GXP, GXA, PXG
Individual dry fruit weight	P2 × P4, P2 × P5, P4 × P2	1.85, 0.44, 0.39	GXG, GXA, GXG
Fresh yield per plant	P3 × P5, P1 × P3, P2 × P6	221.12, 284.34, 230.54	PXG, PXP, PXG
Dry yield per hectare	P1 × P3, P4 × P5, P2 × P6	3.18, 2.72, 2.03	PXP, AXG, GXG
Total extractable colour	P2 × P6, P1 × P5, P5 × P6	37.64, 27.66, 23.25	GXP, PXG, GXP
Capsaicin	P2 × P6, P1 × P3, P1 × P4	-0.32, -0.28, -0.22	GXG, PXP, PXG
Oleoresin	P5 × P6, P1 × P3, P1 × P4	1.69, 1.22, 1.12	PXG, AXP, AXG

(G – good, P – poor, A – average).

parent ranged from –40.35 to 126.32 percent for the character dry yield per hectare and out of 30 hybrids, 23 cross combinations exhibited positive and highly significant heterosis values. Ten crosses exhibited significant and positive heterosis for total extractable colour and maximum of 33.03 was recorded in P5 × P4 (Bydagi Kaddi × Arka Abir). The expression of heterosis for low capsaicin was not so encouraging, as only 8 crosses exhibited negative heterosis and out of which 6 were significant. Similar trend was reported by Mishra *et al*. (7), and Doshi and Shukla (3). The high heterotic response as observed in most of the crosses further supported the predominant role of non-additive component in the inheritance of the character studied.

Evaluation of hybrids based on combination of *per se, sca* and heterosis parameters would be more meaningful than on individual parameters. In the

Table 4. *Per se* performance of parents, crosses and standard heterosis for different characters.

Character	*Per se* performance of crosses		Range of standard heterosis (%)	Significant crosses
	Mean	Range		
Plant height	109.12	75.40 – 149.35	16.81 to 131.37	P4 × P6, P1 × P3, P4 × P1
Branches per plant	53.72	25.13 – 79.46	-42.22 to 82.68	P1 × P6, P3 × P5, P3 × P4
Days to first flowering	65.40	60.20 – 70.50	-3.22 to 13.34	P2 × P6, P2 × P1, P3 × P6, P6 × P5
Days to 50 percent flowering	70.80	65.20 – 77.60	-3.99 to 14.62	P2 × P1, P2 × P6, P5 × P6, P6 × P5
Leaf area index	1.28	1.02 – 1.48	-6.01 to 36.63	P5 × P4, P5 × P6, P5 × P3, P4 × P5
Fruits per plant	12.15	9.49 – 16.71	-22.94 to 137.61	P3 × P1, P5 × P4, P4 × P5, P1 × P5
Fruit length	4.98	3.08 – 6.87	-20.59 to 39.85	P2 × P4, P2 × P3, P4 × P2, P5 × P2
Fruit girth	11.10	6.23 – 21.82	-41.82 to 29.90	P2 × P4, P4 × P2, P2 × P3, P6 × P2
Seeds per fruit	2.34	1.52 – 5.43	-8.24 to 87.65	P2 × P3, P5 × P2, P2 × P4, P4 × P5
Individual green fruit weight	88.13	42.00 – 129.50	-58.60 to 45.08	P5 × P3, P3 × P5, P4 × P1, P5 × P6
Individual dry fruit weight	779.44	279.26 – 1195.52	-44.60 to 90.60	P2 × P4, P4 × P2, P4 × P3, P3 × P4
Fresh yield per plant	6.04	2.43 – 9.21	-51.84 to 99.04	P2 × P6, P2 × P1, P3 × P6, P6 × P5
Dry yield per hectare	113.48	78.00 – 159.50	-40.35 to 126.32	P4 × P5, P5 × P6, P2 × P6, P6 × P2
Total extractable colour	158.66	80.50 – 228.29	-53.09 to 33.03	P5 × P4, P4 × P5, P5 × P6, P2 × P6
Capsaicin	0.84	0.20 – 1.27	-53.57 to 202.38	P6 × P2, P2 × P6, P5 × P4, P4 × P5,
Oleoresin	14.64	12.35 – 16.61	-9.43 to 21.83	P4 × P1, P5 × P6, P1 × P3, P4 × P6

present study based on *per se* performance, heterosis and *sca* effects, the hybrids P4 × P5 (Bydagi Kaddi × Arka Abir) and P2 × P6 (MDU Y × Co 4) were found superior in respect of total extractable colour, low capsaicin besides dry yield and contributing characters. The two short listed hybrids may be tested for yield and other quality traits under different agro-climatic conditions for commercial exploitation of hybrid vigour.

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