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IDENTIFICATION OF SWEET PEPPER (*CAPSICUM ANNUUM* L.) LINES TO DEVELOP F_1 HYBRIDS RESISTANT TO POWDERY MILDEW

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ABSTRACT

Powdery mildew resistant sweet pepper lines were tested in line x tester analysis using commercial varieties as testers. Powdery mildew disease observed in parents and hybrids confirmed the dominant nature of disease resistance, which can be exploited in combination with heterosis for yield. Nonadditive gene action was predominant for plant growth and yield parameters except for number of secondary and tertiary branches. Among the eighteen lines studied, PMR 32 and PMR 45 were good combiners for fruits per plant, PMR 68 and PMR 57 for fruit weight, PMR 68 for early yield, and PMR 45, PMR 70 and PMR 68 for total yield. The good specific combiners for total yield were PMR 27 x IHR 1023, PMR 28 x IHR 1023, and PMR 52 x Arka Mohoni. The maximum heterosis observed over the best parent was 43.6% for total yield, 65.4% for early yield, and 42.1% for fruits/plant.

Key words: *Capsicum annuum* L., sweet pepper, combining ability, heterosis, powdery mildew resistance.

Sweet pepper (*Capsicum annuum* L.) is one of the few vegetable crops in which F_1 hybrids are being cultivated at commercial scale world over. Heterosis breeding is feasible in this crop because of high nonadditive gene effects for yield and major yield contributing traits [1, 2]. Powdery mildew, caused by *Leveillula taurica*, is a serious disease of sweet pepper which causes severe leaf fall, leading to heavy yield losses. Powdery mildew resistance in *Capsicum frutescens* has been reported to be governed by at least three dominant genes with additive gene action [3]. This would offer exploitation of heterosis for yield with powdery mildew resistance.

At the Indian Institute of Horticultural Research (IIHR), Bangalore, powdery mildew resistant (PMR) lines were derived by modified back-cross breeding with *Capsicum baccatum*

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var. *pendulum* as a source of resistance. Among the several PMR lines in BC_4 segregating generation, 18 selections were made based on fruit size, nonpungency, pericarp thickness, and fruit firmness, with emphasis on marketability and consumer preference. It is now aimed to identify superior heterotic PMR lines with good combining ability among these selected lines in order to develop PMR hybrids. The objective of the present study is to evaluate general (gca) and specific combining ability (sca), and also assess the magnitude of heterosis for growth, yield and yield components in the segregating PMR lines.

MATERIALS AND METHODS

The parental lines (Table 1) used in this study were selected primarily for powdery mildew resistance, but they differ in their yielding ability, fruit shape, size, number of fruiting nodes, fruiting habit and branching pattern (di-and trichotomus). The 18 PMR lines selected for high fruit quality were crossed with each of the 3 powdery mildew susceptible (PMS) testers to obtain 54 F_1 hybrids, which were evaluated along with parents under field conditions in the severe disease prone season at IIHR, Bangalore. Five-week-old seedlings were transplanted in the field at 60 x 40 cm spacing in three replications. One of the powdery mildew susceptible checks (Arka Mohini, Arka Gaurav, Arka Basant, IHR 1023 and IHR 1208) was planted after every tenth row and also around the experimental field to ensure spread of powdery mildew disease. Observations were recorded on powdery mildew disease infection, growth parameters, flowering time, fruit set, fruit characters, yield and its components.

All plants in each replication were scored for powdery mildew disease 60 days after transplanting. Scoring pattern was: 0—plants completely free from powdery mildew, 1—plants with up to 25% leaves infected, 2—plants with 26–50% leaves infected, 3—plants with 51–75% leaves infected, and 4—plants with more than 75% leaves infected with powdery mildew. Average disease score of all the plants in each replication was calculated. Entries with average disease score equal or less than 1 were classified as resistant and disease score from 1.1 to 3.0 as moderately resistant and greater than 3 as susceptible.

Replication means for different characters recorded on the parents and hybrids were subjected to line x tester analysis [4]. Heterosis was calculated as increase or decrease in the mean F_1 performance over the midparent (MP) and the best parent for the respective character.

RESULTS AND DISCUSSION

The F_1 hybrids and PMR lines excluding PMR 70 and its crosses were resistant to powdery mildew disease while the testers were susceptible. The PMR 70 and its crosses were moderately resistant showing the involvement of more than one gene for resistance [3]. The disease reaction in parents (Table 1) and respective hybrids (Table 2) confirmed the dominance of disease resistance, suggesting the possibility of exploiting heterosis in combination with powdery mildew resistance.

Table 1. Performance of parents used in crosses of sweet pepper

Parent	Source	Powdery mildew reaction	Fruits per plant	Early yield per plant (g)	Total yield per plant (g)
Lines (females):					
PMR 8	IIHR, Bangalore	Resistant	5.2	5.3	347
PMR 12	IIHR, Bangalore	Resistant	8.8	37.7	486
PMR 14	IIHR, Bangalore	Resistant	8.8	9.3	616
PMR 27	IIHR, Bangalore	Resistant	6.9	15.0	435
PMR 28	IIHR, Bangalore	Resistant	9.7	17.7	619
PMR 30	IIHR, Bangalore	Resistant	4.9	0.0	325
PMR 31	IIHR, Bangalore	Resistant	6.1	0.0	447
PMR 32	IIHR, Bangalore	Resistant	7.9	2.7	526
PMR 38	IIHR, Bangalore	Resistant	7.3	7.3	503
PMR 44	IIHR, Bangalore	Resistant	8.1	32.0	465
PMR 45	IIHR, Bangalore	Resistant	8.5	45.0	506
PMR 52	IIHR, Bangalore	Resistant	7.7	10.0	474
PMR 54	IIHR, Bangalore	Resistant	6.6	29.7	463
PMR 56	IIHR, Bangalore	Resistant	7.3	16.0	509
PMR 57	IIHR, Bangalore	Resistant	6.3	28.3	410
PMR 59	IIHR, Bangalore	Resistant	7.8	43.3	578
PMR 68	IIHR, Bangalore	Resistant	7.3	6.3	442
PMR 70	IIHR, Bangalore	Moderately Resistant	7.4	8.7	457
Testers (males):					
Arka Mohini	IIHR, Bangalore	Susceptible	4.0	11.7	352
IHR 1023	EC-176868 (PLAOR) Turin, Italy	Susceptible	5.9	66.7	377
IHR 1208	EC-21529 (Pick Me Quick) South Dakota	Susceptible	5.8	30.0	487
CD at 5%			3.6	56.7	83

The magnitude of MP heterosis for plant height 20 days after transplanting (DAT) and height at first branching 80 DAT was above 50% while it was above 30% for number of secondary and tertiary branches (Table 3). BP heterosis was also observed for plant height 20 DAI and for number of tertiary and secondary branches 80 DAT (Table 3). Nonadditive gene action expressed for plant height and height at first branching (Table 4) was responsible for high magnitude of heterosis. Additive gene action was predominant for secondary and tertiary branches (Table 4). Rapid genetic advance could be expected for these characters in PMR lines and they can enhance yields, being positively correlated (Table 4).

The F_1 hybrids had more fruits (Table 2) than the parents (Table 1). The magnitude of heterosis for fruiting was much higher than earlier reports [5, 6]. Maximum MP heterosis was 116.6% and heterosis over the best parent was 42.1% in the hybrid PMR 12 x Arka Mohini. All the 54 hybrids expressed MP heterosis while 23 F_1s expressed heterosis over the best parent for number of fruits (Table 3). Heterosis for fruiting potential was attributed to nonadditive gene action (Table 4). For average fruit weight, the magnitude of heterosis was very low, as small fruit size is dominant in pepper [7].

Table 2. Performance of selected F_1 hybrids in sweet pepper

Hybrid	Powdery mildew reaction	Fruits per plant	Early yield per plant	Total yield per plant (g)
PMR 12 x Arka Mohini	Resistant	13.8	42.7	889
PMR 28 x Arka Mohini	Resistant	9.9	55.0	633
PMR 32 x Arka Mohini	Resistant	8.7	8.7	636
PMR 44 x Arka Mohini	Resistant	7.5	19.0	517
PMR 52 x Arka Mohini	Resistant	9.9	15.0	631
PMR 68 x Arka Mohini	Resistant	11.6	28.0	760
PMR 70 x Arka Mohini	MR*	10.2	31.0	727
PMR 8 x IHR 1023	Resistant	10.2	51.3	722
PMR 14 x IHR 1023	Resistant	10.6	11.7	658
PMR 27 x IHR 1023	Resistant	12.3	29.7	637
PMR 32 x IHR 1023	Resistant	8.0	6.0	507
PMR 38 x IHR 1023	Resistant	11.3	23.7	660
PMR 44 x IHR 1023	Resistant	13.3	47.3	725
PMR 59 x IHR 1023	Resistant	9.3	52.7	774
PMR 70 x IHR 1023	MR*	10.7	15.0	690
PMR 12 x IHR 1208	Resistant	9.5	15.7	676
PMR 32 x IHR 1208	Resistant	8.2	27.7	590
PMR 38 x IHR 1208	Resistant	9.4	39.0	683
PMR 45 x IHR 1208	Resistant	12.2	49.0	825
PMR 57 x IHR 1208	Resistant	9.6	110.3	826
PMR 70 x IHR 1208	MR*	11.5	28.3	746
CD at 5%		3.6	56.7	83

*MR—Moderately resistant.

Table 3. Magnitude of heterosis for growth and yield characters in sweet pepper

Character	Maximum heterosis		No. of F_1s superior to	
	mid parent	best parent	mid parent	best parent
Plant height 20 DAT	65.6 (PMR 28 x Arka Mohini)	16.2 (PMR 14 x IHR 1023 & PMR 38 x IHR 1023)	49	11
Height at first branching 80 DAT	50.4 (PMR 68 x Arka Mohini)	27.2 (PMR 68 x Arka Mohini)	45	23
No. of secondary branches	33.2 (PMR 38 x IHR 1208)	4.7 (PMR 68 x Arka Mohini)	40	4
No. of tertiary branches	43.3 (PMR 28 x Arka Mohini)	13.0 (PMR 28 x Arka Mohini)	45	9
No. of fruits per plant	116.7 (PMR 12 x Arka Mohini)	42.1 (PMR 12 x Arka Mohini)	54	23
Early yield per plant	451.7 (PMR 30 x Arka Mohini)	65.4 (PMR 57 x IHR 1208)	41	5
Total yield per plant	118.8 (PMR 57 x IHR 1023)	43.6 (PMR 12 x Arka Mohini)	54	43

The F_1 hybrids were superior to parents in early and total yield (Tables 1, 2). MP heterosis for early yield was as high as 451.7% in the cross PMR 30 x Arka Mohini and the hybrids with significant heterosis over the best parent were PMR 57 x IHR 1208 (65.4%) and PMR 45 x Arka Mohini (57.9%). Higher growth rate and early branching in the hybrids resulted in early flowering and early yield [8]. The magnitude of MP heterosis for total yield (118.8% in PMR 57 x IHR 1023) was very high compared to the earlier reports (16.6 to 29.5%) of Depestre and Espinosa [5]. Maximum heterosis (43.6%) over the best parent (PMR 28) was recorded in the cross PMR 12 x Arka Mohini. The frequency of high yielding F_1s over their respective MP and the best parent was also much higher (Table 3) than reported earlier by Thakur [9]. Nine F_1s were more than 30% heterotic over the best parent. The estimated highest yield was 37.1 tonnes/ha in the PMR 12 x Arka Mohini among hybrids, and 25.8 tonnes/ha in PMR 28 among the PMR lines and 20.3 tonnes in IHR 1208 among PMS testers. High heterosis for fruit yield is attributed to indeterminate growth habit of the hybrids with higher order of branching and more fruiting nodes, as was revealed by correlation studies (Table 4). Wide variability with high mean values in PMR lines due to introgression of genes from wild species and prevalence of nonadditive gene action for yield and yield-related characters contributed to the high magnitude of heterosis for total fruit yield. Nonadditive

Table 4. Correlation coefficients among different characters and ratio of gca:sca variance

Characters	Height at first bran-ching	Days to 50% flower-ing	No. of secon-dary branches	No. of tertiary branches	Fruit weight	Fruits per plant	Early yield	Total yield	Gca:Sca ratio
Plant height 20 DAT	0.46**	–0.59**	–0.10	0.03	0.07	0.24**	0.15*	0.30**	1:235
Height at first branching 50 DAT		–0.27**	0.10	0.22**	0.04	0.43**	0.29**	0.40**	1:11.15
Days to 50% flowering			0.03	–0.06	–0.06	–0.37**	–0.26**	–0.37**	1:63.59
No. of secondary branches				0.70**	0.01	0.17*	0.12	0.19**	1:0.895
No. of tertiary branches					–0.01	0.32**	0.19**	0.32**	1:0.690
Fruit weight						–0.20**	0.22**	0.28**	1:138.23
Fruits per plant							0.38**	0.87**	1:81.59
Early yield								0.50**	1:297.11
Total yield									1:5.49

*,**Significant at P = 0.05 and P = 0.01, respectively.

gene action was predominant for early yield, average fruit weight, fruits per plant, and total yield. Similar results were reported by Joshi [1].

Through line x tester analysis, the lines PMR 30, PMR 27 and PMR 45 were identified as good general combiners for height at first branching 50 DAT and PMR 31 for plant height 20 DAT, PMR 14 and PMR 28 for number of primary branches, PMR 30 for number of secondary branches, PMR 14 for number of tertiary branches, and PMR 44 and PMR 57 for early flowering. Among the lines, PMR 32 and PMR 45 were good general combiners for number of fruits, while PMR 68 and PMR 57 were identified as good general combiners for fruit weight. PMR 68 was the best general combiner for early yield. For total yield per plant, PMR 45 was the best general combiner among the lines, followed by PMR 70, PMR 68, PMR 59, PMR 32 and PMR 52.

The crosses PMR 44 x Arka Mohini, PMR 32 x Arka Mohini, PMR 38 x IHR 1208, PMR 12 x IHR 1023, and PMR 56 x IHR 1023 were good specific combiners for plant height 20 DAT. For average fruit weight, PMR 32 x IHR 1208, PMR 27 x IHR 1023, PMR 52 x Arka Mohini, and PMR 12 x IHR 1208, for number of fruits, PMR 44 x Arka Mohini and PMR 8 x IHR 1023, and for early yield PMR 27 x IHR 1023 and PMR 68 x IHR 1208 were identified as the best specific cross combinations. The good specific combinations for total yield per plant were PMR 27 x IHR 1023, PMR 8 x IHR 1023, PMR 52 x Arka Mohini, PMR 70 x IHR 1023, PMR 38 x Arka Mohini, PMR 31 x Arka Mohini, PMR 68 x IHR 1208, PMR 59 x IHR 1208, PMR 59 x IHR 1023, and PMR 45 x Arka Mohini.

The parents selected in the present investigation can be used after stabilizing the resistance genes, in development of high yielding F_1 hybrids resistant to powdery mildew. Parameters like number of secondary and tertiary branches can be used for improvement through selection.

REFERENCES

1. S. Joshi. 1988. Results of genetic analysis in sweet pepper. Capsicum Newsl. No. 7: 35–36.

2. L. Milkova. 1979. Combining ability in a diallel cross of pepper (*Capsicum annum* L.). Genet. Selelt., **12**(1): 62–67.

3. N. Anand, A. A. Deshpande and T. S. Sridhar. 1987. Resistance to powdery mildew in an accession of *Capsicum frutescens* and its inheritance pattern. Capsicum Newsl., No. 6: 77–78.

4. O. Kempthrone. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, Inc., New York.

5. T. Depestre and J. Espinosa. 1988. Study of the effect of heterosis in pepper (*Capsicum annuum*) under tropical conditions. Agrotech. Cuba, **20**(1): 87–90.

6. B. L. Kaul and P. P. Sharma. 1988. Heterosis and combining ability studies for some fruit characters in bell pepper (*Capsicum annuum* L.). Vegetable Sci., **15**(2): 171–180.

7. I. Khambanonda. 1950. Quantitative inheritance of fruit size in red pepper (*Capsicum frutescens* L.). Genetics, **35**: 322–342.

8. R. Mulge. 1992. Early Generation Testing in Bell pepper (*Capsicum annuum* L.) to Develop F_1 Hybrids Resistant to Powdery Mildew. Ph.D. Thesis. University of Agricultural Sciences, Bangalore.

9. P. C. Thakur. 1987. Gene action, an index for heterosis breeding in sweet pepper. Capsicum Newsl., No. 6: 41–42.