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Performance of Chilli (*Capsicum annuum* L.) hybrids for yield and quality traits

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Abstract

Twenty-eight F_1 combinations of chilli (*Capsicum annuum* L.) obtained from half-diallel cross along with eight diverse parents were evaluated in a field study to elucidate the information on the extent of mean performance of various horticultural traits. The analysis revealed that all the genotypes possessed wide spectrum of variability and showed significant differences for parents and hybrids for the traits studied. For parents UHF CHI 13 (216.20), UHF CHI 15 (193.80), UHF CHI 5 (139.00) and for hybrids H1 (182.60), H9 (181.40) and H7 (172.80) hold highest fruit count per plant. The parents UHF CHI 5 (1047.13 g), UHF CHI 15 (949.62 g) and UHF CHI 7 (912.61 g) and cross combinations H17 (1535.10 g), H8 (1320.00), H6 (1229.76) and H18 (967.60) recorded the high ripe fruit yield per plant. As for earliness, parents UHF CHI 5 (43.33), UHF CHI 11 (45.00), UHF CHI 7 (45.33) and hybrids H27 (42.67), H26 (43.00) and UH28 (43.00) took minimum days for flowering. For pungency UHF CHI 12 (0.28%), UHF CHI 13 (0.26%), DKC-8 (0.24%) and H23 (0.33%), H5 (0.31%), H26 (0.26%) recorded high capsaicin content.

Keywords: *Capsicum annuum*, performance, yield, Capsaicin, oleoresin

Introduction

Chilli is one of the commercially important spice and vegetable crops cultivated across the world for its green and ripe fruits. The domestication of chilli initially occurred in Mexico, with secondary centre in Guatemala (Salvador, 2002). Chilli is the second largest traded commodity after black pepper in the global spice trade. In India, the total area under green chilli cultivation is 391 thousand ha with an annual production of 4.06 million tonnes and for dry chilli, it is 743 thousand ha with

an annual production of 1.9 million tonnes (Anonymous, 2021). In Himachal Pradesh, green chillies are cultivated over an area of 1.22 thousand ha with annual production of 14.53 thousand tonnes. With an immense potential in the export market, India has exported about 45,369 metric tonnes of chillies in the form of green chillies, dried pods, chilli powder and oleoresins to USA, UK, Russia, Canada, Italy, Netherlands, Singapore, Saudi Arabia, UAE and Germany resulting in profit of $ 41 million in 2019 (Anonymous, 2021). Chilli is an essential spice due to its pungency, taste, appealing colour and flavour and has its unique place in the diet as a vegetable and spice crop. Dried red chillies are very high in vitamin A and are an excellent source of β-carotene (Shetty *et al*., 2013). Chillies have anti-bacterial qualities and contain bioflavonoids alongside antioxidants. It is also reported to be effective in protecting against cancer (Pramanick & Srivastava 2013).

In the post-Mendelian era of crop improvement, systematic chilli breeding aims to increase the yield potential and the inheritance pattern of its vital trait, pungency (Reddy *et al*., 2014). The productivity of both green and dry chilli in India is low due to extensive use of local landraces or open-pollinated seeds of improved varieties, biotic and abiotic stresses, development of new races of pathogens and genetic drift in cultivars. Therefore, much concentrated efforts are necessary to improve its yield, quality and host plant resistance against diseases.

Materials and methods

The experiment was carried out during *Kharif*, 2020 at the Experimental Farm, Department of Vegetable Science, College of Horticulture, Dr YS Parmar University of Horticulture & Forestry, Solan (HP). The experimental materials used in the present study consisted of a total thirty six genotypes of chilli. The detail of the genotypes used as parents along with their source is given in the Table 1. The twenty eight F_1 hybrids along with their eight parents were evaluated for various horticultural traits. The experiment was carried out in a randomized complete block design with three replications. Ten competitive plants were randomly selected for recording the observations on 15 characters *viz*., days to 50% flowering, plant height (cm), number of branches per plant, plant spread (cm), number of fruits per plant, fruit length (cm), fruit width (mm), pedicel length (cm), fruit weight (g), ripe fruit yield per plant (g), number of seeds per fruit, 1000 seed weight (g), TSS (ºB), capsaicin (%) and oleoresin (%). The standard cultural practices as per the Package of Practices for Vegetable Crops, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP were followed. Analysis of variance was carried out as per the procedure given by Panse & Sukhatme (1985).

Table 1. List of parental genotypes of chilli.

S. No.	Name of the genotype	Source
P1	DKC-8	Dr YSPUH&F, Nauni
P2	UHF CHI 5	Dr YSPUH&F, Nauni
P3	UHF CHI 7	Dr YSPUH&F, Nauni
P4	UHF CHI 11	Dr YSPUH&F, Nauni
P5	UHF CHI 12	Dr YSPUH&F, Nauni
P6	UHF CHI 13	Dr YSPUH&F, Nauni
P7	UHF CHI 14	Dr YSPUH&F, Nauni
P8	UHF CHI 15	Dr YSPUH&F, Nauni

Results and discussion

The analysis of variance (Table 2) revealed significant differences for all the traits, which indicated the presence of significant variation among the genotypes. Early flowering is an important trait in the crop improvement

Table 2. Analysis of variance for different horticultural traits in chilli

Characters	Replication	Genotype	Error
Df	2	35	70
Days to 50% flowering	24.28	18.83*	2.77
Plant height	4.42	617.85*	13.55
Number of branches/plant	1.63	2.97*	0.10
Plant Spread	38.98	239.65*	20.30
Number of fruits/plant	1331.11	4832.87*	6.54
Fruit length	0.34	13.21*	0.44
Fruit width	1.48	14.33*	0.79
Pedicel length	0.03	0.49*	0.04
Fruit weight	0.60	14.73*	0.35
Ripe fruit yield/plant	1267.22	271133.21*	4931.72
Number of seeds per fruit	53.03	602.29*	50.73
1000 seed weight	0.36	2.72*	0.16
Total Soluble Solids	0.05	3.37*	0.32
Capsaicin	0.00	0.02*	0.0001
Oleoresin	0.23	48.89*	0.45

*Significant at 5% level of significance

programme, as it plays critical role in selecting cultivars for different maturity groups and environments. The data presented in the Table 3 showed that number of days to 50% flowering among different genotypes ranged from 42.67 days to 52.00 days with an overall population mean of 47.04 days. Among the parents, minimum number of days to 50% flowering was taken by UHF CHI 5 (43.33 days) and maximum days was taken by DKC-8 (52 days). Among the hybrids H27 (42.67 days) showed earliness in flower bearing habit, followed by H26 (43.00 days) and H28 (43.00 days), whereas, hybrids H5 (51.67 days) took the maximum number of days to 50% flowering. Similar variation was earlier reported by Kumar *et al*. (2014) with parents ranging from 40.5 to 46.5 days and hybrids from 38.5 to 46.5 days. Janaki *et al*. (2015); Kadwey *et al*. (2016); Nabeela *et al*. (2017) also showed similar results with days to 50% flowering. The mean ranged from 74.30 to 131.50 cm for plant height. UHF CHI 11 (131.06 cm) attained the maximum plant height among the parents, followed by UHF CHI 14 (124.80 cm) and UHF CHI 7 (122.90 cm). DKC-8 (74.30 cm) was found to be the shortest, followed by UHF CHI 15 (93.80 cm) and UHF CHI 12 (95.80 cm). Among the hybrid combinations, H21 (131.50 cm) was found with the highest plant height which was statistically at par with H12 (125.70 cm), followed by H6 (120.80 cm), H20 (120.40 cm) and H24 (117.26 cm). H11 (79.40 cm) was found to be the shortest. Nagaraja *et al*. (2016) also showed similar results in overall population (12 parents and 36 hybrids) ranging from 63.5 to 152.8 cm in plant height. Mamatha *et al*. (2017); Singh *et al*. (2009); Pandiyaraj *et al*. (2017) also have similar findings with the

Table 3. Mean performance of different horticultural traits in parents and hybrids of chilli.

genotype	D50F	PH	NBPP	PS	NFPP	FL	FW	PL	FWT	RFYPP	NSPF	SW	TSS	Cap	Oleo
P1	52.00	74.30	6.73	55.77	54.20	7.20	9.89	3.22	3.90	216.80	54.60	4.94	9.26	0.24	11.34
P2	43.33	113.10	9.26	73.73	139.00	9.77	12.03	4.76	7.60	1047.13	86.20	6.80	8.08	0.05	5.09
P3	45.33	122.90	8.20	79.10	74.60	9.43	18.05	3.82	12.53	912.61	110.40	6.84	6.21	0.01	6.62
P4	45.00	131.06	6.80	80.17	101.40	10.09	8.20	3.88	5.60	550.94	65.40	6.23	8.86	0.09	13.44
P5	49.00	95.80	6.13	60.30	46.80	7.02	10.57	4.13	4.27	185.64	80.40	4.14	9.22	0.28	11.42
P6	48.67	107.13	7.13	76.70	216.20	6.93	8.02	3.17	2.70	554.91	66.40	4.19	10.74	0.26	17.37
P7	48.33	124.80	9.06	84.77	109.20	12.61	10.79	4.16	8.40	891.80	85.80	6.83	8.01	0.10	13.07
P8	47.67	93.80	7.40	76.60	193.80	9.79	8.84	4.28	5.03	949.62	81.80	7.18	9.16	0.23	10.33
Parent mean	47.42	107.86	7.59	73.39	116.90	9.11	10.80	3.93	6.25	663.68	78.87	5.89	8.69	0.16	11.09
H1	47.00	104.80	7.26	68.17	182.60	10.02	8.97	3.64	5.17	906.91	80.70	5.84	8.62	0.23	13.88
H2	48.33	97.20	7.46	76.73	116.00	10.46	12.94	3.60	8.20	796.53	103.20	6.15	7.63	0.19	11.18
H3	47.67	109.20	9.00	81.83	117.80	9.91	10.94	3.68	5.80	671.46	78.86	6.42	9.74	0.23	20.40
H4	50.33	97.70	8.40	70.00	106.00	6.71	9.81	3.64	4.07	409.86	58.67	4.57	9.72	0.23	14.97
H5	51.67	84.13	8.46	57.23	94.00	6.34	5.06	3.36	4.20	350.93	68.26	4.69	10.30	0.31	18.09
H6	47.00	120.80	6.20	81.77	170.80	12.27	10.87	4.07	7.40	1229.76	77.93	4.40	8.96	0.21	13.85
H7	43.67	102.60	8.53	77.40	172.80	9.62	10.00	3.87	5.77	956.16	91.20	5.62	9.24	0.21	10.30
H8	47.67	100.33	8.40	84.50	158.40	12.34	12.67	4.29	8.67	1320.00	82.13	7.17	6.06	0.05	4.93
H9	47.00	114.30	8.06	83.97	181.40	11.18	9.28	4.36	4.87	846.53	96.67	6.60	7.72	0.11	8.43
H10	48.33	94.10	9.00	80.40	107.20	10.98	13.41	3.93	8.93	929.07	116.53	5.34	7.60	0.06	5.71
H11	48.00	79.40	5.80	79.60	168.20	10.00	9.02	4.05	4.20	695.23	79.73	5.20	8.38	0.15	13.29
H12	47.00	125.70	9.26	90.13	127.60	12.12	11.28	4.95	6.73	850.67	77.93	6.05	8.18	0.03	11.46

Table 3. Continued.....

H13	48.00	104.26	7.93	90.07	137.20	15.22	9.62	4.47	6.60	932.96	84.53	6.41	7.98	0.01	7.73
H14	46.67	114.83	8.93	81.40	126.00	11.02	12.51	4.04	7.33	894.60	95.53	6.74	6.70	0.01	14.65
H15	50.33	90.40	7.86	81.00	89.40	9.72	9.74	3.79	8.53	742.02	107.53	5.69	7.35	0.06	5.32
H16	45.33	106.90	6.06	79.70	95.00	9.98	12.84	3.75	7.87	737.83	80.46	6.79	8.64	0.07	13.62
H17	49.33	117.70	8.00	84.13	153.00	12.02	13.06	4.62	10.03	1535.10	82.80	5.78	7.24	0.05	9.28
H18	44.67	101.80	8.33	82.40	123.00	10.81	12.38	3.96	7.93	967.60	96.00	6.56	7.06	0.14	6.62
H19	48.67	113.70	7.13	80.07	73.80	11.31	8.73	4.02	4.80	346.86	75.30	4.17	8.50	0.12	16.16
H20	47.00	120.40	9.00	78.20	97.80	8.85	8.42	3.63	3.26	312.96	76.80	5.28	8.84	0.23	12.54
H21	43.67	131.50	7.06	77.27	103.60	11.70	9.83	4.32	5.70	590.52	75.00	6.37	8.02	0.03	12.84
H22	44.67	110.70	7.73	84.90	127.20	10.82	9.02	4.06	4.47	610.56	75.40	6.64	8.82	0.11	16.00
H23	51.00	82.80	9.00	55.57	84.20	5.65	8.96	3.36	4.17	350.83	65.80	4.77	9.60	0.33	17.56
H24	45.00	117.26	7.06	80.17	171.20	10.27	10.17	3.93	4.10	724.75	75.13	4.46	8.68	0.22	13.85
H25	47.33	91.30	8.46	71.60	138.80	10.46	9.64	4.03	5.36	744.89	90.67	4.19	9.11	0.10	11.96
H26	43.00	107.60	7.66	89.17	136.20	11.80	10.43	4.09	6.73	917.08	98.40	5.72	7.96	0.26	8.30
H27	42.67	104.80	7.46	81.50	154.40	8.78	9.39	3.99	3.66	566.13	71.07	5.49	8.48	0.25	9.43
H28	43.00	117.20	9.26	87.73	91.00	14.07	11.66	4.47	9.33	849.34	98.00	5.95	7.36	0.06	6.06
Crosses mean	46.93	105.84	7.96	79.16	128.74	10.51	10.38	4.00	6.21	778.11	84.30	5.68	8.30	0.14	11.73
SE ±(m)	0.96	2.13	0.18	2.60	1.48	0.39	0.51	0.13	0.34	40.54	4.11	0.23	0.33	0.006	0.39
$CD_{(0.05)}$	2.71	6.01	0.52	7.35	4.17	1.08	1.45	0.36	0.96	114.60	11.62	0.65	0.92	0.016	1.09

D50F: Days to 50% flowering, PH: Plant height (cm), NBPP: Number of branches per plant, PS: Plant Spread (cm), NFPP: Number of fruits per plant, FL: Fruit length (cm), FW: Fruit width (mm), PL: Pedicel length (cm), FWT: Fruit weight (g), RFYPP: Ripe fruit yield per plant (g), NSPF: Number of seeds per fruit, SW: 1000 seed weight (g), TSS: Total soluble solids (^{o}Brix), Cap: Capsaicin (%), Oleo: Oleoresin (%)

present study. The average number of branches per plant were 7.59 for parents and 7.96 for hybrid combinations while population ranges from 5.80 to 9.26. Among the parents, maximum number of branches was recorded in UHF CHI 5 (9.26) which was found at par with UHF CHI 14 (9.06), whereas less number of branches per plant (6.13) was recorded in UHF CHI 12. Among the hybrids the maximum number of branches was recorded in crosses H12 (9.26) and H28 (9.26) which were statistically at par with H3 (9.00), H10 (9.00), H20 (9.00), H23 (9.00), and H14 (8.93), while cross H11 (5.80) recorded the minimum number of branches per plant. Similar results were also reported by Rohini & Lakshmanan (2017). Janaki *et al.* (2015); Gogoi & Gautam (2002); Mamatha *et al.* (2017). Among the parents, UHF CHI 14 exhibited the maximum plant spread (84.77 cm), which was at par with UHF CHI 11, while minimum plant spread was recorded in DKC-8 which was statistically at par with UHF CHI 12. Among the twenty-eight cross combinations, the maximum plant spread was recorded for hybrid H12 (90.13 cm) which was statistically at par with hybrids H8 (84.50 cm), H22 (84.90 cm), H28 (87.73 cm), H26 (89.17 cm) and H13 (90.07 cm). The hybrid, H23 (55.57 cm) exhibited the minimum plant spread. These results are in agreement with findings of Jyothi *et al.* (2011); Wani *et al.* (2013); Nagaraja *et al.* (2016).

Number of fruits have a positive effect on yield and hence genotype with higher number of fruits is essential for the development of high yielding cultivars. The average number of fruits per plant for parents was 116.90 and for hybrids 128.74. The parent UHF CHI 13 (216.20) showed the highest number of fruits per plant, followed by UHF CHI 15 (193.80), UHF CHI 5 (139.00) and UHF CHI 14 (109.20). Among twenty-eight hybrids, 12 combinations showed more number of fruits per plant than the population mean. Hybrid H1 (182.60) had maximum number of fruits per plant which was at par with H9 (181.40), followed by H7 (172.80), H24 (171.20) and H6 (170.80). Minimum number of fruits per plant was recorded in hybrid H19 (73.80). Earlier, Nagaraja *et al.* (2016) also reported that fruits per plant ranged from 109 to 199.5 for parents and 149.5 to 293.5 for the hybrids. Similar results were also reported by Minz *et al.* (2017); Kadwey *et al.* (2016); Singh *et al.* (2009); Sharma *et al.* (2017).

The fruit length ranged from 5.65 to 15.22 cm. Among the parents, the maximum fruit length was recorded in UHF CHI 14 (12.61 cm) and minimum fruit length was observed in UHF CHI 13 (6.93 cm) which was at par with DKC-8 (7.20 cm) and UHF CHI 12 (7.02 cm). Among the hybrids, the maximum fruit length was observed in H13 (15.22 cm) followed by H28 (14.07 cm), H8 (12.34 cm), H6 (12.27 cm) and H12 (12.12 cm). However, minimum fruit length was recorded in hybrid H23 (5.65 cm). These results are in agreement with findings of Jyothi *et al.* (2011); Patel *et al.* (2014); Janaki *et al.* (2015); Nabeela *et al.* (2017); Singh *et al.* (2009); Pandiyaraj *et al.* (2017). Among the parents minimum fruit width was exhibited by UHF CHI 13 (8.02 mm) which was statistically at par with UHF CHI 11 and UHF CHI 15, while maximum fruit width of 18.05 mm was recorded in UHF CHI 7. Among the hybrid combinations minimum fruit width was recorded in H5 (5.06 mm) followed by H20 (8.42 mm). While the maximum fruit width was recorded in H10 (13.41 mm). Present results are in conformity with Janaki *et al.* (2015); Kumar *et al.* (2014); Gogoi & Gautam (2002); Nagaraja *et al.* (2016) & Pandiayraj *et al.* (2017). Pedicel length among the different genotypes ranged from 3.17 to 4.95 cm. Minimum pedicel length for parents was observed in UHF CHI 13 (3.17 cm) while, the maximum pedicel length was found in UHF CHI 5 (4.76 cm). Among the hybrids, minimum pedicel length was observed in H5 (3.36 cm) and H23 (3.36 cm). Maximum pedicel length was observed in H12 (4.95 cm) which was statistically at par with H17. These results are in concurrence with reports of Mamatha *et al.*

(2017); Sharma *et al.* (2017) & Patel *et al.* (2014). Among the parents, the maximum fruit weight was observed in UHF CHI 7 (12.53 g) followed by UHF CHI 14 (8.40 g) and minimum fruit weight was recorded in UHF CHI 13 (2.70 g) followed by DKC-8 (3.90). Among the hybrids maximum fruit weight was recorded in hybrid H17 (10.03) followed by H28 (9.33), CHI 5 × UHF CHI 12 (8.93), H8 (8.67) and H15 (8.53). While minimum fruit weight was observed in H20 (3.26). These results were in agreement with findings of Wani *et al.* (2013); Minz *et al.* (2017); Rohini & Lakshmanan (2017). Fruit yield is a complex trait and is the end product of several basic yield attributing components. Among the parents, UHF CHI 5 (1047.13 g) was showed maximum ripe fruit yield per plant which was statistically at par with UHF CHI 15 (949.62 g). Minimum fruit yield per plant was recorded in UHF CHI 12 (185.64 g) which was statistically at par with DKC-8 (216.80 g). Among hybrids, H17 (1535.10 g) recorded maximum ripe fruit yield per plant followed by H8 (1320.00 g), H6 (1229.76 g) and H18 (967.60 g), while, H20 (312.96 g) showed minimum ripe fruit yield per plant. The present observations are the agreement with the findings of Gogoi & Gautam (2002); Jyothi *et al.* (2011); Patel *et al.* (2014) & Kadwey *et al*. (2016).

The parent, UHF CHI 7 (110.40) showed maximum number of seeds per fruit and DKC-8 (54.60) had minimum number of seeds per fruit which was at par with UHF CHI 11 (65.40). Among the hybrids, H10 (116.53) had maximum number of seeds per fruit followed by H15 (107.53) and H2 (103.20), while, minimum was recorded in H4 (58.67) that was statistically at par with H23 (65.80). These results are in agreement with the findings of Minz *et al.* (2017); Pandiyaraj *et al.* (2017); Singh *et al.* (2009); Jyothi *et al.* (2011); Patel *et al.* (2014). For 1000 seed weight, the parents UHF CHI 15 (7.18 g) showed the highest value and UHF CHI 12 (4.14 g) had minimum seed weight. Among the hybrids, H8 (7.17g) had a maximum value for 1000 seed weight. Lowest value for 1000 seed weight was observed in hybrid H19 (4.17 g). Similar results were also reported by Gogoi & Gautam (2002); Kumar *et al.* (2014); Singh *et al*. (2009); Nagaraja *et al.* (2016).

For total soluble solids, parent UHF CHI 13 showed maximum value (10.74), followed by DKC-8 (9.26) and UHF CHI 12 (9.22). Minimum TSS value was recorded in UHF CHI 7 (6.21). Among the hybrids, maximum TSS value was observed in H5 (10.30) followed by H3 (9.74) and H4 (9.72), While minimum TSS value was recorded in H8 (6.06). These results are in conformity with Singh *et al.* (2009) where the reported TSS ranged from 4.98 to 6.21 for green fruit and 8.01 to 9.41 for ripe fruit in chilli. Capsaicin is an active component of chili peppers. Chilli with high pungency or capsaicin content becomes more popular all over the word due to varied uses in culinary purposes, pharmaceuticals. Among the parents, UHF CHI 12 (0.28%) was found to have the highest capsaicin content. Whereas, significantly less capsaicin was recorded in UHF CHI 7 (0.01%). Among the hybrid combinations, H23 (0.33%) recorded maximum capsaicin content followed by H5 (0.31%) and H26 (0.26 %). Whereas, minimum capsaicin content was recorded in hybrids H13 (0.01%) and H14 (0.01%). Similar results were also reported by Sharma *et al*. (2017); Wani *et al*. (2013); Pandey *et al.* (2008); Minz *et al.* (2017). Capsicum oleoresin is a natural food additive/ dietary supplement used by many food industries. Among the parent, highest oleoresin content was recorded in UHF CHI 13 (17.37%), followed by UHF CHI 11 (13.44%) and UHF CHI 14 (13.07%) while, significantly lowest oleoresin per cent was recorded in UHF CHI 5 (5.09%). Among the F1 cross combinations, the highest oleoresin was recorded in H3 (20.40%), followed by H5 (18.09%), H23 (17.56%) and H19 (16.16%). Hybrid combination H8 (4.93%) had significantly lower oleoresin content. These results were in agreement with findings of Sharma *et al.* (2017); Pandey *et al.* (2008); Singh *et al.* (2009).

Conclusion

For all the 15 traits investigated in this study, there was a wide range of variability for days to 50% flowering (42.67-52.00 days), plant height (74.30-131.50 cm), number of branches per plant (5.80-9.26), number of fruits per plant (54.20-216.20), fruit length (5.65-15.22 cm), fruit width (5.06-18.05 mm), fruit weight (2.70-12.53 g), ripe fruit yield per plant (216.80-1535.10 g), number of seeds per fruit (54.60-116.53), 1000 seed weight (4.14-7.18 g), TSS (5.96-10.74 ºB), capsaicin (0.01-0.33 %) and oleoresin (4.93-20.40 %). The characters showing wide range of variation provide an ample scope for selecting superior types and the selected genotypes can be used in further crossing program for introgression of their desired genes and to obtain heterotic hybrids.

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