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Evaluation of advance breeding lines of chilli (*Capsicum annuum* L.) for fruit yield and related attributes under sub-humid temperate environment

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Abstract

The present investigation was undertaken to assess the performance of 58 advance breeding lines (F_5) derived from ten different intervarietal crosses of chilli to identify the most promising genotypes. These 58 progenies were evaluated along with six varieties including 'Surajmukhi' as standard check in randomized complete block design with three replications during summer, 2015. Sufficient genetic variability was observed for fruit yield, yield contributing and quality traits. On the basis of mean performance, 'DPCh-17 (431 g)' followed by 'DPCh-39 (377 g)', 'DPCh-35' (359 g), 'DPCh-49 (357 g)' and 'DPCh-45 (336 g)' were the top ranking five genotypes for marketable green fruit yield per plant which significantly outperformed standard check 'Surajmukhi (219 g)' with an increase of 44-100 %. The superior performance of these genotypes was the result of their better performance for average fruit weight, number of marketable fruits per plant along with early flowering, early harvest, fruit length, fruit girth, leaf length and leaf width. The genotypes namely 'DPCh-17 (75.99 ASTA units)', 'DPCh-39 (74.35 ASTA units)' and 'DPCh-35 (73.80 ASTA units)' revealed high oleoresin content. 'DPCh-49' with 4th rank for marketable yield per plant had low capsaicin content (0.45 %) and may be preferred one for those like less pungent chilli. Genotypes 'DPCh-17', 'DPCh-39', 'DPCh-35', 'DPCh-49' and 'DPCh-45' appeared to be promising on the basis of higher fruit yield along with desirable performance for yield attributing and quality traits and may be released as new varieties after thorough evaluation or can be utilized in future breeding program.

Keywords: *Capsicum annuum* L., chilli, marketable fruit yield, oleoresin, capsaicin content

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Introduction

Chilli or hot pepper (*Capsicum annuum* L.) belongs to the family Solanaceae. It forms an indispensable adjunct in every house of the tropical world due to its pungency, taste, colour and flavor and has unique place in the diet as a vegetable cum spice crop. The green chilli fruits are rich source of ascorbic acid, phytonutrients, carotenoids and rutin which are of immense importance in pharmaceutical needs (Purseglove 1977). Chilli fruit known for its pungency, caused by capsaicinoids of which, capsaicin and dihydrocapsaicin are the major alkaloids that contribute up to 80% of the total capsaicinoids (Pandey et al. 2008). The alkaloid capsaicin has diverse prophylactic and therapeutic uses in Allopathic and Ayurvedic medicine (Sumathy and Mathew 1984). Red colour in chilli is mainly due to the pigment capsanthin that contributes to about 60% (Bosland 1996) and currently used as natural color additive in food, drugs and cosmetic industry. These pigments are also rich in bioflavonoids which carry most powerful antioxidant properties. Chillies can be processed into paste, powder, dry chilli etc. but its processed product 'oleoresin' is gaining more importance especially from export point of view. It offers uniform quality, longer shelf-life, freedom from micro-organism and lesser freight charges as a result; most of the western countries are shifting towards chilli oleoresin rather than exporting whole chilli or chilli powder. Chilli oleoresin has vast demand in pharmaceutical and food industry as it permits better distribution of color and flavor in foods.

The main aim is to evolve genotypes that have regional specific preference besides having substantial increase for fruit yield and other economic traits along with high quality over the existing popular varieties. In the recent years, efforts have been made to isolate transgressive segregants from different intervarietal crosses involving diverse parents following pedigree method of selection keeping in view the farmer's preference for varieties with desirable plant and fruit attributes besides having

high yield. Therefore, the present investigation was undertaken to evaluate the performance of 64 advance breeding lines derived from 10 diverse crosses of chilli.

Materials and Methods

The investigation was carried out at Vegetable Research Farm, Himachal Pradesh Agricultural University, Palampur (32^0 82 N latitude and 76^0 32 E longitude, 1290.8 m above mean sea level) during summer 2015. The experimental material comprised of 64 genotypes that include 58 F_5 advance breeding lines derived from ten diverse intervarietal crosses and six varieties namely, 'Arka Lohit', 'Pusa Sadabahar', 'Selection 352', 'LCA-206', 'Chilli Sonal' and recommended variety 'Surajmukhi' as the standard check (Table 1). These genotypes were sown on 19th March 2015 in the nursery bed of size 300×100×15 cm. The seedlings were transplanted on 7th May 2015 in randomized complete block design with three replications. Each genotype was planted in two rows of length 2.25 m consisting of ten plants in each replication with inter and intra row spacing of 45 cm, respectively. Data were recorded on five randomly selected competitive plants on days to flowering, days to first harvest, fruit length (cm), fruit girth (cm), pedicel length (cm), leaf length (cm), leaf width (cm), plant height (cm), primary branches per plant, number of marketable fruits per plant, average fruit weight (g), marketable green fruit yield per plant (g), harvest duration (days), dry fruit yield per plant (g). Data on fresh and dry fruit yield were recorded separately on five plants. In addition, ascorbic acid (mg/100g), oleoresin (ASTA Units) and capsaicin (%) contents were estimated as per the methodology suggested by Ranganna (1977) and AOAC (1980). Besides, morphological characterization was carried out for plant growth habit, mature fruit colour, fruit shape,

Table 1: List of genetic material along with their pedigree

S. No.	Line	Pedigree/Crosses	S. No.	Line	Pedigree/Crosses
1	DPCh-1	(PS × Surajmukhi)-1-F_5-1	33	DPCh-33	(PJ × Anugraha)-3-F_5-2
2	DPCh-2	(PS × Surajmukhi)-1-F_5-2	34	DPCh-34	(LCA-436 × Pant C-1)-1-F_5-1
3	DPCh-3	(PS ×Surajmukhi)-1-F_5-3	35	DPCh-35	(LCA-436 × Pant C-1)-3-F_5-1
4	DPCh-4	(PS × Surajmukhi)-2-F_5-1	36	DPCh-36	(LCA-436 × Pant C-1) 3-F_5-2
5	DPCh-5	(PS × Surajmukhi)-2-F_5-2	37	DPCh-37	(LCA-436 × Pant C-1)-3-F_5-3
6	DPCh-6	(PS × Surajmukhi)-2-F_5-3	38	DPCh-38	(LCA-436 × Pant C-1)-5-F_5-1
7	DPCh-7	(CS × Surajmukhi)-F_5-1-1	39	DPCh-39	(LCA-436 × Pant C-1)-5-F_5-2
8	DPCh-8	(CS ×Surajmukhi)-F_5-2-1	40	DPCh-40	(LCA-436 × Pant C-1)-6-F_5-1
9	DPCh-9	(CS × Surajmukhi)-F_5-2-2	41	DPCh-41	Privet Sector hybrid1-2-3-5-1
10	DPCh-10	(CS × Surajmukhi)-F_5-2-3	42	DPCh-42	Privet Sector hybrid-1-2-4-1
11	DPCh-11	(CS × Surajmukhi)-F_5-2-4	43	DPCh-43	Privet Sector hybrid1-2-5-1
12	DPCh-12	(CS × Surajmukhi)-F_5-2-5	44	DPCh-44	Privet Sector hybrid1-2-5-2
13	DPCh-13	(CS × Surajmukhi)-3-F_5-1	45	DPCh-45	Privet Sector hybrid1-2-5-3
14	DPCh-14	(CS × Surajmukhi)-5-F_5-1	46	DPCh-46	Privet Sector hybrid2-3-1-1
15	DPCh-15	(CS × Surajmukhi)-6-F_5-1	47	DPCh-47	Privet Sector hybrid2-3-1-2
16	DPCh-16	(AL ×Surajmukhi)-1-F_5-1	48	DPCh-48	Privet Sector hybrid2-3-4-1
17	DPCh-17	(AL × Surajmukhi)-1-F_5-2	49	DPCh-49	Privet Sector hybrid2-3-4-2
18	DPCh-18	(AL × Surajmukhi)-1-F_5-3	50	DPCh-50	Privet Sector hybrid3-11-2-5-1
19	DPCh-19	(AL × Surajmukhi)-2-F_5-1	51	DPCh-51	Privet Sector hybrid2-11-2-5-3
20	DPCh-20	(AL × Surajmukhi)-2-F_5-2	52	DPCh-52	Privet Sector hybrid2-11-5-2
21	DPCh-21	(AL × Surajmukhi)-3-F_5-1	53	DPCh-53	Privet Sector hybrid2-11-5-2-1
22	DPCh-22	(AL × Surajmukhi)-3-F_5-2	54	DPCh-54	Privet Sector hybrid2-11-5-2-2
23	DPCh-23	(AL × Surajmukhi)-3-F_5-3	55	DPCh-55	Privet Sector hybrid2-11-5-4
24	DPCh-24	(AL × Surajmukhi)-4-F_5-1	56	DPCh-56	Privet Sector hybrid2-11-6
25	DPCh-25	(AL × Surajmukhi)-6-F_5-1	57	DPCh-57	(PAU Sel × Pant C-1)-1-F_5-1
26	DPCh-26	(AL × Surajmukhi)-6-F_5-2	58	DPCh-58	(PAU Sel × Pant C-1)-1-F_5-2
27	DPCh-27	(PJ ×Surajmukhi)-1-F_5-1	59	Arka Lohit	IIHR, Bangalor
28	DPCh-28	(PJ × Surajmukhi)-1-F_5-2	60	Pusa Sadabahar	IARI, New Delhi
29	DPCh-29	(PJ × Surajmukhi)-2-F_5-1	61	Sel. 352	PAU, Ludhiana
30	DPCh-30	(PJ × Surajmukhi)-1-F_5-1	62	Surajmukhi	CSKHPKV, Palampur
31	DPCh-31	(PJ × Surajmukhi)-2-F_5-1	63	LCA-206	LAM Station, A.P.
32	DPCh-32	(PJ × Surajmukhi)-3-F_5-1	64	Chilli Sonal	PAU, Ludhiana

fruit position and fruit bearing habit as suggested by Sharma et al. (2016). The mean values of all observations were statistically analyzed following the F-test (Panse and Sukhatme 1984) using CPCS statistical package.

Results and Discussion

The analysis of variance revealed that mean squares due to genotypes were significant for all yield attributing traits including fruit yield and quality traits (Table 2) indicating the presence of significant variability in the genotypes for all the characters and can be exploited through selection (Krishnamurthy et al. 2013). The variation in the performance of sixty four genotypes for different traits (Table 3) ranged from 38.33 (DPCh-23) - 57.67 days (Pusa Sadabahar) for flowering, 52.0 (DPCh-44) -78.33 days (Surajmukhi) for first harvest, 4.0 (Sel.-352) - 13.73 cm (DPCh-43) for fruit length, 2.56 (LCA-206) - 6.23 cm (DPCh-20) for fruit girth, 2.81 (DPCh-34) - 5.90 cm (DPCh-54) for pedicel length, 5.50 (LCA-206) - 13.99 cm (DPCh-52) for leaf length, 2.36 (DPCh-14) - 5.71 cm (DPCh-51) for leaf width, 43.18 (Arka Lohit) - 83.55 cm (DPCh-17) for plant height, 1.67 (DPCh-42) - 8.40 (DPCh-5) for primary branches/plant, 27.71 (DPCh-54) - 87.76 (DPCh-12) for number of fruits/plant, 2.56 (Arka Lohit) - 6.99 g (DPCh-45) for average fruit weight, 118.88 (DPCh-21) - 431.33 g (DPCh-17) for marketable green fruit yield/plant, 53.67 (DPCh-17) - 65.33 days (DPCh-39) for harvest duration, 15 (DPCh-21) - 58.33 g (DPCh-17) for dry fruit yield/plant, 91.73 (DPCh-57) - 128.07 mg per 100 g (DPCh-51) for ascorbic acid, 38.01 (DPCh-29) - 75.99 ASTA unit (DPCh-36) for oleoresin and 0.35 (DPCh-50) - 0.89 % (Surajmukhi) for capsaicin content. The wide variation in mean performance indicated great extent of diversity among the genotypes for all the characters studied, thus providing immense scope for selection.

Table 2: Analysis of variance for yield and yield contributing, and quality traits in chilli

Traits	Replication	Genotypes	Error
df	2	63	126
I. Yield and yield contributing traits			
Days to flowering	18.07	71.12*	3.58
Days to first harvest	23.73	80.62*	4.26
Fruit length (cm)	0.84	22.43*	0.12
Fruit girth(cm)	0.10	1.94*	0.03
Pedicel length (cm)	0.02	1.36*	0.05
Leaf length (cm)	0.37	14.58*	0.10
Leaf width(cm)	0.03	2.55*	0.05
Plant height (cm)	62.22	274.17*	4.19
Primary branches per plant	0.76	6.01*	0.09
Number of marketable fruits per plant	1.12	441.55*	13.25
Average fruit weight (g)	0.006	4.37*	0.13
Marketable green fruit yield per plant (g)	303.38	15504.27*	140.69
Harvest duration (days)	1.47	26.34*	1.99
Dry fruit yield per plant (g)	156.67	298.89*	11.39
II. Quality traits			
Ascorbic acid content (mg/100g)	200.49	245.90*	10.18
Oleoresin (ASTA Units)	15.53	339.52*	8.03
Capsaicin content (%)	0.003	0.061*	0.001

Earliness is a highly desirable trait in chilli as the market prices are invariably high early in the season. The days to flowering and days to first picking are the indicators of earliness. A perusal of Table 3 revealed that 46 genotypes were significantly earlier in flowering as compared to the standard check 'Surajmukhi'. 'DPCh-23' was the earliest in days to flowering followed by 'DPCh-12', 'DPCh-28', 'DPCh-39', 'DPCh-20', 'DPCh-17', 'DPCh-22', 'DPCh-31', 'DPCh-49' and 'DPCh-7' among top ranking ten genotypes. Similarly, 63 genotypes took significantly lesser days to first harvesting in comparison to 'Surajmukhi'. 'DPCh-44' got the first rank by recording minimum days to first harvesting. 'DPCh-10', 'DPCh-35', 'DPCh-22', 'DPCh-39' and 'DPCh-12' were the other top ranking five genotypes. Five genotypes namely, 'DPCh-12', 'DPCh-28', 'DPCh-39', 'DPCh-22' and 'DPCh-31' were placed among the top ten ranking genotypes for both early flowering and first harvest. Janaki et al. (2015) and Kadwey et al. (2015) have also found variation in the performance of different genotypes for days to flowering and first harvest in their respective genetic material. Janaki et al. (2015) reported variation for days to flowering in 63 genotypes in the range of 24-42 days with LCA-709 as the earliest in flowering.

Fruit length is one of the most important traits which contribute towards fruit yield. Fifty genotypes significantly produce longer fruits than 'Surajmukhi' (Table 3). Among the top five ranking genotypes, 'DPCh-43' had maximum fruit length (13.73 cm) followed by 'DPCh-55', 'DPCh-45', 'DPCh-44' and 'DPCh-37'. Janaki et al. (2015) have also identified genotypes with maximum fruit length of 12.97 cm. Similarly, 37 genotypes exhibited significantly better fruit girth over standard check with maximum in 'DPCh-20' followed by 'DPCh-54', 'DPCh-17', 'DPCh-43' and 'DPCh-51'. For pedicel length, 25 genotypes had significantly smaller pedicel length while 19 other genotypes showed comparable pedicel length to

Table 3: Mean performance of F_5 progenies for different yield and yield contributing, and quality traits in chilli

Traits / Genotypes	Days to flowering	Days to first harvest	Fruit length (cm)	Fruit girth (cm)	Pedicel length (cm)	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	Primary branches per plant	Number of marketable fruits per plant	Average fruit weight (g)	Marketable green fruits yield per plant (g)	Harvest duration (days)	Dry fruits yield per plant (g)	Ascorbic acid content (mg/100 g)	Oleoresin (ASTA Units)	Capsaicin (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
DPCh-1	56.00	67.00	7.19	3.33	3.69	7.36	3.93	52.71	6.77^{5}	45.15	3.68	163.66	63.00	22.33	109.60	62.87	0.84^{3}
DPCh-2	49.33	62.00	6.74	3.34	4.05	8.14	4.17	53.78	7.67^{2}	62.40	3.09	192.33	60.33	25.33	95.63	55.88	0.81
DPCh-3	56.33	66.67	5.45	3.27	3.82	10.08	5.08	72.15	6.80^{4}	73.18^{5}	2.95	215.67	58.67	27.67	99.07	50.52	0.52
DPCh-4	53.00	64.67	6.44	3.31	3.48	8.43	4.30	54.41	7.13^{3}	55.20	2.86	157.33	58.67	18.00	94.90	66.15	0.63
DPCh-5	51.67	61.00	5.86	2.72	4.37	10.99	4.62	57.55	8.40^{1}	63.11	3.05	192.00	57.67	24.33	95.93	59.59	0.57
DPCh-6	44.67	57.00	7.45	3.70	3.50	7.29	3.09	63.86	2.66	45.01	3.59	161.66	62.00	21.33	106.60	64.51	0.73
DPCh-7	41.00	62.67	6.85	3.42	3.06	7.59	3.43	56.05	2.87	43.00	3.02	129.33	61.67	26.67	112.80	48.65	0.81
DPCh-8	51.33	60.33	4.85	4.39	3.52	6.73	2.43	63.63	2.55	52.14	3.61	188.00	60.67	24.67	114.40	42.09	0.72
DPCh-9	44.33	54.33	7.82	3.40	3.72	7.13	2.99	62.36	3.40	58.98	5.38	316.67	63.67^{4}	41.00	109.23	49.19	0.76
DPCh-10	42.67	52.33^{2}	10.28	4.38	3.50	6.88	2.69	81.44^{4}	3.47	49.16	6.57^{4}	323.00	60.33	40.33	112.97	39.91	0.74
DPCh-11	44.33	61.67	7.74	4.51	3.63	7.20	2.66	79.41	2.67	59.24	3.82	226.00	61.00	27.67	104.10	48.92	0.79
DPCh-12	38.67^{2}	53.00	7.79	3.36	3.88	7.55	2.69	60.51	3.47	87.76^{1}	3.81	335.00	59.67	41.33	104.73	39.91	0.81
DPCh-13	48.00	61.00	5.36	2.84	3.43	6.90	2.69	72.44	3.33	53.12	3.17	167.26	62.67	20.67	106.53	41.82	0.64
DPCh-14	43.00	57.00	7.55	3.64	3.37	8.73	2.36	55.33	3.40	50.59	2.83	149.33	58.67	27.00	113.53	42.09	0.71
DPCh-15	41.67	57.00	6.31	3.77	3.48	8.01	3.05	73.15	3.00	41.40	3.58	147.33	57.00	28.33	114.53	49.75	0.76
DPCh-16	44.00	53.33	5.73	4.52	4.07	7.33	3.30	66.18	3.66	52.48	3.97	207.22	61.33	28.00	118.10	58.77	0.66
DPCh-17	39.67	54.33	7.77	5.41^{3}	4.12	9.09	3.51	83.55^{1}	3.53	66.11	6.54^{5}	431. 33^{1}	53.67	58.33^{1}	116.17	74.35^{2}	0.67
DPCh-18	43.67	54.00	6.42	4.45	3.67	8.03	3.61	66.54	2.66	61.90	4.03	250.00	60.00	35.00	114.63	65.05	0.61
DPCh-19	43.00	61.67	4.85	3.42	3.48	7.25	2.85	60.26	3.33	46.10	3.78	173.89	61.00	20.67	119.13	66.15	0.81
DPCh-20	39.33^{5}	58.00	7.06	6.23^{1}	4.58	9.83	3.11	58.71	2.13	60.39	2.95	178.33	55.67	24.67	121.33	68.33	0.62
DPCh-21	46.00	61.67	4.87	3.83	4.06	8.18	2.54	63.67	3.33	40.45	2.95	118.88	59.33	15.00	112.13	55.76	0.85^{2}
DPCh-22	39.67	52.67^{4}	8.05	3.36	5.61	9.78	2.60	64.56	3.40	76.10^{4}	3.40	259.33	56.33	34.67	115.53	65.90	0.62
DPCh-23	38.33^{1}	62.67	5.38	4.22	3.27	9.17	3.54	50.32	3.00	35.33	3.58	126.00	55.33	17.67	110.63	58.63	0.66
DPCh-24	44.00	61.00	5.43	3.48	4.41	6.75	3.51	63.54	3.00	45.00	2.85	127.89	60.67	24.33	118.03	53.57	0.78
DPCh-25	43.67	57.00	7.54	3.02	4.48	9.70	2.60	74.05	4.33	59.20	2.69	159.49	55.67	21.33	108.70	69.43	0.58
DPCh-26	41.00	55.67	7.92	3.30	3.72	8.93	2.73	58.87	3.07	77.77^{3}	3.12	242.33	55.67	32.00	115.23	67.24	0.62
DPCh-27	44.00	63.00	6.33	3.39	3.85	11.74	4.15	48.22	3.40	72.76	3.16	199.67	62.33	28.00	101.50	47.00	0.56
DPCh-28	38.67^{3}	53.33	9.20	3.61	4.42	10.74	3.50	75.49	3.47	64.45	3.87	248.67	62.33	34.33	105.27	46.47	0.71
DPCh-29	42.00	56.67	7.66	4.16	3.73	9.68	3.49	70.32	3.27	70.46	4.11	289.33	60.67	44.00	98.67	38.01	0.72
DPCh-30	50.00	57.00	7.21	3.63	3.53	9.07	4.38	63.12	2.55	42.10	3.36	140.00	56.33	23.67	112.93	42.63	0.56
DPCh-31	40.33	53.00	7.39	3.62	3.23	9.43	4.33	63.06	3.93	63.23	3.62	209.93	59.67	36.67	96.00	45.65	0.41
DPCh-32	47.33	63.67	6.98	4.53	3.55	9.20	4.15	58.82	2.73	57.34	3.49	199.33	58.00	28.67	100.00	46.46	0.44
DPCh-33	47.33	61.67	7.15	3.35	3.45	9.20	4.39	61.91	3.07	41.23	3.38	139.00	55.33	21.67	102.90	39.91	0.47
DPCh-34	49.33	63.67	5.07	3.46	2.81^{1}	9.38	4.77	50.65	2.33	47.01	4.07	190.89	60.33	27.00	106.57	70.52	0.56
DPCh-35	41.00	52.33^{3}	10.15	4.23	4.49	12.67	4.71	82.27^{3}	2.73	54.06	6.63^{3}	358.67^{3}	65.00^{2}	49.67^{3}	100.67	73.19^{5}	0.53
DPCh-36	41.67	53.67	11.25	4.42	3.47	12.45	4.55	80.59	2.47	52.24	6.28	328.00	63.67^{5}	43.00	101.23	75.99^{1}	0.55
DPCh-37	43.33	56.00	12.77	3.36	4.34	11.76	5.05	74.74	3.20	54.02	5.38	290.33	63.00	42.00	98.10	65.57	0.57
DPCh-38	42.33	59.00	8.35	4.03	3.36	10.90	4.88	73.28	3.13	71.62	4.63	331.33	63.00	42.00	107.80	68.33	0.56
DPCh-39	39.00^{4}	52.67^{5}	8.29	3.62	4.00	10.39	4.23	63.53	2.60	86.67^{2}	4.35	376.67^{2}	65.33^{1}	54.00^{2}	104.30	73.80^{3}	0.59
DPCh-40	42.33	55.00	8.35	3.94	4.23	8.75	4.70	68.95	3.27	56.10	4.53	253.00	62.00	43.00	101.27	69.91	0.65
DPCh-41	46.33	56.00	11.81	4.38	4.79	13.92^{2}	5.33^{4}	67.12	3.20	51.08	5.88	309.33	55.33	34.33	109.10	56.58	0.44
DPCh-42	43.67	54.67	10.72	4.95	5.18	11.40	5.13	83.47^{2}	1.67	55.08	4.96	272.00	63.67	45.67	126.37^{2}	54.67	0.40
DPCh-43	44.00	53.67	13.73^{1}	5.23	4.19	12.63	5.17	73.13	2.40	43.45	6.44	279.00	62.67	40.33	124.67^{5}	47.01	0.41
DPCh-44	42.00	52.00^{1}	12.24	3.09	4.91	12.01	5.38^{2}	59.76	2.33	56.52	4.62	261.00	64.67^{3}	43.33	122.67	62.44	0.42
DPCh-45	46.00	53.00	12.99^{3}	4.67	4.48	13.50^{4}	5.13	73.07	1.80	51.08	6.99^{1}	336.33^{5}	59.33	47.33^{4}	108.63	48.11	0.42
DPCh-46	44.67	55.00	7.35	4.30	4.38	10.39	4.46	70.11^{5}	2.20	43.91	5.00	239.33	58.00	36.67	117.93	61.77	0.39
DPCh-47	43.67	61.00	8.48	4.15	4.51	9.63	4.51	80.62	2.33	38.79	4.75	185.33	59.67	25.33	124.90^{4}	54.94	0.39
DPCh-48	43.67	59.33	7.79	4.62	3.28	10.53	4.55	60.36	2.40	51.38	3.95	202.73	57.33	28.67	117.60	56.85	0.45
DPCh-49	40.67	54.67	11.05	4.03	4.74	12.08	4.38	70.67	2.33	71.93	4.96	357.00^{4}	59.00	46.33	113.30	52.01	0.47
DPCh-50	45.67	60.00	11.63	5.14	4.41	13.83^{3}	5.34^{3}	67.91	2.40	33.46	6.16	205.93	63.67	28.00	121.63	56.90	0.35

DPCh-51	48.33	60.33	9.58	5.23	5.21	13.02	5.71[1]	72.09	4.20	50.03	5.79	286.67	62.00	42.33	128.07[1]	56.58	0.36
DPCh-52	42.00	53.67	8.49	4.92	3.57	13.99[1]	5.07	54.53	1.73	42.32	4.10	200.00	56.00	34.67	117.83	45.50	0.56
DPCh-53	44.00	61.33	9.38	5.16	5.03	13.06	5.01	73.54	2.40	41.38	5.57	230.00	57.00	33.00	113.47	47.56	0.60
DPCh-54	47.33	59.33	9.08	6.08[2]	5.90	13.10[5]	5.08	57.67	3.40	27.71	6.64[2]	182.67	60.00	28.33	125.93[3]	60.68	0.38
DPCh-55	47.67	61.33	13.40[2]	4.63	5.18	11.16	5.26[5]	73.62	2.87	45.74	5.15	235.33	57.33	32.67	108.70	54.94	0.57
DPCh-56	41.00	54.00	8.52	3.55	2.92[3]	11.81	4.71	52.44	2.73	62.41	4.98	309.67	56.67	46.67[5]	113.03	62.32	0.50
DPCh-57	50.00	62.67	6.04	3.44	3.12	7.27	3.40	62.05	3.22	54.54	3.51	158.33	55.33	19.67	91.73	47.29	0.71
DPCh-58	51.00	62.33	7.33	3.58	3.41	7.14	3.43	73.32	2.66	54.18	3.53	190.55	56.67	25.67	93.53	39.10	0.73
Arka Lohit	44.33	67.33	4.83	2.58	2.90[2]	7.75	3.62	43.18	4.09	51.54	2.56	130.62	54.33	15.67	115.00	60.86	0.52
P.Sadabahar	57.67	72.67	5.10	4.06	3.63	7.25	3.88	48.80	5.33	65.10	3.17	206.44	60.67	27.33	104.07	73.80[4]	0.84
Sel. 352	56.67	64.67	4.00	2.63	3.64	8.07	4.23	65.46	4.33	57.74	3.44	196.33	56.33	24.67	99.43	61.77	0.55
Surajmukhi	50.67	78.33	5.32	3.32	3.96	8.66	3.97	72.02	5.44	58.22	3.76	219.11	63.00	36.00	102.20	42.64	0.89[1]
LCA-206	54.33	60.67	7.93	2.56	3.41	5.50	4.34	67.85	4.89	58.79	2.82	165.89	59.67	20.00	103.73	69.97	0.55
Chilli Sonal	53.33	58.67	7.38	3.38	3.35	6.92	2.93	75.20	5.66	58.41	3.07	178.89	61.67	23.33	98.70	65.82	0.65
Mean	45.40	58.86	7.89	3.93	3.95	9.58	3.99	65.66	3.46	54.97	4.18	225.51	59.65	31.75	109.43	56.38	0.61
Range	38.33-57.67	52.00-78.33	4.00-13.73	2.56-6.23	2.81-5.90	6.73-13.99	2.36-5.71	43.18-83.55	1.67-8.40	27.71-87.76	2.56-6.99	118.88-431.33	53.67-65.33	15.00-58.33	91.73-128.07	38.08-75.99	0.35-0.89
SE (m) ±	1.55	1.69	0.29	0.14	0.18	0.26	0.17	1.67	0.24	2.97	0.29	9.69	1.15	2.75	2.60	2.31	0.20
C.D. (P≤0.05)	3.03	3.30	0.55	0.28	0.35	0.51	0.33	3.27	0.47	5.82	0.57	18.99	2.62	5.40	5.09	4.53	0.39

*Superscript (1, 2, 3, 4 and 5) indicates top ranking five genotypes.

'Surajmukhi'. Among the top ten genotypes, the minimum pedicel length was noticed for 'DPCh-34' followed by 'Arka Lohit', 'DPCh-56', 'DPCh-7', 'DPCh-57', 'DPCh-31', 'DPCh-23', 'DPCh-48', 'Chilli Sonal' and 'DPCh-38'. A wide variation in the performance of different genotypes of chilli for fruit length and fruit girth have also been reported by Sharma et al. (2014), Sarkar et al. (2009) and Kumar et al. (2014) have found variation for pedicel length in their respective studies with variable genetic material.

Leaves are important organs for photosynthesis and play an important role in plant growth as higher leaf area (leaf length and leaf width) results in more accumulation of carbohydrates. In this context, 34 and 28 genotypes had significantly more leaf length and leaf width in comparison to the standard check 'Surajmukhi', respectively (Table 3). 'DPCh-52' and 'DPCh-51' were placed at top position for respective traits. The critical analysis of data indicated that genotypes namely, 'DPCh-50', 'DPCh-45', 'DPCh-51' and 'DPCh-43' were placed among the top ten with maximum leaf length and leaf width. Khurana et al. (2003) and Verma et al. (2004) also recorded variation among genotypes for leaf length and leaf width. Plant height plays a crucial role in high rainfall areas with comparatively less incidence of fruit rot in tall plants. Genotypes 'DPCh-17', 'DPCh-42', 'DPCh-35', 'DPCh-10', 'DPCh-47', 'DPCh-36', 'DPCh-11' and 'DPCh-28' showed significantly more plant height than 'Surajmukhi', while 20 other genotypes had statistically similar plant height as that of standard check. Primary branches/plant has a great bearing on the total productivity. Accordingly, 'DPCh-5' produced significantly maximum number of branches/plant followed by 'DPCh-2', 'DPCh-4', 'DPCh-3' and 'DPCh-1' over the standard check 'Surajmukhi' (Table 3). Earlier workers have also reported wide variation in their respective breeding material for plant height (Kumar et al. 2014 and Janaki et al, 2015) and primary branches per plant (Kadwey et al. 2015).

Marketable fruits/plant and average fruit weight has direct bearing on fruit yield. Consumer prefers long or medium sized fruits. There is negative correlation between average fruit weight and number of marketable fruits per plant which implies that breeder has to keep a balance to meet increase productivity and consumer preference. Only 12 genotypes exhibited significantly more number of fruits/plant over the check variety 'Surajmukhi' where in 'DPCh-12' followed by 'DPCh-39', 'DPCh-26', 'DPCh-22' and 'DPCh-3' were the top ranking five genotypes (Table 3). Maximum average fruit weight was observed for 'DPCh-45' followed by 'DPCh-54', 'DPCh-35', 'DPCh-10' and 'DPCh-17' which had significantly outperformed the standard check 'Surajmukhi' along with 18 other genotypes. In general, a wide range of variability in the performance of different genotypes for number of marketable fruits/plant and average fruit weight have also been observed by earlier workers namely, Kumar et al. (2014) and Kadwey et al. (2015) for number of marketable fruits/plant and that of Sarkar et al. (2009) and Janaki et al. (2015) for average fruit weight.

High marketable yield is the basic objective of all the crop improvement programs and is of immense importance to the vegetable growers from economic point of view. A new genotype will achieve no success, unless it surpasses the existing cultivars in performance. Out of the 64 genotypes, 24 progenies significantly outperformed the standard check 'Surajmukhi' for marketable green fruit yield/plant (Table 3). Among the top ranking ten genotypes, 'DPCh-17' was the highest yielding genotype followed by 'DPCh-39', 'DPCh-35', 'DPCh-49', 'DPCh-45', 'DPCh-12', 'DPCh-38', 'DPCh-36', 'DPCh-10' and 'DPCh-9' with an increase of 44-100 per cent over 'Surajmukhi'. The marketable fruit yield of top ranking genotype 'DPCh-17' was almost double of 'Surajmukhi'. Long harvest duration has direct bearing in enhancing total yield. 'DPCh-39' showed the longest harvest duration followed by 'DPCh-35' and 'DPCh-44' though at par with standard check 'Surajmukhi' besides 19 other genotypes showed the same performance. On the other hand, only 14 genotypes significantly surpassed the standard check for dry fruit yield/plant in the range of 17-61 % over 'Surajmukhi'. 'DPCh-17', 'DPCh-39' and 'DPCh-35' were the top ranking three genotypes for both fresh and dry fruit yield while rest 11 genotypes also significantly performed better for marketable green yield/ plant. Similarly, variation in the performance of different genotypes have also been reported by earlier workers viz., Krishnamurty et al. (2013) for marketable green fruit yield, and Chattopadhaya et al. (2011) and Pandit and Adhikary (2014) for dry fruit yield/plant in their respective studies.

Table 4: Morphological Characterization of the chilli genotypes

Category	Class	Genotypes
Fresh Market Fruit Color	(a) Yellow	DPCh-9, DPCh-14, DPCh-15, DPCh-16, DPCh-18, DPCh-22, DPCh-24, DPCh-25, DPCh-26, DPCh-30, DPCh-31, DPCh-33, DPCh-34, DPCh-42, DPCh-44 and DPCh-56
	(b) Green	DPCh-2, DPCh-8, DPCh-10, DPCh-11, DPCh-12,DPCh-13, DPCh-19, DPCh-20, DPCh-21, DPCh-23, DPCh-27, DPCh-29, DPCh-35, DPCh-36, DPCh-38, DPCh-40, DPCh-43, DPCh-45, DPCh-49, DPCh-50,DPCh-51, DPCh-52, DPCh-53, DPh-54, DPCh-57,Sel- 352, Pusa Sadabahar, Chilli Sonal and LCA-206
	(c) Purple	DPCh-41, DPCh-46 and DPCh-47
Fruit Shape	(a) Elongate	Arka Lohit, Pusa Sadabahar, Surajmukhi,LCA-206, Chilli Sonal,DPCh-1, DPCh-2, DPCh-3,DPCh-4, DPCh-5, DPCh-6, DPCh-7, DPCh-8, DPCh-9, DPCh-10, DPCh-11, DPCh-13, DPCh-14, DPCh-15, DPCh-16, DPCh-18, DPCh-19,DPCh-20, DPCh-21, DPCh-22, DPCh-23, DPCh-24,DPCh-25, DPCh-26, DPCh-27, DPCh-28, DPCh-29, DPCh-30, DPCh-31, DPCh-33, DPCh-34, DPCh-35, DPCh-36, DPCh-37, DPCh-38, DPCh-39, DPCh-40, DPCh-41, DPCh-42, DPCh-43, DPCh-44, DPCh-45, DPCh-46, DPCh-47, DPCh-48, DPCh-49, DPCh-50, DPCh-51, DPCh-52, DPCh-56, DPCh-57 and DPCh-58
	(b) Compansulate	DPCh-17, DPCh-53, DPCh-54 and DPCh-55
	(c) Oblate	Sel -352
Fruit position	(a) Erect	DPCh-15, DPCh-19, DPCh-27, DPCh-24, DPCh-30, DPCh-34 and DPCh-57
	(b) Decline	LCA-206, Chilli Sonal, DPCh-9, DPCh-10, DPCh-11, DPCh-12, DPCh-13, DPCh-14, DPCh-17,DPC h-26, DPCh-28, DPCh-35, DPCh-41, DPCh-42, DPCh-43, DPCh-44, DPCh-45, DPCh-48, DPCh-49, DPCh-50, DPCh-51, DPCh-52, DPCh-53 and DPCh-54
	(c) Intermediate	DPCh-2, DPCh-16, DPCh-18, DPCh-20, DPCh-21, DPCh-23, DPCh-25, DPCh-33, DPCh-39, DPCh-40, DPCh-46, DPCh-47
Bearing habit	(a) Cluster	Pusa Sadabahar, Surajmukhi, DPCh-1, DPCh-2, DPCh-3, DPh-4, DPCh-5, DPCh-6, DPCh-7,DPCh-19, DPCh-20 and DPCh-23
	(b) Solitary	Sel -352, LCA-206, Chilli Sonal, DPCh-9, DPCh-10, DPCh-11, DPCh-12, DPCh-14, DPCh-15, DPCh-16, DPCh-17, DPCh-21, DPCh-32, DPCh-33, DPCh-34, DPCh-35, DPCh-36, DPCh-37, DPCh-38, DPCh-39, DPCh-40, DPCh-41, DPCh-42, DPCh-43, DPCh-48, DPCh-49, DPCh-50, DPCh-51, DPCh-52, DPCh-53, DPCh-54, DPCh-55, DPCh-56, DPCh-57 and DPCh-58
Plant growth habit	(a) Erect	Arka Lohit, Pusa Sadabahar, DPCh-1, DPCh-2, DPCh-3, DPCh-4, DPCh-5, DPCh-6,DPCh-8 and DPCh-19
	(b) Compact	Sel-352, Surajmukhi, LCA-206, Chilli Sonal, DPCh-7, DPCh-9, DPCh-10, DPCh-11, DPCh-15, DPCh-17, DPCh-20 and DPCh-23
	(c) Prostate	DPCh-41, DPCh-46,, DPCh-49, DPCh-52, DPCh-53, DPCh-55, DPCh-56, DPCh-16, DPCh-18, DPCh-21, DPCh-24 and DPCh-30

Ascorbic acid has unique anti-oxidant properties and also helps in strengthening the immune system of the body against diseases. Chilli is quite rich source of ascorbic acid and thus has enormous potential. Similarly, Oleoresin is an oil soluble extract from the fruits of red chilli and has importance primarily in cosmetic and pharmaceutical industries. Thirty seven genotypes had significantly better ascorbic acid than standard check 'Surajmukhi'. 'DPCh-51', 'DPCh-42', 'DPCh-54', 'DPCh-47' and 'DPCh-43' were the top ranking five genotypes for ascorbic acid contents (Table 3). Of the forty eight genotypes, 'DPCh-36', 'DPCh-17' and 'DPCh-39' were the top ranking three progenies, those had significantly surpassed the standard check 'Surajmukhi' for oleoresin content. Capsaicin is produced by glands in the pepper's placenta which has many health benefits. It is primarily used as pain killer and has anti-carcinogenic properties. Relatively high capsaicin is desirable in chilli, since it is associated with more pungency and hot flavour. 'Surajmukhi' is highly pungent genotype and accordingly forty nine genotypes showed comparable performance for capsaicin to that of 'Surajmukhi'. DPCh-50 had the least capsaicin content along with fourteen others genotypes which contained significantly less capsaicin than 'Surajmukhi'. These genotypes may be beneficial for those who prefer comparatively less pungent chillies. Besides, 'DPCh-49' with 4th rank for marketable yield per plant showed significantly less capsaicin content and may be a promising genotype for those who prefer less pungent chilli fruits. Earlier researchers have also reported variation in performance of different genotypes for ascorbic acid (Wasule et al. 2004 and Chattopadhaya et al. 2011), oleoresin content (Kumar et al. 2014) and capsaicin content (Yatung et al. (2014). Systematic description of germplasm is an important aspect leading to more efficient and desirable use in crop improvement. Moreover, information regarding morphological characters is helpful for the breeders in future research and leading to development of new improved types. The morphological characterization of genotypes has been given in Table 4. It can be concluded that the superior performance of majority of top ranking genotypes namely, 'DPCh-17', 'DPCh-39', 'DPCh-35' and 'DPCh-45' for fruit yield per plant may be attributed to their better performance mainly for average fruit weight, number of marketable fruits per plant along with early flowering, early harvest, fruit length, fruit girth, leaf length and leaf width. These genotypes appeared to be promising on the basis of higher yield along with desirable performance for yield attributing and quality traits and may be released as new varieties after thorough evaluation or can be utilized in future breeding program.

सारांश

वर्तमान अध्ययन मिर्च की उत्कृष्ट प्रभेदों की पहचान के लिये अन्तःकिस्म संकरण से व्युत्पन्न 58 उच्चीकष्त लाइनों का निष्पादन मूल्यांकन किया गया। वर्ष 2015 के ग्रीष्मकाल में इन 58 संततियों का मूल्यांकन सूरजमुखी नियंत्रक व छः किस्मों के यादृक्षिक पूर्ण प्रखण्ड रूपरेखा में 3 प्रतिकृति में किया गया। फल उपज, उपज योगदान एवं गुणवत्ता घटकों में सार्थक अनुवांशिक विविधता पाया गया। औसत निष्पादन के आधार पर 5 उच्च निष्पादन करने वाले प्रभेदों डी.पी.सी.एच.–17 (431 ग्राम), डी.पी.सी.एच.–39 (377 ग्राम), डी.पी.सी.एच.–35 (359 ग्राम), डी.पी.सी.एच.–49 (357 ग्राम) एवं डी.पी.सी.एच.–45 (336 ग्राम) हरी फली/पौध निष्पादन किये जो मानक नियंत्रक सूरजमुखी (219 ग्राम) से ज्यादा सार्थक व अधिक (44–100 प्रतिशत) था। इन उच्च निष्पादन करने वाली प्रभेदों का सबसे बढ़िया परिणाम औसत फल भार, बाजार योग्य फलियों की संख्या प्रति पौध के साथ अगेती पुष्पन, अगेती तुड़ाई, फल की लम्बाई, फल व्यास, पत्ती की लम्बाई व पत्ती की चौड़ाई भी अधिक पायी गयी। प्रभेदों में मुख्यतः ए.एस.टी.ए–15 मूल्य डी.पी.सी.एच–17 (75.99) डी.पी.सी.एच.–39 (74.35) एवं डी.पी.सी.एच.–35 (73.80) ज्यादा था जो उच्च ओलियोरेजिन की मात्रा को स्पष्ट करता है। डी. पी.सी.एच–49 चौथे दर्जे पर बाजार योग्य उपज/पौध में कम कैप्सिसिन की मात्रा (0.40 प्रतिशत) पायी गयी। अतः यह प्रभेद कम तीखापन पसन्द लोगों के लिए उत्तम है। प्रभेद डी.पी.एसी.एच.–17, डी.पी.एसी.एच.–39, डी.पी.एसी.एच.–35, डी.पी.एसी.एच.–49 डी.पी. स.एच.–45 अधिक फल उत्पादन के साथ वांछित गुणों तथा गुणवत्ता घटकों के कारण मूलयांकन उपरान्त नवीन प्रजाति के रूप में या भविष्य में प्रजनन हेतु उपयोग कर सकते हैं।

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