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Evaluation, genetic variability, correlation and path analysis studies in chilli (*Capsicum annuum* L.) genotypes

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Abstract

The experimental materials comprising of fourteen chilli genotypes including 'Surajmukhi' as standard check were evaluated to examine the nature of variability, heritability, genetic advance, correlation and association of various traits with marketable yield. Analysis of variance showed significant differences among the genotypes in terms of both quantitative and qualitative traits. The yield potential of two genotypes, Him Palam Mirch-2 and DPCh-101 was significantly higher than that of check 'Surajmukhi'. High PCV and GCV was recorded for average green fruit weight, marketable green fruits per plant, non-marketable green fruits per plant and total green fruits per plant. High heritability along with high genetic advance was observed for primary branches per plant, internodal length, secondary branches per plant, fruit length, average green fruit weight, marketable green fruits per plant, non–marketable green fruits per plant, total green fruits per plant and marketable fruit yield per plant. Correlation studies showed that marketable green fruits per plant, total green fruits per plant, per cent marketable green fruits per plant and fruit girth had positive significant association, with marketable yield per plant indicating the importance of these traits in selection for yield. Path analysis revealed that total green fruits per plant, average green fruit weight, percent marketable green fruits per plant, fruit length, primary branches per plant and days to first harvest had the maximum positive direct effect on marketable green fruit yield per plant indicating that these traits are the main contributors to fruit yield. Based on these results, it can be concluded that due consideration should be focused on primary and secondary branches, fruit length, average fruit weight, number of fruits per plant and harvest duration for genetic improvement of chilli.

Key words: Chilli, correlation, heritability, genetic advance, path analysis

Chilli (*Capsicum annuum* L.), a member of the Solanaceae family (2n = 24), is a popular commercial vegetable and condiment that is farmed around the world. Chillies were domesticated in Central America, most likely in Mexico, with secondary centers in Guatemala and Bulgaria (Salvador, 2002). Chilli can be used in a variety of forms, including fresh or cooked vegetables, herbs or spices, and a variety of processed foods (Hazra *et al*., 2011). Green chillies are rich source of Vitamin A, C and E. India is the world's largest producer, consumer, and exporter of chilli, with a total area of 309 thousand hectares and a production of 3592 thousand metric tonnes per hectare (NHB, 2020). Andhra Pradesh, Karnataka, Maharashtra, Orissa, Tamil Nadu, Madhya Pradesh, West Bengal, and Rajasthan are the major chilli growing states in India.

In any crop development programme, the collection of diverse germplasm and their systematic evaluation are critical. Chilli has a wide range of plant and fruit characteristics that indicates its potential for generating high-yielding cultivars with acceptable fruit characteristics. The initial and cheapest input to boost the crop production is to make available high yielding and well adapted varieties by initiating a strong breeding programme. The level of success in improving germplasm through selection is determined by genetic variability, which provides the possibility to improve production and quality through a systematic breeding programme (Sharma *et al*. 2020).

Crop improvement with heritable characters, estimation of genetic parameters and their association is of prime importance in breeding programme (Bozokalfa *et al.* 2010; Sood *et al.* (2011); Negi and Sharma 2019).

Yield is a complex quantitative trait which is driven by a large number of genes and is influenced by a variety of environmental factors. Selection of superior genotypes based on yield alone may be ineffective and therefore, to make selection effective, genetic variability must be separated from total variability, allowing the breeder to choose an appropriate breeding programme. Yield is linked to the number of component characters and variability studies alone will not be of much help in improving yield. To initiate a sound selection programme for improving yield, indirect selection of component traits is required based on knowledge of genetic correlations among the characters contributing to yield. Knowledge of correlation alone is often misleading as the correlation observed may not be always true. Simple correlation analysis that relates yield to a single variable may not provide a complete understanding of the importance of each component in determining fruit yield (Okuyama *et al*. 2004). As a result, analysis of inter component correlation is necessary to expose the direct and indirect contribution of each component which is determined by path-coefficient analysis (Sekhon *et al*. 2019). Keeping this in view, the present investigation was planned to evaluate 14 diverse genotypes of chilli for genetic variability, heritability and correlation between yield and other attributes.

Materials and Methods

A field experiment was conducted at Vegetable Research Farm, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur for two consecutive years during summer-rainy season 2020 and 2021. The experimental materials comprising of 14 genotypes of chilli including four GMS lines namely; 'DPChMS 9-2', 'DPChMS11-2', 'DPChMS 26-1', 'DPChMS 29-2' and check 'Surajmukhi' were evaluated in randomized complete block design with three replications. Data were recorded on randomly taken five plants of each genotype in each replication followed by computing their means for the various traits *viz.,* days to 50 % flowering, days to first harvest, fruit length (cm), pedicel length (cm), fruit girth (cm), plant height (cm), primary branches per plant, intermodal length of primary branch (cm), secondary branches per plant, average green fruit weight (g), marketable green fruits per plant, non-marketable green fruit per plant, total green fruits per plant, per cent marketable green fruits per plant, harvest duration (days) and marketable green fruit yield per plant (g). The data were subjected to analysis of variance as suggested by Panse and Sukhatme (1985). The genotypic and phenotypic variations and heritability were calculated as per the method of Burton and De Vane (1953). Genetic advance (GA) was calculated as per Burton and De Vane (1953) and Johnson *et al*. (1955). Coefficients of correlation were calculated as suggested by Al-Jibouri *et al*. (1958) while path coefficients of different traits with fruit yield per plant were carried out as per Dewey and Lu (1959).

Results and Discussion

Mean performance

Chilli genotypes showed wide range of variability for most of the growth and fruit characters in respective years and pooled over the years (Table 1). Genotype 'DPCh-10' significantly took minimum number of days to flowering (46.50) whereas genotype 'DPCh-22-C' significantly took minimum days to first fruit harvest (58.00) over the check 'Surajmukhi' (70.00). The highest numbers of primary branches (5.14) and secondary branches (15.17) per plant were found in genetic male sterile line 'DPChMS 9-2'. Fruit length and girth showed distinct variation among the cultivars. 'DPCh- 10' (9.98 cm) had the longest fruit, followed by 'PBC-535' (9.65 cm), 'DPChMS 29-2' (9.47 cm) and 'DPChMS 26-1' (9.39 cm) which were significantly superior over the check 'Surajmukhi' (5.63). Genotype 'Him Palam Mirch-2' exhibited significantly highest fruit girth (3.98 cm) over check 'Surajmukhi' (3.02). The variation in pedicel length was recorded with highest in genotype DPCh-40 (3.78 cm) and lowest in 'DPChMS11-2' (2.65 cm). Three genotypes were significantly superior and ten genotypes were at par with check 'Surajmukhi' (3.00) for pedicel length. Significantly maximum average fruit weight was found in 'DPCh-10' (3.98g) and 'PBC-535' (3.95g) over the check 'Surajmukhi' (2.25)

Table 1. Mean performance of chilli (*Capsicum annuum* L.) genotypes for various traits pooled over the years

Genotype	Days to 50% flowering	Days to first harvest	Primary branches per plant	Inter nodal length of primary branch (cm)	Secondary branches per plant	Plant height (cm)	Fruit length (cm)	Pedicel length (cm)	Fruit girth (cm)	Average green fruit weight (g)	Marketable green fruits per plant	Non-marketable green fruits per plant	Total green fruits per plant	Percent marketable green fruit per plant	Harvest duration (Days)	Marketable green fruit yield per plant (g)
DPCH MS 9-2	52.67	66.00	5.14	5.78	15.71	57.48	8.17	2.89	2.52	2.12	152.17	9.61	161.77	94.05	51.50	323.03
DPCH MS11-2	52.50	65.83	5.00	6.94	13.83	73.87	8.33	2.65	2.57	2.28	110.76	11.26	122.02	90.57	53.00	250.91
DPCH MS 26-1	49.17	59.33	4.35	5.93	11.43	66.98	9.39	3.22	3.34	3.08	111.43	10.77	122.20	91.13	59.00	342.34
DPCH MS 29-2	47.00	59.17	3.46	6.19	9.20	71.39	9.47	3.05	2.86	2.44	144.99	16.03	161.01	90.15	57.83	358.53
DPCH 10	46.50	60.00	2.99	6.19	8.93	64.37	9.98	2.95	3.23	3.98	79.89	15.19	95.08	84.11	59.17	318.01
PBC-535	50.33	63.83	4.67	4.53	13.46	49.38	9.65	3.11	3.75	3.95	72.34	20.77	93.11	78.27	47.33	285.35
Him PalamMirch -1	51.83	64.33	4.14	6.31	12.41	59.48	6.90	3.43	3.09	2.28	143.40	3.53	146.93	97.57	55.33	327.07
DPCH-101	57.50	71.67	4.80	5.81	13.23	61.56	7.19	3.29	3.03	2.36	192.05	3.49	195.53	97.76	47.83	458.70
VVG	50.83	64.67	4.78	6.73	12.27	77.57	6.57	3.09	2.91	1.97	193.91	3.13	197.04	98.39	57.17	381.25
DPCH-40	48.83	60.67	3.96	6.00	10.97	63.55	9.04	3.78	3.39	3.16	123.03	4.73	127.76	95.96	56.83	390.54
Him PalamMirch -2	50.00	60.67	3.83	6.53	11.21	58.28	8.51	3.48	3.98	3.83	121.85	2.30	124.15	98.21	60.50	467.68
DPCH-6-2	47.50	60.33	3.36	3.46	10.38	50.71	5.20	3.24	2.92	2.22	111.88	8.67	120.55	92.76	58.83	253.02
DPCH22-C	46.50	58.00	3.26	3.74	11.75	51.56	6.91	3.58	2.73	2.18	139.68	5.17	144.85	96.35	54.83	306.56
Surajmukhi (Check)	58.67	70.00	4.42	6.01	12.49	74.23	5.63	3.00	3.02	2.25	139.28	1.89	141.17	98.65	54.50	313.55
CV (%)	2.85	2.37	4.51	4.17	3.45	3.47	2.61	3.94	3.32	4.37	3.86	5.55	3.63	0.90	4.20	2.86
CD at 5%	2.43	2.52	0.31	0.40	0.69	3.66	0.35	0.21	0.17	0.20	8.50	0.77	8.50	1.41	3.90	16.38
SE(m+-)	0.84	0.87	0.11	0.14	0.24	1.26	0.12	0.07	0.06	1.50	2.92	0.27	2.92	0.48	1.34	5.63

whereas lowest fruit weight was reported in genotype 'VVG' (1.97g). The most important yield contributing factor in chilli is the marketable number of fruits per plant. The genotypes differed significantly for number of marketable fruits per plant with maximum in 'VVG' (193.91) as compared to check 'Surajmukhi' (139.28) and lowest in 'PBC-535' (72.34). The genotype 'Him Palam Mirch -2' showed the lowest number of non-marketable fruits per plant (2.30) which was at par with check 'Surajmukhi' (1.89). Two genotypes 'VVG' (197.04) and 'DPCh-101' (195.53) recorded significantly maximum total green fruits per plant while 'Him Palam Mirch -1' (146.93) and 'DPCh22-C' (146.85) showed similar performance to that of check 'Surajmukhi' (141.17). For per cent marketable green fruits per plant, four genotypes namely, 'VVG' (98.39), 'Him Palam Mirch-2' (98.21), 'DPCh-101' (97.76) and 'Him Palam Mirch-1' (97.57) performed at par with check 'Surajmukhi' (98.65). For marketable fruit yield, 'Him Palam Mirch-2' (467.68g) and DPCh-101(458.70g) performed significantly better than check "Surajmukhi' (313.55) whereas genotype 'DPChMS-11-2' recorded the lowest marketable yield (250.91g). The low yield in male sterile lines is obvious due to their segregation into 50% male sterile and 50% male fertile plants and accordingly bears low number of fruits per plant especially in sterile plant under open field conditions. Variations among majority of the characters using variable genetic material have also been reported by many research workers namely, Sharma *et al*. (2014), Patel *et al*. (2015), Srinivas *et al*. (2017) and Ngullie and Biswas (2019), Negi and Sharma (2019), Azadani (2020) and Farwah*et al*. (2020) in variable environments.

Variability studies

The knowledge of phenotypic (PCV) and genotypic coefficients of variation (GCV) are helpful in predicting the amount of variation present in the germplasm which aids in formulating effective breeding programme. The analysis of variance (Table 2) showed that all the varieties slightly differed for all the characters. High magnitude of PCV and GCV were observed for average fruit weight, marketable green fruits per plant, non-marketable green fruits and total green fruits per plant indicating the existence of wide range of genetic variability ensuring sufficient scope for improving these traits through selection. Moderate estimates of PCV and GCV were observed for characters namely, primary branches per plant, secondary branches plant, internodal length of primary branch, fruit length and marketable green fruit yield per plant indicating cautious approach for selection of these traits for improvement. Low GCV and PCV were recorded for days to 50 % flowering, days to first

Table 2. Estimates of parameters of variability for various traits in green chilli pooled over years

Traits	Environment variance	Genotypic Variance	Phenotypic variance	ECV (%)	GCV (%)	(PCV %)	h^2bs	GA (%)
Days to 50 % flowering	2.09	13.44	15.53	2.85	7.23	7.77	86.52	12.99
Days to first harvest	2.25	16.64	18.89	2.37	6.46	6.88	88.11	12.49
Primary branches per plant	0.04	0.47	0.51	4.51	16.53	17.14	93.09	32.89
Inter-nodal length of primary branch (cm)	0.06	1.11	1.16	4.17	18.37	18.83	95.10	36.88
Secondary branches per plant	0.17	3.27	3.44	3.45	15.13	15.52	95.05	30.36
Plant height (cm)	4.76	81.45	86.20	3.47	14.35	14.76	94.00	28.73
Fruit length (cm)	0.04	2.34	2.39	2.62	19.32	19.50	98.21	39.42
Pedicel length(cm)	0.02	0.08	0.10	3.94	9.11	9.92	84.26	17.21
Fruit girth (cm)	0.01	0.17	0.18	3.32	13.30	13.70	94.14	26.52
Average green fruit weight (g)	0.01	0.53	0.54	4.37	26.73	27.09	97.40	54.23
Marketable green fruits per plant	25.64	1221.03	1246.66	3.86	26.64	26.91	97.94	54.30
Non -marketable green fruits per plant	0.21	34.67	34.88	5.55	70.75	70.96	99.39	145.27
Total green fruits per plant	25.65	988.26	1013.91	3.63	22.53	22.82	97.47	45.83
Percent marketable green fruit per plant	0.70	35.61	36.31	0.90	6.41	6.47	98.06	13.07
Harvest Duration (days)	5.39	15.14	20.53	4.20	7.04	8.20	73.75	12.46
Marketable green fruit yield per plant(g)	95.15	4293.14	4388.29	2.86	19.20	19.42	97.83	39.13

PCV and GCV represent phenotypic and genotypic coefficients of variation, respectively; h2 bs: Heritability in broad sense; GA (%): Genetic advance (%) as percent of mean

harvest, pedicel length, fruit girth, plant height, and percent marketable green fruit per plant and harvest duration suggesting limited variability for these traits. The genotypic coefficients of variation for all the traits studied were lesser than the phenotypic coefficients of variation, indicating the role of environment in the manifestation of these traits in different genotypes.

Similar reports were also made by Akula *et al*. (2016), Meena *et al*. (2016) and Negi and Sharma (2019) and Gokulakrishnan *et al*. (2020) for these traits. Stability in the performance of selection of succeeding generations depends on the magnitude of heritable variation present in relation to observed variation. Knowledge of heritability influences the choice of breeding techniques to predict gain from selection and to determine the relative relevance of genetic effects (Negi and Sharma 2019). High heritability estimates were observed for all the characters except harvest duration indicating the greater role of genetic components of variation and lesser influence of environment. High heritability along with high genetic advance was observed for primary branches per plant, internodal length, secondary branches per plant, fruit length, average green fruit weight, marketable green fruits per plant, total green fruits per plant and marketable fruit yield per plant which indicated substantial contribution of additive gene action in the expression and thus selection would be effective for genetic improvement of these traits (Sood *et al*. 2020). High heritability along with low genetic advance was observed for days to 50% flowering, days to first harvest and percent marketable green fruit per plant. Low heritability along with low genetic advance was found in harvest duration which indicates the possible role of dominance and epistatic gene effects and hence, this character could be improved through hybridization. Similar effects have also been reported by Yatung *et al*. (2014), Megharaj *et al*. (2017), Negi and Sharma (2019) and Azadani (2020) in their respective studies.

Correlation and Path analysis

In order to find out the association between yield and related traits the phenotypic and genotypic correlation coefficients were estimated (Table 3). The results revealed that the genotypic correlations were higher than the phenotypic correlations for all the characters. Marketable green fruit yield per plant showed positive and significant correlation with marketable green fruits per plant followed by total green fruits per plant, percent marketable green fruits per plant, pedicel length, fruit girth and internodal length of primary branch at both genotypic and phenotypic levels. Marketable green fruits per plant showed positive correlation with days to 50 % flowering, days to first harvest, primary branches per plant and plant height. A positive and significant association of average red ripe fruit weight was observed with fruit length and fruit girth. In addition, positive and significant association at both genotypic and phenotypic level was recorded for days to 50% flowering, days to first harvest, primary branches per plant, internodal length of primary branch, secondary branches per plant among themselves while plant height had the same with days to 50 % flowering. Similarly, a positive association was found between fruit length and internodal length. Fruit girth, fruit length, pedicel length and average green fruit weight had positive association among themselves while they had negative association with marketable green fruits per plant. Therefore, selections for improvement in chilli based on these traits have to be taken up carefully by not compromising with consumer preference of medium long and medium broad fruits. Genotypic correlation, rather than phenotypic correlation, gives more reliable assessments of genetic relationship between characters, thus helps in determining the characters that should be taken into account for selection during breeding programme (Sharma *et al*. 2010; Negi and Sharma 2019; Azadani 2020).

The mutual association of component characters might vary both in magnitude and direction and the simple correlation coefficient may not reflect the exact relationship between yield and related traits. Therefore, it is necessary to conduct path coefficient analysis which permits a critical examination of specific direct and indirect effects of characters and measures their relative intensity in determining the ultimate yield. The path coefficient analysis required to determining the degree of relationship between yield and its component effects, as well as for examining specific factors that contribute to a given correlation. Path coefficient analysis (Table 4) revealed that total green fruits per plant had the maximum positive direct effect on marketable green

Table 3. Estimates of phenotypic and genotypic correlation coefficients for different pair of traits in marketable green chilli pooled over years

Traits		Days to first harvest	Primary branches per plant	Inter-nodal length of primary branch	Secondary branches per plant	Plant height (cm)	Fruit length (cm)	Pedicel length (cm)	Fruit girth (cm)	Average green fruit weight (g)	Marketable green fruits per plant	Non marketable green fruits per plant	Total green fruits per plant	Percent marketable per green fruit per plant	Harvest duration (Days)	Marketable green fruit yield per plant
Days for flowering	P	0.839*	0.611*	0.340*	0.483*	0.371*	-0.312*	-0.279	-0.175	-0.353*	0.460*	-0.318*	0.451*	0.333*	-0.477*	0.206
	G	0.955*	0.661*	0.401*	0.538*	0.426*	-0.340*	-0.328*	0.184	-0.395*	0.527*	-0.347*	0.520*	0.381*	-0.562*	0.260
Days to first harvest	P		0.687*	0.297	0.604*	0.256	-0.357*	-0.326*	-0.210	-0.338*	0.439*	-0.309*	0.430*	0.257	-0.576*	0.133
	G		0.752*	0.303	0.681*	0.291	-0.396*	-0.375*	-0.225	-0.362*	0.480*	-0.321*	0.472*	0.283	-0.728*	0.150
Primary branches per plant	P			0.372*	0.861*	0.255	-0.067	-0.351*	-0.168	-0.280	0.348*	-0.108	0.367*	0.112	-0.580*	0.062
	G			0.388*	0.884*	0.287	-0.069	-0.421*	-0.187	-0.297	0.357*	-0.101	0.377*	0.114	-0.665*	0.062
Internodal length of primary branch cm)	P				0.081	0.741*	0.311*	-0.263	0.051	0.051	0.249	-0.178	0.244	0.212	0.153	0.404*
	G				0.069	0.790*	0.319*	-0.328*	0.042	0.052	0.247	-0.179	0.241	0.217	0.157	0.413*
Secondary branches per plant	P					-0.074	-0.200	-0.246	0.277	-0.335*	0.278	0.128	0.283	0.130	-0.645*	-0.093
	G					-0.090	-0.192	-0.306*	-0.296	-0.355*	0.278	-0.139	0.282	0.133	-0.787*	-0.103
Plant height (cm)	P						0.009	-0.386*	-0.279	-0.262	0.353*	-0.178	0.359*	0.252	0.223	0.138
	G						0.022	-0.456*	-0.263	-0.289	0.360*	-0.183	0.365*	0.267	0.237	0.135
Fruit length (cm)	P							-0.093	0.384*	0.702*	-0.494*	0.654*	-0.427*	-0.629*	0.033	0.139
	G							-0.094	0.385*	0.714*	-0.501*	0.661*	-0.433*	-0.644*	0.021	0.142
Pedicel length (cm)	P								0.386*	0.143	0.112	-0.443*	0.044	0.363*	0.181	0.442*
	G								0.470*	0.159	0.112	-0.474*	0.035	0.410*	0.239NS	0.476*
Fruit girth (cm)	P									0.806*	-0.417*	0.059	-0.452*	-0.215	0.180	0.427*
	G									0.850*	-0.438*	0.062	-0.475*	-0.231	0.173	0.443*
Average green fruit weight (g)	P										-0.703*	0.436*	-0.699*	-0.584*	0.138	0.190
	G										-0.723*	0.444*	-0.721*	-0.600*	0.149	0.193
Marketable green fruits per plant	P											-0.644*	0.990*	0.757*	-0.113	0.514*
	G											-0.649*	0.990*	0.765*	-0.169	0.506*
Non -marketable green fruits per plant	P												-0.529*	-0.950*	-0.166	-0.473*
	G												-0.533*	-0.959*	-0.197	-0.477*
Total green fruits per plant	P													0.662*	-0.154	0.482*
	G													0.672*	-0.225	0.473*
Percent marketable green fruit per plant	P														0.191	0.475*
	G														0.235	0.478*
Harvest duration (Days)	P															0.112
	G															0.087

Residual effect at phenotypic level (P) =0.03726 and genotypic level (G) = -0.0210 Significant at P≤0

Table 4. Estimates of direct and indirect effects of different traits on marketable green fruit yield per plant at phenotypic (P) and genotypic (G) levels in green chilli pooled over years

Traits		Days to flowering	Days to first harvest	Primary branches per plant	Internodal length of primary branch (cm)	Secondary branches per plant	Plant height (cm)	Fruit length (cm)	Pedicel length (cm)	Fruit girth (cm)	Average green fruit weight (g)	Marketable green fruits per plant	Non - marketable green fruits per plant	Total green fruits per plant	Percent marketable green fruit per plant	Harvest duration	(Days) R
Days for flowering	P	0.013	0.108	0.015	-0.013	-0.077	-0.034	-0.088	-0.000	-0.033	-0.278	-1.670	0.112	1.842	0.300	0.017	0.206
	G	0.083	0.451	0.525	-0.109	-0.398	-0.159	-0.120	-0.048	0.078	-0.555	-0.857	-0.073	1.164	0.478	-0.199	0.260
Days to first harvest	P	0.011	0.128	0.017	-0.012	-0.096	-0.023	-0.102	-0.001	-0.039	-0.266	-1.594	0.108	1.749	0.232	0.021	0.133
	G	0.079	0.472	0.597	-0.083	-0.504	-0.109	-0.139	-0.054	0.096	-0.501	-0.780	-0.0681	1.056	0.354	-0.257	0.150
Primary branches per plant	P	0.007	0.088	0.025	-0.014	-0.137	-0.023	-0.019	-0.001	-0.032	-0.220	-1.265	0.038	1.492	0.101	0.021	0.062
	G	0.055	0.355	0.794	-0.106	-0.654	-0.107	-0.024	-0.062	0.080	-0.418	-0.580	-0.021	0.842	0.143	-0.235	0.062
Internodal length of primary branch (cm)	P	0.004	0.038	0.009	-0.039	-0.012	-0.068	0.088	-0.000	0.009	0.040	-0.905	0.062	0.990	0.192	-0.005	0.404*
	G	0.033	0.143	0.308	-0.273	-0.051	-0.296	0.113	-0.048	-0.018	0.073	-0.402	-0.038	0.539	0.273	0.056	0.413*
Secondary branches per plant	P	0.006	0.076	0.022	-0.003	-0.159	0.007	-0.057	-0.000	-0.053	-0.263	-1.010	0.049	1.151	0.118	0.023	-0.093
	G	0.045	0.322	0.702	-0.019	-0.740	0.034	-0.068	-0.045	0.126	-0.499	-0.452	-0.030	0.631	0.167	-0.278	-0.103
Plant height (cm)	P	0.004	0.033	0.006	-0.028	0.012	-0.091	0.003	-0.001	-0.053	-0.206	-1.283	0.062	1.461	0.228	-0.008	0.138
	G	0.035	0.138	0.228	-0.216	0.067	-0.374	0.008	-0.067	0.112	-0.406	-0.585	-0.039	0.816	0.335	0.084	0.135
Fruit length (cm)	P	-0.004	-0.046	-0.001	-0.012	0.032	-0.001	0.286	-0.000	0.073	0.552	1.795	-0.229	-1.734	-0.568	-0.001	0.139
	G	-0.028	-0.187	-0.055	-0.087	0.142	-0.008	0.353	-0.014	-0.164	1.004	0.815	0.140	-0.968	-0.807	0.007	0.142
Pedicel length (cm)	P	-0.003	-0.042	-0.008	0.010	0.039	0.035	-0.027	0.003	0.073	0.113	-0.405	0.155	0.178	0.328	-0.007	0.442*
	G	-0.027	-0.177	-0.335	0.090	0.226	0.171	-0.033	0.146	-0.201	0.223	-0.182	-0.100	0.077	0.514	0.084	0.476*
Fruit girth (cm)	P	-0.002	-0.027	-0.004	-0.002	0.044	0.026	0.109	0.001	0.190	0.634	1.516	-0.020	-1.836	-0.195	-0.006	0.427*
	G	-0.015	-0.106	-0.149	-0.011	0.219	0.099	0.136	0.069	-0.427	1.194	0.712	0.013	-1.062	-0.290	0.061	0.443*
Average green fruit weight (g)	P	-0.004	-0.043	-0.007	-0.002	0.053	0.024	0.200	0.000	0.153	0.787	2.556	-0.153	-2.841	-0.527	-0.005	0.190
	G	-0.033	-0.171	-0.236	-0.014	0.262	0.108	0.252	0.023	-0.363	1.405	1.176	0.094	-1.612	-0.753	0.053	0.193
Marketable green fruits per plant	P	0.006	0.056	0.009	-0.009	-0.044	-0.032	-0.141	0.000	-0.079	-0.553	-3.633	0.226	4.023	0.684	0.004	0.514*
	G	0.044	0.227	0.283	-0.068	-0.206	-0.135	-0.177	0.016	0.187	-1.016	-1.627	-0.137	2.214	0.960	-0.060	0.506*
Non -marketable green fruits per plant	P	-0.004	-0.039	-0.002	0.007	0.022	0.016	0.187	-0.001	0.011	0.343	2.342	-0.351	-2.151	-0.858	0.006	-0.473*
	G	-0.029	-0.152	-0.080	0.049	0.103	0.069	0.233	-0.069	-0.027	0.624	1.055	0.212	-1.193	-1.203	-0.070	-0.477*
Total green fruits per plant	P	0.006	0.055	0.009	-0.009	-0.045	-0.033	-0.122	0.000	-0.085	-0.549	-3.597	0.186	4.07	0.598	0.006	0.482*
	G	0.043	0.223	0.299	-0.066	-0.209	-0.137	-0.153	0.005	0.203	-1.013	-1.610	-0.113	2.237	0.843	-0.080	0.473*
Percent marketable green fruit per plant	P	0.004	0.033	0.003	-0.008	-0.021	-0.023	-0.179	0.001	-0.040	-0.459	-2.753	0.333	2.691	0.903	-0.007	0.475*
	G	0.032	0.133	0.091	-0.059	-0.099	-0.100	-0.227	0.060	0.099	-0.843	-1.245	-0.203	1.503	1.254	0.083	0.478*
Harvest duration (Days)	P	-0.006	-0.074	-0.014	-0.006	0.103	-0.020	0.009	0.000	0.034	0.108	0.410	0.058	0.627	0.173	-0.036	0.112
	G	0.047	-0.344	-0.528	-0.043	0.582	-0.089	0.007	0.035	-0.074	0.209	0.274	-0.042	-0.504	0.294	0.354	0.087

Residual effect at phenotypic level (P) =0.03726 and genotypic level (G) = -0.0210 Significant at P ≤0.05; bold values indicate direct effects of correlation coefficient with marketable green fruit yield per plant r correlation coefficient with red fruit yield per plant

fruit yield per plant followed by average green fruit weight, percent marketable green fruits per plant, fruit length, primary branches per plant, days to first harvest, days to flowering and pedicel length at both phenotypic and genotypic levels. Besides, fruit girth contributed to some extent directly to marketable green fruit yield per plant at phenotypic level while non- marketable green fruits per plant and harvest duration contributed the similar effects at genotypic level. Such a change in direction and magnitude of direct and indirect effects might be due to environmental factors influencing various traits. The negative direct effects of internodal length of primary branch, secondary branches per plant, plant height and marketable green fruits per plant were recorded both at phenotypic and genotypic levels. The earlier research workers namely, Kumar *et al*. (2012), Pandit and Adhikary (2014), Negi and Sharma (2019), Deepo *et al*. (2020) also reported direct contribution of different traits on marketable green fruit yield per plant

Based on the present investigation it can be concluded that 'Him Palam Mirch -2', 'DPCh10', 'DPCh-40' were the most promising genotypes for marketable fruit yield and related traits. Based on parameters of genetic variability and correlation studies, the focus should be given for fruit length, fruit girth, and average fruit weight, number of fruits per plant and harvest duration for genetic improvement of chilli.

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