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GENETIC VARIABILITY STUDIES IN CHILLI (*Capsicum annuum* L.) IN MID HILLY REGIONS OF UTTARAKHAND

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ABSTRACT
The present investigation was carried out during Kharif 2016 at College of Horticulture, Bharsar with 19 genotypes of chilli (*Capsicum annuum* L.) in a Randomized Block Design with 3 replications to estimate the genetic variability, heritability and genetic advance for 24 traits. Analysis of variance revealed significant differences among the genotypes for all the traits studied indicating the presence of sufficient variability in the studied material. The GCV was higher than PCV and the difference between PCV and GCV was narrow for most of the characters revealing little influence of the environment in the expression of these traits. High magnitude of PCV and GCV were observed for all the traits studied except plant stem girth (9.74, 12.18), days to first flowering (5.10, 5.84), days to 50% flowering (3.2, 4.30) and capsaicin content (3.20, 4.18). High heritability coupled with high genetic advance as per cent of mean was observed for all the characters except plant height(34.64), plant stem girth (63.87), days to first flowering (76.24), days to 50% flowering (55.23) and capsaicin content (58.69) indicating the predominance of additive gene action making the simple selection more effective.

INTRODUCTION

Chilli (Capsicum annuum L.) a member of the Solanaceae family, originated from South and Central America. Chilli is an indispensable spice due to its pungency, taste, appealing colour and flavour and has its unique place in the diet as a vegetable cum spice crop (Gadaginmath, 1992). The alkaloid capsaicin present in placenta of the chilli fruit responsible for its pungency has diverse prophylactic and therapeutic uses in Allopathic and Ayurvedic medicine (Sumathy and Mathew, 1984) and can directly scavenge various free radicals (Bhattacharya *et al.,* 2010). Chilli is a good source of vitamin C (ascorbic acid) and is used in food and beverage industries (Bosland and Votava, 2000). It has also acquired a great importance because of the presence of 'oleoresin', which permits better distribution of colour and flavour in foods. In India, the area under chilli cultivation is 2, 38,000 hectares with an annual production of 1.492 million tonnes and productivity of 2,39,2000 MT/ha. India is the largest producer, consumer and exporter of chilli in the world (National Horticulture Board, 2016-17). Andhra Pradesh leads the country in its production, productivity and export followed by Karnataka, West Bengal, Madhya Pradesh and Orissa. The productivity of the crop is low due to many limiting factor ssuch as lack of superior genotypes or improved cultivars foruse in breeding programme to develop potential hybrids. So,there is need for development of new varieties and hybrids with high productivity. The critical assessment of nature and magnitude of variability in the germplasm stock is one of the important pre-requisites for formulating effective breeding methods (Krishna *et al*., 2007). Improvement in any crop is proportional to the magnitude of its genetic variability presentin germplasm. Greater the variability in a population, there are the greater chance for effective selection for desirable types(Vavilov, 1951). Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. Higher the heritable variation, greater will be the possibility of fixing the characters by selection. Hence, heritability studies are offore most importance to judge whether the observed variation for a particular character is due to genotype or due to environment. Heritability estimates may not provide clear predictability of the breeding value. Thus, estimation of heritability accompanied with genetic advance is generally more useful than heritability alone in prediction of the resultant effect for selecting the best individuals (Johnson *et al*., 1955).Therefore, the present investigation was carried out with aview to study the genetic variability, heritability and geneticadvance for yield and yield component characters. As the information on the nature and magnitude of variability for yield and other characters present in germplasm pool owing to genetic and non-genetic causes, is an important basic pre-requisite for starting any systematic breeding programme in identifying superior lines or varieties, an investigation was undertaken involving 19 genotypes of chilli.

MATERIALS AND METHODS

The experiment was carried out with 19 genotypes (Table 1) of chilli at College of Horticulture, Bharsar and is located between 290 20'-290 75' N latitude and 780 10'-780 80' E

longitude, covering about 5540 km^2 area. A total of 19 genotypes were raised in a Randomized Block Design with two replications. The nursery was raised during first week of April and the seedlings were transplanted at a spacing of 45 cm × 30 cm in a row of 1.62 m^2 experimental plot during third week of May. Each row consisted of 12 plants, of which five competitive plants were selected at random for recording the observations. plant height (cm), plant spread (cm^2), plant stem girth (cm)number of primary branches, number of secondary branches, number of tertiary branches, total number of branches, days to first flowering, days to 50% flowering, number of fruits per plant, fruit length (cm), average fruitweight (g), fresh fruit yield per plant (g), fresh fruit yield per plot (kg), fresh fruit yield per hectare (q/ha), ascorbic acid content (mg/100g) (Anonymous., 1975) , chlorophyll 'a' content, chlorophyll 'b' content (Yashida *et al*. (1972), pericarp thickness (mm), average dry fruit weight (g), dry fruit yield per plant (g), number of seed per fruit, seed weight per fruit (g) and capsaicin content (%) Sadashivam and Manikkam (1996).The crop was raised as per the recommended package of practices.

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1985). Genotypic and phenotypic correlation coefficients of variability were estimated according to the Burton and Devane (1953) by using the following formulae.

$$GCV(\%) = \frac{\sqrt{\text{Genotypic Variance}(Vg)}}{\text{General mean of population}\,(\overline{x}) \times 100}$$

$$PCV(\%) = \frac{\sqrt{\text{Phenotypic variance}(Vp)}}{\text{General mean of population}\,(\overline{x}) \times 100}$$

PCV and GCV were classified as per Robinson *et al*. (1949).

0-10% - Low

10-20% - Moderate

20% and above - High

Heritability in broad sense was calculated by the formula as suggested by Allard (1960).

$$\text{Heritability}(\%) = \frac{Vg}{Vp} \times 100$$

Where,

Vg = Genotypic variance [Vg = (Mg - Me) / r]

Vp = Phenotypic variance [Vg + Ve]

Heritability percentage was categorised as per Robinson (1966).

0-30% - Low

30-60% - Moderate

60% and above - High

The expected genetic advance (GA) resulting from selection of five per cent superior individuals was worked out as suggested by Allard (1960).

Genetic advance = H x µ p x K

Where,

K = 2.06 (Selection differential at 5 per cent selection index)

µp = Phenotypic standard deviation

H = Heritability in broad sense

Genetic gain expressed as per cent ratio of genetic advance and population mean was calculated by the method given by Johnson *et al*. (1955).

$$\text{Genetic gain}(\%) = \frac{\text{Genetic advance}}{\text{General mean of population}\,(\overline{x}) \times 100}$$

The genetic advance as per cent mean was categorised as suggested by Johnson *et al*. (1955).

0-10% - Low

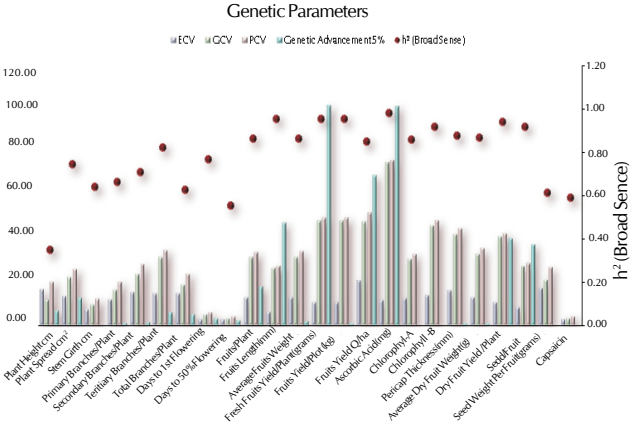
10-20% - Moderate

20% and above - High

RESULTS AND DISCUSSION

Analysis of variance (Table 2) revealed significant differences among the genotypes for all the traits indicating presence of significant variability in the genotypes which can be exploited through selection. These findings are in line with earlier reports Janaki *et al*. (2015), Kadwey *et al*. (2015), Pandiyaraj *et al*. (2016), Patel *et al*. (2015), Sharma and Sridevi (2016). The extent of variability with respect to 19 characters in different genotypes measured in terms of mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) along with the amount of heritability (h^2), expected genetic advance and genetic advance as per cent of mean (GAM) are presented in Table 3.

The mean performances of genotypes (Table 3) for different traits indicated that the high range of variability was recorded for fresh fruit yield per plant (33.06-214.48g), followed by number of seeds per plant (31.00-115.00), Ascorbic acid content (mg) (11.86-179.20). Relatively low range of variability was recorded in capsaicin content (0.09-0.11%) followed by plant stem girth (2.27-3.30), number of primary branches



Where: GCV - genotypic coefficient of variation, PCV - phenotypic coefficient of variation, h^2(b) - heritability in broadsense, GA - genetic advance and GAM - genetic advance as percent of mean (GAM)

Figure 1: Values of GCV, PCV, h ^{2} (broad sense) and GAM for 24 different characters in chilli.

Table 1: List of chilli genotypes used in the experiment and their source

Treatment	Genotypes	Source
T_1	Bydagi dabbi	Karnataka
T_2	Bydagi kaddi	Karnataka
T_3	Sankeswar	Uttarakhand
T_4	Hill local	Uttarakhand
T_5	Kandhamullaku chilli (SMALL)	Kerala
T_6	Ranichauri local	Uttarakhand
T_7	Madhya Pradesh local	Madhya Pradesh
T_8	Bharsar local-1	Uttarakhand
T_9	Nainital local	Uttarakhand
T_{10}	Pant nagar local	Uttarakhand
T_{11}	Banvasi local	Karnataka
T_{12}	Arka lohit	IIHR, Bengaluru
T_{13}	Pant C-1*	Uttarakhand
T_{14}	Pusa sadabahar	IARI, New Delhi
T_{15}	Varadha	Uttarakhand
T_{16}	Lakhori	Uttarakhand
T_{17}	Kandhamullaku chilli (LARGE)	Kerala
T_{18}	Arka suphal	IIHR, Bengaluru
T_{19}	Bharsar local-2	Uttarakhand

*- Check cultivar

4.30), capsaicin content (3.20 and 4.18) indicating the existence of wide range of genetic variability in the germplasm for these traits. This also indicates broad genetic base, less environmental influence and these traits are under the control of additive gene effects and hence, there is a good scope for further improvement of these characters through simple selection.These findings arein agreement with results of Ajjappalavara and Channagoudra (2009), Jadhav *et al*. (2004) for days to first flowering and days to 50% flowering, Kumar *et al*. (2003) for capsaicin content.The estimates of PCV and GCV were moderate and high for plant height (11.94 and 20.28), number of primary branches (16.36 and 20.16) and plant stem girth (18.79 and 23.77). These results are in conformity with findings of earlier works of Kumar *et al*. (2010), Munshi *et al*. (2010) for no. of primary branches per plant and Singh and Singh (2012) for plant height and plant stem girth.

High heritability coupled with moderate genetic advance as per cent of mean was observed for all the traits studied except plant height, plant stem girth, number of primary branches, days to first flowering, days to 50% flowering, capsaicin

Table 2: Analysis of variance for different characters in chilli (*Capsicum annuum* L.

1.	Plant height (cm)	4..84	158.46**	61.17
2.	Plant spread (cm²)	11.47	176.25**	18.48
3.	Plant stem girth (cm)	0.107	0.247**	0.03
4.	Number of primary branches	0.102	1.102**	0.162
5.	Number of secondary branches	0.008	2.110**	0.258
6.	Number of tertiary branches	1.452	32.90**	2.257
7.	Total number of branches	2.535	33.568**	5.603
9.	Days to 50% flowering	2.181	8.611**	1.832
10.	Number of fruits per plant	6.906	274.052**	14.13
11.	Fruit length(mm)	0.545	1683.425**	28.62
12.	Average fresh fruit weight (g)	0.042	2.855**	0.148
13.	Fresh fruit yield/ Plant (grams)	87.129	7739.002**	125.37
14.	Fresh fruit Yield/ Plot(kg)	0.010	1.108**	0.018
15.	Fresh fruit yield Q/ha	116.87	4248.562**	242.806
16.	Ascorbic acid content (mg)	4.2402	7444.588**	56.500
17.	Chlorophyll 'a' content	0.0002	0.006**	0.0003
18.	Chlorophyll 'b' content	0.0003	0.0185**	0.0005
19.	Pericarp Thickness (mm)	0.107	1.260**	0.0579
20.	Average Dry Fruit Weight (g)	0.026	0.903**	0.044
21	Dry Fruit Yield per Plant (g)	79.68	1227..73**	27..62
22	Number of seeds per fruit	6.33	1106.66**	32.59
23	Seed weight per fruit (g)	0.232	0.589**	0.103
24	Capsaicin (%)	0.000004	0.000004**	0.000008

- relatively significant *-highly significant

(2.33-4.66), number of secondary branches (2.40-5.86) and days to 50% flowering (44.40-50.46) and these findings are in accordance with those of Sharma and Sridevi (2016), Jogi *et al*. (2015).

The genotypic coefficient of variation (GCV) was higher than the phenotypic coefficient of variation (PCV) for all the characters (Table 3) and the difference between GCV and PCV was narrow indicating the little influence of environment on the expression of these characters and considerable amount of variation was observed for all the characters. The estimates of PCV and GCV were high for almost all the traits studied except for plant stem girth (9.74 and 12.18), days to first flowering (5.10 and 5.84), days to 50% flowering (3.2 and

indicating the role of additive and non-additive gene action and further improvement of this character would be easier through mass selection, progeny selection or any modified selection procedure aiming to exploit the additive gene effects rather than simple selection. As reported by Tembhurne *et al*. (2008), Suryakumari *et al*. (2010) .

The findings indicate that there exists adequate genotypic variation in the genotypes for almost all the traits studied showing high values of PCV, GCV and high heritability coupled with high genetic advance as per cent of mean suggesting predominance of additive gene action and lower influence of environmental factors in the expression of these traits with possibility for improvement through selection.

Table 3: Estimates of mean, range, components of variance, heritability and genetic advance for yield and its component characters in chilli (*Capsicum annuum* L.)

Sr.No.	Characters	Range	Mean	PCV	GCV	Heritability (%)	Genetic gain (%)	Genetic Advance as per cent of mean
1.	Plant height (cm)	30.06-61.06	47.69	11.94	20.28	34.64	14.47	6.90
2.	Plant spread (cm^2)	23.26-51.46	32.53	22.28	25.91	73.99	39.49	12.84
3.	Plant stem girth (cm)	2.27-3.30	2.70	9.74	12.18	63.87	16.03	0.43
4.	Number of primary branches	2.33-4.66	3.41	16.36	20.16	65.84	27.35	0.93
5.	Number of secondary branches	2.40-5.86	3.32	23.59	28.10	70.46	40.79	1.35
6.	Number of tertiary branches	6.26-16.31	10.16	31.45	34.75	81.9	58.63	5.95
7.	Total number of branches	12.33-22.20	16.24	18.79	23.77	62.46	30.59	4.97
8.	Days to first flowering	30.73-39.80	33.71	5.10	5.84	76.24	9.17	3.09
9.	Days to 50% flowering	44.40-50.46	46.97	3.2	4.30	55.23	4.89	2.30
10.	Number of fruits per plant	17.06-50.40	29.76	31.27	33.73	85.97	59.73	17.77
11.	Fruit length (mm)	59.14-132.03	88.54	26.52	27.20	95.07	53.27	47.17
12.	Average fresh fruit weight (g)	1.70-5.08	3.00	31.64	34.15	85.87	60.41	1.81
13.	Fresh fruit yield/ Plant (grams)	33.06-214.48	104.44	48.23	49.41	95.29	96.99	101.30
14.	Fresh fruit Yield/ Plot (kg)	0.39-2.57	1.24	48.26	49.44	95.28	97.04	1.21
15.	Fresh fruit yield Q/ha	24.27-158.63	76.56	47.72	51.88	84.61	90.43	69.24
16.	Ascorbic acid content (mg)	11.86-179.20	66.20	74.96	75.81	97.76	152.68	101.07
17.	Chlorophyll 'a' content	0.05-0.21	0.14	30.36	32.84	85.46	57.82	0.08
18.	Chlorophyll 'b' content	0.05-0.31	0.16	46.04	48.10	91.61	90.77	0.15
19.	Pericarp Thickness (mm)	0.56-2.60	1.51	41.87	44.79	87.37	80.62	1.21
20.	Average Dry Fruit Weight (g)	0.84-3.03	1.62	32.86	35.30	86.64	63.01	1.02
21	Dry Fruit Yield per Plant (g)	20.41-85.38	49.03	40.78	42.16	93.54	81.25	39.84
22	Number of seeds per fruit	31.00-115.00	69.29	27.30	28.52	91.66	53.84	37.31
23	Seed weight per fruit (g)	1.19-2.65	1.92	20.90	26.76	61.03	33.64	0.64
24	Capsaicin (%) content	0.09-0.11	0.11	3.20	4.18	58.69	5.05	0.00

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