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GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN F_5 GENERATION OF CHILLI (*CAPSICUM ANNUM* L.)

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ABSTRACT

A field experiment titled "Genetic variability, Heritability and Genetic Advance in F_5 generation of chilli (*Capsicum annum* L.)" was carried out during the 2024-25 growing season at the experimental farm of the Department of Horticulture, VNMKV, Parbhani. The study involved ten genotypes, including the check varieties Parbhani Mirchi and Pusa Jwala and was laid out in a randomized block design with three replications. The primary objective was to evaluate variability, heritability, genetic advance and trait correlations to facilitate the selection of superior genotypes. Analysis of variance (ANOVA) showed highly significant differences among the genotypes for all the traits observed, indicating substantial genetic diversity. Among the evaluated lines, PBNC-5-W4-2-3 and PBNC-6-W4-1-2 demonstrated superior performance in terms of green fruit yield and key horticultural characteristics, outperforming the standard check varieties. The phenotypic coefficient of variation (PCV) exceeded the corresponding genotypic coefficient of variation (GCV) for all the traits evaluated. However, the differences between PCV and GCV were relatively small for the majority of the characters. The highest values for phenotypic and genotypic coefficients of variation were found in green fruit yield per hectare, followed closely by green fruit yield per plot and green fruit yield per plant. Likewise, high PCV and GCV values were observed for powdery mildew incidence, thrips infestation, whitefly infestation, number of fruits per plant, pedicel length and pericarp thickness. High heritability coupled with high genetic advance as percent of mean was observed for number of fruits per plant, green fruit yield per plant, per plot, per hectare, pericarp thickness, pedicel length, plant spread N-S and plant spread E-W, indicating strong additive gene action and scope for improvement through phenotypic selection.

Key words : Chilli, Genetic advance, Heritability, Variability, GCV, PCV.

Introduction

Chilli (*Capsicum annuum* L.) is an important crop valued both as a vegetable and a spice, cultivated widely across tropical and subtropical regions around the globe. (Hazra *et al*., 2011). It has chromosomal number 2n=24 and is a member of the Solanaceae family. In the sixteenth century, it was brought to India from Brazil. It was domesticated around 7000 BC and is endemic to Tropical America, with Gautemala serving as a secondary centre of origin. Of the 30 species in the genus Capsicum, five are cultivated: *Capsicum annuum* L., *Capsicum frutescens* L., *Capsicum chinense* and *Capsicum pubescens* and *Capsicum baccatum* L. (Bosland and Votava, 2000; Wang and Bosland, 2006; Ince *et al*., 2010). In the Indian subcontinent, it is one of the most popular and valuable cash crops, cultivated for its dried red and green fruits, which are used as spices.

It has become a highly valued crop in India and holds a special place among vegetables in Indian cuisine due to its delicate taste, pleasant flavour and richness in ascorbic acid, along with other essential vitamins and minerals. Vitamin C heals cellular damage, strengthens the immune system and prevents respiratory infections. Vitamin A serves as an anti-inflammatory agent, immunity booster

and good retinoid activity. Chillies are low in sodium and cholesterol free, rich in vitamin A, vitamin C, vitamin E and a good source of potassium and folic acid. It with bright colour and less pungency are preferred in Europe and in the West. (Manjula *et al*., 2011; Sharanakumar *et al*., 2011). Chillies are used in both green and dry forms in all culinary preparations. Chilli is the most common ingredient in Indian curry. In curry, it is used as a paste, powder, broken, split or whole form. The mature fruits of chilli are widely used in stuffings, bakings and pizza, preparations of soups and stews for imparting flavour and also used in pickles and brined with cucumber.

India leads in chilli production followed by China and Pakistan. India is the world's largest producer, consumer and exporter of chilli. According to National Horticulture Board, during the year 2023-24 India had a production of 4670.66 tonnes. Madhya Pradesh is the leading producer with a production of 1039.19 tonnes contributing 22.25 per cent of total production followed by Karnataka (694.22 tonnes) (14.86%), Bihar (490.81 tonnes) (10.51%) and Andhra Pradesh (450.02 tonnes) (9.63%). Maharashtra ranks fifth in India with a production of 438.38 tonnes of green chilli (NHB 2023-24).

The critical assessment of nature and magnitude of variability in the germplasm stock is one of the important prerequisites for formulating effective breeding methods as the genetic improvement of any crop depends on magnitude of genetic variability and the extent of heritability of economically important characters, though the part played by environment in the expression of such character also needs to be taken into account. Improvement in any crop is proportional to the magnitude of its genetic variability present in germplasm. It is essential not only for the selection of desirable traits but also for providing valuable insights into choosing diverse parent plants for hybridization programmes. The degree to which the environment influences character expression and the potential for improvement following selection are both determined by heritability and genetic advancement.

Materials and Methods

The experimental material for the present study comprised eight F_5 progenies and two standard checks obtained from the Horticulture Research Scheme (Vegetable), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was conducted during the *Kharif* season of 2024-25 at Instructional Cum-Research Farm, Horticulture Research Scheme (Vegetable), V.N.M.K.V., Parbhani, using a Randomized Block Design with three replications. The experiment consisted of eight F_5 genotypes and two standard checks, with each entry planted in seven rows at a spacing of 60 cm × 50 cm. The list of genotypes and checks are given in Table 1. The During the evaluation, observations were recorded following standard procedures for the following traits: plant height (cm), number of primary branches, plant spread in the North-South (cm) and East-West (cm) directions, fruit length (cm), fruit diameter (mm), pedicel length (cm), pericarp thickness (mm), number of fruits per plant, average fruit weight (g), green fruit yield per plant (g), green fruit yield per plot (kg), green fruit yield per hectare (quintals), number of pickings per plant, capsaicin content (%), incidence of leaf curl and powdery mildew diseases (%) and infestation by whitefly and thrips pests (%). The Parameters of variability were calculated as per formulae given by Burton and De Vane (1953). Heritability in broad sense and expected genetic advance was determined as per formula given by Allard (1960) and Johnson *et al.* (1955).

Table 1 : List of genotypes and checks of chilli.

Treatment	Genotype	Source
T_1	PBNC-1-W4-1	VNMKV Parbhani
T_2	PBNC-3-W4-1-1	VNMKV Parbhani
T_3	PBNC-3-W4-2-1	VNMKV Parbhani
T_4	PBNC-5-W4-1-1	VNMKV Parbhani
T_5	PBNC-5-W4-2-3	VNMKV Parbhani
T_6	PBNC-6-W4-1-2	VNMKV Parbhani
T_7	PBNC-7-W4-1	VNMKV Parbhani
T_8	PBNC-8-W4-1	VNMKV Parbhani
T_9	Parbhani Mirchi (check)	VNMKV Parbhani
T_{10}	Pusa Jwala (check)	IARI New Delhi

Results and Discussion

Analysis of variance

The analysis of variance revealed statistically significant differences among the genotypes for all traits studied (Table 2), indicating that the germplasm possesses a significant level of variation.

Estimation of genetic parameters

The phenotypic coefficients of variation (PCV) were generally higher than the genotypic coefficients of variation (GCV) across all the traits studied, though the differences were relatively small for most traits. The highest values for phenotypic and genotypic coefficients of variation were found in green fruit yield per hectare (43.46% and 43.01%, respectively), followed closely by green fruit yield per plant (41.14% and 41.08%) and green fruit yield per plot (41.10% and 41.05%). Likewise, high PCV and GCV values were observed for powdery mildew incidence (58.86% and 56.94%), thrips infestation

Table 2 : Analysis of variance in chilli genotypes.

Characters	Replication (df:2)	Genotype (df:9)	Error (df:18)
Plant height	0.004	509.855**	0.322
No. o primary branches	0.054	1.096**	0.037
Plant Spread N-S	0.219	383.948**	0.149
Plant Spread E-W	0.692	369.405**	0.414
Days to initiation of flowering	0.223	13.152**	0.384
Days to 50% flowering	0.559	24.487**	0.307
Length of fruit(cm)	0.029	11.384**	0.113
Diameter of the fruit(mm)	0.260	2.433**	0.131
Pedicel length(cm)	0.033	2.185**	0.032
Pericarp thickness(mm)	0.011	0.583**	0.011
No. of fruit/plant	0.006	11281.905**	0.034
Average wt. of the fruit(g)	0.004	1.440**	0.013
Green fruit yield/plant(g)	413.073	388142.962**	353.05
Green fruit yield/plot(kg)	0.828	933.921**	0.741
No. of picking /plant	0.014	2.119**	0.030
Green fruit yield /ha (q)	90.705	46662.439**	323.224
Capsaicin%	0.00024	0.013**	0.0004
PDI of leaf curl virus%	1.803	15.968**	1.032
PDI of powdery mildew%	1.575	40.887**	0.910
White fly infestation (%)	5.397	32.117**	1.243
Thrips infestation (%)	0.554	30.348**	1.171

* and ** significant at 5% and 1%, respectively.

for genetic improvement through selection. Similar trends were seen in plant spread in the east-west direction (20.50% and 20.47%), plant spread in the north-south direction (20.61% and 20.60%) and length of fruit (19.21% and 18.93%). Other traits that exhibited moderate variability included capsaicin% (18.44 and 17.64), plant height (16.88% and 16.86%), leaf curl virus incidence (14.89 and 14.89), number of pickings per plant (14.17% and 13.87%), number of primary branches (12.76% and 12.14%) and fruit diameter (10.44% and 9.66%). Low PCV and GCV values were detected for days to initiation of flowering (5.11, 4.98) and days to 50% flowering (5.06, 4.97). The present study's results regarding the number of fruits per plant are consistent with the findings of Chattopadhyay *et al*. (2011), Datta and Das (2013), Bundela *et al*. (2017), Nagaraju *et al*. (2018) and Vyas *et al*. (2021). Similarly, green fruit yield per plant corresponds with the observations reported by Krishnamurthy *et al*. (2013), Dhaliwal *et al*. (2015) and Nagaraju *et al*. (2018).

The highest heritability value of 100% was recorded for the number of fruits per plant, suggesting that this trait is entirely governed by genetic factors and would respond very well to

Table 3 : Estimate of phenotypic and genotypic coefficients of variation, heritability, genetic advance and genetic advance as % mean for various characters in Chilli.

Characters	Range	Mean	PCV	GCV	Heritability %	Genetic advancement	Genetic adv. as % mean
Plant height	51.96 - 92.6	77.27	16.88	16.86	99.81	26.82	34.70
No. of primary branches	4.33 - 6.03	4.89	12.76	12.14	90.45	1.16	23.77
Plant Spread N-S	36.3 - 67.1	77.27	20.61	20.6	99.88	23.28	42.40
Plant Spread E-W	36.1 - 66.5	4.89	20.50	20.47	99.66	22.80	42.10
Days to initiation of flowering	39.56 - 45.2	42.13	5.11	4.897	91.71	4.07	9.66
Days to 50% flowering	52.86 -61.13	57.09	5.06	4.97	96.32	5.73	10.05
Length of fruit(cm)	8.204 - 12.7	10.24	19.21	18.93	97.07	3.93	38.41
Diameter of the fruit(mm)	7.59 - 10.39	9.07	10.44	9.655	85.37	1.66	18.37
Pedicel length(cm)	1.49 - 4.33	2.54	33.98	33.25	95.71	1.70	67.00
Pericarp thickness(mm)	0.82 - 2.02	1.31	34.11	33.11	94.21	66.21	66.21

(37.05% and 35.00%), whitefly infestation (36.99% and 34.94%), number of fruits per plant (33.92% and 33.92%), pedicel length (33.98% and 33.25%) and pericarp thickness (34.11% and 33.11%). The average fruit weight showed PCV and GCV values of 14.57% and 14.37%, respectively, suggesting moderate variability and potential selection. This was followed closely by plant height (99.8%), plant spread in the North-South direction (99.8%) green fruit yield per plant (99.7%), green fruit yield per plot (99.7%) and plant spread in East-West direction (99.6%), all of which showed very high heritability and therefore showed strong genetic control. Other traits that

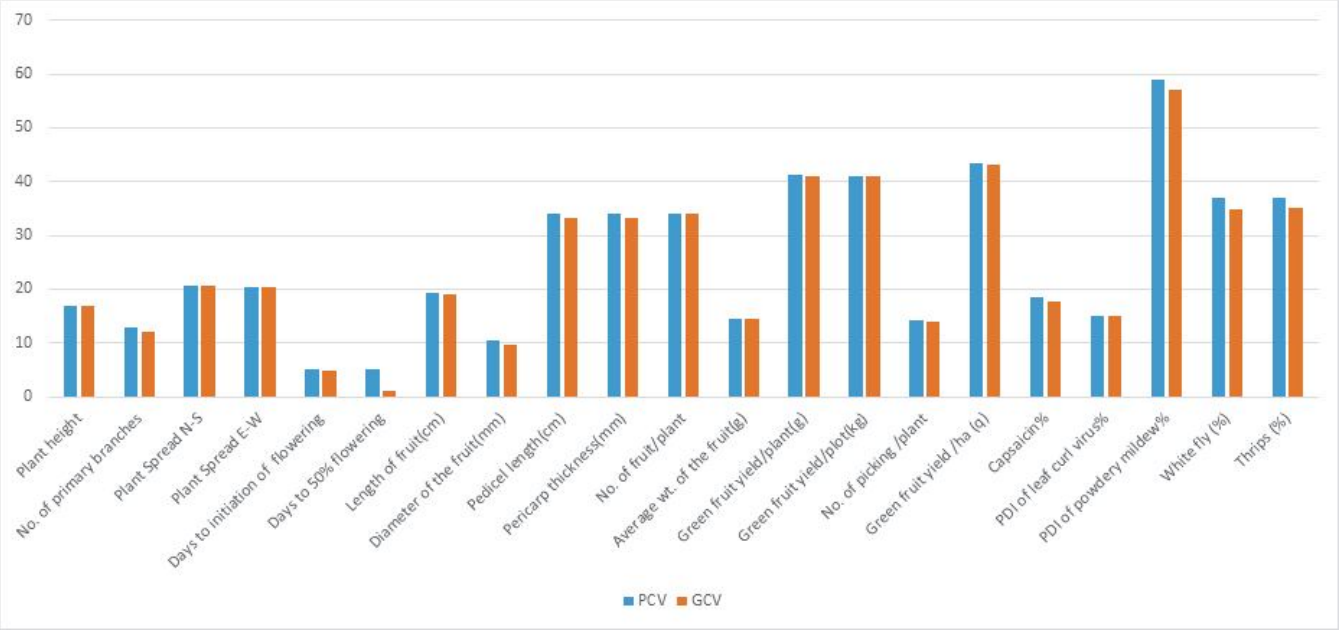

Fig. 1 : Genotypic and phenotypic coefficient of variation for quantitative and qualitative traits in chilli.

Table 4 : Estimate of phenotypic and genotypic coefficients of variation, heritability, genetic advance and genetic advance as % mean for various characters in Chilli

Characters	Range	Mean	PCV	GCV	Heritability %	Genetic advancement	Genetic adv. as % mean
No. of fruit/plant	104.56-271.4	180.76	33.92	33.92	100.00	126.32	69.88
Average wt. of the fruit(g)	4.23- 6.03	4.79	14.57	14.37	97.32	1.40	29.21
Green fruit yield/plant(g)	439.57-1610.1	875.01	41.14	41.08	99.73	739.62	84.52
Green fruit yield/plot(kg)	21.54- 78.98	42.95	41.10	41.05	99.76	36.28	41.08
No. of picking /plant	5.23-7.28	6.01	14.17	13.87	95.86	1.68	27.98
Green fruit yield /ha (q)	113.50-536.78	288.90	43.46	43.01	97.95	253.38	87.70
Capsaicin%	0.24 - 0.45	0.37	18.44	17.64	91.49	0.12	34.76
PDI of leaf curl virus%	13.6 - 21.76	16.45	14.89	14.89	82.82	4.18	25.41
PDI of powdery mildew%	2.03- 11.56	6.41	58.86	56.94	93.61	7.27	113.50
White fly (%)	4.76- 14.96	9.18	36.99	34.94	89.22	6.24	67.99
Thrips (%)	4.76 - 13.6	8.90	37.05	35.00	89.25	6.06	68.13

also recorded high heritability include green fruit yield per hectare (97.9%), average fruit weight (97.3%), fruit length (97.0%), days to 50% flowering (96.3%), days to initiation of flowering (91.7%), number of pickings per plant (95.8%), pedicel length (95.7%), pericarp thickness (94.2%), fruit diameter (85.3%), capsaicin content (91.4%) and number of primary branches (90.4%). These traits, combined with their high genotypic and phenotypic coefficients of variation, suggest that they are under strong genetic influence and have good potential for improvement through selection. The highest genetic advance as a percentage mean was recorded for the percent disease index of powdery mildew, followed by green fruit yield per hectare, green fruit yield per plant, and number of fruits per plant. Similar findings on very high heritability in chilli were reported by Manju and Sreelathakumary (2002), who observed extremely high heritability for traits such as yield per plant, capsaicin content, number of fruits per plant, fruit length, fruit diameter and fruit weight. Chattopadhyay *et al.* (2011) also recorded high heritability for days to 50% flowering, fruit traits and capsaicin content. Mishra *et al.* (2015) reported high heritability for both average fruit weight and green fruit yield per plant.

Conclusion

All the traits examined across the 10 genotypes displayed a wide and notable range of variability. For every trait assessed, the phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV). However, the relatively small differences between them indicate limited environmental influence, suggesting that phenotypic selection for these traits would be effective. Each trait showed high heritability combined with a high genetic advance as a percentage of the mean, implying that additive gene action primarily governs their expression. As a result, direct selection would be a reliable strategy for trait improvement. Based on the findings of the current study, the genotypes PBNC-5-W4-2-3 and PBNC-6-W4-1-2 demonstrated superior performance in terms of yield and yield-contributing traits, surpassing the standard check in various other horticultural characteristics. As such, these genotypes hold significant potential and may be considered for inclusion in future breeding programs to achieve targeted improvements.

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