**The study on Genetic Variability in Chilli Landraces**

*ABSTRACT*

The field experiment was conducted during summer and winter season, 2020 and summer season, 2021 at the Experimental Farm of Regional Horticultural Research and Training Station Dhaulakuan, District Sirmour (HP), Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. The experimental material comprising of variable 19 chilli landraces which were collected from different villages of Block Shillai and compared with the recommended cultivar DKC-8. The data were analyzed and the inferences were drawn for PCV and GCV, heritability (%) and genetic advance, High PCV and GCV were recorded for green fruit yield plant-1. Heritability was recorded maximum for all the traits under study and high value of genetic advance at 5 per cent selection intensity was recorded for green fruit yield per plant, number of green fruits per plant. These findings highlight the substantial genetic variability among local chilli landraces and their potential as valuable genetic resources. The study clearly demonstrates the effectiveness of selection in improving yield-related traits, indicating that these landraces can be effectively utilized in breeding programs aimed at enhancing chili productivity and adaptation.

*Keywords:* Landraces, Heritability, Genetic advance, Chilli

*Introduction*

Chilli (*Capsicum spp.*) is one of the most important spice and vegetable crops cultivated across the world. Belonging to the family Solanaceae, chilli is grown extensively for its pungent fruits, which are widely used for culinary, medicinal, and industrial purposes. India is recognized as the largest producer, consumer, and exporter of chilli, contributing significantly to the global spice trade. In addition to its economic importance, chilli also plays a vital role in the livelihoods of small and marginal farmers in many regions, particularly in hilly and tribal areas. Chilli is known for its immense genetic diversity, particularly in traditional landraces maintained by farmers over generations (Raghavendra *et al.,* 2017).

“Chilli contains a range of essential nutrients and bioactive compounds which are known to exihibit antimicrobial, antioxidant, antiviral, anti-inflammatory and anticancer properties. It is good source of vitamin C and possesses other vitamins *i.e.* A, B6, K and minerals like iron, calcium, magnesium, potassium and thiamine” (Chakrabarty *et al.*, 2017). Pungency in chilli is due to an active compound called capsaicin, which can directly scavenge free radicals within the body thus act as an anti-cancerous compound.

Green chilli is grown on 364,000 ha area in India, with an annual production of 3851,000 MT and a productivity of 10.58 t/ha, while dried chilli is grown on 683,000 ha area with an annual production of 1702,000 MT and a productivity of 2.49 t/ha (Anonymous, 2020). “India is the highest producer, consumer and exporter of chilli, accounting for nearly 33 per cent of the country's total spice exports and a 16 per cent share of global spice trade. Andhra Pradesh is the leading producer of chilli in India, followed by Telangana and Madhya Pradesh. Andhra Pradesh and Himachal Pradesh have 46.57 q/ha and 11.9 q/ha productivity respectively. Himachal Pradesh has larger area but occupied with varieties of low yield potential. This indicates that there is need to increase average productivity of chilli in Himachal Pradesh by cultivating pre-adapted landraces because these landraces may prove are high yielding when grown *ex-situ” (Singh, T. N., et al., 2024)*.

These landraces are often well adapted to local agro-climatic conditions and possess a rich repository of traits such as disease resistance, drought tolerance, fruit quality and high capsaicin content (Chakrabarty *et al.*, 2017). However, this genetic potential remains underutilized in mainstream breeding programs, mainly due to a lack of systematic evaluation and characterization. Understanding the extent of genetic variability within and among landraces is crucial for crop improvement. Parameters such as phenotypic and genotypic coefficients of variation (PCV and GCV), heritability, and genetic advance provide insights into the nature and magnitude of variability for key traits, and guide breeders in selecting superior genotypes. The present study was undertaken to assess the genetic variability in 19 chilli landraces collected from Block Shillai in Himachal Pradesh, in comparison with a recommended cultivar. The objective was to evaluate the extent of genetic variation in important agronomic traits over multiple seasons and to identify promising landraces that could be utilized in breeding programs aimed at improving yield and adaptability.

***Materials and methods***

The investigation was carried out during summer and winter seasons of 2020 and the summer season of 2021 at RHRT&S of Dr YSP UHF, Dhaulakuan, Sirmour (HP), India. The investigation site is located at an elevation of 468 m amsl in agro-climatic Zone 1 of Himachal Pradesh. The Local chilli landraces were collected from different villages of Sirmour district of Himachal Pradesh and compared with the recommended cultivar DKC-8.

The observations referring to fruit characteristics were cataloged from five selected plants per landrace per replication and their means were analyzed statistically. All the landraces were assessed for the following traits: Days to 50 per cent flowering, Days to green fruit maturity, fruit length, fruit breadth Number of green fruits plant-1, Average fruit weight (g) Fruit yield plant-1(g).

*Statistical analysis*

The data recorded was analyzed by using MS-Excel and OPSTAT. The mean values of each genotype in each replication for all the traits under study were subjected to statistical analysis as per Randomized Complete Block Design.

**Parameters of variability**

Parameters of variability were estimated as per formula given by Burton and Devane (1953).

**Phenotypic coefficient of variation (PCV)**

PCV (%) x 100

**B) Genotypic coefficient of variation (GCV)**

GCV (%) = x 100

Where:

Ve = Me

Vg = Genotypic variance (Mg - Me)/r

Vp = Phenotypic variance (Vg + Ve)

PCV and GCV were interpreted as shown below (Cherian, 2000)

Less than 15% = Low

15-30% = Moderate

More than 30% = High

**Heritability**

Heritability in broad sense was calculated as per the formula given by Burton and Devane (1953) and Allard (1960).

H (%) =

Where,

H = Heritability

Vg = Genotypic variance (Mg – Me)/r

Vp = Phenotypic variance (Vg + Ve)

**Genetic advance**

The expected genetic advance resulting from selection of five per cent superior individuals was calculated as per Allard (1960):

GA = H × σp × K

Where,

H = Heritability (%)

σp = Phenotypic standard deviation

K = Selection differential at 5% selection index (K = 2.06)

***Results and Discussions***

*Variability studies*

Variability study for different characteristics of chilli landraces was done by Bartlett’s chi square test for testing the goodness of fit and test of homogeneity. Since Bartlett’s test is insignificant for summer seasons 2020 and 2021, therefore it was pooled for these two seasons. Data were heterogeneous when Bartlett’s test was implied on three seasons, hence the inferences for winter season are drawn separately.

*Phenotypic and genotypic coefficients of variation*

As per the data in Table-1, high PCV and GCV (*i.e*. > 30%) were recorded for green fruit yield per plant. “Green fruit yield in winter season was greatly influenced by the seasonal effects. Magnitude of PCV was found higher than that of GCV which indicated that expression of the characters was greatly influenced by the environment. Valuable selection could be done using green fruit yield in summer seasons. Therefore, variability in the characters is not only due to the genotype but environment has also played an important role for influencing variation” (Singh, T. N., et al., 2022). The finding of high PCV and GCV are in accordance with the inferences made by Jyothi *et al*. (2011) and Krishnamurthy *et al*. (2016) for ripe fruit yield per plant; green fruit yield per plant were reported by Pandit and Adhikari (2014)

In summer seasons, moderate amount of PCV and GCV (*i.e.*15-30%) were recorded for average green fruit weight (28.56 and 28.73%), number of green fruits per plant (22.23 and 22.30%) and fruit girth (17.49 and 17.86%). In winter season, moderate amount of PCV and GCV (*i.e.* 15-30%) were recorded for average green fruit weight (29.54 and 29.73%), number of green fruits per plant (25.00 and 25.08%) and fruit girth (17.98 and 18.38%). Results are in accordance with the inferences made by Krishnamurthy *et al*. (2016) and Kumar *et al*. (2020) for fruit girth; plant height by Janaki *et al*. (2015) and Patel *et al*. (2015); days to 50 per cent flowering by Janaki *et al*. (2015) and Jogi *et al*. (2017).

Low PCV and GCV (*i.e*. < 15%) in summer seasons were observed for days to 50 per cent flowering (11.93 and 12.53%) and days to maturity (mature green stage) (9.91 and 10.36%). In winter season, low PCV and GCV were reported for days to 50 per cent flowering (7.61 and 7.77) and days to maturity (mature green stage) (4.63 and 4.72%). Low PCV and GCV indicated that genotypes possessed comparatively low genetic variation for these characteristics. Hence, these characteristics cannot be used for selection programmes.

*Heritability and Genetic advance*

Fisher (1918) was the first to separate heritable and non heritable components of continuous variation in metric traits. The proportion of phenotypic variation passed down from parents to offspring is referred to as heritability. Heritable variation accounts for the majority of genetic variability. The greater the heritable differences, the more likely it is that the characters will be fixed by selection. According to Comstock and Robinson (1952), genetic advance is an increase in the genetic value of a new population as compared to the original population, and it is determined by heritability, phenotypic variation, and selection rate. As a result, calculating genetic progress is essential in order to determine the efficacy of selection.

In summer seasons (Table-1), the heritability range for the different characteristics was varied from 90.63 to 99.37%. The values were greater for green fruit yield (96.48%), fruit girth (95.92), days to maturity (mature green stage) (93.05%), days to 50 per cent flowering (90.63%) and fruit length (90.04%). In winter season, heritability range was varied from 86.45 to 99.42%. High heritability was recorded for number of fruits per plant (99.42%), green fruit yield per plant (99.03%), average green fruit weight (98.77%), days to maturity (mature green stage) (96.17%), days to 50 per cent flowering (95.84%), fruit girth (95.69%), and fruit length (86.45%). “High value of heritability was recorded in summer and winter seasons for all the characteristics which indicated their simple inheritance pattern irrespective of number of genes governing them. Selection of plants based on highly heritable quantitative traits is easy and reliable” (Singh, T. N., et al., 2022). Thus, greater improvement could be expected for these characters. It is also inferred that both the seasons, “summer and winter, could be utilized in evaluating landraces, which will certainly hasten the process of conventional breeding programme. But, obviously, plant height in summers and number of ripe fruits in winter will be characteristics of focus”. In earlier studies, high heritability has also been recorded for plant height by Nahak *et al*. (2018) and Mondal *et al*. (2020); number of fruits per plant by Jyothi *et al.* (2011), Nahak *et al*. (2018), Kumar *et al*. (2020) and Tirupathamma *et al*. (2021); average green fruit weight by Nahak *et al*. (2018);

In summer seasons (Table-1), high values of genetic advance at 5 per cent selection intensity were recorded for green fruit yield per plant (131.98), number of fruits per plant (32.78), Whereas in winter season, the values of genetic advance were greater for green fruit yield per plant (137.16) followed by number of fruits per plant (33.31). The results were in close agreement with those of Gupta et al. (1984), Jyothi et al. (2011), who have reported high genetic advance for green fruit yield per plant, number of fruits per plant, ripe fruit yield per plant and number of ripe fruits per plant. High heritability coupled with high genetic advance for above mentioned characteristics indicated that selection on the basis of these traits could be effective for improving yield in chilli landraces as these traits were controlled by additive genes and selection could be beneficial for the enhancement of these characteristics.

***Conclusion***

The present study revealed considerable genetic variability among the chilli landraces evaluated across multiple seasons. High phenotypic and genotypic coefficients of variation (PCV and GCV) were recorded for green fruit yield per plant, particularly in the summer season, indicating a strong potential for selection. However, the higher magnitude of PCV over GCV suggests that environmental factors significantly influence trait expression. High heritability estimates, coupled with high genetic advance for traits such as green fruit yield per plant, number of fruits per plant, fruit girth, and fruit length, indicate that these traits are largely governed by additive gene action and can be effectively improved through selection. The consistency of these results across both summer and winter seasons supports the stability of these traits in different environments. Overall, the findings suggest that targeted selection based on green fruit yield and related traits could be a promising approach for the genetic improvement of chilli landraces. These landraces possess valuable agronomic potential and can serve as a rich genetic resource in future breeding programs aimed at enhancing yield and adaptability in chilli.

***DISCLAIMER (ARTIFICIAL INTELLIGENCE)***

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript.

***References***

Allard RW. 1960. *Principles of Plant Breeding*. John Wiley and Sons, New York, USA. 485p.

Anonymous. 2020. Area of chillies dried and green (ha) and production quantity (tonnes) in 2019-20, In: Second Advance Estimate of Area and Production of Horticulture crops. [www.nhb.gov.in](http://www.nhb.gov.in) cited on 30th August, 2021.

Burton GW and Devane EW. 1953. Estimating heritability in tall fescue (*Festuca arundiancea*) from replicated clonal material. *Agronomy Journal* **45:**478-81.

Chakarbarty S, Islam AKMM and Islam AKMA. 2017. Nutritional benefits and pharmaceutical potentialities of chilli. *Fundamental and Applied Agriculture* **2:**227-32.

Cherian E. 2000. *Genetic Variability in Capsicum chinense* Jacq.M.Sc*.* Thesis. Kerala Agricultural University, Kerala, India. 82p.

Comstock RE and Robinson HF. 1952. Estimation of average dominance of genes. *In: Heterosis*. Iowa State College Presss, Ames pp. 494-16.

Gupta CR and Yadav RDS. 1984. Genetic variability and path analysis in chilli (*Capsicum annuum* L.). *Genetica Agraria* **38:**425-32.

Janaki M, Naidu LN, Raman CV and Rao MP. 2015. Assessment of genetic variability, heritability and genetic advance for qualitative traits in chilli (*Capsicum annuum* L.). *The Bioscan* **10:**729-33.

Jogi MY, Madalageri MB, Mallimar M, Bawoor S, Vittal M and Porika H. 2017. Genetic variability studies in chilli (*Capsicum annuum* L.) for growth and yield. *International Journal of Pure and Applied Bioscience* **5**:858-62.

Jyothi KU, Kumari SS and Ramana CV. 2011. Variability studies in chilli (*Capsicum annuum* L.) with reference to yield attributes*. Journal of Horticulture Sciences* **6:**133-135.

Krishnamurthy SL, Reddy KM and Rao AM. 2016. Genetic variation, path and correlation analysis in crosses among Indian and Taiwan parents in chilli. *Vegetable Science* **40:**210-13.

Kumar TGH, Patil HB, Jayashree and Gowda DCM. 2020. Genetic variability studies in green chilli (*Capsicum annuum* L.). *International Journal of Chemical Studie*s **8:**2460-63.

Mondal CK, Acharyya P and Hazra P. 2020. Studies on genetic variability in chilli (*Capsicum annuum* L*.*) in the sundarban region of West Bengal. *International Journal of Current Microbiology and Applied Sciences* **9:**1938-43.

Nahak SC, Nanda A, Sahu GS, Tripathy P, Dash SK, Patnaik A and Pradhan SR. 2018. Studies on variability, heritability and genetic advance for yield and yield contributing characters in chilli (*Capsicum annuum* L.). *Journal of Pharmacognosy and Phtochemistry* **7:** 2506-2510.

Pandit MK and Adhikary S. 2014. Variability and heritability estimates in some reproductive charcters and yield in chilli (*Capsicum annuum* L.). *International Journal of Plant and Soil Sciences* **3:**845-53.

Patel DK, Patel BR, Patel JR and Kuchhadiya GV. 2015. Genetic variability and characters association studies for green fruit yield and quality component traits in chilli (*Capsicum annuum* var. *longum* (dc.) Sendt.). *Electronic Journal of Plant Breeding* **6:**472-78.

Raghavendra H, Puttaraju TB, Varsha D and Krishnaji J. 2017. Stability analysis in chilli (*Capsicum annuum* L.) for yield and yield attributing traits. *Journal of Applied Horticulture* **19:**218-21.

Tirupathamma TL, Ramana CV, Naidu NL and Sasikala. 2021. Assessment of genetic variability for biochemical traits in paprika (*Capsicum annuum* L.) genotypes. *International Journal of Chemical Studie*s **9:**3242-45.

Singh, T. N., Joshi, A. K., Vikram, A., Yadav, N., & Prashar, S. (2024). Mean performances, character associations and multi-environmental evaluation of chilli landraces in north western Himalayas. Scientific Reports, 14(1), 769.

Singh, T. N., Joshi, A. K., Vikram, A., & Dogra, R. K. (2022, April). Genetic Variability and Stability Analysis in Chilli (Capsicum annuum L.) Landraces of North-Western Himalayas. 2022, 2, x. In Presented at the 1st International Electronic Conference on Horticulturae (Vol. 16, p. 30). s Note: MDPI stays neu-tral with regard to jurisdictional claims in published maps and institu-tional affiliations..

**Table-1: Estimation of phenotypic and genotypic coefficients of variation, heritability and genetic advance for various traits in chilli conducted over summer and winter seasons**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Characters** | **PCV** | | **GCV** | | **Heritability**  **(%)** | | **Genetic**  **Advance** | |
| **Summer** | **Winter** | **Summer** | **Winter** | **Summer** | **Winter** | **Summer** | **Winter** |
| **Days to 50 per cent flowering** | 12.53 | 7.77 | 11.93 | 7.61 | 90.63 | 95.84 | 12.32 | 12.80 |
| **Days to maturity (mature green stage)** | 10.36 | 4.72 | 9.91 | 4.63 | 91.57 | 96.17 | 15.41 | 10.33 |
| **Fruit length (cm)** | 22.55 | 22.36 | 21.40 | 20.79 | 90.04 | 86.45 | 3.03 | 2.83 |
| **Fruit girth (cm)** | 17.86 | 18.38 | 17.49 | 17.98 | 95.92 | 95.69 | 0.32 | 0.32 |
| **Number of green fruits per plant** | 22.30 | 25.08 | 22.23 | 25.00 | 99.37 | 99.42 | 32.78 | 33.31 |
| **Average green fruit weight (g)** | 28.73 | 29.73 | 28.56 | 29.54 | 98.85 | 98.77 | 1.72 | 1.75 |
| **Green fruit yield per plant (g)** | 31.84 | 36.23 | 31.28 | 36.06 | 96.48 | 99.03 | 131.98 | 137.14 |