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Genetic diversity of Chilli (*Capsicum annuum* L.)

Pattika Madhu [a], Sushma Nema [a], Yogendra Singh [b*], Kanchan S. Bhan [b] and Keerti Tantwai [a]

[a] Biotechnology Centre, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 482004, Madhya Pradesh, India.
[b] Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 482004, Madhya Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present study on the morphological characterization of chilli (*Capsicum annuum* L.) was conducted at Maharajpur Vegetable Farm, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. Utilizing 43 genotypes from different regions of Madhya Pradesh, the study aimed to enhance crop improvement programs by understanding genetic diversity. Present study was conducted on forty- three genotypes of chilli collected from Department of Horticulture, Department of Plant Breeding Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur. Genotypes have harboured appreciable amounts of variation for morphological, growth and yield attributing traits were analyzed for Phenotypic co efficient of variance (PCV), Genotypic co efficient of variance (GCV) and heritability along with genetic advance. Genetic divergence through multivariate analysis using D2 statistics was done and clustering of forty-three genotypes was done using Tocher's method of clustering analysis. GCV and PCV were resulted as moderate and high level whereas heritability coupled with Genetic advance were recorded as moderate to high level. 6 clusters formed in 43 genotypes using Mahalanobis D2.

**Corresponding author: E-mail: yogendrasinghbt@gmail.com;*

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1. INTRODUCTION

Chilli belongs to the family Solanaceae and has a chromosome number of 2n = 24. In the temperate zone, they grow as herbaceous annuals and are propagated by seeds. Chilli is aspice as well as vegetable crop Mexico, Guatemala, and Bulgaria are thought to be the chilli's three primary places of origin. TheCapsicum genus contains 30 species, five of which are cultivated [1,2]. These five species have mostly been used as vegetables and spices for thousands of years: *Capsicum annuum* L., *C. frutescens, C. chinense, C. pubescens, and C. baccatum.* Chilli was first introduced into India by the Portuguese in 16th century. The most common variety of capsicum farmed in India is *Capsicum annuum*, but *C. frutescens* and *C. chinense* are also produced in some areas, particularly in the country's north-eastern region and the states of Andhra.

Pradesh, Karnataka and Kerala. Initially introduced to India by the Portuguese in the 16th century. Baruah and Barua [3] chillies are grown globally, with India and China being major producers and exporters [4]. Despite its economic significance, chilli cultivation faces challenges such as diseases and insect infestations, limiting production and quality.

India, a significant player in the global chilli market accounting for 36 percent of total global chilli exports [5]. Recently Madhya Pradesh shown remarkable growth in the production of chilli and occupies 3rd position in the largest chilli producing states cultivated over 88,675 ha, productivity 2353 kg/ha (Spice board India 2019-20). chilli struggles with enhancing yields due to factors like the lack of superior cultivars and diseases. Genetic diversity analysis is crucial for crop improvement, aiding in the identification of suitable parental combinations and varieties [6,7].

To enhance crop improvement programs, understanding genetic diversity is crucial. Variability in populations is influenced by genetic and environmental factors. A study by (Johannsen et al., 1999) highlighted that variation in a population is due to both heritable and non-heritable factors in segregating populations, whereas variation within pure lines is primarily influenced by environmental factors. This understanding is essential for effective breeding operations.

Aklilu et al. [8] conducted a study on 49 hot pepper varieties for genetic variability, heritability, and genetic advance. Significant variability was found in traits like leaf area index and pericarp thickness, with high heritability observed in fruiting date, fruit length, plant height, internode length, and fruit diameter. Genetic advance was moderate to high for traits including internode length, number of branches, fruit diameter and weight, pericarp thickness, and leaf area index.

Vaishnavi et al. studied 36 bird's eye chili genotypes, finding high genetic variability, heritability, and genetic advance in traits such as plant spread, fruit length, yield, and chemical contents like capsaicin and oleoresin [9].

Genetic diversity in 30 chili genotypes (*Capsicum annuum* L.). Significant variability was found in twelve studied traits which was examined by Yatung et al. [10]. The genotypes were grouped into six clusters through cluster analysis, with Cluster III having the most (14) and Clusters IV and V having the least (1) genotypes. The highest inter-cluster distance was observed between Clusters II and IV (459.81), and the lowest was between Clusters I and IV (36.04). Cluster III exhibited the highest intra-cluster distance (D2 = 67.66), while Cluster II had the lowest (D2 = 11.19).

2. MATERIALS AND METHODS

The present study was conducted on vegetable farm Maharajpur, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. 43 genotypes obtained from different regions of Madhya Pradesh were used as a source material for this study. The list of germplasm is given in the Table no.01. The germplasm was initially sown in seed beds in September and later transplanted to the main field in October 2021. The transplantation was carried out following a randomized block design (RBD) with a spacing of 60 cm x 50 cm, and each plot measured 2.40×2.50m². The study involved observing various morphological and quantitative traits in chilli plants. These traits included plant growth habit (spreading, semi-upright, or upright), leaf colour, leaf shape, number of flowers per axil, flower position, fruit

set, fruit colour at maturity, intensity of fruit colour, fruit shape, fruit position, days of flowering, days to 50% flowering, plant height, number of primary branches, number of secondary branches, number of fruits per plant, fruit length, average fruit weight, and fruit yield per plot. These observations were made on randomly chosen, tagged plants, and the data were averaged based on five plants per treatment. The study included statistical analysis techniques like mean, range, variance components calculation, coefficient of variability estimation [11], heritability assessment, genetic advance determination, and Mahalanobis D^2 analysis for measuring genetic divergence based on morphological traits [12,13,14].

3. RESULTS AND DISCUSSION

In the morphological characterization of 43 chilli genotypes: Days to Flower Initiation: Ranged from 37 to 58 days, with a mean of 45.36 days. High heritability (76%) and moderate genetic advance (20.73%) were observed. Days 50% Flowering: Ranged from 51 to 71 days, with a mean of 55.295 days. High heritability (79.3%) and moderate genetic advance (47.39%) were noted. Plant Height (cm): Average height was 48.677 cm, with a range of 44.98 cm to 58.27 cm. High genetic advance (48.37%) and high heritability (92.19%) were observed. Number of Primary Branches: Ranged from 4.40 to 8.78. High genetic advance (48.88%) and moderate heritability (52.4%) were noted. Number of Secondary Branches: Ranged from 2.01 to 5.95, with a mean of 3.612. Moderate heritability (27.89%) and moderate genetic advance (18.95%) were observed. Number of Fruits per Plant: Ranged from 39.3 to 103, with a mean of 79.11. High heritability (90.68%) and moderate genetic advance (57.05%) were noted. Fruit Length: Ranged from 5.65 cm to 12.40 cm, with a mean of 8.992 cm. High heritability (86.55%) and high genetic advance (56.30%) were observed. Average Fruit Weight: Mean weight was 5.364 g, ranging from 4.00 to 10.00 g. High heritability (78.00%) and high genetic advance (36.15%) were observed. Fruit Yield per Plot (kg): Ranged from 0.31 kg to 1.74 kg, with a mean of 1.26 kg. High heritability (97%) and high genetic advance (90.06%) were observed for this trait.Similar observations were reported in chilli by [15,16,17,18].

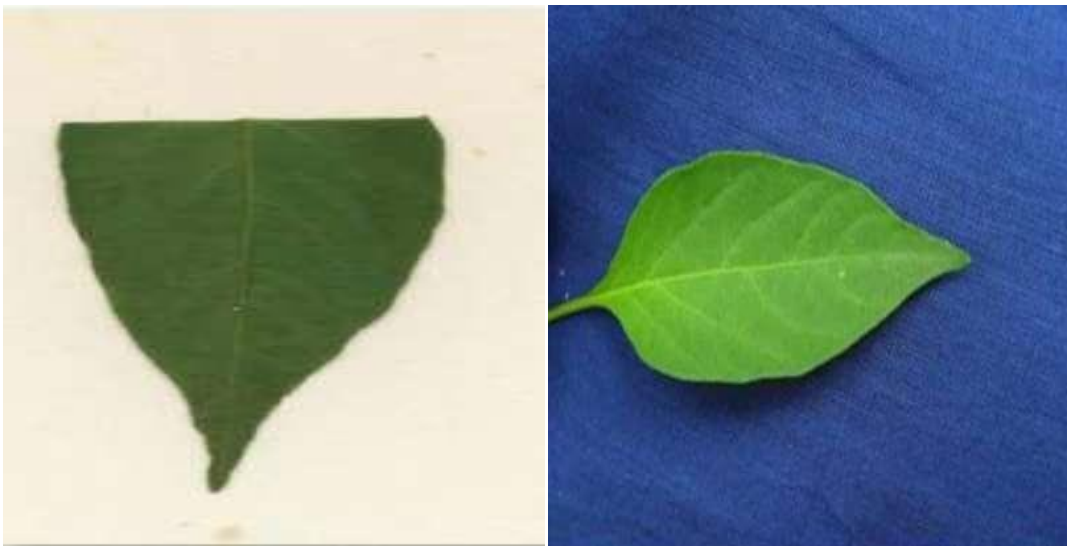
Table1. List of Chilli germplasm used for diversity analysis

S.no	Germplasm	Location
1	RHRCH64-1	MPKV,Rahuri
2	LCAS-20	LAM,Guntur
3	DDC-98/1	Dharwad(UHS)
4	RHRCH-10-2	MPKV,Rahuri
5	ACS18-08	AAU,Anand
6	SKAU-89	SKUA&T, Srinagar
7	NDCSel-1	NDUA&T,Ayodhya
8	MPC -5	MadhyaPradesh
9	K-2 check	Karnataka
10	Amritsar	Punjab
11	Guntur	AndhraPradesh
12	Chapata	Telangana
13	JawaharSelection-20181	MadhyaPradesh
14	Teja	AndhraPradesh
15	KashiAnmol	SriLankan
16	MPKHC-1	MadhyaPradesh
17	MPC-6	MadhyaPradesh
18	MPC-7	MadhyaPradesh
19	MPHC-1	MadhyaPradesh
20	G-4	Nashik,Maharashtra
21	MPCTC-1	MadhyaPradesh
22	MPKHC-2	MadhyaPradesh
23	Pusa Jwala	NewDelhi
24	Red top	MadhyaPradesh
25	MPC-10	MadhyaPradesh

S.no	Germplasm	Location
26	Kohinoor	MadhyaPradesh
27	MPCTC-2	MadhyaPradesh
28	MPKC-1	MadhyaPradesh
29	MPC-1	MadhyaPradesh
30	MPC-2	MadhyaPradesh
31	MPC-8	MadhyaPradesh
32	MPC-3	MadhyaPradesh
33	MPC-4	MadhyaPradesh
34	JawaharSelection-1	MadhyaPradesh
35	JawaharSelection-18	MadhyaPradesh
36	JawaharSelection-19	MadhyaPradesh
37	JawaharSelection-20182	MadhyaPradesh
38	MPC-9	MadhyaPradesh
39	JawaharSelection-2018HYB	MadhyaPradesh
40	JCS-6	MadhyaPradesh
41	JCS-7	MadhyaPradesh
42	JCS-8	MadhyaPradesh
43	JCS-9	MadhyaPradesh

Table 2. Morphological characterization of chilli genotypes based on DUS guideline

S. No	Characters	States	No. of genotypes	Score	Frequency in %
1	Plantgrowthhabit	Spreading	1	3	2
		Semiupright	41	5	96
		Upright	1	7	2
2	Leaf colour	Lightgreen	-	1	
		Green	42	2	98
		Purple	1	3	2
3	Leaf shape	Deltoid	-	1	-
		Ovate	-	2	-
		Lanceolate	43	3	100
4	Number.offlowe rsperaxil	One	40	1	93
		Two	2	2	5
		Threeormore	1	3	2
5	Flower position	Drooping	1	3	2
		Semidrooping	40	5	94
		Erect	2	7	4
6	Fruitset	Low	-	3	-
		Medium	40	5	94
		High	3	7	6
7	Fruitcolour at maturity stage	Yellow	1	1	2
		Orange	-	2	-
		Red	41	3	96
		Purple	1	4	2
		Green	-	5	-
8	Fruit: Intensityf colour	Light	-	3	-
		Medium	43	5	100
		Dark	-	7	-
9	Fruitshape	Elongate	25	1	-
		Almostround	-	2	58
		Triangular	18	3	-
10	Fruitposition	Pendant	1	3	2
		Intermediate	40	5	94
		Erect	2	7	4



A. Leaf profile in cross section (Dark green) B. Leaf shape (Lanceolate)

Fig.1. Leaf Characteristics

A. Semi upright growth habit B. Upright growth habit

C. Branching habit

Fig. 2. Plant growth habit

A. Semi drooping flower position B. Erect flower position

Fig. 3. Flower position

A. White colour B. Purple colour

Fig. 4. Flower colour

In the study, 43 genotypes were grouped into 6 clusters based on divergence analysis. Similar results has been reported by [19,20] These clusters were not correlated with geographical distribution. Cluster-1 was the largest, comprising 18 genotypes (MPKC-1,MPC-8,Redtop,MPC-6,Kashi Anmol,MPC-7,JS-18,Tej MPKHC-1,MPHC-8, Amritsar,2018chillivar–1AVTII,MPC-1,G-4,Guntur,MPKHC-2, MPCTC-2,JCS-6.), followed by cluster-2 with 14 genotypes (MPC-3,JS-1,K-2check,2018chilliHYB-5AVTII, Chapata, MPC-4, Kohinoor, MPC-9, MPC-2, MPC-10, SKAU-89). Cluster-3 had 4 genotypes (JS-19, JCS-7, MPCTC-2, JCS-8), while cluster-4 and cluster-5 each had 4 genotypes (2018Chillivar–2AVTII, JCS-9, RHRCH-10-2, ACS18-08, LCAS-20). Cluster-6 consisted of 1 genotype (RHRCH64-1).

In this study, 43 chilli accessions were evaluated to understand the variability in morphological and yield-related traits. The research took place at Maharajpur Vegetable Farm, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur. Evaluating traits like growth, yield, and quality provides crucial insights into crop performance, crucial for crop improvement programs. Understanding the genetic variability in the population is fundamental for successful breeding initiatives.

A. Erectfruitposition B. Intermediate Fruit Position

Fig.5. Fruit Position

A. Triangular B. Elongate

Fig. 6. Fruitshape

A. Purple colour B. Greenandred colour C. Yellow colour

Fig. 7. Fruit colour

Table 3. Contribution of different traits toward clustering in chilli genotype

Source	Times ranked	Contribution%
Days of flowering	4	0.44%
Daysof50%flowering	1	0.11%
Plant height (cm)	35	3.88%
No. of primary branches	41	4.54%
No. of secondary branches	23	2.55%
No. of fruit per plant	306	33.89%
Fruit length (cm)	203	22.48%
Average Fruit weight(gm)	281	31.12%
Fruit yield per plot kg	9	1.%

In this study, 43 chilli genotypes were evaluated, focusing on traits like primary and secondary branches, flowering patterns, fruit production, plant height, and more. Significant variability was observed in these traits, aligning with previous studies. Qualitative features such as plant growth habit, leaf shape, color, and fruit characteristics were used to categorize the genotypes, consistent with earlier research. Genetic parameters were calculated, indicating moderate to high variation in traits like fruit length, weight, and yield. The study also found high heritability and genetic advance in specific traits, echoing findings from previous research workers [9,21, 22].

The study analyzed genetic diversity in 43 chilli genotypes using Mahalanobis D^2 analysis. Significant variability was observed among the traits studied. Genotypes were grouped into six clusters, with varying inter-cluster distances. The findings align with previous research by Yatung et al. [10].

4. CONCLUSION

The analysis of variance in the germplasm indicated significant differences among genotypes for various morphological and yield-related traits, including plant height and secondary branches. These traits exhibited moderate to high Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV), suggesting environmental influence. All traits showed strong GCV and PCV, indicating high heritability and genetic advancement. D2 analysis highlighted genetic variance among the forty-three chilli genotypes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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