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GENETIC DIVERSITY STUDIES IN BIRD'S EYE CHILLI (*CAPSICUM FRUTESCENS* L.) GENOTYPES

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ABSTRACT

A field experiment was conducted during 2024–25 at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Bengaluru, to evaluate genetic diversity among ten bird's eye chilli (*Capsicum frutescens* L.) landraces under the Eastern Dry Zone of Karnataka. The genotypes were evaluated in a randomized complete block design with three replications and observations were recorded on growth, yield and quality traits. Genetic divergence estimated using Mahalanobis D^2 statistics grouped the landraces into three clusters, indicating the presence of considerable variability. Fresh fruit yield per plant, leaf area and 100-fruit dry weight contributed most to total divergence, showing their major role in differentiating the genotypes. Inter-cluster distances were higher than intra-cluster distances, with the maximum divergence observed between Cluster II and Cluster III, suggesting good scope for selection of diverse parents. Cluster mean analysis indicated that Cluster III, represented by genotype COHS-37, exhibited superior performance for several yield and quality traits. The results demonstrate that selection of genetically diverse genotypes, particularly from widely separated clusters, can be effectively utilized in breeding programmes aimed at improving yield and quality in bird's eye chilli under dry zone conditions.

Keywords **:** Bird's eye chilli, genetic divergence, cluster analysis, yield traits.

Introduction

India's varied agro-climatic regions create great potential for testing and boosting lesser-known crops. Chilli (*Capsicum spp.*) is a major cash crop as both spices and vegetable in India. It is mainly known for its pungency, vibrant colour and taste (Hill *et al.*, 2013). India tops the world with the largest chilli growing area (8.52 lakh ha), production (27.82 lakh tons) and productivity (3.26 lakh tons/ha) (Anon., 2023a) with the export earnings of 12,492 crores (Anon., 2023b), indicates its true staple in food, traditions and business. The genus *Capsicum* comprises 25 wild species, of which five have been domesticated. *Capsicum frutescens*, commonly known as bird's eye chilli, is one of the five cultivated species, which belongs to Solanaceae family. It is a diploid species (2n = 24) that originated in the Amazon basin of Brazil and the Tabasco region of Mexico (Lima *et al*., 2017).

This bird's eye chilli grows as a semi-woody, perenial plant that handles shade well, gives tiny upright fruits for five to seven years, though the best harvests come in the first few years. The pods pack a nutritional punch with plenty of capsaicinoids, vitamin C and color (Takahashi *et al*., 2018). On top of that, it is also used in special dishes, pickles, processed products and traditional medicinal preparations (Bhoomika *et al.*, 2022). Birds eye chilli has several other names like African pepper, Mexican chilli, Tabasco pepper, Hmarchate, Zanibar pepper, Mizo chilli, Shimatogarashi, Jeerige Menasu, Sooji Menasu and Kanthari Mulaku (Vaishnavi *et al.*, 2018).

Genetic diversity is a basic requirement for crop improvement, as it provides the raw material for selection of superior genotypes with desirable agronomic and quality traits. In Bird's eye chilli (*Capsicum frutescens* L.), which is valued for its pungency, yield and adaptability, assessment of genetic divergence among genotypes is essential for identifying promising parental lines for breeding programmes. Mahalanobis D^2 statistics is a widely accepted multivariate technique for estimating genetic divergence by simultaneously considering several quantitative characters, thereby providing a comprehensive measure of genetic diversity among genotypes. Based on D^2 values, cluster analysis enables the grouping of genotypes into distinct clusters, reflecting their degree of genetic relatedness and divergence. Such classification helps in identifying genetically diverse clusters and crosses between genotypes belonging to widely separated clusters are expected to produce superior recombinants. Evaluating genetic diversity and clustering pattern of Bird's eye chilli genotypes under the Eastern Dry Zone of Karnataka is particularly important due to the region's moisture stress and environmental variability. So, this study was conducted to assess the genetic diversity and clustering pattern of ten bird's eye chilli genotypes using Mahalanobis D^2 statistics under the Eastern Dry Zone of Karnataka, with a view to identify divergent and promising genotypes for future breeding programmes.

Materials and Methods

A field investigation was carried out during the year 2024–25 at the College of Horticulture, Bengaluru, with the objective of assessing variability in growth, yield and quality traits in different bird's eye chilli landraces collected from different geographical locations (Table 1). The experimental material comprised ten landraces were laid out in a randomized complete block design with three replications to ensure reliable comparison among the landraces.

Table 1 : List of bird's eye chilli landraces used in the experiment and their location.

Landrace	Locations
COHS - 3	Terakanahalli, Sirsi (Uttara Kannada).
COHS - 4	Balethota, Sirsi (Uttara Kannada)
COHS - 10	Sankadgundi, Sirsi (Uttara Kannada)
COHS - 18	Kadve, Sirsi (Uttara Kannada)
COHS - 24	Hanjibail, Siddapura (Uttara Kannada)
COHS - 25	Sankadgundi, Sirsi (Uttara Kannada)
COHS - 31	Kudregundi, Koppa (Shivamogga)
COHS - 37	Naveelgol big (Uttara Kannada)
COHS - 39	Sirsi local medium (Uttara Kannada)
COHS - 42	Kumta local red (Uttara Kannada)

Seeds were raised in protrays using a suitable growing medium and healthy seedlings of 60 days age were transplanted to the main field at a spacing of 1 m × 1 m. Crop nutrition was managed by applying 150:75:75 kg ha^{-1} of NPK in the form of urea, single super phosphate and muriate of potash fertilizer respectively. Cultural operations such as irrigation, weeding and plant protection were undertaken as required throughout the crop period. Data were collected on growth, flowering and yield traits such as plant height, number of primary branches, plant spread, leaf area, days taken to 50 % flowering, days to first harvest, stalk length, fruit length, fruit girth, individual fruit weight, 100-fruit fresh weight, 100-fruit dry weight, number of seeds per fruit, fresh fruit and dry fruit yield per plant. Multivariate analysis was performed to estimate genetic divergence among the genotypes using Mahalanobis D^2 statistics as proposed by Mahalanobis (1936). Grouping of genotypes into different clusters was carried out following Tocher's method as outlined by Rao (1952). Statistical analyses were conducted using the R software version 4.3.1.

Results and Discussion

The relative contribution per cent of individual trait to the total genetic divergence among ten bird's eye chilli genotypes evaluated under the Eastern Dry Zone of Karnataka was presented in figure 1. Fresh fruit yield per plant contributed the highest share to total divergence (11.5%), followed by leaf area at 210 DAT (10.6%) and 100-fruit dry weight (10.2%), indicating that yield expression, canopy vigour and fruit biomass were the major factors differentiating the genotypes. Moderate contributions were recorded for 100-fruit fresh weight (7.5%), colour value (7.2%), number of primary branches (5.6%) and number of seeds per fruit (5.5%), highlighting the combined influence of yield, morphological and quality-related traits on genetic divergence. The remaining characters exhibited minimal to negligible contributions, suggesting limited variability among the evaluated landraces for these traits.

Table 2 : Cluster composition based on D^2 statistics in bird's eye chilli landraces

Cluster Group	No. of Genotypes	List of Genotypes
Cluster I	**6**	COHS - 42, COHS - 4, COHS - 18, COHS - 25, COHS - 10 and COHS - 24
Cluster II	**3**	COHS - 31, COHS - 3 and COHS - 39
Cluster III	**1**	COHS - 37

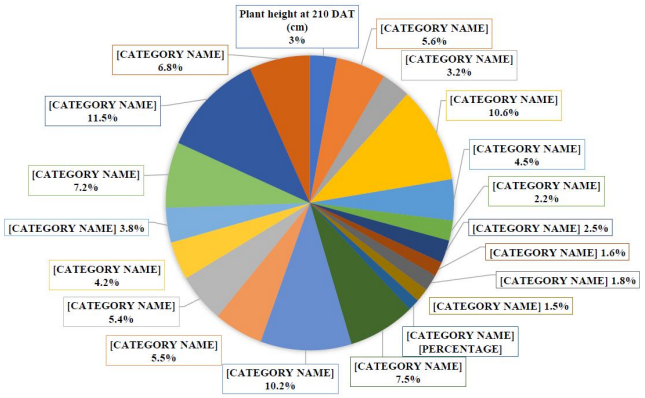

Fig. 1 : Per cent contribution of the different characters to the total divergence in bird's eye chilli landraces.

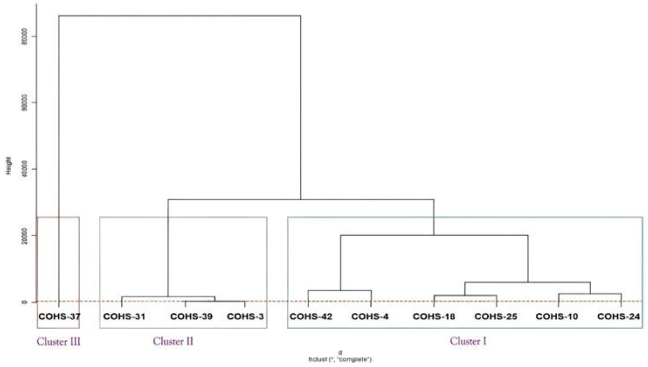

Fig. 2 : Hierarchical clustering of bird's eye chilli landraces.

Table 3 : Intra cluster and inter cluster D^2 values on bird's eye chilli landraces

Cluster Distances			
	Cluster I	**Cluster II**	**Cluster III**
Cluster I	6651.69	22303.09	44225.32
Cluster II		284.51	80470.25
Cluster III			0

Clustering of the ten bird's eye chilli landraces based on Mahalanobis D^2 statistics using Tocher's method resulted in the formation of three distinct clusters, indicating the presence of structured genetic divergence among the genotypes (Table 2). Cluster I comprised six landraces, Cluster II included three landraces, while Cluster III was represented by a single landrace, reflecting its distinct genetic constitution (Figure 2). Dutonde *et al.* (2008), Dutta and Jana (2010), Pujar *et al.* (2017) and Negi and Sharma (2019) also found maximum genotypes in cluster I. The magnitude of intra-cluster distances varied widely, with Cluster I recording the highest intra-cluster distance (6651.69), suggesting considerable genetic heterogeneity within the group, whereas Cluster II exhibited a much lower intra-cluster distance (284.51), indicating close genetic similarity among its constituent landraces (Table 3). Cluster III showed an intra-cluster distance of zero due to the presence of only one genotype. Inter-cluster divergence values revealed pronounced genetic differentiation among the clusters, with the highest distance observed between Cluster II and Cluster III (80470.25), followed by Cluster I and Cluster III (44225.32), while the divergence between Cluster I and Cluster II was comparatively lower (22303.09). The wide inter-cluster distances involving Cluster III suggest that the landrace in this cluster is genetically highly divergent and could serve as a potential parent for hybridisation with genotypes from Clusters I or II to exploit maximum genetic variability. Similar findings were reported by earlier workers, who also suggested that crossing genetically diverse parents helps in obtaining desirable transgressive segregants (Mishra *et al.*, 2001; Srinivas *et al.*, 2013; Janaki *et al.*, 2015; Negi and Sharma, 2019).

Table 4 : The mean of sixteen characters for cluster in bird's eye chilli landraces

Characters	**Cluster I**	**Cluster II**	**Cluster III**
Plant height at 210 DAT (cm)	90.83	87.84	98.67
Primary branches at 210 DAT	14.26	14.81	14.03
Plant spread at 210 DAT (cm^2)	7254.73	7537.38	7328.93
Leaf area at 210 DAT (cm^2)	10.41	9.52	10.92
SPAD values at 180 DAT	44.69	45.66	46.67
Days to fifty per cent flowering	79.78	81.44	88.67
Days to first harvest	124.33	126.44	118.00
Stalk length (cm)	2.97	2.62	2.97
Fruit length (cm)	2.74	1.88	4.14
Fruit width (mm)	5.86	4.64	9.80
Individual fruit fresh weight (g)	0.65	0.30	1.62
100 fruit fresh weight (g)	64.07	30.33	161.13
100 fruit dry weight (g)	19.47	12.58	38.76
Number of seeds per fruit	14.24	9.00	21.73
Oleoresin (%)	7.08	10.34	10.10
Ascorbic acid (mg/100g)	192.22	75.56	106.67
Capsaicin (%)	1.01	1.23	1.33
Colour value (ASTA units)	375.25	316.47	351.82
Fresh fruit yield per plant (kg)	143.37	126.68	233.35
Dry fruit yield per plant (kg)	45.13	44.89	67.11

Cluster mean analysis revealed distinct differences among the three clusters for growth, yield and quality traits, reflecting their divergent genetic potential. Cluster III recorded the highest mean values for plant height (98.67 cm), leaf area at 210 DAT (10.92 cm^2), SPAD values (46.67), days to fifty per cent flowering (88.67), fruit length (4.14 cm), fruit width (9.80 mm), individual fruit weight (1.62 g), 100-fruit fresh weight (161.13 g), 100-fruit dry weight (38.76 g), number of seeds per fruit (21.73), oleoresin content (10.10%), capsaicin content (1.33%), fresh fruit yield per plant (233.35 g) and dry fruit yield per plant (67.11 g), indicating its superiority for yield and quality-associated traits. Cluster II exhibited the highest mean for number of primary branches (14.81), plant spread (7537.38 cm^2), days to first harvest (126.44) and ascorbic acid content (75.56 mg/100g), suggesting its relative advantage for canopy

development, earliness-related traits and nutritional quality. Cluster I showed comparatively higher mean values for stalk length (2.97 cm) and colour value (375.25 ASTA units), indicating better fruit appearance attributes. The observed variation in cluster means demonstrates that different clusters excelled for specific sets of traits and the superior performance of Cluster III for yield and quality traits, coupled with its high inter-cluster divergence, suggests that crosses involving genotypes from this cluster with those from Clusters I or II could be effectively exploited to generate transgressive segregants and improve yield and quality in bird's eye chilli. Such differences can be effectively used as a basis for selecting suitable and diverse parents for specific traits in hybridization programmes (Farhad, 2010; Janaki *et al.*, 2015; Bijalwan *et al.*, 2018).

Conclusion

The present investigation revealed substantial genetic variability among the ten bird's eye chilli genotypes evaluated under the Eastern Dry Zone of Karnataka, indicating good scope for selection and crop improvement. Traits associated with yield, leaf area and fruit biomass played a major role in differentiating the genotypes, while cluster analysis confirmed the presence of distinct and widely divergent groups. The superior performance of the genotype grouped in Cluster III, particularly COHS-37, for several yield and quality parameters suggests its potential as a valuable parent in hybridization programmes. Genotypes in Cluster II, such as COHS-31, COHS-3 and COHS-39, also showed desirable performance for specific growth and quality traits, indicating their usefulness in trait-specific improvement. Overall, the study demonstrates that selection of genetically diverse and superior genotypes from different clusters can be effectively utilized for developing high-yielding and quality bird's eye chilli cultivars suited to dry zone conditions.

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