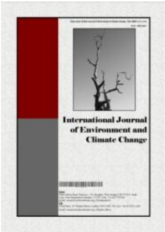

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Phenotypic Screening of Chilli Genotypes Collected from Different Regions

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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

The experiment was performed at Maharajpur Farm under the Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.) during the Kharif season 2019-2022 and planted in Randomized Complete Block Design (RCBD) with three replications. The characterization of thirty genotype for thirty-five qualitative traits articulated no variability for trait i.e., the monomorphic trait was non-enveloping fruit calyx cover, two descriptors were found to be moderately diverse, which were with medium fruit intensity of the red colour (at the mature unripe stage) and the narrow triangular shape of fruit with the Shannon-Weaver diversity index H'=0.46 & H'=0.50, both of these are fruit related traits. The descriptor intensity of pubescence (hairiness) of the stem had the highest diversity index of 1.82. The studies highlighted some of the genotypes with the distinctness, MPKC-1(Katni collection) addressed unique features with green with purple tinge leaf colour, purple petal colour, upright fruit orientation, absence of fruit curvature, purple fruit colour at ripening maturity, ovate leaf and erect plant habit, depicting it like a wild relative of capsicum and could be utilized as the morphological descriptor.

Keywords: Monomorphic; characterization; shannon-weaver diversity index; morphological descriptors.

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1. INTRODUCTION

One of the most significant *Solanaceou*s vegetable and spice crops in India is the chilli (C*apsicum annum Linn*.). India is the largest producer, exporter and consumer of chillies in the world [1]. Along with the convention utilization of capsicum as fresh fruits, processed sauce, pickling, canning, dried spices, industrial extract, etc requirements are also enhanced in the market. Further, capsicum is aggrandizing its significance due to the presence of nutrition sources like ascorbic acid (vitamin C), carotenoids (pro-vitamin A), tocopherols (vitamin E), flavonoids, capsaicinoids and also as a non-food it is used in defence as ethnobotanical products [2,3]. The rise in importance of chilli demands yields enhancement, through the collection and characterization of genotype. The genetic diversity of germplasms resources is the basis of breeding, and the determination of plant genetic variation and diversity via phenotypic traits can be conducive to understanding the level of genetic variation in a short amount of time [4].

Furthermore, genetic variety is vital for selecting parents with stronger combination potential and for obtaining superior genotypes [5]. The raw material which is genotype to the plant breeder is the pool of genes that must be identified, isolated, and melded into the genome of a new genetic entity that expresses a unique and desirable phenotype [6]. The crafting of raw material into high yielding varieties needs to go through domestication, refinement and maintenance, which is done by local farmers and characterization of these farmer's varieties could be a potential source of revolutionary genes in plant breeding [7,8]. The diversified gene pool and intensive selection designed for varietal development followed by molecular characterization give a precise idea about the upcoming utilization of existing genetic diversity [9]. As per the Protection of Plant Varieties and Farmers' Right Act (PPV&FRA), 2001, the protection of these varieties is given based on Distinctiveness, Uniformity and Stability (DUS). The presented research phenotypically assessed the diversity, as the diverse genotypes are an excellent source of developing new varieties for crop improvement [9].

2. MATERIALS AND METHODS

The experiment was performed at Maharajpur Farm under the Department of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur (M.P.) during the Kharif season 2019-2022. The thirty genotypes of capsicum were collected from Indian Institute of Vegetable Research (IIVR), Varanasi, different regions of Madhya Pradesh and South (Table 1). The genotypes were planted in Randomized Complete Block Design (RCBD) with three replications. Phenotypic assessments of capsicum genotypes were done based on thirty-five qualitative traits (Table 2).

Table 1. Experimental material

S.No	Material	Collection
1.	KASHI ANMOL	IIVR, Varanasi
2.	K2	IIVR, Varanasi
3.	MPKHC-1	Khandwa collection
4.	KASHMIRI	Northern collection
5.	MPKHC-2	Khandwa collection (M.P.)
6.	2020/CHIVAR-1	IIVR, Varanasi
7.	G 4	IIVR, Varanasi
8.	2020/CHIVAR-2	IIVR, Varanasi
9.	2018 CHIHYB 03	IIVR, Varanasi
10.	KASHI GAURAV	IIVR, Varanasi
11.	2020/CHIVAR-3	IIVR, Varanasi
12.	MPSC-1	Sehore collection (M.P.)
13.	2020/CHIVAR-4	IIVR, Varanasi
14.	MPHC-1	Hirdayanagar collection (M.P.)
15.	MPKC-1	Katni collection (M.P.)
16.	RED TOP	Southern collection
17.	GUNTUR	Southern collection
18.	TEJA	Southern collection
19.	CHAPATA	Southern collection
20.	MPCTC-1	Gosalpur collection (M.P.)
21.	PUSA JWALA	IIVR, Varanasi
22.	2020/CHIVAR-5	IIVR, Varanasi

S.No	Material	Collection
23.	2020/CHIVAR-6	IIVR, Varanasi
24.	2018/CHIHYB - 5	IIVR, Varanasi
25.	2020/CHIVAR-7	IIVR, Varanasi
26.	2020/CHIVAR-8	IIVR, Varanasi
27.	2019/ CHIHYB- 6	IIVR, Varanasi
28.	2020/CHIVAR-9	IIVR, Varanasi
29.	MPC-1	Tribal collection (M.P.)
30.	MPC-2	Devnagar collection (M.P.)

Table 2. Morphological traits

A. Plant traits	**E. Fruit traits**
Habit	Colour (at mature unripe stage)
Anthocynin colour of node	Intensity of colour (at mature unripe stage)
B. Stem traits	Shape
Intensity of Anthocynin colouration	Curvature
Intensity of pubescence (hairiness)	Intensity of Curvature
Pubescence (hairiness)	Neck at Basal End
Shape	Cross sectional corrugation (at level of placenta)
C. Leaf traits	Sinuation of Pericarp
Colour	Texture of surface
Intensity of green colour	Colour (at ripe maturity)
Intensity of purple colour	Intensity of colour (at maturity)
Shape	Colour Transition
Undulation	Glossiness
Pubescence (hairiness)	Shape at the base
Intensity of pubescence (hairiness)	Shape of apex
D. Flower traits	Calyx Cover
Petal colour	Calyx Margin
Anther Colour	Calyx Constriction
Flower/fruit Orientation	Pedicel attachment

Shannon-Weaver diversity index (H) was used to calculate the phenotypic diversity of the characterized farmers' varieties following the protocol used by Sotto and Rabara, (2007). An arbitrary scale was adapted from Jamago and Cortes, [10] to categorize the computed indices into maximum (H = 1.00), high (H = 0.76–0.99), and moderate (H = 0.46–0.75) and low diversity (0.01–0.45). The phenotypic frequencies calculated were further used to estimate Shannon's Diversity Index (H) according to Negassa, [11] to assess the present diversity.

$$H= -\sum [pi \times \log pi]$$

Where, pi is the portion of the total number of entries belonging to the i^{th} class.

3. RESULTS AND DISCUSSION

Shannon diversity index (H′) was generated to compare phenotypic diversity for the characters utilised in the study and its assessment is an important activity in evaluating the germplasms collections in a gene bank. The diversity analysis of the chilli genotype revealed a low overall average Shannon Diversity index (H′) of o.32, which did not agree with Nsabiyera et al. [12] with a moderate mean H' index (0.52).

From ancient times, these visual observations (scoring) were used as an aid in determining genetic diversity in the gene pool. The characterization of thirty chilli genotypes for thirty-five qualitative traits articulated no variability for trait i.e., the monomorphic trait was non-enveloping fruit calyx cover. Among all the qualitative traits scores, the predominant descriptor with <90% frequent occurrence were green leaf colour, absence of intensity of leaf purple colour, white flower petal colour, drooping fruit or flower orientation, all these traits also revealed invariance with H'=0.0. Fonseca et al. [13] observed similar zero divergences for trait white flower petal colour, while the results were not in propinquity with Nahak et al. [14]. Twenty-seven traits scored were dominated by one descriptor in each trait, with the most frequent contribution ranges of 80-90% and low diversity indices ranging between 0.17-0.45 as depicted in Table 2, were red fruit colour at ripening maturity (86.6%), absence of fruit neck at the basal end (83.3%), dark fruit intensity of colour at ripening maturity (83.3%), one stage fruit colour transition (83.3%), lanceolate leaf shape (83.3%), dented fruit calyx margin (80.0%) and presence of anthocyanin colouration of node (80.0%). The propinquity in results was found for traits of red fruit colour at ripening maturity, one stage fruit colour transition, dented fruit calyx margin and lanceolate leaf shape by Santhosha et al. [15]. Leaf pubescence with a similar low H' index (0.25) predicted genotype belongs to a wild relative by Sran and Jindal, [16]. The index is used to assess allelic richness and evenness in which a low H' index suggests that the frequency classes for individual characters are very imbalanced and that there is a paucity of genetic diversity [17]. Two descriptors were found to be moderately diverse, which were medium fruit intensity of the red colour (at the mature unripe stage) and the narrow triangular shape of fruit with the indices H'=0.46 & H'=0.50, both of these traits are fruit related. The descriptor intensity of pubescence (hairiness) of the stem had the highest diversity index of 1.82.

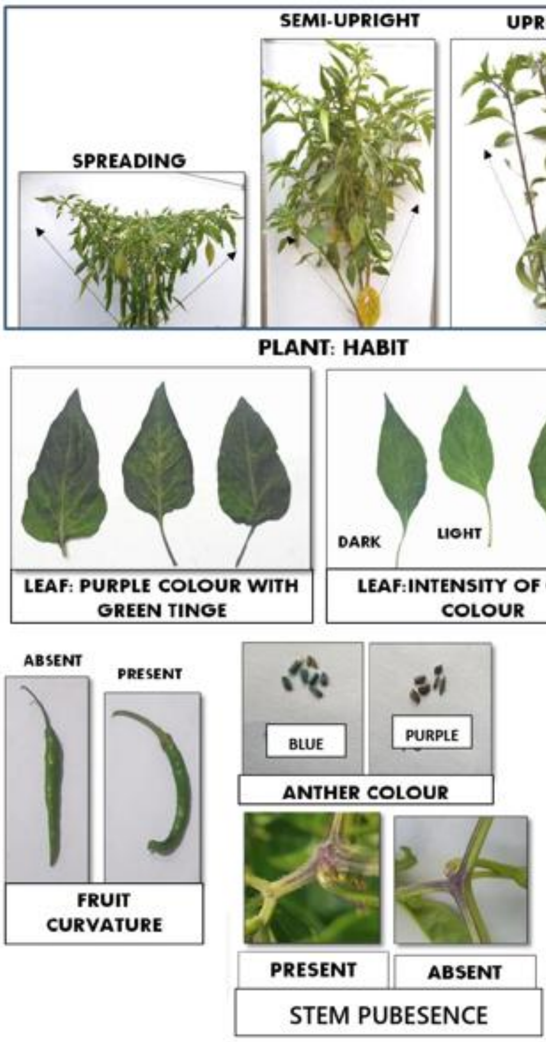
The studies highlighted some of the genotypes with the distinctness of germplasms MPKC-1addressed unique features such as green with purple tinge leaf colour, purple petal colour, upright fruit orientation, absence of fruit curvature, purple fruit colour at ripening maturity, ovate leaf and erect plant habit, depicting it like a wild relative of capsicum and could be utilized as a morphological marker.

Table 3. Morphological Characterization depicting the predominate state, frequency percentage and Shannon diversity indices (H') collection for each descriptor scored

S.no	Characterises	States	Freq %	H' Index	Unique genotype
		Invariant			
1.	Fruit: Calyx Cover	Non-enveloping	100.0	0.00	-
		Enveloping	00.00		-
2.	Leaf: Colour	Green	96.67	0.06	-
		Purple	3.33		MPKC-1
3.	Leaf: Intensity of purple colour	Absent	96.66	0.06	-
		Light	3.333		MPKC-1
		Medium	0		-
		Dark	0		-
4.	Flower: Petal colour	White	96.66	0.06	-
		Yellowish green	0		-
		Purple	3.33		MPKC-1
		Low diversity			
5.	Flower/fruit Orientation	Drooping	90	0.17	-
		Semi-Drooping	3.33		2020/CHIVAR-6
		Erect	6.66		2020/CHIVAR-7,MPKC-1
6.	Fruit Curvature	Absent	13.33	0.17	MPC-1 MPC-2
		Present	86.66		-
7.	Neck at Basal End	Absent	83.33	0.20	-
		Present	16.66		-
8.	Fruit Colour Transition	One stage	83.33	0.20	-
		Two stage	16.66		MPHC-1 MPKC-1
		>Two stage	0		-
9.	Leaf: Intensity of pubescence (hairiness)	Sparse	66.66	0.22	-
		Medium	3.333		-
		Strong	3.333		-
10.	Plant: Anthocynin colour of node	Absent	20	0.22	-
		Present	80		-
11.	Fruit: Calyx Margin	Smooth	20	0.22	-
		Dented	80		-
12.	Fruit: Colour (at ripe maturity)	Yellow	3.33	0.23	MPKHC-1
		Orange	3.33		MPKHC-2

S.no	Characterises	States	Freq %	H' Index	Unique genotype
		Red	86.66		-
		Brown	0		-
		Purple	6.66		MPKC-1
13.	Stem: Pubescence (hairiness)	Present	76.67	0.24	-
		Absent	23.33		2020/CHIV AR-1
14.	Leaf: Shape	Lanceolate	83.33	0.24	-
		Ovate	10		MPCTC-1
		Broad elliptical	6.66		MPKC-1
15.	Leaf: pubescence (hairiness)	Absent	26.66	0.25	-
		Present	73.33		-
16.	Fruit: Calyx Constriction	Absent	26.66	0.25	-
		Present	73.33		-
17.	Fruit: Intensity of colour (at maturity)	Light	10	0.26	-
		Medium	73.33		-
		Dark	83.33		-
18.	Fruit: Colour (at mature unripe stage)	White	0	0.27	-
		Cream	0		-
		Green	70		-
		Purple	30		MPKC-1,MPC-2
19.	Fruit: Pedicel attachment	Weak	53.33	0.30	-
		Strong	46.66		-
20.	Anther Colour	Yellow	0	0.30	-
		Blue	50		-
		Purple	50		-
21.	Fruit Texture of surface	Smooth	16.66	0.33	-
		Slightly Rough	73.33		-
		Rough	10		-
22.	Fruit Intensity of Curvature	Less	23.33	0.33	-
		Medium	60		-
		Strong	3.333		-
23.	Stem: Shape	Round	23.33	0.33	G 4
		Angled	70		MPC-1 MPC-2
		Flat	6.66		G 4
24.	Fruit: Shape of apex	Acute	60	0.34	-
		Blunt	36.66		-
		Depressed	3.33		-
		Depressed and Acute	0		-
25.	Fruit: Cross sectional corrugation (at level of placenta)	Round	20	0.35	-
		Slightly corrugated	70		-
		Strongly corrugated	10		-
26.	Fruit: Shape at the base	Acute	46.66	0.35	-
		Round	50		-
		Sunken	3.33		-
27.	Plant: Habit	Spreading	13.33	0.35	-
		Semi-upright	70		-
		Upright	16.66		-
28.	Leaf: Undulation	Weak	56.66	0.38	-
		Medium	36.66		-
		Strong	6.666		-
29.	Leaf: Intensity of green colour	Light	20	0.38	-
		Medium	63.33		-
		Dark	13.33		-
30.	Fruit: Glossiness	Weak	20	0.41	-
		Medium	60		-
		Strong	20		-
31.	Plant: Intensity of Anthocynin colouration	Weak	33.33	0.45	-
		Medium	30		-
		Strong	16.67		-

S.no	Characterises	States	Freq %	H' Index	Unique genotype
32.	Fruit: Sinuation of pericarp	Weak	40	0.45	-
		Medium	43.33		-
		Strong	16.66		-
Medium diversity					
33.	Fruit: Intensity of colour (at mature unripe stage)	Light	26.66	0.46	-
		Medium	46.66		-
		Dark	26.66		-
34.	Fruit Shape	Oblate	0	0.50	-
		Circular	0		-
		Cordate	3.33		-
		Square	0		-
		Rectangular	0		
		Trapezoidal	10		MPHC-1
		Moderate triangular	30		MPKHC-1
		Narrow Triangular	53.33		MPC-1
		Horn Shape	3.33		MPC-2
High diversity					
35.	Stem: Intensity of pubescence (hairiness)	Sparse	16.66	1.82	-
		Medium	30		-
		Strong	30		-
Average diversity				0.32	



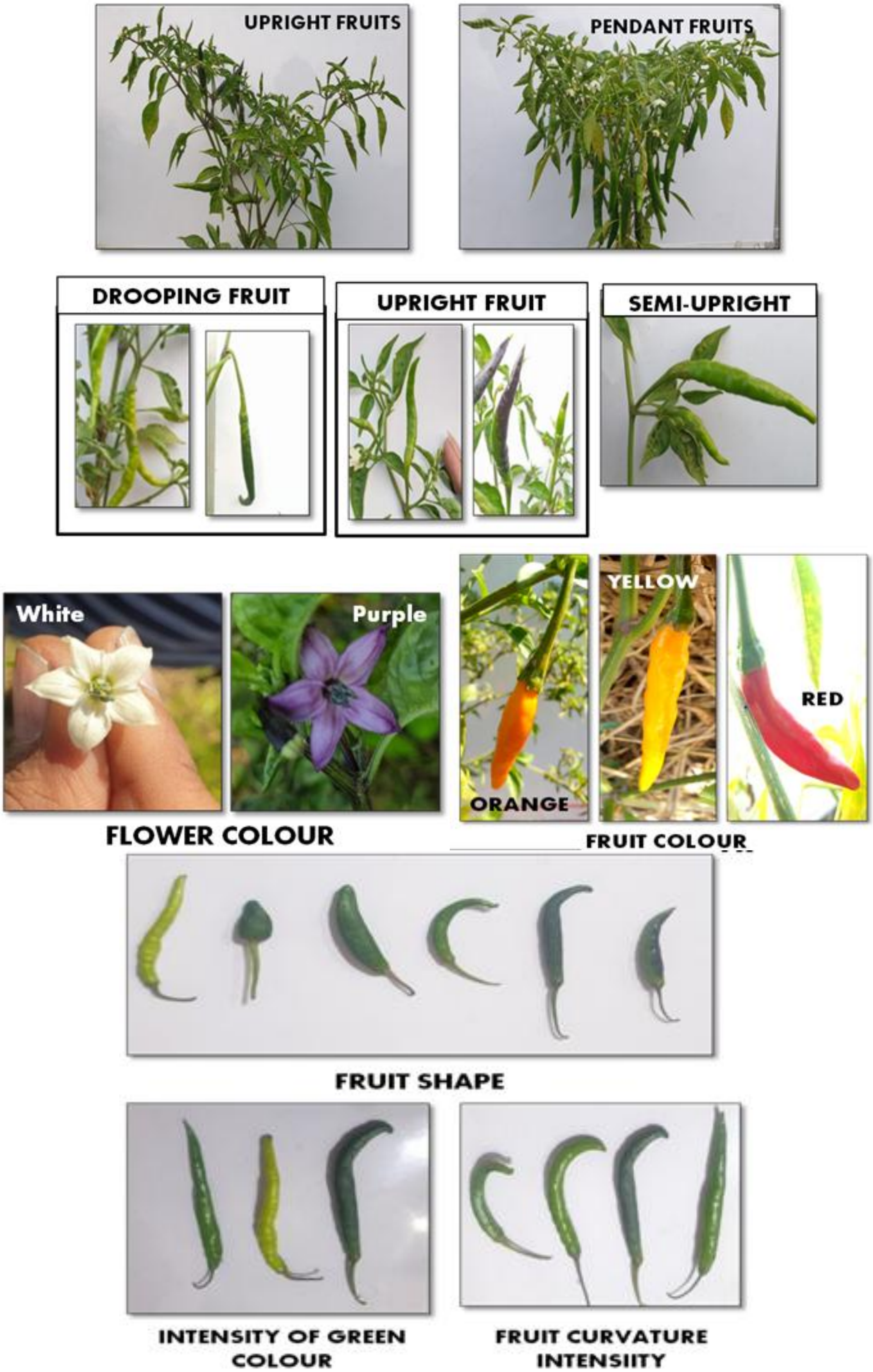
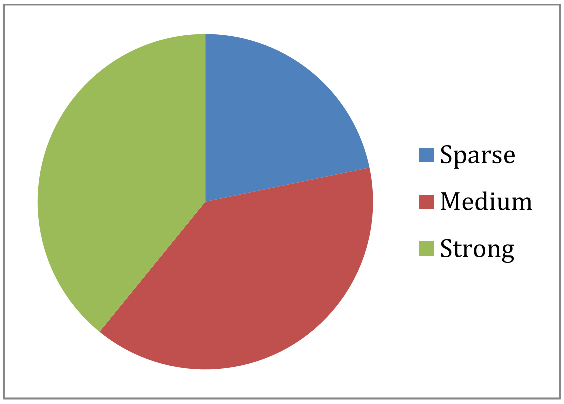
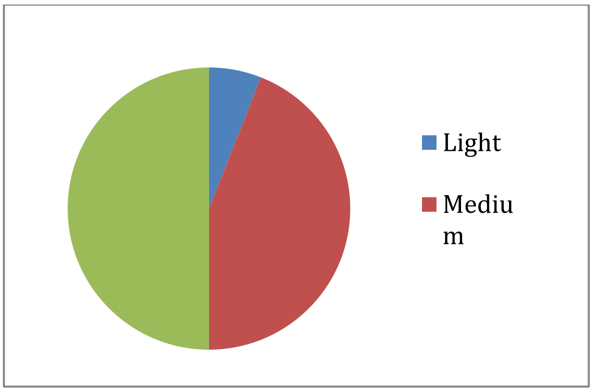


Image 1. Images depicting morphological traits

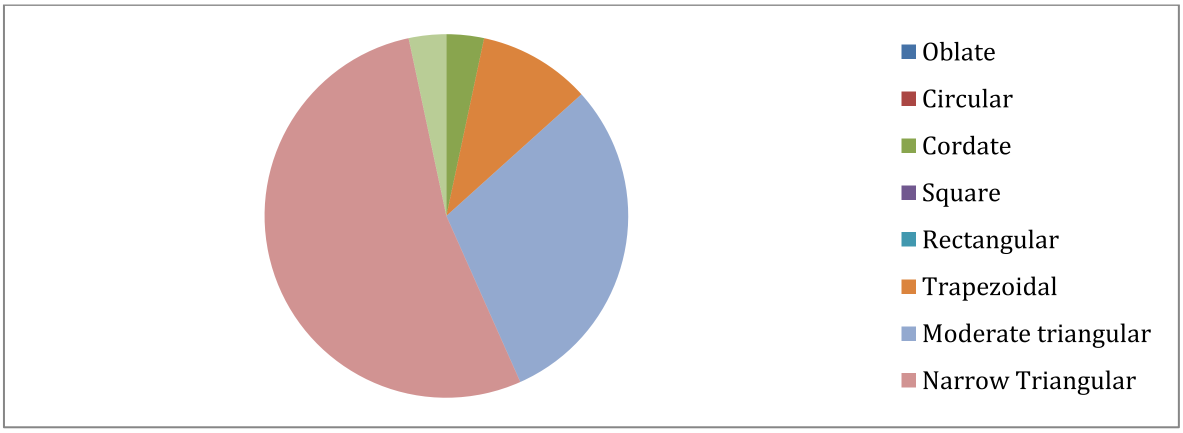


A. Stem: Intensity of pubescence (hairiness)



B. Fruit: Intensity of colour (at mature unripe stage)

C.



D. Fruit Shape

Fig. 1. Frequency percentage of highly divergent traits

4. CONCLUSION

The current study revealed the pattern and structure of phenotypic variation in a collection of 30 chilli genotype, which is important for successful pre-breeding, management, and exploitation in crop improvement programmes, as well as for increasing the crop's genetic potential. Several low diversity aspects may be highlighted in future collection visits to boost gene bank variation. Our findings indicate that indirect selection of chilli genitors based on various morphological traits could be beneficial for biotic and abiotic stress management, as the phenotypic feature leaf pubescence reduces water loss during heat stress and is a non-preference trait for many insects, and the drooping fruit habit and spreading plant habit protect the plant from direct incidence of light, making it suitable for biotic and abiotic stress management. Various morphological descriptors, such as yellow, orange, and purple fruit colour, upright fruit orientation, purple flower, cordate, oblate, and trapezoid fruit shape, might be employed in hybridised breeding programmes. Furthermore, the information we produced supplements the vigorous breeding programme of high-yielding and climate-resilient varieties of end users' preferences, as well as promotes varietal choice alternatives for expediting advantages and strengthening agro-biodiversity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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