Biological Forum – An International Journal **14(2a): 120-130(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Morphological characterization of Chilli (*Capsicum annuum* L.) Germplasm for the Mining of Breeding Traits

Rahul Sonaniya* and S.K. Singh
Department of Plant Breeding and Genetics, College of Agriculture,
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh), India.

(Corresponding author: Rahul Sonaniya)*
(Received 28 April 2022, Accepted 18 June, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: An experiment was conducted on 48 chilli genotypes for the mining of diverse morphological breeding traits. A total of 37 morphological traits were considered as per DUS guidelines. All the genotypes were grown in randomized block design in three replications. Maximum variations were reported for fruit shape in longitudinal section followed by plant habit, leaf shape, leaf undulation of margin, fruit glossiness, fruit bearing habit, fruit sinuation of pericarp, fruit texture of surface, fruit color at ripe maturity, fruit shape at the base and fruit shape of apex. Among the different traits assessed, green leaf color, green unripe fruit color, absence of blossom end appendage and light yellow seed color showed 100% frequency for these traits. Higher frequency was also observed for solitary type of fruit bearing habit (95.83%), fruit curvature (97.92%), red color at ripe (95.83%), one color transition (97.92%), enveloping type of calyx cover (91.67%), acute shape at base (97.92%) and apex (89.58%). The distribution frequency of the traits like ovate leaf shape (10.42%) followed by moderately triangular fruit shape in longitudinal section (10.42%), strong fruit sinulation of pericarp (10.42%) respectively were very low. Yellow flower petal color; erect fruit orientation, 2-3 fruit bearing habit, cluster bearing habit, absence of fruit curvature, yellow fruit color, orange fruit color and two stage color transition round fruit shape at base acquires 2.08 % frequency. Genotypes Pusa jwala, MPOJCC 1, MPRJJCC 4, MPJCC 8, MPJKJCC 1, MPJCC 20 found a wide range of variations in qualitative traits. The unique traits reported in very minimal would be considered as important morphological breeding traits for the development of diverse chilli varieties with special identity. These findings will help to identify the genetically pure traits linked with the chilli genotypes during maintenance breeding programme.

Keywords: Chilli Genotypes, Morphological characterization, Plant breeding, Spice, Vegetable, diversity, unique traits.

INTRODUCTION

Chilli (*Capsicum annuum* L.) makes an appearance as one of the most crucial economical and popular grown vegetable and spice for its green fruits and dry form respectively). Besides, it is used in many processing industries for different products such as pepper sauce, ground pepper and dried pepper, pickled pepper; Peppers play an important role as a spice in many of the world food cuisines (Bosland *et al.*, 2012). It is estimated that 25% of people consuming some form of pepper daily (Smith, 2015). The genus Capsicum consists of about 25 wild and 5 domesticated species, viz., *C. annuum* L., *C. frutescens* L., *C. chinense* Jacq., *C. baccatum* L. and *C. pubescens* Ruiz and Pavon (Wang and Bosland 2006). It belongs to family solanaceae and the primary centre of origin for *C. annuum* is semi-tropical Mexico (Whitmore *et al.*, 2001). It was brought to Europe by Columbus in 1493 as the peppery spice that signified the success of his quest. It was first introduced in India from Brazil by the Portugese towards the end of 15th century and its cultivation became popular in the 17th century.

In 2020-21, total area of chilli in India was 7,32,213 ha, with the production of 19,88,304 lakh tons with vast majority of production occurring in Andhra Pradesh (42%) followed by Telengana (20.48%) and then by Madhya Pradesh (14.71%). Total area and production of spices in Madhya Pradesh is 6,99,994 ha and 32,37,655 tons respectively. Chilli covers the area of 1,13,366 ha (16.19%) and production of 2,62,616 lakh tons (8.1%) (Spice board, India 2020).

The genus capsicum consists of a diverse range of plants and fruits, and varies enormously with respect to morphology, yield and nutrition related parameters (Srinivas *et al.*, 2021). There are many of the land races/ varieties which are continuously cultivated by the

farmers around the country among which majority of the varieties are either local varieties or hybrids. For the genetic improvement of chilli crop, it is mandatory for researchers to first collect, characterize and then identify the important breeding traits so as to utilize it in genetic improvement programme. The first step for the improvement programme is collective and then morphological characterization on the basis of diverse breeding traits in chilli germplasm. Morphological characterization based on qualitative traits of crops is a very important and essential first step in any crop improvement and breeding programme (Joshi *et al*., 2020). Cultivars can be recognised and differentiated based on relative differences in morphology of different morphological parameters like seed, seedling and plant growth. Morphological characterization of chilli germplasm accessions has been studied for most plant and fruit traits. Evaluation and Characterization of chilli germplasm becomes a necessary step for utilizing the available diversity for improvement of the crop. Many chilli varieties having immense differences for different traits are being cultivated among different parts of country and some of the variations are so localized that their cultivation other than their zone is completely unknown. Due to their localized distribution, some of these promising varieties are yet to be known. So, it becomes a necessary to estimate the performance of local varieties as well as cultivated varieties along with characteristics of chilli recommended for cultivation in different climatic zones for identifying suitable donors having different desirable attributes under the agro-ecological condition of the central region of India. The purpose of this study is to evaluate various chilli genotypes and to characterize them to know their morphological characteristics. The study also aids in differentiating morphological characteristics from each other and to access the variations present in genotypes under inspection with identification of promising genotypes and traits which can be used in further breeding programme.

MATERIALS AND METHOD

Experimental site. The present investigation was carried out at Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh (India) in the two season (*Rabi*2020-21/ summer and *Kharif* 2021-22). Jabalpur is situated on the banks of holy Narmada River in the state of Madhya Pradesh, with coordinates "23.1815° N, 79.9864° E", at an elevation of 412 meter above MSL, in the Mahakoshal region of Madhya Pradesh. The climate here is mild, and generally warm and temperate. In winter, there is much more rainfall in Jabalpur than in summer. In Jabalpur, the average annual temperature is 25.5°C | 77.9°F. Precipitation here is about 1208 mm | 47.6 inch per year.

Experimental design and plant material used. Forty eight chili genotypes were evaluated in RBD (Randomized block design) with 3 replications during the summer season of 2020-21 from month February to August.

S. No.	Name of genotype	Collection from	Year of collection
1.	MPJCC 1	Bedia, M.P.	2014
2.	MPJCC 2	Bedia, M.P.	2014
3.	MPJCC 3	Bedia, M.P.	2014
4.	yellow chilli	Khargone, M.P.	2014
5.	MPJCC 4	Khargone, M.P.	2014
6.	MPJCC 5	Khargone, M.P.	2014
7.	MPJCC 6	Khargone, M.P.	2014
8.	MPJCC 7	Badwani, M.P.	2014
9.	MPJCC15	Badwani, M.P.	2014
10.	MPJCC16	Badwani, M.P.	2014
11.	MPJCC17	Shajapur M.P.	2014
12.	MPJKJCC1	Baramullaka, Kashmir	2014
13.	MPBJCC2	Patna, Bihar	2014
14.	MPJCC14	Khargone, M.P.	2014
15.	MPJCC12	Khargone, M.P.	2014
16.	MPJCC21	Bedia, M.P.	2014
17.	MPJCC18	Bedia, M.P.	2014
18.	MPJCC 13	Bedia, M.P.	2014
19.	MPJCC19	Khandwa, M.P.	2015
20.	MPDJCC 1	Delhi	2015
21.	MPRJCC 1	Jodhpur, Rajasthan	2015
22.	MPKJCC 1	Banglore, Karnataka	2015
23.	pusa jwala	Jodhpur, Rajasthan	2015
24.	MPRJCC 2	Jodhpur, Rajasthan	2015
25.	MPOJCC 1	Bhubaneswar, Odisha	2015
26.	MPJCC20	Sagar, M.P.	2015
27.	MPJCC24	Alipur, M.P.	2015
28.	MPRJCC 3	Sikar, Rajasthan	2015
29.	MPRJCC4	Sikar, Rajasthan	2015

30.	MPRJCC5	Sikar, Rajasthan	2015
31.	MPMJCC 1	Amravati, Maharastra	2015
32.	MPUPJCC 1	Prayagraj, U.P.	2015
33.	MPUPJCC 2	Lucknow, U.P.	2015
34.	MPHRJCC1	Faridabad, Haryana	2016
35.	MPOJCC2	Bhubaneswar, Odisha	2016
36.	MPDJCC2	Delhi	2016
37.	MPBJCC 1	Patna, Bihar	2016
38.	MPJCC 8	Khargone, M.P.	2016
39.	MPJCC22	Jhabua, M.P.	2016
40.	MPJCC8	Jhabua, M.P.	2016
41.	MPJCC9	Khargone, M.P.	2016
42.	MPJCC10	Khargone, M.P.	2016
43.	MPMGJCC 1	Shillong, Meghalaya	2016
44.	MPMGJCC 2	Shillong, Meghalaya	2016
45.	MPUPJCC3	Banaras, U.P.	2016
46.	KashiAnmol	IVRI, U.P.	2016
47.	MPJCC23	Raipur, Chattisgarh	2016
48.	MPUPJCC4	Prayagraj, U.P.	2016

Management and cultural practices. The seeds were sown under field conditions in earthen pots in a mixture of soil and vermicompost during end of December month and transplanted during middle February month at a spacing of 60 cm × 45 cm and a plot size of $5m^2$. The full dose of FYM at 25 tonnes/ha was applied during the last field preparation. The recommended dose of nitrogen, phosphorus, and potassium @ 120:60:50 kg/hectare was applied in the form of Urea, SSP and MOP respectively. The entire amount of P and K and half dose of N were used before transplanting and mixed completely in the soil. The remaining half dose of N was given 30 and 60 DAT as top dressing.

Data collection and analysis. During the field work, various qualitative traits were recorded. Five plants from each treatment were randomly selected and tagged for recording the observations. The data was taken in the form of descriptor codes assigned by PPV and FRA & UPOV for the crop Chilli. Observations were recorded at nursery stage like seedling anthocyanin and other stages of crop growth when the character under study was fully expressed for example traits related to fruit were recorded when plant reached horticultural maturity and fruit reached an optimum length and girth. The final data collected was analyzed by computing the mean value of the data taken from all the five tagged plants by using MS excel.

RESULTS AND DISCUSSION

Morphological characterization

Plant growth characteristics. All the data regarding morphological characterization is furnished in Tables 1-3. A significant amount of variation was found among the different chilli cultivars for morphological characters. Plant growth habit was characterized as spreading, semi-upright and upright where semi-upright was found dominant (68.75%) while that of upright (22.92%) and for spreading (8.33%) which indicates a high yield potential in majority of genotypes as upright plant height and medium and strong branching leads to higher yields. Erect types are prime importance as they receive good amount of sunlight which speeds up the assimilate production in the plant. Singh *et al*. (2020). Coloration of seedling was seen in many cultivars (72.92%) and the Cultivars having anthocyanin coloration of nodes are more in number (87.50%) and were categorized as weak (14.29%), medium (23.81%) and strong (61.90%) Bhattacharya *et al.* (2010) reported that anthocyanin minimize the proliferation of cancer cells; prevent lipid damage in food and protect against diseases of the heart. Likewise, Rodriguez and Kimura (2004) mentioned that antioxidants can neutralize or reduce the activity of free radicals, associated with cardiovascular diseases. Genotypes with sparse stem pubescence were higher in number (82.05%) while genotypes with intermediate stem pubescence were low in number (17.95%). Majority of the cultivars had AngledStem shape (62.50%) and some with round shape (37.50%).

Leaf characteristics. Most of the genotypes have lanceolate leaf shape (83.33%) and ovate leaf shape occurred in some genotypes (10.42%) while some genotypes have broad elliptic (6.25%) leaf shape. In the present investigation dark green leaf color was observed more frequent (50%) while medium green color was observed less frequent (35.42%) and that of light green color was minimum (14.58%). Similar results were reported by Ferdousi *et al.* (2021) in chilli genotypes. The dark green color of leaves is generally due to presence of high chlorophyll content in the leaves which ultimately leads to increased yield hence; it becomes a good criterion for selection felite cultivars **(**Pachiyappan and Saravannan 2016). Leaf pubescence was present (60.42%) and characterized as sparse (100%) while in 39.58% leaf pubescence was absent. This is in agreement with the results reported by Smith and Heiser (1951) who mention that for *C. frutescens* leaf pubescence tends to be scarce.

Table 1: Characterization of chilli germplasm following descriptor based qualitative characters for plant growth, leaf, flower, fruit and seeds characteristics.

	Character	Type	Descriptor Code	Number of Genotypes	Frequency (%)
Plant Growth Characteristics	Seedling: Anthocyanin	Absent	1	13	27.08
		Present	9	35	72.92
	Plant: Habit	Spreading	3	4	8.33
		Semi-Upright	5	33	68.75
		Upright	7	11	22.92
	Plant: Anthocyanin (nodes)	Absent	1	6	12.50
		Present	9	42	87.50
	Plant: Intensity of anthocyanin	Weak	3	6	14.29
		Medium	5	10	23.81
		Strong	7	26	61.90
	Stem: Pubescence	Absent	1	9	18.75
		Present	9	39	81.25
	Stem: Intensity of pubescence	Sparse	3	32	82.05
		Medium	5	7	17.95
		Strong	7	0	0
	Stem: Shape	Round	3	18	37.50
		Angled	5	30	62.50
		Flat	7	0	0
Leaf Characteristics	Leaf: Color	Green	3	48	100
		Purple	5	0	0
	Leaf: Intensity of color	Light	3	7	14.58
		Medium	5	17	35.42
		Dark	7	24	50.00
	Leaf: Shape	Lanceolate	3	10	83.33
		Ovate	5	5	10.42
		Broad elliptic	7	3	6.25
	Leaf: Undulation of margin	Weak	3	22	45.83
		Medium	5	22	45.83
		Strong	7	4	8.33
	Leaf: pubescence	Absent	1	46	95.83
		Present	9	2	4.17
Flower Characteristics	Leaf: Intensity of pubescence	Sparse	3	2	100.00
		Medium	5	0	00
		Strong	7	0	00
	Flower: Petal color	White	3	47	97.92
		Yellow	9	1	2.08
	Flower: Anther color	Yellow	3	0	0
		Pale blue	5	31	64.58
		Purple	7	17	35.41
	Flower/ Fruit: orientation	Drooping	3	37	77.08
		Semi-drooping	5	10	20.83
		Erect	7	1	2.08
Fruit Characteristics	Fruit: Bearing habit	Solitary	3	46	95.83
		2-3	5	1	2.08
		Cluster	7	1	2.08
	Fruit: Color (at mature unripe stage)	Green	7	100	100.00
		Purple	9	0	0
	Fruit: Intensity of color (at mature unripe stage)	Light	3	7	14.58
		Medium	5	17	35.42
		Dark	7	24	50.00
	Fruit: Shape in longitunal section	22	45.83	22	45.83
		18	37.50	18	37.50
		5	10.42	5	10.42
		3	6.25	3	6.25
	Fruit: Curvature	Absent	1	1	2.08
		Present	9	47	97.92
	Fruit: Curvature intensity	Low	3	39	82.98
		Medium	5	6	12.77
		High	7	2	4.26
	Fruit: Neck at basal end	Absent	1	15	31.25
		Present	9	33	68.75

Seed Characteristics	Fruit: Sinuation of pericarp	Weak	3	37	77.08
		Medium	5	6	12.50
		strong	7	5	10.64
	Fruit: Texture of surface	Smooth	3	33	27.08
		Slightly rough	5	13	68.75
		Rough	7	2	4.17
	Fruit: Color (at ripe maturity)	Yellow	1	1	2.08
		Orange	2	1	2.08
		Red	3	46	95.83
	Fruit: Intensity of color (at maturity)	Light	3	8	16.67
		Medium	5	33	68.75
		Dark	7	7	14.58
	Fruit: Color transition	One stage	3	47	97.92
		Two stage	5	1	2.08
	Fruit: Glossiness	Weak	3	5	10.42
		Medium	5	31	64.58
		Strong	7	12	25.00
	Fruit: Shape at the base	Acute	3	47	97.92
		Round	5	1	2.08
		Sunken	7	0	0
	Fruit: Shape of apex	Acute	1	43	89.58
		Blunt	3	5	10.42
		Depressed	5	0	0
	Fruit: Calyx Cover	Non-enveloping	1	4	8.33
		Enveloping	9	44	91.67
	Fruit: Calyx Margin	Smooth	1	33	68.75
		Dented	9	15	31.25
	Fruit: Calyx Constriction	Absent	1	27	56.25
		Present	9	21	43.75
	Fruit: Pedicel attachment	Weak	1	19	39.58
		Strong	9	29	60.42
	Fruit: Blossom end appendage	Absent	1	48	100.00
		Present	9	0	0
	Seed: Color	Light Yellow	3	48	100.00

Table 2: Morphological characterization of chilli genotype based on qualitative trait for plant growth, leaf and flower.

Plant growth characteristics								Leaf characteristics						Flower characteristics		
Genotypes	**Seedling Anthocyanin**	**Plant Habit**	**Plant: Anthocyanin (nodes)**	**Plant: Intensity of anthocyanin**	**Stem: Pubescence**	**Stem: Intensity of pubescence**	**Stem Shape**	**Leaf Color**	**Leaf: Intensity of color**	**Leaf Shape**	**Leaf: Undulation of margin**	**Leaf: pubescence**	**Leaf: Intensity of pubescence**	**Flower Petal color**	**FlowerAnthercolor**	**Flower orientation**
MPJCC 1	1	5	9	7	9	3	5	3	7	3	3	1	-	3	5	3
MPJCC 2	9	5	9	7	1		5	3	3	3	3	1	-	3	5	3
MPJCC 3	9	5	9	5	9	3	5	3	5	3	5	1	-	3	7	3
yellow chilli	9	5	9	3	9	5	5	3	3	3	5	9	3	3	5	5
MPJCC 4	9	5	9	7	9	3	5	3	5	3	3	9	3	3	5	5
MPJCC 5	9	5	9	5	9	3	3	3	5	3	3	1	-	3	5	3
MPJCC 6	9	5	9	3	9	3	5	3	5	3	3	1	-	3	5	3
MPJCC 7	1	5	9	7	1		5	3	5	3	5	9	3	3	7	3
MPJCC 15	9	5	9	5	9	3	5	3	7	3	7	9	3	3	7	5
MPJCC 16	9	5	9	7	9	5	3	3	7	3	5	9	3	3	7	3
MPJCC 17	1	5	9	7	9	3	3	3	5	3	5	9	3	3	5	3

MPJKJ CC 1	9	7	9	7	9	3	5	3	5	5	3	1		3	5	3
MPBJC C 2	9	7	1	-	1		3	3	5	3	5	9	3	3	5	5
MPJCC 14	9	7	9	5	9	3	3	3	7	3	3	9	3	3	5	5
MPJCC 12	9	5	9	7	9	3	5	3	7	3	5	1	-	3	5	3
MPJCC 21	1	5	9	7	9	3	5	3	5	3	3	9	3	3	5	3
MPJCC 18	1	5	9	3	9	3	5	3	5	3	3	1		3	5	3
MPJCC 13	9	5	9	5	9	3	5	3	7	3	3	1		3	5	3
MPJCC 19	1	7	9	7	9	3	5	3	7	3	5	1		3	7	5
MPDJC C 1	1	5	9	3	1		3	3	5	3	5	9	3	3	5	3
MPRJJ CC 1	9	5	9	5	9	3	3	3	3	3	5	1	-	3	5	3
MPKJC C 1	9	7	9	3	9	3	5	3	3	7	3	9	3	3	5	3
pusa jwala	9	3	9	7	9	5	3	3	3	3	3	9	3	3	5	3
MPRJJ CC 2	1	7	1	-	1		3	3	7	7	3	1	-	3	5	3
MPOJC C 1	9	3	9	7	9	3	3	3	3	3	3	9	3	3	5	3
MPJCC 20	9	5	9	7	1		5	3	5	5	5	9	3	3	7	3
MPJCC 24	9	7	9	7	9	5	5	3	7	3	5	1	-	3	5	3
MPRJJ CC 3	1	5	9	7	9	3	5	3	7	3	5	9	3	3	7	3
MPRJJ CC 4	1	3	9	7	9	5	5	3	7	3	3	9	3	3	5	3
MPRJJ CC 5	1	5	1	-	9	3	3	3	5	3	3	9	3	3	5	3
MPMPJ CC 1	9	7	9	7	1		5	3	7	3	5	1	-	3	5	5
MPUPJ CC 1	9	5	9	7	9	3	5	3	5	3	3	9	3	3	5	3
MPUPJ CC 2	9	5	9	7	9	3	5	3	5	3	5	9	3	3	7	3
MPHRJ CC 1	9	5	9	7	9	3	5	3	7	3	5	9	3	3	7	5
MPOJC C 2	9	5	9	5	9	3	3	3	7	5	7	9	3	3	5	7
MPDJC C 2	9	7	9	7	9	3	3	3	5	3	3	1	-	3	7	3
MPBJC C 1	9	7	9	5	9	3	5	3	7	3	5	9	3	3	7	3
Guntoor	1	5	9	7	9	5	5	3	5	3	5	9	3	3	5	3
MPJCC 22	9	5	9	5	9	3	5	3	7	3	3	9	3	3	5	3
MPJCC 8	9	3	9	7	1		3	3	7	3	7	9	3	3	7	3
MPJCC 9	9	7	1	-	9	3	5	3	7	3	3	1	-	3	5	3
MPJCC 10	9	5	1	-	9	3	5	3	7	3	5	9	3	3	5	3
MPMG JCC 1	9	5	1	-	9	5	3	3	7	7	7	9	3	9	7	5
MPMG JCC 2	1	5	9	3	9	3	5	3	3	3	3	1		3	7	3
MPUPJ CC 3	9	5	9	5	9	3	3	3	7	5	3	9	3	3	7	5
Kashian mol	9	5	9	7	9	3	3	3	7	3	5	1	-	3	7	3
MPJCC	9	5	9	7	1		3	3	7	5	5	9	3	3	7	3

23																
MPUPJ CC 4	9	5	9	7	9	3	5	3	7	3	5	1	-	3	7	3
	1-absent 9- present	3-spreading 5- semi-upright 7- upright	1-Absent 9- present	3-weak 5-medium 7- strong	1-Absent 9- present	3-sparse 5-medium 7-strong	3-round 5-angled 7-flat	3-green 5-purple	3-light 5-medium 7-dark	3-lanceolate 5-ovate 7-broad elliptic	3-weak 5-medium 7-strong	1-present 9-absent	3-sparse 5-medium 7-strong	3-white 9-yellow	3-yellow 5-pale blue 7- purple	5-semi drooping 7- erect

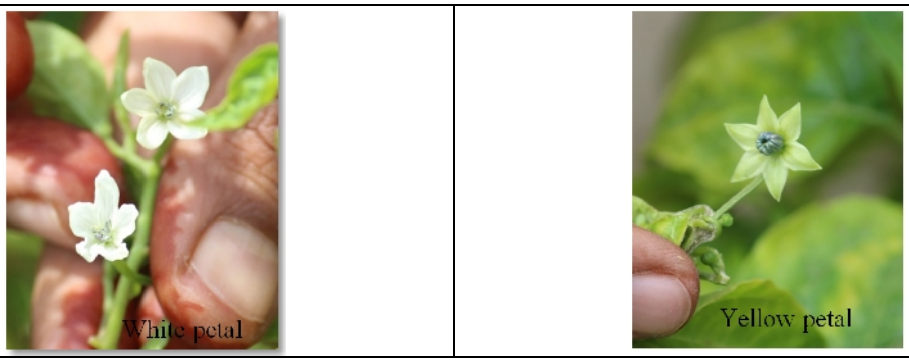
Table 3: Morphological characterization of chilli genotypes based on qualitative trait for fruit and seed.

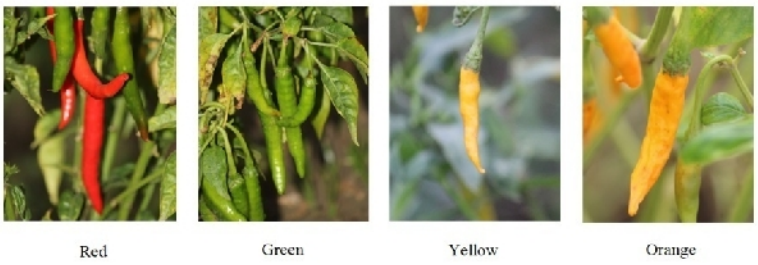
	Fruit characteristics														Seed characteristics						
Genotypes	**Fruit: Bearing habit**	**Fruit: Color (at mature unripe stage)**	**color intensity**	**Fruit: Shape in longitunal section**	**Fruit: Curvature**	**Fruit: Curvature intensity**	**Fruit: Neck at basal end**	**Fruit: Sinuation of pericarp**	**Fruit: Texture of surface**	**Fruit: Color (at ripe maturity)**	**Fruit: Intensity of color (at maturity)**	**Fruit: Color transition**	**Fruit: Glossiness**	**Fruit: Shape at the base**	**Fruit: Shape of apex**	**Fruit: Calyx Cover**	**Fruit: Calyx Margin**	**Fruit: Calyx Constriction**	**Fruit: Pedicel attachment**	**Fruit: Blossom end appendage**	**Seed Color**
MPJCC 1	3	7	7	8	9	3	9	3	5	3	5	1	5	3	1	9	9	1	9	1	3
MPJCC 2	3	7	7	8	9	3	1	3	3	3	5	1	5	3	3	9	9	1	1	1	3
MPJCC 3	3	7	7	9	9	5	1	3	5	3	5	1	3	3	1	9	9	9	9	1	3
yellow chilli	3	7	7	8	9	3	9	3	3	1	7	1	5	3	1	9	9	9	1	1	1
MPJCC 4	5	7	7	8	9	1	1	1	1	1	7	1	5	1	1	9	9	9	1	1	1
MPJCC 5	1	7	5	8	9	1	9	1	1	1	7	1	5	1	1	9	9	1	1	1	1
MPJCC 6	1	7	1	7	9	1	1	1	1	2	5	1	7	1	1	1	9	1	1	1	1
MPJCC 7	1	7	7	8	9	1	9	1	5	1	7	1	1	1	1	9	9	9	1	1	1
MPJCC 15	1	7	5	8	9	1	1	1	5	1	5	1	7	1	1	9	1	9	9	1	1
MPJCC 16	1	7	5	8	9	1	9	1	1	1	5	1	5	1	1	9	1	1	9	1	1
MPJCC 17	1	7	5	9	9	1	9	5	7	1	5	1	5	1	1	9	1	1	9	1	1
MPJKJC C 1	1	7	7	6	1		1	5	7	1	5	1	5	1	1	9	1	1	9	1	1
MPBJC C 2	1	7	5	8	9	1	9	1	5	1	1	1	7	1	1	9	1	1	9	1	1
MPJCC 14	1	7	5	9	9	5	9	1	1	1	5	1	7	1	1	9	9	9	1	1	1
MPJCC 12	1	7	5	9	9	1	9	7	1	1	5	1	5	1	1	9	1	9	9	1	1
MPJCC 21	1	7	5	9	9	1	9	7	5	1	1	1	7	1	1	9	1	1	9	1	1
MPJCC 18	1	7	5	9	9	1	9	7	5	1	1	1	7	1	1	9	1	1	9	1	1
MPJCC 13	1	7	5	9	9	5	1	7	5	1	5	1	5	1	1	9	1	9	9	1	1
MPJCC 19	1	7	7	9	9	1	9	7	7	1	5	1	5	1	1	9	1	9	9	1	1
MPDJC C 1	1	7	1	9	9	1	1	5	5	1	1	1	7	1	1	9	1	1	9	1	1
MPRJJC C 1	1	7	1	9	9	5	1	1	5	1	5	1	5	1	1	9	9	9	1	1	1
MPKJC C 1	1	7	1	9	9	5	1	1	5	1	5	1	1	1	1	9	1	1	1	1	1

pusa jwala	1	7	1	9	9	7	9	5	5	1	5	1	5	1	1	9	9	9	9	1	1
MPRJJCC 2	1	7	1	9	9	7	1	1	5	1	5	1	7	1	1	1	1	1	1	1	1
MPOJCC 1	1	7	5	8	9	1	9	1	5	1	5	1	5	1	1	9	1	1	1	1	1
MPJCC 20	1	7	5	8	9	1	9	5	1	1	5	1	1	1	1	1	1	1	1	1	1
MPJCC 24	1	7	7	9	9	5	9	5	5	1	1	2	5	1	1	9	1	9	1	1	1
MPRJJCC 3	1	7	5	8	9	1	1	1	5	1	5	1	5	1	1	9	1	9	9	1	1
MPRJJCC 4	1	7	7	9	9	1	1	1	1	1	5	1	5	1	1	9	1	1	1	1	1
MPRJJCC 5	1	7	5	6	9	1	1	1	1	1	5	1	5	5	1	9	1	9	1	1	1
MPMPJCC 1	1	7	7	9	9	1	9	1	5	1	1	1	5	1	1	9	1	9	9	1	1
MPUPJCC 1	1	7	7	9	9	1	9	1	1	1	5	1	1	1	1	9	1	1	9	1	1
MPUPJCC 2	1	7	7	8	9	1	9	1	5	1	5	1	7	1	1	9	9	9	9	1	1
MPHRJCC 1	1	7	7	9	9	1	9	1	5	1	5	1	5	1	1	9	9	9	9	1	1
MPOJCC 2	7	7	5	8	9	1	9	1	5	1	5	1	5	1	1	9	1	1	9	1	1
MPDJCC 2	1	7	7	8	9	1	9	1	7	1	1	1	5	1	1	9	1	1	9	1	1
MPBJCC 1	1	7	5	9	9	1	9	1	5	1	5	1	5	1	1	9	1	9	9	1	1
Guntoor	1	7	5	8	9	1	9	1	1	1	5	1	5	1	1	9	1	9	9	1	1
MPJCC 22	1	7	5	9	9	1	9	1	5	1	7	1	7	1	1	9	9	1	9	1	1
MPJCC 8	1	7	5	9	9	1	9	1	1	1	5	1	7	1	1	1	1	1	9	1	1
MPJCC 9	1	7	7	9	9	1	9	1	1	1	7	1	5	1	1	9	1	1	1	1	1
MPJCC 10	1	7	5	7	9	1	9	1	1	1	5	1	5	1	1	9	9	1	9	1	1
MPMGJCC 1	1	7	1	7	9	1	9	1	5	1	5	1	5	1	1	9	1	1	1	1	1
MPMGJCC 2	1	7	5	8	9	1	9	1	1	1	5	1	5	1	1	9	1	1	1	1	1
MPUPJCC 3	1	7	5	8	9	1	9	1	5	1	1	1	5	1	1	9	1	1	1	1	1
Kashian mol	1	7	7	6	9	1	9	1	5	1	7	1	5	1	1	9	1	9	9	1	1
MPJCC 23	1	7	5	7	9	1	1	1	1	1	5	1	5	1	1	9	1	1	9	1	1
MPUPJCC 4	1	7	5	7	9	1	9	1	1	1	5	1	7	1	1	9	1	9	9	1	1
	5-2-1 7-cluster	7-green 9-purple	5-medium 7-dark	8-n.triangular 9-hornshaped	1-absent 9-present	5medium 7-high	1-absent 9-present	5-medium 7-strong	5-s.rough 7-rough	2-orange 1-red	5-medium 7-dark	1-one stage 5-two stage	5-medium 7-strong	5-roung 7-sunken	1-blunt 5-depressed	1-non enveloping 9-enveloping	1-smooth 9-dented	1-absent 9-present	1-weak 9-strong	1-absent 9-present	3-light yellow 5-yellow

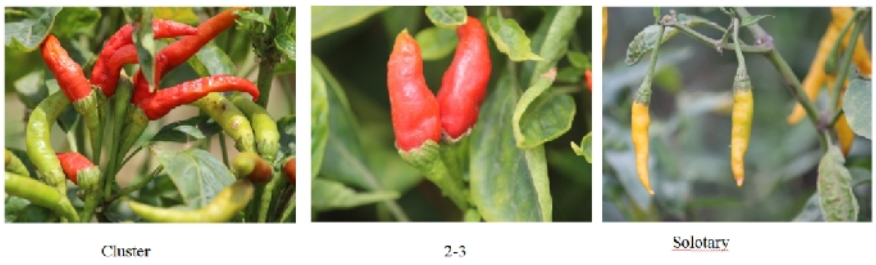
Flower characteristics. Almost all the genotypes having white corolla color (97.92%) except one which was yellow (2.08%). Attractive flower color is a desirable trait as it helps in attracting pollinators during the pollination process. The above agrees with Pickersgill, (1980) who mentions that in capsicum, two groups of flowers are defined: white and purple. In the group of white flowers, there are two subgroups, the one made up of *C. baccatum* and a second that groups *C. annuum*, *C. chinense*, *and C. frutescens*. The group of purple flowers are the species *C. eximium* Hunz., *C. cardenasii* and *C. pubescens*. On the other hand, Smith and Heiser (1951) reported that in *C. frutescens*, the flowers are greenish-yellow, and for *C. annuum*, they are white. There was a wide variation in terms of anther color, genotypes having pale blue (64.58%) and purple

(35.41%). Flower position and stigma exertion highly influences the degree and mode of pollination, it was characterized as drooping and semi-drooping which was seen in 77.08% and 20.83% genotypes respectively.

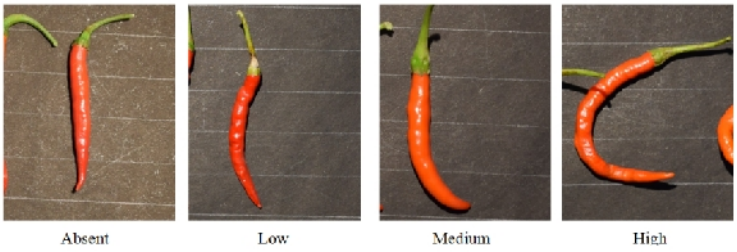




Fruit Color



Fruit Position



Fruit Curvature

Fruit and seed characteristics. Most of the cultivars have solitary fruit bearing habit (95.83%) while 2-3 and cluster type also seen in 2.08% each. All the genotypes were green in color at immature fruit stage with maximum intensity of medium (50%) followed by dark (35.42%) and then light (14.58%) with minimum intensity. Most of the cultivars have red ripe fruit color (95.83%) and in them maximum with medium intensity (66.75%) followed by light intensity (16.67%) and dark intensity (14.58%) were less in number while one cultivar is dark yellow and one is medium orange in color at ripe which is 2.08% each. Drooping fruit position (77.08%) was dominant over semi drooping (20.83%) followed by erect (2.08%), an erect nature allows for maximum and uniform exposure of all leaves and other vegetative parts to better sunlight and would also result in an increase in dry matter production and an increase in yield. Attractive fruit color, lesser fruit pubescence and smooth fruit texture are the factors which determine consumer acceptability of the product and hence, these traits become a good selection criterion for a breeder. Fruit calyx cover was found

enveloping in maximum cases (91.67%) and non-enveloping in few cases (8.33%). Base shape was found acute (97.92%) and round (2.08%) while apex shape was found acute (89.58%) and blunt (10.42%). According to Andrews (1995), the accessions belonging to the *C. annuum* species are characterized by having small, ovoid fruits with two locules, the fruit—a bloated berry—with different colors. All the cultivars were devoid of Blossom end fruit appendages, similar findings were also found by Nsabiyera *et al.* (2013). Most of the genotypes seen with neck at the base of fruit (68.75%) and some without neck (31.25%). Sinuation of pericarp was weak (77.08%), medium (12.50%) and strong (10.64%). Fruit curvature was present in 97.92% of cultivars and absent in 2.08% cultivars. Curvature intensity was low in many genotypes (82.98%) followed by medium (12.77) and least with high curvature (4.26). In most of the cases fruit shape in longitudinal section was horn shaped (45.83%) followed by narrow triangular (37.50%), moderately triangular (10.42%) and few in the case of trapezoidal (6.25%). Fruit texture is slightly rough in many cases (52.08%) followed by smooth (39.58%) and rough (8.33%) texture. Fruit pedicel attachments were found strong in more cultivars (60.42%) and weak (39.58%) in some cultivars. Medium fruit glossiness were dominant in maximum cultivars (64.58%) followed by strong gloss (25%) and least with weak gloss (10.42%). Fruit transition were one in stage in 97.92% cultivars and two stages in 2.08%. All the cultivars have light yellow colored seeds. Present findings conferthat there is variation in the above-mentioned traits in a considerable amount even within a species for all the traits studied which can be exploited for the further breeding programme. Also, all the characteristics of the genotypes under study were following the characteristics confirmed by PPV and FRA & UPOV.

CONCLUSIONS

Based on morphological characterization analysis, all the cultivars were characterized for the identification of unique breeding traits. Overall study revealed that a considerable amount of variation was present among all the genotypes under study. Genotypes Pusa jwala, MPOJCC 1, MPRJJCC 4, MPJCC 8, MPJKJCC 1, MPJCC 20, MPOJCC 2, MPUPJCC 3, MPJCC 23, MPKJCC 1, MPRJJCC 2, MPMGJCC 1, MPJCC 10, MPJCC 4, MPJCC 6, MPJCC 10, MPUPJCC 4, MPRJJCC 5, MPJCC 12, MPJCC 21, MPJCC 18, MPJCC 13, MPJCC 19, MPJCC 17, MPDJCC2, yellow chilli, MPJCC 7, MPUPJCC 1, MPJCC 2, and MPBJCC 2 found a wide range of variations in morphological traits. These were the genotypes that exhibited a wide range of variations and genotypes need further testing and to be released as a substitute of already existing chilli varieties or they can be involved in the further breeding programme for the development of superior varieties or hybrids for yield and quality improvement of chilli.

FUTURE SCOPE

The specific traits will be of great importance in breeding programme of the crop for addition of new traits in some of the important cultivars in seed production chain. Majority of the varieties go through a long journey in seed production chain only for good adaptability and unique morphological traits linked makes the identification easy in between different varieties of the same crop.

Acknowledgement. The authors are very thankful to Department of Plant Breeding and Genetics, College of Agriculture, Jabalpur for providing valuable material for this experiment.
Conflict of interest. None.

REFERENCES

Andrews, J. (1995). *Peppers: The domesticated capsicums*. University of Texas Press.

Bhattacharya, A., Chattopadhyay, A., Mazumdar, D., Chakravarty, A., & Pal, S. (2010). Antioxidant constituents and enzyme activities in chilli peppers. *International journal of vegetable science*, *16*(3), 201-211.

Bosland, P. W., Votava, E. J., &Votava, E. M. (2012). *Peppers: vegetable and spice capsicums* (Vol. 22). Cabi.

Ferdousi, J., Zakaria, M., Hoque, M. A., Saha, S. R., Ivy, N. A., & Hossain, M. I. (2021). Morphoogical Characterization of Twenty One Sweet Pepper (*Capsicum annuum* L.) Genotypes Collected from Native and Alien Sources. *European Journal of Biology and Biotechnology*, *2*(5), 1-8.

Joshi, U., Rana, D. K., Singh, V., & Bhatt, R. (2020). Morphological characterization of chilli (*Capsicum annum* L.) genotypes.

Nsabiyera, V., Logose, M., Ochwo-Ssemakula, M., Sseruwagi, P., Gibson, P., & Ojiewo, C. O. (2013). Morphological characterization of local and exotic hot pepper (*Capsicum annuum* L.) collections in Uganda. *Bioremediation, Biodiversity and Bioavailability*, *7*(1), 22-32.

Pachiyappan, R., & Saravannan, K. (2016). Studies on genetic variability and correlation for fruit yield and fruit quantity characters of okra. *Asian Journal of Horticulture*, *11*(1), 101-104.

Pickersgill, B. (1980). Some aspects of interspecific hybridization in Capsicum. In *Preliminary report at The 4th EUCARPIA Capsicum working group meetings, Wageningen, Netherlands, 1980*.

Act, P. P. V. F. R. Protection of Plant Varieties and Farmers Right Authority.

Rodriguez-Amaya, D. B., & Kimura, M. (2004). *Harvest Plus handbook for carotenoid analysis* (Vol. 2, pp. 63-pp). Washington: International Food Policy Research Institute (IFPRI).

Singh, A.K., Biswas, U., Kumar, R. R., Swain, S. and Swarnam, T. P. (2020). Morphological and genetic diversity among farmers' varieties of urdbean (*Vigna mungo* L.) Hepper of Andaman and Nicobar Islands Agro-Ecosystems. *Legume Research, 43*(2): 172-178.

Smith, S. H. (2015). In the shadow of a pepper-centric historiography: Understanding the global diffusion of capsicums in the sixteenth and seventeenth centuries. *Journal of Ethnopharmacology, 167*, 64-77.

Srinivas, J., Reddy, K. R., Saidaiah, P., Anitha, K., Pandravada, S. R. and Balram, M. (2021). Studies on Genetic Divergence in Chilli (*Capsicum annuum* L.) under Southern Telangana Region. *Biological Forum – An International Journal, 13*(2): 522-528.

UPOV (2019). Union Intern pour la prot des obtentions végétales, 48.

Wang, D., & Bosland, P. W. (2006). The genes of Capsicum. *Hort Science, 41*(5), 1169-1187.

Whitmore, T. M., Whitmore, T. M., & Turner, B. L. (2001). *Cultivated landscapes of Middle America on the eve of conquest*. Courier Corporation.

How to cite this article: E Rahul Sonaniya and S.K. Singh (2022). Morphological characterization of Chilli (*Capsicum annuum* L.) Germplasm for the Mining of Breeding Traits. *Biological Forum – An International Journal, 14*(2a): 120-130.