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## Morphological characterization of chilli (*Capsicum annum* L.) genotypes

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Chilli (*Capsicum annum* L.) is one of the most important vegetable cum spice crops grown worldwide. India is the leading producer of chilli in the world. Morphology based characterization of chilli was undertaken to identify characteristics which could be helpful in breeding programmes. This study is of great significance in determining the distinctiveness, uniformity, and stability of various chilligenotypes. In the present investigation, 15 genotypes of chilli collected from NBPGR Bhowali, IIVR Varanasi, and Srinagar Garhwal were evaluated for their qualitative morphological characterization using a Randomized block experimental design. A fair amount of variation was found in the morphological characterization analysis. Among the different traits assessed, round stem shape, anthocyanin colouration of nodes, entire leaf margin, white corolla colour, dentate calyx margin, round stem shape, and few others showed 100% frequency; a higher frequency was also observed for Green stem colour (93.33%), sparse stem pubescence (86.66%), lanceolate leaf shape (93.33%) and obtuse fruit shape at pedicel attachment (86.66%). Genotypes Kashi Anmol, Taiwan-1, Saidpur Collection, Srinagar Local, and IC-119308 found a wide range of variations in qualitative traits, and the study suggested these genotypes can be used for breeding purpose after further testing.

**Keywords:** Chilli, Genotypes, Morphological characterization, Plant breeding, Spice, Vegetable

### Introduction

Chilli (*Capsicum annum* L.), belongs to the family Solanaceae. It is popularly known as hot pepper, red pepper or Chilli pepper and was originated in tropical America<sup>1</sup>. It is an important vegetable cum spice crop grown in the tropical, subtropical as well as temperate regions of India. Fruits of chilli are rich sources of vitamins A, C and E with minerals like manganese, potassium, thiamine, molybdenum, foliate and copper. Pungency in chillies is caused by capsaicinoids (Capsaicin and its analogues collectively)<sup>2,3</sup>. It was introduced by Columbus in Europe in 15<sup>th</sup> century and has since spread to rest of the globe along the spice trading routes to Africa, India, China, and Japan. It was introduced to India by Portuguese into Southern parts of India in 16<sup>th</sup> century<sup>4,5</sup> and cultivation spread out throughout India by the end of 19<sup>th</sup> century<sup>6,7</sup>.

India is the world's largest producer, consumer, and exporter of chilli. India exports chilli to various countries like USA, Canada, UK, Saudi Arabia, Singapore, Malaysia, Germany, and many countries across the world. The major regions where chilli is cultivated in India are Andhra Pradesh, Maharashtra,

Karnataka, Uttar Pradesh, Punjab, Tamil Nadu, Rajasthan, Orissa, West Bengal, and Madhya Pradesh<sup>8</sup>. The area under green chilli's cultivation in India is 0.309 million hectares with a production of 3.592 million tonnes and under dried chilli is 0.752 million hectares with a production of 2.149 million tonnes<sup>9,10</sup>.

Morphological characterization based on qualitative traits of crops is a very crucial and essential first step in any crop improvement and breeding programme<sup>11,12,13</sup>. Parental purity judgement and Varietal identification are an important factor for the released genotypes<sup>14,15</sup>. Cultivars can be identified and differentiated based on differences in morphology of seed, seedling and grown up plant. Morphological characterization of chilli germplasm accessions has been studied for most plant and fruit traits<sup>2</sup>. Evaluation and Characterization of chilli germplasm becomes a necessary step for utilizing the available diversity for improvement of the crop<sup>16</sup>.

Many chilli varieties having tremendous variability for different characters are being cultivated in different parts of India and some of the variations are so localized that their cultivation beyond the zone is completely unknown. Due to their localized distribution, some of these promising varieties are yet

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to be known. So, it is necessary to evaluate the performance and characteristics of local varieties as well as cultivated varieties of chilli recommended for cultivation in different climatic zones for identifying suitable donors having different desirable attributes under the agro-ecological condition of the Himalayan region of Uttarakhand. The aim of this study is to characterize various chilli genotypes to know their morphological characteristics and differentiate them from each other and to access the variations present in genotypes under consideration and identify promising genotypes and traits which can be used in future breeding programme.

## Materials and Method

### Experimental site

The present investigation was carried out at Department of Horticulture, Horticultural Research Centre, Chauras campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand (India). It is situated in Alaknanda valley which lies between 78°47'30" E longitude and 30°13'0" N latitude, at an elevation 540 meter above MSL, in the lesser Himalayan region. The experimental site has a sub-tropical climate, with both the extremes in the temperature, *i.e.*, winter and summer seasons. The temperature reaches up to 35-40 °C from May to June. The experimental site exhibits dry summer and rigorous rain in the month from April to July. Soil status of the site was sandy loam in texture and having  $p^H$  5.97. Nutrient status of the soil was 3.21% carbon, 238 Kg/ha available nitrogen, 16.86 Kg/ha available phosphorus, and 98.7 Kg/ha available potassium.

### Experimental design and plant material used

Fifteen genotypes *viz.*, Kashi Anmol, Taiwan-1, Saidpur Collection, Srinagar Local, CO-5686-1, IC-119277, IC-119300, IC-119267, IC-119306, IC-119308, IC-119298, IC-119290, IC-119279, IC-119276, IC-121489 were evaluated in RBD (Randomized block design) with 3 replications during the Summer season of 2019 from month April to October.

### Management and cultural practices

The seeds were sown under protected conditions in raised seed beds during end of February month and transplanted during middle April month at spacing of 45 cm × 45 cm and a plot size of 1.35m × 1.35m. The full dose of FYM at 20 tonnes/ha was applied during the last ploughing. The recommended dose of nitrogen, phosphorus, and potassium at

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. 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<sup>15</sup>, IPGRI, AVRDC and CATIE<sup>17</sup>, & UPOV<sup>18</sup> for the crop Chilli. Observations were recorded at 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 analysed 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 are Tables 1-4. A significant amount of variation was found among the different chilli cultivars for morphological characters. Plant growth habit was characterized as intermediate and erect, where erect was found dominant (66.66%) while that of intermediate (33.33%). Most of the cultivars show intermediate branching habit (93.33%) while dense branching habit was shown by very less cultivars (6.66%) which indicates a high yield potential in majority of genotypes as erect plant height and medium and strong branching leads to higher yields<sup>12,19</sup>. Cultivars having green stem colour were dominant (93.33) and that of green stem with purple stripes were very less (6.66%). Genotypes with sparse stem pubescence were higher in no. (86.66%) while genotypes with intermediate stem pubescence were low in no. (13.33%). All the cultivars had Round Stem shape and nodes of all cultivars have anthocyanin colouration. Cultivars based on intensity of anthocyanin colouration of nodes were categorised as weak (6.66%), medium (46.66%) and strong (46.66%).

#### Leaf characteristics

Most of the genotypes have lanceolate leaf shape (93.33%) while ovate leaf shape occurred very less in genotypes (6.66%). Manju and Sreelathakumary<sup>20</sup>

Table 1 — Characterization of chilli germplasm following descriptor based qualitative characters for plant growth, leaf and flower characteristics

	Character	Type	Descriptor Code	Number of Genotypes	Frequency (%)
Plant Growth Characteristics	Plant Growth Habit	Intermediate	5	5	33.33
		Erect	7	10	66.66
	Branching Habit	Intermediate	5	14	93.33
		Dense	7	1	6.66
	Stem Colour	Green	1	14	93.33
		Green with purple stripes	2	1	6.66
	Stem Pubescence	Sparse	3	13	86.66
		Intermediate	5	2	13.33
	Stem Shape	Round	3	15	100
	Anthocyanin Colouration of Nodes	Present	9	15	100
	Intensity of anthocyanin colouration of Nodes	Weak	3	1	6.66
		Medium	5	7	46.66
	Leaf Shape	Strong	7	7	46.66
		Ovate	2	1	6.66
Leaf Margin	Lanceolate	3	14	93.33	
	Entire	1	15	100	
Leaf Characteristics	Leaf Colour	Green	1	3	20
		Dark Green	2	12	80
	Leaf Pubescence	Absent	0	4	26.66
		Sparse	3	10	66.66
Flower Characteristics	Corolla Colour	Intermediate	5	1	6.66
		White	1	15	100
	Anther Colour	Purple	6	4	26.66
		Green with white filament	99-a	10	66.66
	Calyx Margin	Green with Purple filament	99-b	1	6.66
		Dentate	3	15	100
	Flower Position	Pendent	3	3	20
		Intermediate	5	12	80
	Stigma Exertion	Same Level	5	3	20
		Exerted	7	12	80
Calyx Annular Constriction	Absent	0	15	100	
Flower Colour	White	b	15	100	

Table 2 — Characterization of chilli germplasm following descriptor based qualitative characters for fruit and seed characteristics

Fruit Characteristics	Fruit Calyx Cover	Enveloping	9	15	100
	Mature Fruit Colour	Green	3	15	100
		Light Red	7	1	6.66
	Ripe Fruit Colour	Red	8	10	66.66
		Dark Red	9	4	26.66
		Pendent	3	6	40
	Fruit Position	Intermediate/Semi Pendent	4	8	53.33
		Erect	7	1	6.66
		Elongate	1	12	80
	Fruit Shape	Triangular	3	2	13.33
		Campanulate	4	1	6.66
	Fruit Shape at pedicel attachment	Obtuse	2	13	86.66
		Truncate	3	1	6.66
		Cordate	4	1	6.66
	Blossom end Fruit Shape	Pointed	1	12	80
		Blunt	2	2	13.33
		Sunken	3	1	6.66

(Contd.)

Table 2 — Characterization of chilli germplasm following descriptor based qualitative characters for fruit and seed characteristics (*Contd.*)

	Blossom end Fruit appendages	Absent	0	15	100
	Fruit Cross Section	Slightly Corrugated	3	12	80
	Corrugation	Intermediate	5	2	13.33
		Corrugated	7	1	6.66
	Neck at base of Fruit	Absent	0	15	100
		Weak	3	10	66.66
	Sinuation of Pericarp	Medium	5	3	20
		Strong	7	2	13.33
	Fruit Curvature	Absent	1	2	13.33
		Present	9	13	86.66
	Curvature Intensity	Low	3	15	100
	Fruit Shape in Longitudinal Section	Trapezoidal	6	1	6.66
		Moderately Triangular	7	3	20
		Narrowly Triangular	8	11	73.33
Seed Characteristics	Seed Colour	Light Yellow	1	15	100

Table 3 — Morphological Characterization of Chilli genotypes based on Qualitative traits for Plant growth, leaf, and flower characteristics

Genotype	Plant Growth Characteristics					Leaf Characteristics					Flower Characteristics								
	Plant Growth Habit	Branching Habit	Stem colour	Stem Pubescence	Stem shape	Anthocyanin colouration of nodes	Intensity of Anthocyanin colouration of nodes	Leaf shape	Leaf Margin	Leaf Colour	Leaf Pubescence	Corolla Colour	Anther colour	Calyx Margin	Flower Position	Stigma Exertion	Calyx Constriction	Annular Constriction	Flower colour
Kashi Anmol	5	7	2	3	3	9	7	3	1	2	0	1	99-a	3	3	7	0		b
Taiwan-1	5	5	2	3	3	9	7	3	1	2	0	1	99-a	3	5	7	0		b
Saidpur Collection	7	5	2	3	3	9	7	3	1	2	3	1	6	3	3	5	0		b
Srinagar Local	7	5	2	5	3	9	7	3	1	2	3	1	99-a	3	5	7	0		b
CO-5686-1	7	5	2	5	3	9	7	3	1	2	3	1	99-a	3	5	7	0		b
IC-119277	5	5	2	3	3	9	5	3	1	2	0	1	99-a	3	5	7	0		b
IC-119300	5	5	2	3	3	9	7	3	1	2	3	1	99-a	3	5	7	0		b
IC-119267	5	5	2	3	3	9	5	3	1	1	3	1	99-a	3	5	7	0		b
IC-119306	7	5	2	3	3	9	5	3	1	2	3	1	6	3	5	7	0		b
IC-119308	7	5	2	3	3	9	5	3	1	2	3	1	6	3	3	7	0		b
IC-119298	7	5	2	3	3	9	7	3	1	2	3	1	99-a	3	5	5	0		b
IC-119290	7	5	2	3	3	9	5	3	1	1	3	1	99-a	3	5	7	0		b
IC-119279	7	5	2	3	3	9	5	2	1	1	3	1	99-a	3	5	7	0		b
IC-119276	7	5	2	3	3	9	5	3	1	2	5	1	99-b	3	5	7	0		b
IC-121489	7	5	1	3	3	9	3	3	1	2	0	1	99-a	3	5	5	0		b
Status of Characteristics according to minimal descriptors of Vegetable Crops	5: Intermediate 7: Erect	5: Intermediate 7: Dense	1: Green 2: Green with Purple Stripes	3: Sparse 5: Intermediate	3: Round	9: Present	5: Medium 7: Strong	3: Lamnecoliate	1: Entire	1: Green 2: Dark Green	0: Absent 3: Sparse	1: White	99-a: Green with White Filament 99-b: Green with Purple Filament 6: Purple	3: Entire	3: Pendant 5: Intermediate	5: Same Level 7: Exerted	0: Absent 1: Present		a: Purple b: White

observed green leaf colour 90% and sparse leaf pubescence 87.55%. All the cultivars have entire leaf margin. Datta and Das<sup>2</sup> reported that in more than 50% cases leaf pubescence was sparse (which was like present finding) and same in the case of green leaf colour. In the present investigation dark green leaf colour was observed more frequent (80%) while green colour was observed less frequent (20%) The dark green colour 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 of elite cultivars<sup>21</sup>. Leaf

pubescence was characterized as sparse (66.66%) and absent (26.66%).

#### Flower characteristics

All the genotypes were found having white corolla colour. Attractive flower colour is a desirable trait as it helps in attracting pollinators during the pollination process<sup>22</sup>. There was a wide variation in terms of anther colour, genotypes having anthers green with white filament were maximum (66.66%) followed by purple (26.66%) and green with Purple filament (6.66%). All the cultivars were found having entire calyx margin. Flower position and stigma exertion

Table 4 — Morphological Characterization of Chilli genotypes based on Qualitative traits for fruit and seed characteristics

Genotype	Fruit Characteristics													Seed Characteristics	
	Fruit Calyx Cover	Mature fruit colour	Ripe Fruit Colour	Fruit Position	Fruit Shape	Fruit Shape at Pedicel Attachment	Blossom End Fruit Shape	Fruit Cross Section Corrugation	Neck at base of Fruit	Situation of Pericarp	Fruit curvature	Curvature Intensity	Fruit Shape in Longitudinal section	Seed Colour	
Kashi Anmol	9	3	8	3	1	2	1	3	0	3	9	3	8	1	
Taiwan-1	9	3	7	4	4	4	3	7	0	7	9	3	6	1	
Saidpur Collection	9	3	8	3	1	2	1	5	0	3	9	3	8	1	
Srinagar Local	9	3	8	3	3	2	2	3	0	3	1	3	7	1	
CO-5686-1	9	3	9	4	1	2	1	3	0	3	9	3	8	1	
IC-119277	9	3	9	4	1	2	1	3	0	3	9	3	8	1	
IC-119300	9	3	8	4	1	2	1	3	0	3	9	3	8	1	
IC-119267	9	3	8	4	1	2	1	3	0	5	9	3	7	1	
IC-119306	9	3	8	3	1	2	1	3	0	7	1	3	8	1	
IC-119308	9	3	9	3	1	3	1	3	0	5	9	3	7	1	
IC-119298	9	3	9	4	1	2	1	3	0	3	9	3	8	1	
IC-119290	9	3	8	4	1	2	1	3	0	3	9	3	8	1	
IC-119279	9	3	8	4	1	2	1	3	0	3	9	3	8	1	
IC-119276	9	3	8	7	3	2	2	5	0	5	9	3	8	1	
IC-121489	9	3	8	3	1	2	1	3	0	3	9	3	8	1	

  

Status of Characteristics according to minimal descriptors of Vegetable Crops	9. Enveloping	3. Green	7. Light Red 8. Red 9. Dark Red	3. Pendent 4. Intermediate 7. Erect	1. Elongate 3. Triangular 4. Campanulate	2. Obtuse 3. Truncate 4. Cordate	1. Pointed 2. Blunt 3. Sunken	3. Slightly Corrugated 5. Intermediate 7. Corrugated	0. Absent 1. Present	3. Weak 5. Medium 7. Strong	1. Absent 9. Present	3. Low 5. Medium 7. High	6. Trapezoidal 7. Moderately Trapezoidal 8. Horn Shaped	1. Light Yellow
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highly influences the degree and mode of pollination, it was characterized as pendent and intermediate which was seen in 20% and 80% genotypes respectively. Stigma exertion was characterized as Exerted (80%) and same level (20%). Similar results were also reported by Ogwu *et al.*<sup>19</sup>, Amiteye *et al.*<sup>23</sup> and Pradheep *et al.*<sup>24</sup> in crop okra. There was absence of annular constriction of calyx in every genotype. Flower colour was white in every genotype.

**Fruit and seed characteristics**

All the cultivars have enveloping fruit calyx cover and green mature fruit colour. Most of the cultivars have red ripe fruit colour (66.66%), while cultivars having dark red colour (26.66%) and light red colour (6.66%) were less in number. Intermediate/semi pendent fruit position (53.33%) was dominant over pendent (40%) and erect (6.66%), 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 Ogwu *et al.*<sup>19</sup> Attractive fruit colour, lesser fruit pubescence and smooth fruit texture are the factors which determine consumer acceptability of the product hence, these traits become a good selection criterion for a breeder<sup>12,25</sup>. Based on fruit shape, cultivars were grouped into elongate (80%), triangular (13.33%) and campanulate (6.66%). Fruit shape at pedicel

attachment was found obtuse (86.66%), truncate (6.66%) and cordate (6.66%). Blossom end fruit shape was found pointed (80%), blunt (13.33%) and sunken (6.66%). All the cultivars were devoid of Blossom end fruit appendages, similar findings were also found by Nsabiyeera *et al.*<sup>26</sup> Slight corrugation of cross section (80%) was dominant over intermediate (13.33%) and corrugated (6.66%). All the genotypes lack neck at the base of fruit. Situation of pericarp was weak (66.66%), medium (20%) and strong (13.33%).Fruit curvature was present in 86.66% of cultivars and absent in 13.33% cultivars. Curvature intensity was low in all genotypes. In most of the cases fruit shape in longitudinal section was narrowly triangular (73.33%) and in very few cases it was trapezoidal (6.66%) and moderately triangular (20%). All the cultivars have light yellow coloured seeds. Present findings confer 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<sup>15</sup>, IPGRI, AVRDC and CATIE<sup>17</sup>, & UPOV<sup>18</sup>.

**Conclusions**

Based on Morphological Characterization analysis, morphological features of all the cultivars were

observed. It can be concluded that a considerable amount of variation was present among all the genotypes under study. Different traits were used under study, round stem shape, anthocyanin colouration of nodes, entire leaf margin, white corolla colour, dentate calyx margin, round stem shape, and flower colour showed 100% frequency, a higher frequency was also observed for Green stem colour, sparse stem pubescence, lanceolate leaf shape and obtuse fruit shape at pedicel attachment. The study suggested that genotypes like Kashi Anmol, Taiwan-1, Saidpur Collection, Srinagar Local and IC-119308 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.

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