Research Article

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# Morphological characterization of Indian turmeric (*Curcuma longa* L.) genotypes using DUS descriptor

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## Abstract

Fifteen genotypes of turmeric, a commercially important crop having nutraceutical and pharmaceutical value, were characterized for 24 characters in the form of multiscale scores given by DUS guidelines. Among the characters studied, three genotypes were found to be monomorphic, 12 were dimporphic and nine were polymorphic characteristics. Apart from the DUS characters, there were some noticeable variation in the selected genotypes which can act as morphological markers for identification of genotypes; they are collar girth of the pseudostem, pigmentation in leaf lamina at initial stage which fades off in later stage and red pigmentation in emerging shoot at initial stage of sprouting. The morphological characterization of genotypes will help in linking a character to a specific trait, with potential in utilization for trait specific selection.

*Keywords:* Coma bract, descriptor, DUS, inflorescence, pigmentation, turmeric

## Introduction

Turmeric (*Curcuma longa*. L) is grown as rhizomatous annual crop, used as a medicine, condiment and as a dye in India and many East Asian countries for centuries. As far as turmeric is concerned, the variability is more in centres of origin (Sasikumar, 2005; Sasikumar *et al.*, 1996). Existence of wide variability among the cultivars with respect to yield attributes, and quality characters has been reported by many researchers (Ratnambal *et al*., 1986; Velayudhan *et al*., 1999; Anandaraj *et al*., 2014; Prasath *et al*., 2016; Aarthi *et al*., 2018). In order to develop a planned breeding programme, it is mandatory to know the variations and the level of reproducibility over generations among the various accessions available in the germplasm. Morphological characterization is an important tool even in the era of molecular characterization because of its reliability and easy identification with less resources for certain stable characters unaltered with environmental interactions. Protection of Plant Varieties and Farmers Right Act (2001) of India insists on distinctness, uniformity and stability (DUS) characterization of extant, farmer's and new varieties, and recommends the registration of varieties for any one specific novel character. This guideline helps in categorizing the morphological characters which are measured quantitatively and qualitatively, as well (PPV & FRA, 2009). Therefore, the present study was undertaken to characterize a set of 15 turmeric genotypes for different morphological and rhizome characters based on DUS guidelines.

## Materials and methods

Fifteen genotypes of turmeric, *viz.* Suvarna, IISR Prathiba, IISR Pragati, SLP-389/1, SC-61, Acc. 849, BSR-2, CO-2, Varna, Duggirala Red, Rajendra Sonia, Punjab Haldi-1, Megha Turmeric-1, Rajapuri and Narendra Haldi-98 were characterized at ICAR-Indian Institute of Spices Research, Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala.

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Crop was grown during two consecutive seasons of 2016-17 and 2017-18 in a randomized block design with three replications. The field was maintained under uniform recommended cultural practices (Jayashree *et al.*, 2015). Five plants of uniform size and vigour was selected for recording observations. Genotypes were evaluated for 24 DUS traits *viz.*, pseudostem habit (cm), plant height (cm), number of shoots, number of leaves on main stem, leaf disposition, petiole length (cm), leaf lamina length (cm), leaf lamina width (cm), dorsal leaf colour, ventral leaf colour, leaf venation pattern, leaf margin, pseudostem colouration, coma bract colour, coma bract tip colour, rhizome habit, rhizome shape, primary rhizome length, number of mother rhizome, rhizome internode pattern, status of tertiary rhizome, primary rhizome inner core colour, duration and dry recovery (%). The assessment of characters was done at 150$^{th}$ day after planting for vegetative characters and after harvest for rhizome characters (PPV & FRA, 2009). Observation based on colour was recorded under natural light using Royal Horticultural Colour (RHC) chart.

## Results and discussion

Morphological characters are predominantly used as markers for easy differentiation of genotypes because the characters are expressed genetically involving one or more genes. Among the 15 genotypes studied, considerable variation was recorded for all the important characters. Out of 24 characters assessed based on DUS descriptors, three characters viz., leaf lamina length, leaf colour in ventral side and pseudostem anthocyanin colouration were found to be monomorphic, 12 were dimporphic and nine were polymorphic characteristics. Though classically turmeric genotypes are grouped based on pseudostem height, duration and dry recovery, the variability among the floral character like coma bract colour which ranged from white, green, pink and purple, can also be considered for grouping the genotype. Grouping can be done for rhizome colour as wide variation on primary rhizome inner colour is also documented among the selected 15 genotypes (Table 1).

## Plant and leaf characteristics

The characters pertaining to plant and leaf characters are presented in Table 1.

**Table 1. Grouping traits of turmeric based on DUS descriptors**

| Sl. no. | Characteristics | State | Score | No. of genotypes | Reference genotypes |
|---|---|---|---|---|---|
| 1. | Plant: Pseudo stem habit | Compact (1) | 1 | 6 | IISR Prathiba, Suvarna, Acc 849, Narendra Haldi-98, Duggirala Red, Megha Turmeric-1 |
| | | Open (9) | 9 | 9 | BSR-2, SLP-389/1, CO-2, Rajendra Sonia, Varna, SC-61, IISR Pragati, Rajapuri, Punjab Haldi-1 |
| 2. | Plant: Height (cm) | Short (<85) | 3 | 0 | - |
| | | Medium (85-100) | 5 | 1 | SLP-389/1 |
| | | Tall (>100) | 7 | 14 | IISR Prathiba, Suvarna, Acc 849, Narendra Haldi- 98, Duggirala Red, Megha Turmeric-1, BSR-2, CO-2, Rajendra Sonia, Varna, SC-61, IISR Pragati, Rajapuri, Punjab Haldi -1 |
| 3. | Plant: No. of shoots | Few (<3) | 1 | 6 | Suvarna, Acc 849, BSR-2, Varna, Narendra H-aldi 98, Rajapuri |
| | | Medium (3-5) | 3 | 8 | IISR Prathiba, IISR Pragati, SLP-389/1, SC-61, CO-2, Duggirala Red, Rajendra Sonia, Megha Turmeric |
| | | Many (>5) | 5 | 1 | Punjab Haldi |
| 4. | Plant: Number of leaves | Few (<5) | 3 | 15 | IISR Pragati, SLP-389/1, SC-61, Varna, Punjab Haldi -1 on main shoot |
| | | Intermediate (5-10) | 5 | 10 | Suvarna, IISR Prathiba, Acc 849, Narendra Haldi-98, Duggirala Red, Megha Turmeric-1, BSR-2, CO-2, Rajendra Sonia, Rajapuri |
| | | Many (>10) | 7 | 0 | - |
| 5. | Plant: Leaf disposition | Erect (<45°) | 3 | 7 | BSR-2, IISR Prathiba, CO-2, Acc 849, Duggirala Red, Megha Turmeric, Narendra Haldi-98 |
| | | Semi-erect (45°-85°) | 5 | 7 | Suvarna, Rajendra Sonia, Varna, SC-61, IISR Pragati, Rajapuri, Punjab Haldi-1 |
| | | Horizontal (>85°) | 7 | 1 | SLP-389/1 |

| Sl. no. | Characteristics | State | Score | No. of genotypes | Reference genotypes |
|---|---|---|---|---|---|
| 6. | Leaf: Petiole length (cm) | Short (<15) | 3 | 0 | - |
| | | Intermediate (15-25) | 5 | 9 | Suvarna, IISR Pragati, SLP-389/1, SC-61, Acc 849, Varna, Narendra Haldi-98, Punjab Haldi-1, Rajapuri |
| | | Long (>25) | 7 | 6 | IISR Prathiba, BSR-2, CO-2, Duggirala Red, Rajendra Sonia, Megha Turmeric-1 |
| 7. | Leaf: Lamina length (cm) | Short (<30) | 3 | 0 | - |
| | | Medium (30-40) | 5 | 0 | - |
| | | Long (>40) | 7 | 15 | IISR Prathiba, Suvarna, Acc 849, Narendra Haldi - 98, Duggirala Red, Megha Turmeric-1, BSR-2, SLP- 389/1, CO-2, Rajendra Sonia, Varna, SC-61, IISR-Pragati, Rajapuri, Punjab Haldi -1 |
| 8. | Leaf: Lamina width (cm) | Narrow (<10) | 3 | 0 | - |
| | | Medium (10-15) | 5 | 5 | IISR Pragati, SLP-389/1, Rajendra Sonia, Punjab Haldi-1, Megha Turmeric-1 |
| | | Broad (>15) | 7 | 10 | Suvarna, Prtahiba, SC-61, Acc 849, BSR-2, CO-2, Varna, Duggirala Red, Narendra Haldi-98, Rajapuri |
| 9. | Leaf: Colour on dorsal side | Light green | 3 | 7 | BSR-2, IISR Prathiba, Suvarna, Rajendra Sonia, SC-61, Rajapuri, Punjab Haldi-1 |
| | | Green | 5 | 8 | SLP-389/1, CO-2, Acc 849, Varna, IISR Pragati, Duggirala Red, Megha Turmeric-1, Narendra Haldi-98 |
| | | Dark green | 7 | 0 | - |
| 10. | Leaf: Colour on ventral Side | Green | 5 | 15 | IISR Prathiba, Suvarna, Acc 849, Narendra Haldi-98, Duggirala Red, Megha Turmeric-1, BSR-2, SLP-389/1, CO-2, Rajendra Sonia, Varna, SC-61, IISR Pragati, Rajapuri, Punjab Haldi-1 |
| | | Dark green | 7 | 0 | - |
| 11. | Leaf: Venation pattern | Close | 3 | 14 | BSR-2, IISR Prathiba, Suvarna, CO-2, Rajendra Sonia, Acc 849, Varna, SC-61, IISR Pragati, Duggirala Red, Narendra Haldi-98, Rajapuri, Punjab Haldi-1, Megha Turmeric-1 |
| | | Distant | 5 | 1 | SLP-389/1 |
| 12. | Leaf: Margin | Even | 3 | 13 | BSR-2, Suvarna, SLP-389/1,CO-2, Rajendra Sonia, Acc 849, Varna, SC-61, IISR Pragati, Narendra Haldi-98, Rajapuri, Punjab Haldi-1, Megha Turmeric-1 |
| | | Wavy | 5 | 2 | IISR Prathiba, Duggirala Red |
| 13. | Pseudo stem: Anthocyanin colouration | Absent | 1 | 15 | IISR Prathiba, Suvarna, Acc 849, Narendra Haldi-98, Duggirala Red, Megha Turmeric-1, BSR-2, SLP-389/1, CO-2, Rajendra Sonia, Varna, SC-61, IISR Pragati, Rajapuri, Punjab Haldi-1 |
| | | Present | 9 | 0 | - |
| 14. | Coma bract: Colour | White | 1 | 4 | IISR Prathiba, IISR Pragati, BSR-2, CO-2 |
| | | Coloured | 9 | 11 | Duggirala Red, Punjab Haldi, Rajendra Sonia, Rajapuri, Varna, Suvarna, Megha Turmeric-1, SC-61, Acc 849, Narendra Haldi-98, SLP-389/1 |
| 15. | Bract tip: Colour | White | 1 | 5 | IISR Prathiba, IISR Pragati, BSR-2, CO-2 |
| | | Rose | 3 | 5 | Rajapuri, Varna, Suvarna, Megha Turmeric-1, SC-61, SLP-389/1 |
| | | Purple | 5 | 2 | Acc 849, Narendra Haldi-98 |
| | | Green | 7 | 3 | Duggirala Red, Punjab Haldi, Rajendra Sonia |
| 16. | Rhizome: Habit | Compact | 3 | 8 | BSR-2, IISR Prathiba, Rajendra Sonia, Acc 849, Varna, Megha Turmeric-1, Narendra Haldi-98, Suvarna |
| | | Intermediate | 5 | 6 | CO-2, SC-61, Rajapuri, IISR Pragati, Duggirala Red |
| | | Loose | 7 | 1 | SLP-389/1, Punjab Haldi-1 |
| 17. | Rhizome: Shape | Straight | 3 | 8 | BSR-2, CO-2, SLP-389/1, Rajendra Sonia, SC-61, IISR Pragati, Rajapuri, Punjab Haldi |
| | | Curved | 5 | 7 | IISR Prathiba, Suvarna, Acc 849, Varna, Narendra Haldi-98, Duggirala Red, Megha Turmeric-1 |
| 18. | Rhizome: Length (Primary) | Short (<5 cm) | 3 | 0 | - |

| Sl. no. | Characteristics | State | Score | No. of genotypes | Reference genotypes |
|---|---|---|---|---|---|
| | | Medium (5-10 cm) | 5 | 11 | Suvarna, IISR Prathiba, IISR Pragati, Acc. 849, BSR-2, CO-2, Duggirala Red, Rajendra Sonia, Narendra Haldi-98, Punjab Haldi-1, Megha Turmeric |
| | | Long (>10 cm) | 7 | 4 | SLP-389/1, SC-61, Varna, Rajapuri |
| 19. | Rhizome: Number of mother rhizomes | One | 1 | 5 | Suvarna, Acc. 849, Narendra Haldi-98, Megha Turmeric, Duggirala Red |
| | | 2-3 | 3 | 6 | IISR Pragati, SLP-389/1, CO-2 Varna, Punjab Haldi-1, Rajapuri |
| | | More than 3 | 5 | 4 | IISR Prathiba, SC-61, BSR-2, Rajendra Sonia, |
| 20. | Rhizome: Internode pattern | Close (<1) | 3 | 4 | IISR Prathiba, Acc. 849, BSR-2, Narendra Haldi-98, Duggirala Red |
| | | Distant (>1) | 5 | 11 | SC-61, Rajendra Sonia, Pragati, SLP-389/1, CO-2, Varna, Punjab Haldi-1, Rajapuri, Suvarna, Megha Turmeric-1 |
| 21. | Rhizome: Status of tertiary rhizome | Absent | 1 | 6 | SLP-389/1, IISR Prathiba, Punjab Haldi-1, Rajendra Sonia, Varna, Suvarna |
| | | Present | 9 | 9 | IISR Pragati, Acc. 849, Narendra Haldi-98, CO-2, BSR-2, Megha Turmeric-1, Rajapuri, SC-61, Duggirala Red , Megha Turmeric-1 |
| 22. | Rhizome: Inner core colour | Orange | 3 | 5 | BSR-2, CO-2, Rajendra Sonia, Punjab Haldi-1, IISR Pragati, IISR Prathiba, SLP-389/1, Duggirala Red |
| | | Lemon yellow | 5 | 4 | SC 61, Rajapuri, Acc 849, Narendra Haldi-98 |
| | | Reddish yellow | 7 | 6 | Suvarna, Varna, Megha Turmeric-1 |
| 23. | Crop duration | Short (<180) | 3 | 2 | IISR Pragati, SLP 3891/1 |
| | | Medium (181-200) | 5 | 8 | Suvarna, Varna, SC-61, Rajendra Sonia, Megha Turmeric-1, Rajapuri& Punjab Haldi-1 |
| | | Long (>200) | 7 | 5 | Narendra Haldi 98, Duggirala Red, BSR-2, IISR Prathiba, Acc 849, CO-2 |
| 24. | Dry recovery (%) | Low (<15) | 3 | 3 | Punjab Haldi 1, Rajendra Sonia |
| | | Intermediate (15-20) | 5 | 6 | BSR-2, IISR Prathiba, SLP-389/1, IISR Pragati, Duggirala Red, Megha Turmeric-1, CO-2 |
| | | High (>20) | 7 | 6 | Acc 849, Suvarna, Varna, SC-61, Rajapuri, Narendra Haldi-98 |

The pseudostem habit of turmeric is characterized as compact and open. Among the genotypes studied, six were compact and nine were open. Plant height being a polymorphic characteristic among the genotypes studied, none was under short statures, SLP-389/1 was of medium (85 to 100 cm) and 14 were under tall category (104 to 166 cm). Number of shoots was more in Punjab Haldi-1, six genotypes had shoots less than three, and eight genotypes had shoots in the range of 3 to 5. More number of leaves was recorded in 10 genotypes with range of 5-10 leaves in main tiller. Leaf petiole length was intermediate in nine genotypes and long in six. Leaf lamina length was long in all the selected genotypes. Leaf width was medium in five, while remaining ten were broad. Leaf venation and leaf disposition was unique in SLP-389/1. Leaf margin was wavy in IISR Prathiba and Duggirala Red. Pseudostem anthocyanin colouration and leaf colour on ventral side was observed to be monomorphic as it was absent in all (Table 2). Similar study on turmeric characterization based on DUS character was reported by Deb and Chakrobarty (2017).

**Floral characteristics**

*Curcuma spp.* are differentiated based on inflorescence. The variability in coma bract colour is evident across the species (Sharma *et al.,* 2011). The inter species variability in coma bract is evident in case of *C. longa*. The turmeric inflorescence can be characterized based on coma bract colour which is differentiated in to four colours (Fig. 1). Five genotypes were white, five genotypes were rose, two genotypes were purple and three genotypes were green (Table 2).

**Rhizome characters**

Rhizome, being the economical part in turmeric, the variation range is more among the genotypes studied. Rhizome habit is characterized based on the primary attachment to the mother rhizome. SLP-389/1 is characterized under loose habit, eight were compact and six were intermediate.

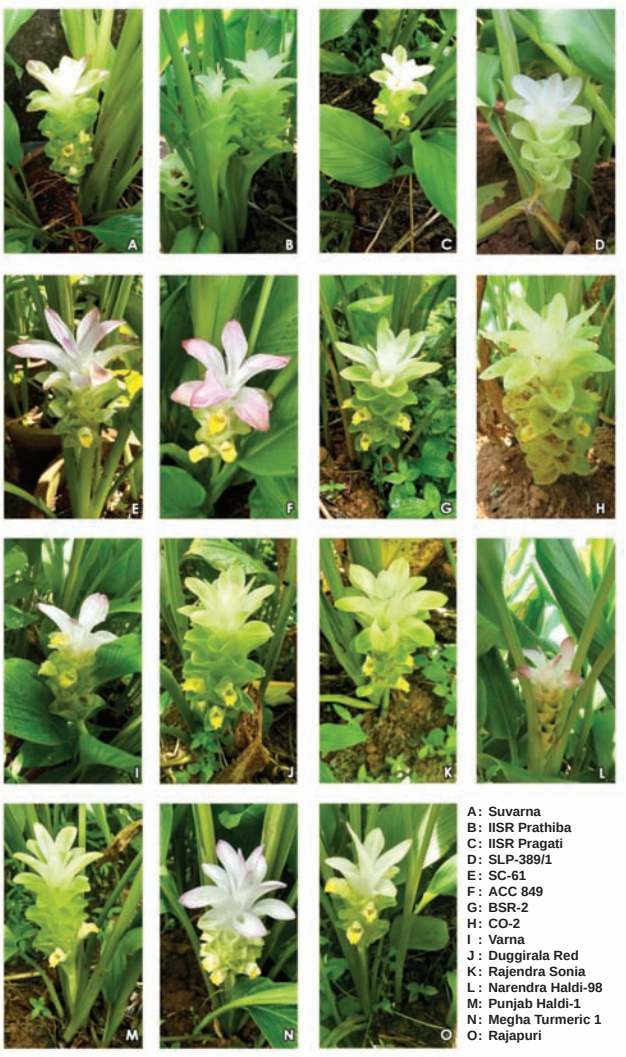


**Fig. 1. Morphological variation in coma bract**

Among the genotypes studied eight were having straight rhizomes and seven were curved. The market price is fixed based on the length of primary rhizome; wide variability is seen in rhizome length. Eleven were medium length (5 to 10 cm) and four were long with more than 10 cm length and none were categorized under short category. Mother rhizome is used as a planting material to get good yield (Padmadevi *et al.*, 2012) and has high curcumin content because of degradation of starch, so mother rhizome influence the curcumin content, the genotypes differs with number of mother rhizome per plant (Neeraja *et al.*, 2017). Five genotypes were having 1-2 mother rhizome, six genotypes were having 2-3 and four genotypes were having more than three mother rhizome. Internode pattern was close in four genotypes and eleven had distant venation pattern. The color of rhizome decides the turmeric powder colour and the export market is based on the colour of turmeric powder apart from curcumin content. Wide variation was noticed in the turmeric rhizome colour (Fig. 2). The colour was categorized based on RHS colour chart (Table 3). Flower colour in caranation was characterized using RHS colour chart by Bhargav *et al.* (2018). Four genotypes Rajapuri, SC-61, Acc. 849 and Narendra Haldi-98 were categorized as lemon yellow colour, eight were orange colour and three were reddish yellow colour. SLP-389/1 and IISR Pragati are short duration type (less than 180 days), eight genotypes are medium (181-200 days)

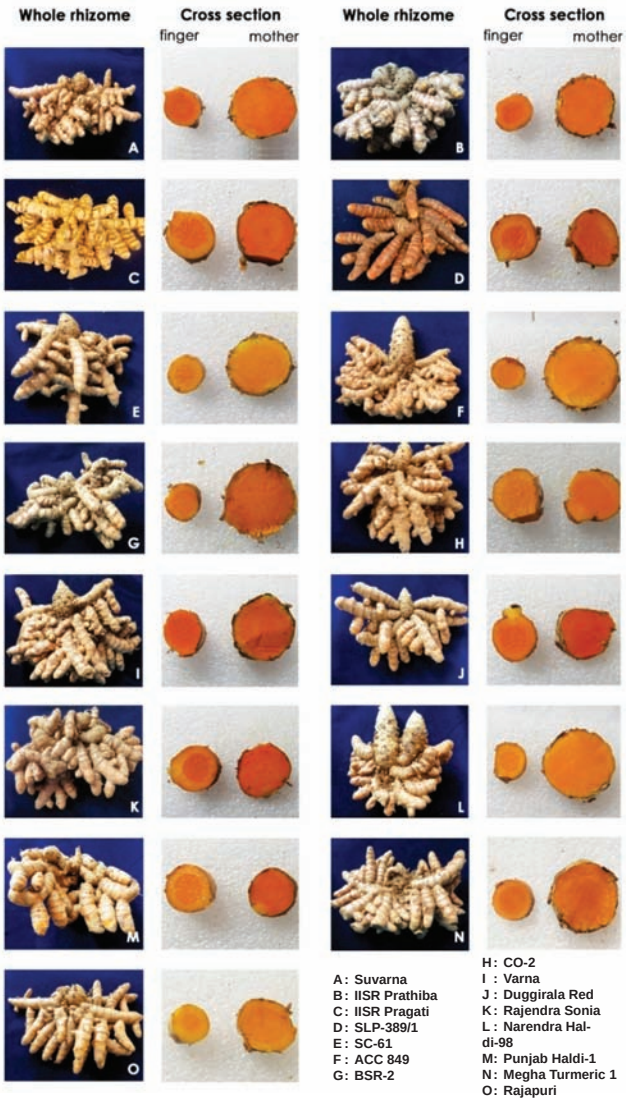


**Fig. 2. Morphological variation in whole rhizome, cross section of primary and mother rhizome**

**Table 2. Morphological characterization of turmeric genotypes using scoring for vegetative characters**

| Characters | Suvarna | IISR Prathiba | IISR Pragati | SLP-389/1 | SC-61 | Acc 849 | BSR2 | CO-2 | Varna | Duggriala Red | Rajendra Sonia | Narendra Haldi-98 | Punjab Haldi-1 | Megha Turmeric-1 | Rajapuri |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 1 | 1 | 9 | 9 | 9 | 1 | 9 | 9 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| 2. | 7 | 7 | 7 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 3. | 1 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 1 | 5 | 3 | 1 |
| 4. | 5 | 5 | 3 | 3 | 3 | 5 | 5 | 5 | 3 | 5 | 5 | 7 | 3 | 5 | 5 |
| 5. | 5 | 3 | 5 | 7 | 5 | 3 | 3 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 |
| 6. | 5 | 7 | 5 | 5 | 5 | 5 | 7 | 7 | 5 | 7 | 7 | 5 | 5 | 7 | 5 |
| 7. | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 8. | 7 | 7 | 5 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 5 | 7 | 5 | 5 | 7 |
| 9. | 3 | 3 | 5 | 5 | 3 | 5 | 3 | 5 | 5 | 5 | 3 | 5 | 3 | 5 | 3 |
| 10. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 11. | 3 | 3 | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 12. | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 | 3 | 3 | 3 | 3 |
| 13. | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14. | 9 | 1 | 1 | 9 | 9 | 9 | 1 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 15. | 3 | 1 | 1 | 3 | 3 | 5 | 1 | 1 | 3 | 7 | 7 | 5 | 7 | 3 | 3 |
| 16. | 3 | 3 | 5 | 7 | 3 | 3 | 3 | 5 | 3 | 5 | 3 | 3 | 5 | 3 | 5 |
| 17. | 5 | 5 | 3 | 3 | 3 | 5 | 3 | 3 | 5 | 5 | 3 | 5 | 3 | 5 | 3 |
| 18. | 5 | 5 | 5 | 7 | 7 | 5 | 5 | 5 | 7 | 5 | 5 | 5 | 5 | 5 | 7 |
| 19. | 1 | 5 | 3 | 3 | 5 | 1 | 5 | 3 | 3 | 1 | 5 | 1 | 3 | 1 | 3 |
| 20. | 5 | 3 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 3 | 5 | 3 | 5 | 5 | 5 |
| 21. | 1 | 1 | 9 | 1 | 9 | 9 | 9 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 9 |
| 22. | 7 | 3 | 3 | 3 | 5 | 5 | 3 | 3 | 7 | 3 | 3 | 5 | 3 | 7 | 5 |
| 23. | 5 | 7 | 3 | 3 | 5 | 7 | 7 | 7 | 5 | 7 | 5 | 7 | 5 | 5 | 5 |
| 24. | 7 | 5 | 5 | 5 | 7 | 7 | 5 | 3 | 7 | 5 | 3 | 7 | 3 | 5 | 7 |

and five are long duration types (>200 days). The variation in rhizome colour was reported by Mishra *et al.* (2015). Percentage of dry recovery was low in three genotypes, intermediate in six genotypes and in another six genotypes, it was high recovery with more than 20 per cent. Similar observation was made in ginger using DUS guidelines to characterize the somaclones (Aswathy Dev, 2013).

**Table 3. Colour of the primary rhizome as per RHS colour**

| Genotype | RHS colour group; Fan 1 |
|---|---|
| Suvarna | Orange group N25 A |
| IISR Prathiba | Orange group 25 A |
| Pragati | Orange group 25 A |
| SLP-389/1 | Orange group 25 A |
| SC-61 | Yellow orange group 23A |
| Acc 849 | Yellow orange group 23A |
| BSR2 | Orange group 25 A |
| CO-2 | Orange group 25 A |
| Varna | Orange group N25 A |
| Duggriala Red | Orange group 25 A |
| Rajendra Sonia | Orange group 25 A |
| Narendra Haldi-98 | Yellow orange group 23A |
| Punjab Haldi-1 | Orange group 25 A |
| Megha Turmeric-1 | Orange group N25 A |
| Rajapuri | Yellow orange group 23A |

Apart from the DUS characters, there were some noticeable variation in the selected genotypes which can act as morphological marker for identification of genotypes, they are collar girth of the pseudostem, pigmentation in leaf lamina at initial stage and fades off in later stage, both characters were evident in Acc. 849 and Narendra Haldi-98 (Fig. 3). Development of red pigmentation in emerging shoot at initial stage of sprouting, which fades off in later stage is a peculiar characteristic observed in SLP-389/1. Nair and Aarthi (2018) reported that red colouration is heritable morphological marker and used for developing intervarietal F1 hybrids.

The turmeric genotypes were characterized as per DUS guidelines for qualitative and quantitative characters. The present study concluded the available variation in the selected genotypes. Variation for colour in the coma bract of turmeric inflorescence and primary rhizomes have been emphasized. Specific characters apart from DUS

character like collar girth, leaf lamina pigmentation, emerging shoot pigmentation were identified and can be used as a morphological marker for genotype identification. The variations analysed using DUS characters offers a bright scope for selection based on desirable morphological traits, which can be used in the future breeding programmes.

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