



## Characterization of chrysanthemum (*Dendranthema grandiflora*) genotypes as per DUS guidelines

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### ABSTRACT

Characterization and establishment of distinctiveness among 30 chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes was carried out using morphological descriptors adopted from the DUS guidelines developed by PPV and FR authority on chrysanthemum. The genotypes were characterized for 41 essential characters among which six characters were monomorphic, five dimorphic and 30 were polymorphic indicating their potential for varietal characterization and distinctiveness. Out of 30 chrysanthemum genotypes studied, eight were found to be distinctive on the basis of 10 essential characters. The rest of the 22 genotypes remained in groups of two or three without being differentiated for similar traits and therefore, it is suggested to use other biological markers/DNA fingerprinting. This study will be useful for breeders/researchers/farmers to identify distinctiveness in chrysanthemum genotypes and to seek protection under Protection of Plant Varieties and Farmers Rights Act.

**Key words:** Characterization, Chrysanthemum, DUS test, FR Act and PPV

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is popular flower crop of commercial importance. It is one of the leading commercial flower crops, which is important both as cut flower and potted plant in the international market. It is being cultivated for more than 2,000 years (Martin and Benito 2005). Chrysanthemum is believed to be the native of northern hemisphere chiefly Europe and Asia. It belongs to the family Asteraceae comprised of about 40 species, with rapid speciation (Liu *et al.* 2012). This genus shows considerable variations in morphology and ploidy levels ( $2n = 2x = 18$ , to  $2n = 36, 54, 72$ , upto 90) with complex evolutionary history (Liu *et al.* 2012).

In India, tremendous efforts on germplasm collection and screening have been made. However, in order to develop an efficient breeding program, it is necessary to characterize and understand diversity among various accessions available in the gene bank. In the present study DUS descriptors are used to characterize chrysanthemum genotypes.

Government of India has enacted the Protection of Plant Varieties and Farmers Rights Act, 2001 (PPV and FR Act) to encourage public/private investment in research and development of new plant varieties by giving

protection. The plant varieties must fulfill the distinctiveness, uniformity and stability (DUS) criteria for protection under the Act and hence, there is a need to characterize chrysanthemum varieties according to DUS test guidelines for chrysanthemum prescribed by PPV and FR Authority (Anonymous 2010).

Characterization of genotypes is useful to identify and avoid duplication. Qualitative characters being more stable over generations (Raut 2003) hence, are reliable for characterization of varieties. Therefore, the present study was planned to characterize the available chrysanthemum genotypes for qualitative and quantitative traits as per DUS guidelines.

### MATERIALS AND METHODS

Chrysanthemum genotypes collected from different secondary sources are maintained at ICAR-IIHR, Hesaraghatta, Bengaluru, which is located in the north part of Bengaluru district in Karnataka. The morphological characterization of selected 30 chrysanthemum genotypes (Table 1) was carried out as per the guidelines of DUS (Distinctiveness, Uniformity and Stability) on chrysanthemum developed by Protection of Plant Varieties and Farmer's Rights Authority (PPV and FRA), Government of India, New Delhi at ICAR-IIHR, Bengaluru during 2013-14. The observations were recorded on 41 essential characters of the 78 DUS characters (Anonymous, 2010) at specified stages of crop growth period when characteristics under study had full expression.

All characteristics were recorded at the time of full

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Table 1 Details of chrysanthemum genotypes with source, flower type and colour used in the study

Genotypes	Source	Flower type	Flower colour
Anmol	NBRI, Lucknow	Decorative	Pink
Ajay	NBRI, Lucknow	Pompon	Pink
Garden Beauty	PAU, Ludhiana	Double Korean	Salmon
Birbal Sahni	NBRI, Lucknow	Pompon	White
Arka Ravi	IIHR, Bengaluru	Korean	Bronze
Sunil	NBRI, Lucknow	Double Korean	Purple
Flirt	PAU, Ludhiana	Quilled	Purple
Fitonia	NBRI, Lucknow	Anemone	Yellow
NBRI Little Hemant	NBRI, Lucknow	Pompon	Bronze
NBRI Little Darling	NBRI, Lucknow	Pompon	Purple
Jayanti	NBRI, Lucknow	Decorative	Yellow
Co-Semi Double	TNAU, Coimbatore	Reflexing	Yellow
Co-1	TNAU, Coimbatore	Double Korean	Yellow
Statesman	NBRI, Lucknow	Anemone	Yellow
Winter Queen	PAU, Ludhiana	Quilled	Red
Kargil	NBRI, Lucknow	Spoon	White
Chandini	NBRI, Lucknow	Semi- Double	Yellow
Nilima	IIHR, Bengaluru	Decorative	Salmon
Yellow Gold	IIHR, Bengaluru	Decorative	Yellow
Red Gold	IIHR, Bengaluru	Double Korean	Greyish Orange
Arka Ushakiran	IIHR, Bengaluru	Semi – Double	Yellow
Red Stone	NBRI, Lucknow	Single Korean	Red
Arka Kirti	IIHR, Bengaluru	Double Korean	White
Coffee	NBRI, Lucknow	Pompon	Bronze
Pusa Anmol	IARI, New Delhi	Double Korean	Salmon
Arka Pankaj	IIHR, Bengaluru	Decorative	Pink
Appu	NBRI, Lucknow	Anemone	Red
Nayantara	NBRI, Lucknow	Anemone	Yellow
Vijaykiran	NBRI, Lucknow	Double Korean	Yellow
Shukla	NBRI, Lucknow	Double Korean	White

flowering. Observations on vegetative parts were recorded on the middle third of the stem. The colours of vegetative parts were observed on plants exposed to maximum light. Observations on floral parts were made on terminal flower heads. In single and semi-double varieties, when the outer two to three rows of disc florets in the terminal flower head have dehisced; in double flowered varieties, when the terminal flower head is fully open but before senescence sets in. Stem, stipule and leaf characteristics were observed on the middle third of the stem.

## RESULTS AND DISCUSSION

Morphological characters have been predominant tools used by breeders for distinguishing lines or cultivars in public domain. Characterization of genotypes using important characters has its own merits, since it provides relevant information about important agronomic characters

in genotypes (Shukla *et al.* 2011). To establish distinctiveness among chrysanthemum genotypes, 41 essential descriptors were used. Helani and Jiuying (2011) evaluated chrysanthemum cultivars using 58 morphological characteristics according to DUS test.

A total of 41 morphological characteristics were studied in which 36 were visually assessed and five were measured. Qualitative characters being more stable over generations (Raut, 2003), hence, are reliable for characterization of varieties. Out of 36 visually assessed DUS descriptors studied, five were found to be monomorphic, five characteristics were dimorphic and 26 characteristics were polymorphic and among five measurable characters, one character keel number was found to be monomorphic and four characteristics were polymorphic. This high polymorphism level of visually assessed characters might be attributed to the fact that all the genotypes from different regions have got broader genetic base.

### Plant and leaf characteristics

The characteristics pertaining to the plant and leaf traits are presented in Table 2. The plant height ranged from short to tall, 10 genotypes had short (20-40 cm), 10 medium (41-60 cm) and 10 genotypes recorded tallest plant (>60 cm). Ramteke and Murlidharan (2012) also reported similar results in soybean. Based on the plant type, seven genotypes were non-bushy and 23 were bushy plant type. Among the bushy genotypes, six were upright, 16 semi-upright and one genotype was spreading growth habit, which is distinct from all other genotypes for this particular character. Panwar *et al.* (2012) and Sood *et al.* (2011) characterized different genotypes based on plant growth type in rose and capsicum, respectively. The stem anthocyanin colouration was found to be dimorphic and was absent in 16 genotypes and present in 14 genotypes. Stem anthocyanin colouration was also used for conforming distinctiveness of rice varieties by Chakrabarty *et al.* (2012).

The genotype Red Stone stood distinct in 30 genotypes with short leaf lamina, medium leaf lamina was recorded by six genotypes, while 23 genotypes recorded long leaf lamina. Majority of the varieties (19) had broader leaf width, four genotypes recorded medium and narrow leaf width was observed among seven genotypes. Joshi *et al.* (2011) studied leaf length and width in rice varieties based on DUS morphological descriptors. All the 30 genotypes were observed to have serrated type of leaf margin. The depth of lowest lateral sinus of leaf ranged from shallow to medium, maximum numbers of genotype (21) recorded shallow depth and nine genotypes had medium depth. The magnitude of leaf serration ranged from shallow to deep. It was observed that three genotypes were having shallow serration, 21 medium and four genotypes recorded deep leaf serrations.

The colour evaluation using RHS colour chart is a common procedure for colour description worldwide which is a qualitative analysis (Singh *et al.* 2011). The leaf colour was assessed by referring RHS colour chart and the

Table 2 Characterization of 30 chrysanthemum genotypes for plant and leaf characteristics as per DUS guidelines

Characteristics	States	Reference genotypes
Plant: Height(cm)	Very short (<20)	Ajay, Garden Beauty, Anmol, Red Stone, Pusa Anmol, NBRI Little Hemant, Co-1, Jayanti, Nayantara, Arka Ushakiran
	Short (20-40)	
	Medium (41-60)	
Plant: Type	Non bushy	Ajay, Anmol, Pusa Anmol, Birbal Sahni, Arka Ravi, Jayanti, Statesman
	Bushy	Garden Beauty, Red Stone, Vijaykiran, Co- Semi Double, NBRI Little Hemant, Co-1, Yellow Gold, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Fitonia, NBRI Little Darling, Winter Queen, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti
Only bushy Varieties- plant: Growth habit	Upright	Co- Semi Double, Co-1, Yellow Gold, Nilima, Flirt, Chandini
	Semi-upright	Garden Beauty, Red Stone, Vijaykiran, NBRI little Hemant, Fitonia, Arka Pankaj, Nayantara, Coffee, Appu, NBRI Little Darling, Winter Queen, Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti
	Spreading	Kargil
Stem: Anthocyanin colouration	Absent	Ajay, Garden Beauty, Anmol, Red Stone, Pusa Anmol, Co-Semi Double, Arka Ravi, Fitonia, Coffee, NBRI Little Darling, Statesman, Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti
	Present	Kargil, Appu, Flirt, Winter Queen, Chandini, Co-1, Yellow Gold, Jayanti, Arka Pankaj, Nayantara, Nilima, Vijaykiran, Birbal Sahni, NBRI Little Hemant
Leaf : Length of lamina (cm)	Short(<5)	Red Stone
	Medium (5-7)	Ajay, Yellow Gold, Statesman, Chandini, Shukla, Kargil
	Long (>7)	Red Gold, Sunil, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Co-1, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Garden Beauty, Anmol, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant
Leaf : Width of lamina (cm)	Narrow(<4)	Red Stone, Yellow Gold, Nayantara, Chandini, Shukla, Red Gold, Kargil
	Medium (4-5)	Statesman, Jayanti, Ajay, Birbal Sahni
	Broad (>5)	Garden Beauty, Anmol, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1, Fitonia, Arka Pankaj, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Winter Queen, Sunil, Arka Ushakiran, Arka Kirti
Leaf: Margin	Serrated	Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman, Chandini, Co-1, Yellow Gold, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant
	Entire	
Leaf : Depth of lowest lateral sinus	Shallow	Ajay, Garden Beauty, Red Stone, Pusa Anmol, Birbal Sahni, NBRI Little Hemant, Yellow Gold, Jayanti, Arka Pankaj, Nayantara, Coffee, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran
	Medium Deep	Arka Kirti, Chandini, Co-1, Fitonia, Nilima, Anmol, Vijaykiran, Co- Semi Double, Arka Ravi
Leaf : Magnitude of serration	Shallow	Shukla, Red Gold, Arka Ravi
	Medium	Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Birbal Sahni, NBRI Little Hemant, Co-1, Yellow Gold, Jayanti, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, Winter Queen, Statesman, Chandini, Sunil, Kargil, Arka Ushakiran, Arka Kirti
Leaf: Colour (lower side)	Deep	NBRI Little Darling, Fitonia, Co-Semi double
	RHS colour chart	Yellow Gold, Sunil, Kargil (N 137 A); Red Gold, Arka Ushakiran (137 A); Ajay, Jayanti, Birbal Sahni, NBRI Little Hemant, Co-1, Fitonia, Arka Pankaj, Appu, Flirt, Arka Kirti (137 B); Pusa Anmol, Coffee, Nilima, Winter Queen (137 C); Shukla (N 137 C); NBRI Little Darling (N 138 B); Garden Beauty, Anmol, Red Stone, Vijaykiran, Co-Semi Double, Arka Ravi, Nayantara, Statesman (147 B); Chandini (147 C)
Leaf: Shape of base	Acute	Ajay, Garden Beauty, Red Stone, Birbal Sahni, Yellow Gold, Nayantara, Nilima, Appu, NBRI Little Darling, Winter Queen, Statesman, Chandini
	Obtuse	Shukla, Red Gold, Kargil, Fitonia, Coffee
	Rounded	Anmol, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1, Jayanti, Flirt, Arka Ushakiran, Arka Kirti
	Truncate	Sunil, Arka Pankaj
	Cordate	
Leaf : Pubescence of lower side	Asymmetric	
	Weak	Pusa Anmol, Birbal Sahni, Arka Ravi, Coffee, Statesman, Chandini, Shukla
	Medium	Flirt, NBRI Little Darling, Winter Queen, Fitonia, Arka Pankaj, Nayantara, Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Co-Semi Double, NBRI Little Hemant
	Strong	Co-1, Yellow Gold, Jayanti, Nilima, Appu, Sunil, Red Gold, Kargil, Arka Ushakiran, Arka Kirti

reference number was indicated for each genotype. The genotypes Sunil, Arka Pankaj depicted truncate leaf base, obtuse leaf base was observed in Shukla, Red Gold, Kargil, Fitonia, Coffee and the remaining 12 and 11 genotypes showed acute and rounded leaf base, respectively. Ramteke and Murlidharan (2012) and Gupta *et al.* (2010) in soybean used leaf shape as one of the descriptor for morphological characterization and Sood *et al.* (2011) in bell pepper. Pubescence on the lower side of leaf reported polymorphism ranging from weak to strong, seven genotypes recorded weak pubescence, 13 recorded medium and 10 genotypes

recorded strong pubescence on lower side of leaf. Chakrabarty *et al.* (2012) used leaf pubescence character for confirming the distinctiveness of example varieties in rice.

#### Floral characteristics

The characteristics pertaining to floral traits are presented in Table 3 and 4. The inflorescence form was found to be monomorphic, i.e. corymbiform among all 30 genotypes (Table 3). Three types of flower heads were recorded, single flower head in Winter Queen and Kargil,

Table 3 Characterization of 30 chrysanthemum genotypes for floral traits as per DUS guidelines

Characteristics	States	Reference genotypes
Inflorescence: Form	Corymbiform Pyramidal Cylindrical	Ajay, Anmol, Pusa Anmol, Birbal Sahni, Arka Ravi, Jayanti, Statesman
Flower head: Type	Single Semi-double Double	Winter Queen, Kargil Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1, Yellow Gold, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Chandini, Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti Statesman, Jayanti, Birbal Sahni
Flower head: Diameter	Small Medium Large	Jayanti, Fitonia, Chandini, Kargil Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant, Co-1, Yellow Gold, Arka Pankaj, Nayantara, Coffee, Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman Nilima
Semi-double varieties only	Few Medium	Appu, Fitonia, Nayantara, Red Stone, Arka Ravi, Vijaykiran Pusa Anmol, Co-Semi Double, Co-1, Chandini, Sunil, Shukla, Red Gold, Arka Kirti
Flower head: Number of rows of ray florets	Many	Arka Ushakiran, Flirt, NBRI Little Darling, Yellow Gold, Arka Pankaj, Coffee, Nilima, Ajay, Garden Beauty, Anmol, NBRI Little Hemant
Ray floret: Longitudinal axis of majority of ray florets	Reflexing Straight Incurving	Kargil, Appu, NBRI Little Darling, Winter Queen, Fitonia, Garden Beauty, Co-Semi Double Co-1, Ajay, Anmol Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti, Flirt, Statesman, Chandini, Yellow Gold, Jayanti, Arka Pankaj, Coffee, Nilima, Red Stone, Vijaykiran, Pusa Anmol, Birbal Sahni, Arka Ravi, NBRI Little Hemant
Ray floret: Longitudinal axis of ray florets of outer row	Twisted Broken Reflexing Straight Incurving	Nayantara  Red Stone, Vijaykiran, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Yellow Gold, Fitonia, Nilima, Appu, Flirt, NBRI Little Darling, Winter Queen, Sunil, Shukla, Red Gold, Kargil Ajay, Anmol, Pusa Anmol, Co-1 Arka Ushakiran, Arka Kirti, Statesman, Chandini, Jayanti, Arka Pankaj, Coffee, Garden Beauty, Birbal Sahni
Flower head: predominant type of ray florets	Twisted Broken Ligulate Incurved Spatulate	Nayantara  Ajay, Anmol, Co-Semi Double, Yellow Gold, Fitonia, Appu, Chandini, Shukla, Arka Ushakiran, Arka Kirti Red Stone, Vijaykiran, Pusa Anmol, Birbal Sahni, Arka Ravi, NBRI Little Hemant, Jayanti, Nayantara, Garden Beauty, Co-1, Arka Pankaj, Coffee, Nilima, Flirt, NBRI Little Darling, Winter Queen, Statesman, Sunil, Red Gold, Kargil
Ray floret:	Quilled Funnel shaped Short	
		Ajay, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1,

Contd.

Table 3 (Continued)

Characteristics	States	Reference genotypes
Length of corolla tube		Yellow Gold, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Statesman, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti
	Medium	Garden Beauty, Anmol
	Long	Winter Queen, Birbal Sahni
Varieties with short corolla tube only:	Concave	Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Statesman, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Ajay
Ray floret: cross section of ray floret	Flat	
	Convex	Yellow Gold, Arka Kirti
Varieties with short corolla tube only:	Absent	
	Present	Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant, Co-1, Fitonia, Yellow Gold, Jayanti, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti
Ray floret: Keel		Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Statesman, Chandini, Co-1, Yellow Gold, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Ajay, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant
Varieties with short corolla tube only: Ray floret: Keel Number	One	
	Two	
	Three More than three	
Varieties with long corolla tube only:	Quilled	
	Spatulate	Winter Queen
Ray floret: shape of end	Incurved	Birbal Sahni
Ray floret: Length of outer florets	Short	Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti, Appu, NBRI Little Darling, Statesman, Chandini, Co-1, Yellow Gold, Jayanti, Fitonia, Coffee, Ajay, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, NBRI Little Hemant
	Medium	Garden Beauty, Arka Ravi, Arka Pankaj, Nayantara, Nilima, Flirt
	Long	Winter Queen
Ray floret : Width of outer florets	Narrow	Statesman, Kargil
	Medium	Sunil, Red Gold, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Chandini, Co-1, Jayanti, Fitonia, Nayantara, Coffee, Ajay, Garden Beauty, Anmol, Vijaykiran, Pusa Anmol, Birbal Sahni
	Broad	Red Stone, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Yellow Gold, Arka Pankaj, Nilima, Shukla
Ray floret: Ratio (length/width)	Low	Chandini, Jayanti, Fitonia, Red Stone, NBRI Little Hemant
	Medium	Ajay, Anmol, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Co-1, Appu, Shukla, Kargil, Arka Ushakiran, Arka Kirti
	High	Sunil, Red Gold, Flirt, NBRI Little Darling, Winter Queen, Statesman, Yellow Gold, Arka Pankaj, Nayantara, Coffee, Nilima, Garden Beauty, Arka Ravi

Table 4 Characterization of 30 chrysanthemum genotypes for floral traits as per DUS guidelines

Characteristics	States	Reference genotypes
Ray floret : Shape of tip	Pointed	Garden Beauty, Red Stone, Arka Ravi, Co-1, Yellow Gold, Nayantara, Flirt, NBRI Little Darling, Winter Queen, Chandini, Sunil, Shukla, Arka Ushakiran
	Rounded	Kargil, Arka Kirti, Jayanti, Arka Pankaj, Red Stone, Birbal Sahni, NBRI Little Hemant
	Truncated	
	Dentate	Ajay, Anmol, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, Fitonia, Coffee, Nilima, Appu, Statesman, Red Gold
Ray floret : Number of	Fringed	
	One	Sunil, Shukla, Kargil, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman, Chandini, Co-1, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima,

Contd.

Table 4 (Continued)

Characteristics	States	Reference genotypes
colours of inner side		Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi
	Two	NBRI Little Hemant, Yellow Gold, Red Gold
	> Two	
Ray floret: colour of inner side of majority of ray florets (for grouping purpose)	White	Birbal Sahni, Kargil, Arka Kirti, Shukla
	Yellow	Nayantara, Vijaykiran, Arka Ushakiran, Yellow Gold, Chandini, Statesman, Jayanti, Co-1, Co-Semi Double, Fitonia
	Pink	Ajay, Anmol, Arka Pankaj
	Salmon	Pusa Anmol, Nilima, Garden Beauty
	Red	Winter Queen, Red Gold, Red Stone, Appu
	Purple	NBRI Little Darling, Flirt, Sunil
	Bronze	Arka Ravi, NBRI Little Hemant, Coffee
	Green	
	Colour blend	
Ray floret : Primary colour of inner side	RHS colour chart	Jayanti (2 A), Fitonia (3 A), Chandini (5 A), Co-1 (6 A), Vijaykiran (9 A), Arka Ravi (22 A), Appu, Red Stone (46 A), Winter Queen (60 A), NBRI Little Darling, Flirt, Sunil (71 A), Anmol (75 A), Kargil (155 A), Coffee (169 A), Arka Red Gold (171 A), Arka Ushakiran (2 B), Nayantara, Yellow Gold, Statesman (5 B), NBRI Little Hemant (9 B), Garden Beauty (64 B), Arka Kirti (4 C), Arka Pankaj, Arka Arka Arka Nilima(63 C), Co- Semi Double, Shukla (NN 155 C), Pusa Anmol (51 D), Ajay (N 66 D), Birbal Sahni (NN 155 D)
Ray floret : Secondary colour of inner side	RHS colour chart	NBRI Little Hemant (26 A), Arka Arka Arka Yellow Gold (170 A), Arka Red Gold (5 A)
Ray floret distribution of secondary colour of inner side	At tip	Red Gold
	Distal half	Yellow Gold, NBRI Little Hemant
	Basal half	
	At base	
	On margins	NBRI Little Hemant
Ray floret: Pattern of secondary colour of inner side	Solid	Red Gold
	Flushed	NBRI Little Hemant
	Diffused stripes	NBRI Little Hemant, Yellow Gold
	Clearly defined stripes	
	Flecked	
	Flecked and striped	
	Mottled	
Ray floret : Texture of surface	Smooth	Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti, Appu, Flirt, NBRI Little Darling, Winter Queen, Statesman, Chandini, Co-1, Yellow Gold, Jayanti, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant
	Textured	
Single of semi-double varieties only:	RHS colour chart	Arka Arka Arka Yellow Gold (3 A), Pusa Anmol, Nayantara (9 A), Red Gold, Fitonia (12 A), Anmol, Chandini (13 A), Red Stone, Arka Ravi, Coffee, Kargil, Winter Queen (14 A), Arka Pankaj (15 A), Vijaykiran, Appu (17 A), Co-Semi Double (23 A), Garden Beauty, NBRI Little Hemant, Sunil, Arka Ushakiran (14 B), Flirt (15 B), Ajay, Birbal Sahni, Co-1, Arka Kirti (17 B), NBRI Little Darling (153 B), Shukla (5 C)
Disc : colour at anther dehiscence		
Disc : Distribution of disc florets	Type 1	Anmol, Birbal Sahni, Yellow Gold, Jayanti, Nilima, Statesman
	Type 2	Ajay, Garden Beauty, Pusa Anmol, NBRI Little Hemant
	Type 3	Vijaykiran, Co-1, Coffee, Flirt, Chandini, Sunil, Arka Red Gold
	Type 4	Shukla, Kargil, Arka Ushakiran, Arka Kirti, Appu, NBRI Little Darling, Winter Queen, Fitonia, Arka Pankaj, Nayantara, Red Stone, Co-Semi Double, Arka Ravi

Contd.

Table 4 (Continued)

Characteristics	States	Reference genotypes
Disc floret : Type	Needle shaped	
	Quilled	
	Funnel shaped	
	Tubular	
	Petaloid	Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Birbal Sahni, Arka Ravi, NBRI Little Hemant, Co-1, Yellow Gold, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Winter Queen, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti
Disc floret : Clour	RHS colour chart	Vijaykiran, Pusa Anmol, (N 144 A); Ajay, Anmol, Co-Semi Double, Flirt, Red Gold, Arka Ushakiran (N 144 B); Arka Pankaj (N 144 C); Shukla, Arka Arka Arka Yellow Gold (1 A); NBRI Little Hemant (2 A); Arka Ravi, Co-1, Sunil (7 A); Chandini, Sunil, Kargil (12 A); Arka Kirti (13 A); Nayantara (150 A); Coffee (153 A); Birbal Sahni (14 B); Garden Beauty, Red Stone, Nilima, Appu, NBRI Little Darling (151 B); Winter Queen (151 C); Fitonia (151 D)
Flower type	Pompon	Ajay, Birbal Sahni, NBRI Little Darling, NBRI Little Hemant, Coffee
	Anemone	Fitonia, Statesman, Appu, Nayantara
	Spider	
	Incurving	Anmol, Arka Ravi, Sunil, Jayanti, Co-1, Chandini, Nilima, Yellow Gold, Red Gold, Arka Ushakiran, Red Stone, Arka Kirti, Pusa Anmol, Arka Pankaj, Vijaykiran, Shukla
	Reflexing	Garden Beauty, Co- Semi Double
	Spoon type	Kargil
	Quilled	Flirt, Winter Queen
	Incurved	
	Ball type	
	Economic use	Garden display
Cut flower		Anmol, Arka Ravi, Sunil, Flirt, Jayanti, Nilima, Yellow Gold, Red Gold, Arka Pankaj
Pot culture		Sunil, Fitonia, NBRI Little Darling, NBRI Little Hemant, Jayanti, Kargil, Arka Ushakiran, Red Stone, Pusa Anmol, Appu
Loose flower		Birbal Sahni, Flirt, Co- Semi Double, Co-1, Statesman, chandini, Coffee, Pusa Anmol, Shukla, Jayanti, Nilima, Yellow Gold, Red Gold, Arka Ushakiran, Arka Kirti, Arka Pankaj
Ground cover		
Others		

double in Statesman, Jayanti and Birbal Sahni and 25 genotypes depicted semi-double flower head. Panwar *et al.* (2012) also used different flower type (single, semi-double and double) for grouping of rose genotypes. Gupta and Datta (2005) categorized 30 chrysanthemum genotypes based on their flower types. One of the desirable characters i.e. large flower diameter was recorded only in the genotype Nilima, small in Jayanti, Fitonia, Chandini and Kargil, 25 genotypes recorded medium flower head diameter. This was supported by Ghimiray *et al.* (2005) in chrysanthemum and Panwar *et al.* (2012) in rose. The number of rows of ray florets was recorded to be few by six genotypes, medium by eight and many rows were recorded among the remaining 11 genotypes. This was comparable with the study of Qu *et al.* (2013) in chrysanthemum.

In the present study, four different types of longitudinal axis of majority of ray florets was recorded, genotype Nayantara was only genotype with twisted axis, genotypes Co-1, Ajay and Anmol showed straight axis, remaining seven and 19 genotypes showed reflexing and incurving axis, respectively. Further, three predominant type

of ray florets were recorded in which 10, eight and 12 genotypes depicted ligulate, incurved and spatulate type of ray florets, respectively. The genotypes Winter Queen and Birbal Sahni recorded long corolla tube length, similarly, Garden Beauty and Anmol had medium corolla tube length. The presence of keel and its number on the ray floret was monomorphic that all the genotypes with short corolla tube were having keel on their ray florets and also all recorded two number of keel. Further, shape at the end of ray floret was recorded only in genotypes with long corolla tube. Two genotypes with long corolla tube showed two different shapes at the end of their ray florets such as spatulate in Winter Queen and incurved in Birbal Sahni. The length and width of outer ray florets ranged from short to long and narrow to broad, respectively. Short and medium length was observed among 23 and six genotypes, respectively. Only one genotype Winter Queen was recorded to long length of ray florets. Only two genotypes, Statesman and Kargil recorded narrow width of ray floret.

Further, three different types of shape at the tip of ray floret were recorded, genotype Arka Ravi had both rounded

and dentate tip, Red Stone had both pointed and rounded tip, 12 genotypes had only pointed tip, five had only rounded tip and 11 had dentate tip (Table 4). Batra *et al.* (2012) and Gantait *et al.* (2012) also evaluated different floral parameters in chrysanthemum genotypes. The two different colours on the inner side of ray florets were

recorded in NBRI Little Hemant, Arka Arka Yellow Gold and Arka Red Gold and remaining 27 genotypes have only one colour. Panwar *et al.* (2012) also grouped rose genotypes based on number of colour on inner side of petals. The primary colour on the inner side of the ray florets was recorded by referring RHS colour chart and the

Table 5 Grouping of 30 chrysanthemum genotypes based on DUS guidelines

Characteristics	No. of genotypes	Reference genotypes
Plant type		
Bushy	23	Garden Beauty, Red Stone, Vijaykiran, Co-Semi Double, NBRI Little Hemant, Co-1, Yellow Gold, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Fitonia, NBRI Little Darling, Winter Queen, Chandini, Sunil, Shukla, Red Gold, Kargil, Arka Ushakiran, Arka Kirti
Non bushy	7	Ajay, Anmol, Pusa Anmol, Birbal Sahni, Arka Ravi, Jayanti, Statesman
Type of flower head		
Single	2	Winter Queen, Kargil
Semi double	25	Ajay, Garden Beauty, Anmol, Red Stone, Vijaykiran, Pusa Anmol, Co-Semi Double, Arka Ravi, NBRI Little Hemant, Co-1, Yellow Gold, Fitonia, Arka Pankaj, Nayantara, Coffee, Nilima, Appu, Flirt, NBRI Little Darling, Chandini, Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti
Double	3	Statesman, Jayanti, Birbal Sahni
Longitudinal axis of majority of ray florets		
Reflexing	7	Kargil, Appu, NBRI Little Darling, Winter Queen, Fitonia, Garden Beauty, Co-Semi Double
Straight	2	Co-1, Ajay, Anmol
Incurving	19	Sunil, Shukla, Red Gold, Arka Ushakiran, Arka Kirti, Flirt, Statesman, Chandini, Yellow Gold, Jayanti, Arka Pankaj, Coffee, Nilima, Red stone, Vijaykiran, Pusa Anmol, Birbal Sahni, Arka Ravi, NBRI Little Hemant
Twisted	1	Nayantara
Colour of inner side of majority of ray florets		
White	4	Birbal Sahni, Kargil, Arka Kirti, Shukla
Yellow	10	Nayantara, Vijaykiran, Arka Ushakiran, Yellow Gold, Chandini, Statesman, Jayanti, Co-1, Co-Semi Double, Fitonia
Pink	3	Ajay, Anmol, Arka Pankaj
Salmon	3	Pusa Anmol, Nilima, Garden Beauty
Red	4	Winter Queen, Red Stone, Red Gold, Appu
Purple	3	NBRI Little Darling, Flirt, Sunil
Bronze	3	Arka Ravi, NBRI Little Hemant, Coffee
Flower type		
Pompon	5	Ajay, Birbal Sahni, NBRI Little Darling, NBRI Little Hemant, Coffee
Anemone	4	Fitonia, Statesman, Appu, Nayantara
Incurving	16	Anmol, Arka Ravi, Sunil, Jayanti, Co-1, Chandini, Nilima, Yellow Gold, Red Gold, Arka Ushakiran, Red Stone, Arka Kirti, Pusa Anmol, Arka Pankaj, Vijaykiran, Shukla
Reflexing	2	Garden Beauty, Co- Semi Double
Spoon type	1	Kargil
Quilled	2	Flirt, Winter Queen
Economic use		
Garden display	9	Ajay, Garden Beauty, Winter Queen, Kargil, Red Stone, Pusa Anmol, Appu, Nayantara, Vijaykiran
Cut flower	9	Anmol, Arka Ravi, Sunil, Flirt, Jayanti, Nilima, Yellow Gold, Red Gold, Arka Pankaj
Pot culture	10	Sunil, Fitonia, NBRI Little Darling, NBRI Little Hemant, Jayanti, Kargil, Arka Ushakiran, Red Stone, Pusa Anmol, Appu
Loose flower	16	Birbal Sahni, Flirt, Co-Semi Double, Co-1, Statesman, chandini, Coffee, Pusa Anmol, Shukla, Jayanti, Nilima, Yellow Gold, Red Gold, Arka Ushakiran, Arka Kirti, Arka Pankaj

reference numbers were indicated. Singh *et al.* (2011) assessed the flower colour in gerbera using RHS colour chart. Similarly, the secondary colour was different in each genotype with different reference numbers. The solid pattern of distribution at the tip of inner side of ray floret was recorded in Red Gold, flushed and diffused stripes pattern at distal half and on margin of ray floret was recorded in NBRI Little Hemant and diffused stripe at distal half portion was recorded in Yellow Gold. The texture on the surface of ray florets was found to be smooth in all 30 genotypes. Four types of distribution of disc florets were observed. Type 1, 2, 3 and 4 was showed by six, four, seven and 13 genotypes, respectively. The type of disc floret also showed monomorphism among all genotypes that all the 30 genotypes recorded petaloid type of disc florets.

The genotypes were grouped for six grouping characters of DUS guidelines developed by Protection of Plant Varieties and Farmers Rights Authority (PPV and FRA), New Delhi (Table 5). Panwar *et al.* (2012) in rose, Sood *et al.* (2011) in bell pepper, Yadav *et al.* (2013) in Indian mustard and Shukla *et al.* (2011) in rice also grouped genotypes based on characters as per DUS guidelines.

Among 35 polymorphic descriptors recorded, ten characters revealed distinctive profiles for eight genotypes. The distinctive/unique profile obtained by the genotype Kargil for plant growth habit which is the only one genotype with spreading type of growth habit. Genotype Red Stone was distinct for short leaf lamina. The genotype Arka Nilima was distinct from all other genotypes for flower head diameter. The two characters such as longitudinal axis of majority of ray floret and longitudinal axis of ray florets of outer row showed distinctive profile for the genotype Nayantara, which is the only one genotype having twisted type for both the characters. For flower type, genotype Kargil showed unique profile with spoon type of flower. Thus, morphological descriptors could be used to establish distinctiveness of among different genotypes. Similar attempts for establishment of distinctiveness have also been made by Gupta *et al.* (2010), Joshi *et al.* (2011), Shukla *et al.* (2011), Chakrabarty *et al.* (2012), Ramteke and Murlidharan (2012) and Yadav *et al.* (2013) in different crops. Since, 22 genotypes remained in groups of two or three without being differentiated for similar traits and therefore it is suggested to use other biological markers/DNA fingerprinting. This study will be useful for breeders/researchers/farmers to identify chrysanthemum genotypes and to seek protection under Protection of Plant Varieties and Farmers Rights Act.

The present investigation concluded that the existence of wide variations for various vegetative and floral traits in 30 chrysanthemum genotypes offered a good scope of selecting the suitable genotypes for all the economic traits. Further, these identified diverse genotypes with peculiar characteristics may be used as parents in the crop improvement programme for evolving elite genotypes.

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## REFERENCES

- Anonymous. 2010. Guidelines for the conduct of test for Distinctiveness, Uniformity and Stability on Chrysanthemum. Published by Protection of Plant Varieties and Farmers Rights Authority (PPV and FRA), Government of India, pp 1–66.
- Batra A, Banerji B K And Dwivedi A K. 2012. Morphological and biochemical characterization of Chrysanthemum cultivars. *BVAAP* **20**(2): 192–5.
- Chakrabarty S K, Joshi M A, Singh Y And Dadlani M. 2012. Example varieties for DUS testing in rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **82**(12): 1, 011–5.
- Gantait S S, Pal P And Ghosdastdar K K. 2012. Phenotypic stability for flower yield and its components of some selected spray chrysanthemum cultivars. *Acta Horticulturae* **937**: 313–20.
- Ghimiray T S, Sarkar I and Roy A. 2005. Variability studies in chrysanthemum grown over two environments. *Crops Research* **6**(3): 514–6.
- Gupta A, Mahajan V, Khatai P And Srivastva A K. 2010. Distinctness in Indian soybean (*Glycine max*) varieties using DUS characters. *Indian Journal of Agricultural Sciences* **80**(12): 1, 081–4.
- Gupta V N And Datta S K. 2005. Morphological and chemical characterization of thirty small flowered Chrysanthemum cultivars. *Journal of Ornamental Horticulture* **8**(2): 91–5.
- Helani Q And Jiuying F. 2011. Morphological difference and DNA diversity between flower-colour sport and original cultivar of chrysanthemum with small flowers. *Journal of Northeast Agricultural University* **18**(4): 15–20.
- Joshi A, Agrawal R C And Chawla H S. 2011. Assessment of distinctiveness, uniformity and stability of indigenous aromatic rice (*Oryza sativa*) varieties based on morphological descriptors. *Indian Journal of Agricultural Sciences* **81**(7): 595–601.
- Liu P L, Wan Q, Guo Y P, Yang J And Rao G Y. 2012. Phylogeny of the genus chrysanthemum I.: evidence from single-copy nuclear gene and chloroplast DNA sequences. *Plos one* **7**(11): 1–12.
- Martin M C, and Benito M E G. 2005. Survival and genetic stability of *Dendranthema grandiflora* Tzelev shoot apices after cryopreservation by vitrification and encapsulation-dehydration. *Cryobiology* **51**: 281–9.
- Panwar S, Singh K P and Namita. 2012. Assessment of variability, heritable components and grouping of Indian rose (*Rosa × hybrida*) genotypes based on DUS guidelines. *Indian Journal of Agricultural Sciences* **82**(10): 875–80.
- Qu C M, Zhang J C, Lv X Q, Chen Jy and Chen R D. 2013. The quantity analysis on phenotypic traits of *chrysanthemum* germplasm. *Acta Horticulturae* **977**: 205–12.
- Ramteke R And Murlidharan P. 2012. Characterization of soybean (*Glycine max*) varieties as per DUS guidelines. *Indian Journal of Agricultural Sciences* **82**(7): 572–7.
- Raut V M. 2003. Qualitative genetics of soybean- a review. *Soybean Research* **1**: 1–28.
- Shukla S K, Joshi D C, Srivastava R K, Qureshi M I and Singh U S. 2011. Suitability of RAPD and ISSR to complement agro-morphological DUS descriptors for establishing

- distinctiveness in indigenous local strains of Kalanamak rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **81**(11): 994–00.
- Singh S, Dhyani D, Yadav A K and Rajkumar S. 2011. Flower colour variations in gerbera (*Gerbera jamesonii*) population using image analysis. *Indian Journal of Agricultural Sciences* **81**(12): 1,130–36.
- Sood S, Sood R and Vidyasagar. 2011. Morphological characterization of bell pepper (*Capsicum annuum* var. *grossum*) genotypes and their application for distinctness, uniformity and stability testing. *Indian Journal of Agricultural Sciences* **81**(3): 240–6.
- Yadav A K, Singh D and Arya R K. 2013. Morphological characterization of Indian mustard (*Brassica juncea*) genotypes and their application for DUS testing. *Indian Journal of Agricultural Sciences* **83**(12): 1,0305–16.