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MORPHOLOGICAL DISTINCTIVENESS, UNIFORMITY AND STABILITY (DUS) ASSESSMENT OF MARIGOLD (*TAGETES* SPP.) GENOTYPES

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ABSTRACT

The distinctiveness, uniformity, and stability (DUS) characterization of marigold (*Tagetes* spp.) provides essential information for varietal identification and protection. In the present study, 15 genotypes, including two checks, were evaluated using 35 DUS traits as per the protection of Plant variety and Farmers Right (PPV&FR) Authority guidelines. Of these, 25 traits were visually assessed and nine were measured physically, with flower colours determined using the Royal Horticultural Society Colour Chart (6th ed.). The genotypes exhibited wide variation in leaf, plant and floral traits. Visual traits such as anthocyanin pigmentation, growth habit, leaf dentation, floret type and flower colour further differentiated the genotypes. Overall, the morphological descriptors effectively distinguished all genotypes, except for plant and flower fragrance and leaf type, which were uniform across entries. The study highlights the utility of DUS descriptors for reliable identification, breeding, and registration of marigold varieties under the PPV&FR framework.

Keywords : DUS, *Tagetes*, Varietal identification, PPV & FR, Morphological descriptors.

Introduction

Marigold (*Tagetes* spp.), a member of the family Asteraceae, is one of the most widely grown ornamental crops across the world. It was introduced to India by the Portuguese in the 16th century (Kumar *et al.*, 2018) and has since become a popular loose flower crop owing to its adaptability, short growth duration, wide range of attractive colours and good keeping quality (Cicevan *et al.*, 2022). In India, marigold flowers are extensively used for religious offerings, decorations at social ceremonies and landscape management (Giri *et al.*, 2019). Besides its ornamental value, marigold holds industrial importance as a rich source of carotenoids, particularly lutein, which is widely used in food and poultry industries (Heuzé *et al.*, 2017). The crop is broadly categorized into two commercially important groups, viz., African marigold (*T. erecta* L.) and French marigold (*T. patula* L.) which

differ in flower size, shape and plant architecture. In addition, marigold possesses bioactive compounds with antibacterial, antifungal, insecticidal, and medicinal properties, further enhancing its economic significance. Morphological traits offer essential phenotypic information for which DUS (Distinctiveness, Uniformity and Stability) descriptors are most precise and reliable for varietal identification and registration. The DUS testing system is fundamental for plant variety protection and serves as the cornerstone for establishing legal rights over new cultivars. In ornamental crops like marigold (*Tagetes* spp.), morphological characterization through standardized DUS descriptors enables accurate identification and differentiation of genotypes, which is crucial for breeding programs and variety registration processes (Joshi *et al.*, 2018).

Materials and Methods

A total of 15 marigold genotypes were included in this study, which included two check varieties (Pusa

Narangi Gainda and Pusa Deep) and a collection obtained from Sikkim. (Table 1).

Table 1: List of genotypes used in the present study

Sr. No	Genotypes	Sr. No	Genotypes	Sr. No	Genotypes
1	GPB-A-MGO-1*	6	GPB-A-MGY-14	11	GPB-A-MGO-5
2	GPB-A-MGO-2	7	Check Pusa Narangi Gainda	12	GPB-A-MGO-4
3	Check Pusa Deep	8	GPB-A-MGP-16	13	GPB-A-MGO-6
4	GPB-A-MGP-15	9	GPB-A-MGO-10	14	GPB-A-MGO-3
5	GPB-A-MGY-13	10	GPB-A-MGO-8	15	GPB-A-MGO-7

*All the genotypes were collected from the Department of Genetics and Plant breeding, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Observations on 35 essential traits (Table 2) were recorded at different crop growth stages as listed in the DUS guidelines for *Tagetes* spp. in India (<https://www.plantauthority.gov.in/>); of these, 25 traits were visually assessed and nine were measured physically. All observations, assessments and measurements of the genotypes were taken during the full flowering stage, except hypocotyl: anthocyanin colouration and hypocotyl: intensity of anthocyanin colouration, which was taken after 10-20 days of seed sowing (at 2-4 leaf stage). However, the time of first flowering after transplanting was recorded at first flowering stage.

Flower-related traits were recorded once the flowers had fully opened. The methods prescribed in the DUS guidelines were followed, which included single measurement on a group of plants or plant parts (MG), measurement on several individual plants or plant parts (MS), visual assessment of a group based on a single observation (VS), and visual assessment of individual plants or plant parts (VG). For traits involving colour, the Royal Horticultural Society (RHS) Colour Chart (6th edition, 2015) was used to assess colour characteristics.

Results and Discussion

Categorization of marigold genotypes based on DUS guidelines

Physically measured traits

Traits, such as leaf length and width (cm), terminal leaf width (cm), days to first flowering after transplanting, flower diameter (cm), peduncle length (cm), length and width of the outer ligulate floret (cm) and plant height (cm) served to distinguish the marigold genotypes into different categories (Table 2). Plant height among the genotypes ranged from 51.57 cm to 101.63 cm, with 13 genotypes falling into the

medium category (40–90 cm) and two into the tall type (>90 cm). Leaf length was grouped into three categories, where the majority (ten genotypes) exhibited medium sized leaves, and five genotypes had long leaves. Though leaf width distinguished the genotypes into narrow, medium and broad type, width of terminal leaflet grouped most of the genotypes (12) into broad category. Based on peduncle length observations, only one genotype possessed a long peduncle.

All the genotypes showed late flowering, probably due to unusual high temperature and dryness during cropping period, which may have altered normal physiological processes and delayed floral initiation. A range of flower diameter was observed from very small to very large, where majority of the genotypes (seven) had short and narrow outer ligulate florets.

Visually assessed traits

Categorization of marigold genotypes based on DUS guidelines with respect to visually assessed traits is presented in Table 2. Visual observation of anthocyanin colouration intensity in hypocotyl and stem differentiated the genotypes into three separate groups. Most of the genotypes (nine) recorded medium pigmented hypocotyl and stem, while weak pigmentation was observed in few. No anthocyanin pigmentation was recorded in hypocotyl, as well as in stem, for genotype GPB-A-MGY-14. For growth habit, genotypes were either upright (four), semi upright (nine) or spreading (two) with all genotypes exhibiting compound pinnate type leaves. Dark green colour on the upper side of leaf was observed in two genotypes only, the rest had medium or weak colouration. Leaf margin indentation varied from shallow to medium to deep. All genotypes had fragrant vegetative and floral parts.

The shape of flower head was found irregular in nine genotypes and round in six genotypes. Based on the type of floret present in flower head, one genotype each showed tubulate & ligulate type, and tubuligulate & ligulate type, whereas only tubuligulate floret type was observed in 12 genotypes and one genotype showed all ligulate floret type. Number of ligulate floret whorls in genotypes having tubulate and ligulate florets were either medium or many. Ligulate floret shape was found to be flat in only one genotype, the rest were intermediate type only. Few genotypes had round apex with no incision for ligulate floret, while the apex was truncate in one genotype. Presence of incision was found in all the other 11 genotypes. All the genotypes had single flower colour except one. The RHS colour codes are mentioned in the Table 3. Based on type of colour distribution in ligulate floret having

two colours, Check Pusa Deep showed small sized type 1 distribution.

Conclusion

The evaluation of 35 DUS traits effectively differentiated the 15 marigold genotypes, demonstrating considerable morphological variability within the collection. This diversity offers valuable scope for selecting genotypes with distinct ornamental features, thereby supporting breeding programmes aimed at trait improvement. Moreover, the clear trait-based categorization provides a baseline dataset that can strengthen variety registration processes and facilitate the protection of marigold cultivars under the PPV&FR framework, which is the mandatory Sui generis system adopted in India for being an International Union for the Protection of New Varieties of Plants (UPOV) member nation.

Table 2: DUS characterization of 15 marigold genotypes

Sr. No.	Characteristics	States	Genotypes*	Stage of observation#	Type of assessment @
1	Hypocotyl: anthocyanin colouration	Absent	6	a	VG
		Present	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15		
2	Hypocotyl: intensity of anthocyanin colouration	Weak	5, 7, 11, 12, 13	a	VG
		Medium	1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15		
		Strong	3, 4		
3	Plant: fragrance (Vegetative parts)	Absent	-	b	VG
		Present	All		
4	Flower: fragrance	Absent	-	c	VG
		Present	All		
5	Plant: height (up to the tip of leaves from ground level measured in cm)	Very short (≤ 20)	-	c	MG
		Short ($>20 \leq 40$)	-		
		Medium ($>40 \leq 90$)	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15		
		Tall ($>90 \leq 150$)	8, 10		
		Very tall (>150)	-		
6	Plant: growth habit	Upright	1, 2, 9, 10	c	VG
		Semi upright	5, 6, 7, 8, 11, 12, 13, 14, 15		
		Spreading	3, 4		
7	Stem: anthocyanin colouration	Absent	6	c	
		Present	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15		
8	Stem: intensity of anthocyanin colouration	Weak	5, 11, 12, 14	c	VG
		Medium	2, 3, 6, 7, 8, 9, 10, 13, 15		
		Strong	1, 4		
9	Leaf: type	Simple	-	c	VS
		Pinnate	All		
10	Leaf: length	Short	-	c	VG
		Medium	4, 7, 9, 12, 13		
		Long	1, 2, 3, 5, 6, 8, 10, 11, 14, 15		

11	Leaf: width	Narrow	2, 3, 4, 9, 11, 33	c	VG
		Medium	7, 12, 15		
		Broad	1, 5, 6, 8, 10, 14		
12	Leaf: intensity of green colour on upper side (at the time of first flowering)	Light	2, 17	c	VG
		Medium	1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15		
		Dark	3, 4		
13	Only varieties with pinnate leaves: terminal leaflet: width	Narrow	-	c	VG
		Medium	7, 8, 9		
		Broad	1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 14, 15		
14	Leaf margin: depth of indentation	Shallow	6, 7, 8, 11, 12, 13, 14	c	VG
		Medium	1, 2, 5, 9, 10, 15		
		Deep	3, 4		
15	Flower head: length of peduncle of terminal flower head	Short	1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	c	VG
		Medium	3, 4, 5		
		Long	2		
16	Shape of flower head: view from above	Round	1, 2, 8, 9, 10, 14, 15	c	VG
		Irregular	3, 4, 5, 6, 7, 11, 12, 13		
17	Flower head: floret type	All tubulate	-	c	VS
		Tubulate and ligulate	8		
		Tubuligulate and ligulate	4		
		All tubuligulate	1, 2, 3, 5, 6, 9, 10, 11, 12, 13, 14, 15		
		All ligulate	7		
18	Flower head: diameter	Very small	3, 4, 11	c	VG
		Small	5, 6		
		Medium	7, 8, 13, 14		
		Large	12, 13		
		Very large	1, 2, 9, 10		
19	Only varieties with tubulate and ligulate floret type: flower head: number of ligulate floret whorls	Very few	-	c	VG
		Few	-		
		Medium	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13		
		Many	1, 2, 14, 15		
20	Ligulate floret: shape	Flat	8	c	VG
		Intermediate	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15		
		Trumpet	-		
21	Ligulate floret: incision of margin	Absent	1, 2, 3, 4	c	VG
		Present	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15		
22	Only varieties with incision of margin absent: ligulate floret: shape of apex	Round	1, 2	c	VG
		Truncate	3		
23	Outer ligulate floret: length	Short	3, 4, 5, 6, 8, 14, 15	c	VG
		Medium	1, 7, 11, 12, 13		
		Long	2, 10		
24	Outer ligulate floret: width	Narrow	3, 4, 5, 6, 11, 15	c	VG
		Medium	7, 9, 12		
		Broad	1, 2, 8, 13, 14		
25	Flower head: number of colours	One	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	c	VG
		Two	3		
26	Only varieties with one	RHS Colour Chart	Refer Table 3	c	VS

	flower head colour: flower head: colour	(indicate reference number)			
27	Only varieties with two flower head colours: tubulate and/or tubuligulate floret:	One	-	c	VG
		Two	3		
28	Tubulate and/or tubuligulate floret: main colour	RHS Colour Chart (indicate reference number)	31A	c	VS
29	Only varieties with tubulate and/or tubuligulate florets with two colours: tubulate and/or tubuligulate floret: secondary colour	RHS Colour Chart (indicate reference number)	Refer Table 3	c	VS
30	Only varieties with two flower head colours: ligulate floret: number of colours	One	-	c	VG
		Two	3		
31	Only varieties with two flower head colours: ligulate floret: main colour	RHS Colour Chart (indicate reference number)	53B	c	VG
32	Only varieties with two ligulate floret colours: ligulate floret: secondary colour	Whitish	-	c	VS
		Light yellow	-		
		Dark yellow	-		
		Light orange	-		
		Medium orange	3		
		Red	-		
33	Only varieties with two ligulate floret colours: ligulate floret: distribution of colour	Type 1	3	c	VG
		Type 2	-		
		Type 3	-		
34	Only varieties with type 1 ligulate floret colour distribution: ligulate floret: size of central colour zone	Very small	-	c	VG
		Small	3		
		Medium	-		
		Large	-		
		Very large	-		
35	Time of first flowering after transplanting (in days)	Early (≤ 40)	-	b	VG
		Medium ($>40 - \leq 60$)	-		
		Late (>60)	All		

#Code Growth stage

a 10-20 days of seed sowing (at 2-4 leaf stage)

b First flowering stage

c Full flowering stage

@MG: Measurement by a single observation of a group of plants or parts of plants

MS: Measurement of a number of individual plants or parts of plants

VG: Visual assessment by a single observation of a group of plants or part of plants

VS: Visual assessment by observations of individual plants or parts of plant

*Genotypes

1 GPB-A-MGO-1

2 GPB-A-MGO-2

3 Check Pusa Deep

4 GPB-A-MGP-15

5 GPB-A-MGY-13

*Genotypes

6 GPB-A-MGY-14

7 Check Pusa Narangi Gaiinda

8 GPB-A-MGP-16

9 GPB-A-MGO-10

10 GPB-A-MGO-8

*Genotypes

11 GPB-A-MGO-5

12 GPB-A-MGO-4

13 GPB-A-MGO-6

14 GPB-A-MGO-3

15 GPB-A-MGO-7

Table 3: Flower colour of 15 marigold genotypes

Sr. No.	Genotypes	FC
1	GPB-A-MGO-1*	N30-D55
2	GPB-A-MGO-2	N25C-73
3	Check Pusa Deep	-
4	GPB-A-MGP-15	25C
5	GPB-A-MGY-13	5A-97
6	GPB-A-MGY-14	3-B
7	Check Pusa Narangi Gaiinda	25A
8	GPB-A-MGP-16	28A-24
9	GPB-A-MGO-10	33B
10	GPB-A-MGO-8	30-B
11	GPB-A-MGO-5	17A-256
12	GPB-A-MGO-4	25A-59
13	GPB-A-MGO-6	23C
14	GPB-A-MGO-3	21A
15	GPB-A-MGO-7	17A-79

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Conflict of interest. None.

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