



Evaluation of French Marigold (*Tagetes patula* L.) Varieties for Growth, Pot Presentability and Yield

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Author's contribution

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at College of Horticulture, Sri Konda Laxman Telangana Horticultural University, Rajendranagar, Hyderabad during Rabi 2021-2022 and 2022-2023. The experiment was laid in completely randomized design with five treatments and four replications to study the growth, pot presentability and yield of French marigold. Pusa Arpita recorded maximum plant height (22.73, 37.95 and 48.92 cm), plant spread (E-W) (15.81, 22.10 and 27.48), plant spread (N-S) (14.83, 21.55 and 26.26 cm), number of branches (9.10, 12.73 and 17.60), number of leaves (25.45, 51.50 and 73.63), stem diameter (6.99, 8.04 and 9.32 mm), chlorophyll (SPAD) (65.90, 57.56 and 50.29) at 30, 60 and 90 DAT, respectively. Pot presentability score (92.28), yield per plant (60.30 g) and yield per pot (179.36 g) were recorded maximum in Arka Pari. Different varieties have different growth regulating mechanisms, contrary to vegetative growth, in some genotypes the cell division and multiplication might be very high in reproductive phases due to the higher absorption of nutrients and metabolisms in flowering.

Keywords: *Tagetes patula* L.; varietal evaluation; growth; pot presentability; yield.

1. INTRODUCTION

Marigold (*Tagetes* spp.) is one of the most important loose flower crop, belongs to the family Asteraceae and is native to the Mexico. There are around 50 species in the genus *Tagetes*, but two of the most common and widely grown for commercial purposes are *Tagetes erecta* (African marigold) and *Tagetes patula* (French marigold). Due to its ease of cultivation and greater adaptability, marigolds are becoming one of the most lucrative pot flowering crops and are also becoming more and more popular among flower nurseries. *Tagetes patula* is prized for its vivid colors and ornamental charm. French marigold thrives in containers and is perfect for mass planting in the field, window boxes, hanging baskets, bedding, herbaceous borders, and rockery. For healthy growth, a mild climate is necessary. Rapid urbanization and shifting lifestyles have increased demand for potted plants in India. When choosing types for pot culture, pot presentability is a crucial factor. French marigold enhances the visual appeal of pots by producing flowers all season long. It is more practical for pot production due of its hardy characteristics and low crop maintenance requirements. For every crop to produce high-quality seeds and follow sound management techniques, varietal characterization and the identification of particular features are crucial (Pramila et al. 2011). Therefore, this study was conducted to identify the most suitable variety exhibiting the maximum number of desirable traits.

2. MATERIALS AND METHODS

The present experiment was carried out at College of Horticulture, Rajendranagar, during

Rabi seasons of 2021-2022 and 2022-2023. The experiment was laid in completely randomized design with 5 treatments and 4 replications to study the performance of 5 different french marigold varieties. Sowing was done in first fortnight of October for first season and second fortnight of September in second season in protrays. Seeds were sown in protrays with a media containing cocopeat and vermicompost in 1:1 ratio. Black PVC pots were taken, the media was prepared with a ratio of soil: cocopeat: FYM in 1:1:1, then pots were filled with this media. Thirty days old healthy seedlings were selected, three plants per pot were carefully transplanted in each pot. Data was recorded in terms of growth, pot presentability and yield from the five randomly selected plants. These parameters, were statistically analyzed.

2.1 Pot Presentability Score

Pot presentability was evaluated on the basis of point system modified after Conover (1986). The parameters assessed and the corresponding points allocated to each, out of a total of 100 points are as follows Table 1.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data for plant height was subjected to CRD and presented in Table 1. Maximum pooled data for plant height was recorded in T₂: Pusa Arpita (22.78, 37.95, and 48.92 cm) while minimum pooled data for plant height was observed in T₄: CGFM-1 (15.75, 23.28, and 29.84 cm) at 30, 60

and 90 DAT respectively. The plant height plays a great role in flowering plants for pot cultivation. Kher (1989) stated that the plant height should be 1.5 to 2.5 times the pot height. The varieties were cultivated in 6 inch pot (15.24 cm) the ideal plant height range should be between 22.86 cm to 38.1 cm. Maynard and David (1987) proved that change in plant height could be caused by the expression of the dominant gene due to favorable environment in genotypes. The differences in plant height might be due to genes controlling cell division, cell elongation and may also depends on plant growth promoting hormones which controls height. Similar pattern of differences were observed by Rajiv Kumar (2014), Kavana et al. (2024) in chrysanthemum, Khanvilkar et al. (2003), Rao et al. (2005), Ingle et al. (2011), Bhawna, (2019) Netam et al. (2019) Kumar et al. (2020), Thirumalmurugan et al. (2020), Gaurav and Basavaraj (2021), Nishitha, (2022), Priya et al. (2022) and Thakur and Dhatt (2023) in marigold.

3.1.2 Plant spread (E-W) (cm)

The data for plant spread (E-W) (cm) was represented in Table 2. T₂: Pusa Arpita recorded the maximum pooled plant spread (E-W) (15.81, 22.10 and 27.48 cm) while T₄: CGFM-1 showed the minimum plant spread (E-W) with (12.50, 17.37, and 23.02 cm) at 30, 60 and 90 DAT. The plant spread should be 1.5 to 2.5 times to the height of the pot. (Kher 1989). The spread should fall between 22.86 to 38.1 cm. Taller varieties exhibited greater plant spread than short varieties according to Poonam and Kumar (2007). Similar results were seen for genotypes that displayed highly significant variations in plant spread by Kavana et al. (2024) in chrysanthemum, Singh et al. (2003), Narsude et al. (2010), Raghuvanshi and Sharma (2011) and Choudhary et al. (2014), Bhawna, (2019), Netam et al. (2019), Srinivas and Rajashekhar (2020) and Thakur and Dhatt (2023) in marigold.

Table 1. Parameters and Pot presentability score

Parameters	Max points	Description	Score	
A) Flowering				
1	Number of flowers per pot	20	>200 flowers per pot	20
			100-200	18
			50-100	15
			30-50	12
			< 30	10
2	Flower size	10	2.0-4.0 cm	10
			4.0-6.0 cm	8
			6.0-8.0 cm	6
			8.0-10.0 cm	4
3	Colour	10	Flower with clear colour and no fading, no residue	10
			Slightly fading and dull colour	8
			Very dull and faded	6
B) Shape and Form				
4	Stem and foliage	20	Plant self-supportive with very strong stems having healthy foliage and free from any infestation like insect, pests, diseases and bruises	20
			Plants less supportive with relatively less strong stem, foliage somewhat healthy and having little pests and disease infestation and bruises	15
			Plants not self-supportive, having less strong stems with unhealthy foliage and considerable infestation of pests and diseases and bruises	10
5	Plant height	10	Plants in balance with pot neither too tall, nor too small generally 2.5 times to the height of the pot	10
			Plants too large or too small to height of the pot	6
6	Plant spread	10	Plant spread in balance with pot, neither too large nor too small, generally equal to the height of the plant	10
7	Plant appearance as a whole plant	20	Fresh appearance, no indication of senescence, mechanical and insect damage in flowers/stems/shoots/ foliage	20
			Fresh appearance but slight indication of scenescence	15
			Dull appearance and considerable indication of scenescence	10
Total score		100		

Table 2. Performance of french marigold (*Tagetes patula* L.) varieties with respect to plant height (cm) at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Treatments	Plant height (cm)								
	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Gaiinda	21.97	21.99	21.98	35.37	35.61	35.49	47.77	47.85	47.81
T ₂ : Pusa Arpita	22.78	22.68	22.73	37.87	38.04	37.95	48.88	48.96	48.92
T ₃ : Pusa Deep	21.38	21.18	21.28	33.21	33.74	33.47	46.08	46.00	46.04
T ₄ : CGFM-1	15.45	16.05	15.75	22.88	23.67	23.28	29.65	30.03	29.84
T ₅ : Arka Pari	16.02	16.18	16.10	23.74	23.93	23.83	30.71	30.38	30.54
SEm±	0.65	0.59	0.45	0.76	0.58	0.43	0.69	0.71	0.5
CD at 5 %	1.97	1.78	1.34	2.3	1.77	1.32	2.07	2.14	1.57

DAT: Days after transplanting

Table 3. Performance of french marigold (*Tagetes patula* L.) varieties with respect to plant spread (E-W) (cm) at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Treatments	Plant spread (E-W) (cm)								
	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Gaiinda	14.17	14.36	14.27	21.88	21.95	21.91	26.13	26.91	26.52
T ₂ : Pusa Arpita	15.27	16.36	15.81	22.09	22.11	22.10	27.16	27.81	27.48
T ₃ : Pusa Deep	13.57	13.88	13.73	20.08	20.13	20.10	25.03	26.50	25.77
T ₄ : CGFM-1	12.56	12.43	12.50	17.02	17.73	17.37	22.96	23.09	23.02
T ₅ : Arka Pari	12.69	12.74	12.72	18.66	18.17	18.41	23.59	23.89	23.74
SEm±	0.37	0.45	0.29	0.62	0.52	0.37	0.58	0.55	0.42
CD at 5 %	1.11	1.35	0.89	1.88	1.56	1.12	1.75	1.66	1.29

3.1.3 Plant spread (N-S) (cm)

The data for plant Spread (N-S) (cm) was depicted in Table 3. T₂: Pusa Arpita recorded the maximum pooled plant spread (N-S) (14.83, 21.55 and 26.26 cm) while T₄: CGFM-1 showed the minimum plant spread (N-S) with (11.98, 16.49, and 22.78 cm) at 30, 60 and 90 DAT. Poonam and Kumar (2007) reported that plant spread is more in taller varieties than shorter varieties in chrysanthemum and it might be also due to increased number of branches and variations in different variety-environmental interaction. Similar results were noted by Kavana et al. (2024) in chrysanthemum, Narsude et al. (2010), Raghuvanshi and Sharma (2011) and Choudhary et al. (2014) and Thakur and Dhatt (2023) also observed similar variations in different varieties of marigold.

3.1.4 Number of branches

The data for number of branches per plant was represented in Table 4. T₂: Pusa Arpita recorded the maximum pooled number of branches (9.10, 12.73, and 17.60) at 30, 60, and 90 DAT, respectively, while T₄: CGFM-1 showed the minimum number of branches with (6.00, 10.28, and 14.55) at the corresponding stages. Differences in number of branches in various genotypes might be attributed by the genetic constitution of the different varieties. The morphology of different plant genotypes depends on gene diversity. This findings are in accordance with Munikrishanppa et al. (2013) in China aster, Kavana et al. (2024) in chrysanthemum, Khanvilkar et al. (2003), Verma et al. (2004), Naik et al. (2005), Narsude et al. (2010), Singh and Singh (2010), Raghuvanshi and Sharma (2011), Choudhary et al. (2014), Bhawna, (2019), Netam et al. (2019), Thirumalmurugan et al. (2020), Nishitha, (2022) and Thakur and Dhatt (2023) in marigold.

3.1.5 Number of leaves

The data for number of leaves was represented in Table 5. Pooled data on number of leaves were recorded maximum in T₂: Pusa Arpita with (25.45, 51.50, and 73.63) at 30, 60, and 90 DAT respectively, while minimum were recorded in T₄: CGFM-1 with (19.25, 41.53, and 63.93) leaves at the same stages. Different varieties grow at different rates, which may be related to their genetic composition. The variation in the number of leaves per plant is due to the variation in the rate of vegetative growth among the varieties

that could be attributed to their genetic makeup and also due to the photoperiods which prevailed during the field experiment in marigold (Rao et al. 2005) the production of more branches per plant may be the cause of the increased number of leaves (Verma et al. 2004) in marigold. Previously Zosiamliana et al. (2013) in china aster, Singh and Misra (2008), Raghuvanshi and Sharma (2011), Bhawna, (2019) and Netam et al. (2019) in marigold, noted a similar variation in the number of leaves per plant.

3.1.6 Stem diameter (mm)

An interpretation of the stem diameter data is provided in Table 6. Pooled data on stem diameter was recorded maximum in T₂: Pusa Arpita (25.45, 51.50, and 73.63 mm), while minimum was recorded in T₄: CGFM-1 (4.54, 5.74, and 6.90 mm) at 30, 60, and 90 DAT respectively. The variations in genotype stem diameter may have its origins in the genetic sequence of the plant. According to Kanamadi and Patil (1993) the expression of the dominant gene in a congenial environment for chrysanthemum cultivars may be the cause for the increase in plant stem diameter. The variation in stem girth was also reported in Verma et al. (2004), Narsude et al. (2010), Mahantesh et al. (2018) and Priya et al. (2022) in marigold.

3.1.7 Chlorophyll (SPAD)

The data for chlorophyll was displayed in Table 7. Pooled data on chlorophyll was recorded maximum in T₂: Pusa Arpita (65.90, 57.56, and 50.29), while minimum was recorded in T₄: CGFM-1 (60.49, 47.92, and 38.29) at 30, 60, and 90 DAT respectively. Differential traits of the varieties, environmental factors, and other management factors may be the cause of the variation in chlorophyll pigment. variation in the leaf's total chlorophyll content caused by variations in the genetic composition or constitution of the varieties. Similar findings were observed by Panwar et al. (2013) and Beniwal et al. (2017) in marigold.

3.2 Pot Presentability Score

From the Table 8. it was found that the pooled data on pot presentability score was recorded maximum in T₅: Arka Pari (92.28) which was at par with T₄: CGFM-1 (91.85) followed by T₃: Pusa Deep (81.23), T₁: Bidan Kali Gaiinda (79.60) and minimum pot presentability score was recorded in T₂: Pusa Arpita (45.70).

Table 4. Performance of french marigold (*Tagetes patula* L.) varieties with respect to plant spread (N-S) (cm) at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Plant spread (N-S) (cm)									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Ginda	13.21	13.54	13.37	20.84	21.35	21.09	24.05	26.05	25.05
T ₂ : Pusa Arpita	14.62	15.05	14.83	21.03	22.07	21.55	26.27	26.25	26.26
T ₃ : Pusa Deep	13.58	13.21	13.40	20.15	21.15	20.65	25.80	25.99	25.89
T ₄ : CGFM-1	11.95	12.02	11.98	16.48	16.49	16.49	22.67	22.90	22.78
T ₅ : Arka Pari	12.32	12.74	12.53	17.49	16.93	17.21	23.13	23.17	23.15
SEm±	0.42	0.44	0.29	0.49	0.51	0.28	0.59	0.55	0.45
CD at 5 %	1.14	1.31	0.88	1.48	1.55	0.84	1.79	1.66	1.36

DAT: Days after transplanting

Table 5. Performance of french marigold (*Tagetes patula* L.) varieties with respect to number of branches at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Number of branches									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Ginda	8.00	8.55	8.28	12.05	12.15	12.10	16.00	16.35	16.18
T ₂ : Pusa Arpita	9.00	9.20	9.10	12.40	13.05	12.73	17.30	17.90	17.60
T ₃ : Pusa Deep	7.94	7.65	7.79	11.45	11.70	11.58	15.65	15.95	15.80
T ₄ : CGFM-1	5.85	6.15	6.00	10.00	10.55	10.28	14.45	14.65	14.55
T ₅ : Arka Pari	5.95	6.20	6.08	10.45	10.95	10.70	14.95	15.00	14.98
SEm±	0.47	0.59	0.39	0.26	0.39	0.22	0.42	0.53	0.32
CD at 5 %	1.42	1.79	1.18	0.79	1.19	0.68	1.27	1.61	0.98

Table 6. Performance of french marigold (*Tagetes patula* L.) varieties with respect to number of leaves at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Number of leaves									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Ginda	23.95	24.25	24.10	47.90	48.00	47.95	70.00	70.90	70.45
T ₂ : Pusa Arpita	25.40	25.50	25.45	51.15	51.85	51.50	73.30	73.95	73.63
T ₃ : Pusa Deep	21.65	22.01	21.83	44.70	44.20	44.45	67.65	67.70	67.68

Number of leaves									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₄ : CGFM-1	18.95	19.55	19.25	41.10	41.95	41.53	63.80	64.05	63.93
T ₅ : Arka Pari	19.76	20.00	19.88	41.85	42.00	41.93	64.30	64.70	64.50
SEm±	0.61	0.67	0.55	0.56	0.76	0.48	0.89	0.67	0.64
CD at 5 %	1.84	2.02	1.67	1.70	2.29	1.46	2.69	2.03	1.93

DAT: Days after transplantin

Table 7. Performance of french marigold (*Tagetes patula* L.) varieties with respect to stem diameter (mm) at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Stem diameter (mm)									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Gaiinda	6.17	6.33	6.25	7.31	7.35	7.33	8.29	8.35	8.32
T ₂ : Pusa Arpita	6.97	7.01	6.99	8.00	8.08	8.04	9.20	9.44	9.32
T ₃ : Pusa Deep	6.02	6.00	6.01	6.76	6.94	6.85	7.99	8.08	8.03
T ₄ : CGFM-1	4.49	4.60	4.54	5.47	6.01	5.74	6.81	6.99	6.90
T ₅ : Arka Pari	4.99	5.01	5.00	6.24	6.33	6.28	7.22	7.51	7.36
SEm±	0.23	0.28	0.19	0.28	0.25	0.22	0.35	0.35	0.32
CD at 5 %	0.70	0.83	0.58	0.85	0.76	0.67	1.06	1.04	0.97

Table 8. Performance of french marigold (*Tagetes patula* L.) varieties with respect to chlorophyll (SPAD) at 30, 60, 90 DAT during Rabi 2021-22 and 2022-23

Chlorophyll (SPAD)									
Treatments	30 DAT			60 DAT			90 DAT		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Gaiinda	63.93	64.32	64.13	55.74	56.22	55.98	48.12	48.38	48.25
T ₂ : Pusa Arpita	65.53	66.27	65.90	57.44	57.68	57.56	49.76	50.82	50.29
T ₃ : Pusa Deep	63.79	63.29	63.54	52.41	53.48	52.94	46.47	46.01	46.24
T ₄ : CGFM-1	60.06	60.91	60.49	47.78	48.07	47.92	38.09	38.50	38.29
T ₅ : Arka Pari	60.83	61.77	61.30	48.08	49.46	48.77	39.15	38.71	38.93
SEm±	0.49	0.60	0.26	0.46	0.67	0.41	0.36	0.67	0.42
CD at 5 %	1.48	1.81	0.79	1.40	2.03	1.24	1.09	2.03	1.27

DAT: Days after transplanting

Table 9. Performance of french marigold (*Tagetes patula* L.) varieties with respect to pot presentability score during Rabi 2021-22 and 2022-23

Treatments	Pot presentability score		
	2021-22	2022-23	Pooled
T ₁ : Bidan Kali Gaiinda	79.45	79.75	79.60
T ₂ : Pusa Arpita	76.80	77.20	77.00
T ₃ : Pusa Deep	80.85	81.60	81.23
T ₄ : CGFM-1	91.75	91.95	91.85
T ₅ : Arka Pari	92.25	92.30	92.28
SEm±	0.57	0.64	0.47
CD at 5 %	1.70	1.94	1.42

Table 10. Performance of french marigold (*Tagetes patula* L.) varieties with respect to yield per plant (g) and yield per pot (g) during Rabi 2021-22 and 2022-23

Treatments	Yield per plant (g)			Yield per pot (g)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T ₁ : Bidan KaliGaiinda	42.26	43.19	42.72	136.58	137.77	137.17
T ₂ : Pusa Arpita	41.46	42.02	41.74	124.29	125.26	124.77
T ₃ : Pusa Deep	57.56	58.38	57.97	171.50	172.28	171.89
T ₄ : CGFM-1	58.80	59.91	59.35	177.79	178.84	178.31
T ₅ : Arka Pari	59.96	60.64	60.30	178.97	179.76	179.36
SEm±	0.68	0.67	0.47	0.89	0.92	0.74
CD at 5 %	2.05	2.02	1.42	2.67	2.77	2.24

Plants show extensive and complex variations in stature and form. Plant height and spread should be 1.5 to 2.5 times to the pot height for good pot presentability score (Kher 1989). The pot presentability score differs with different varieties. It depends on plant form and shape, number of flowers, flower diameter etc., differences in these scores for different genotypes were also recorded by Archana et al. (2019) in chrysanthemum and Dilita et al. (2019) in azaleas.

to vegetative growth, in some genotypes the cell division and multiplication might be very high in reproductive phases due to the higher absorption of nutrients and metabolisms in flowering. Differences in yield in different genotypes were also reported by Poornima et al. (2006) and Munikrishanappa et al. (2013) in china aster, Kavana et al. (2024) in chrysanthemum, Shivakumar et al. (2015), Gulia et al. (2017) and Gaurav and Basavaraj (2021) in marigold.

3.3 Flower Yield

3.3.1 Yield per plant

From the Table 9. it was found that the pooled data on yield per plant was recorded maximum in T₅: Arka Pari (60.30 g) which was at par with T₄: CGFM-1 (59.35 g) followed by T₃: Pusa Deep (57.97 g), T₁: Bidan Kali Gaiinda (42.72 g) and minimum yield per plant was recorded in T₂: Pusa Arpita (41.74 g). The most crucial factors in determining the appropriateness and versatility of flower varieties are yield and yield-related characteristics. Flower yield exhibited highly positive correlation with number of flowers per plant, with the increase in number of flowers per plant, the yield per plant too increases (Mahantesh et al. 2016). Different varieties have different growth regulating mechanisms, contrary

3.3.2 Yield per pot

The data on yield per pot was represented in Table 9. it was found that the pooled yield per pot was recorded maximum in T₅: Arka Pari (179.36 g) which was at par with T₄: CGFM-1 (178.31g) followed by T₃: Pusa Deep (171.89 g), T₁: Bidan Kali Gaiinda (137.17 g) and minimum yield per pot was recorded in T₂: Pusa Arpita (124.77 g). Yield is a poly-genetically controlled quantitative character and highly influenced by the environment in french marigold. French marigold cultivars differed in flower yield may be due to inherent capacity of genotypes and influencing factors such as number of flowers per plant (Priya et al. 2022). Analogous results were also recorded by Deepa et al. (2016), Poornachandragowda et al. (2016) and Gaurav and Basavaraj (2021) in marigold.

4. CONCLUSION

Pusa Arpita recorded the highest values for plant height, plant spread, number of branches, number of leaves, stem diameter, and chlorophyll content. However, Arka Pari showed the highest scores for pot presentability, yield per plant, and yield per pot. Despite the superior vegetative growth observed in Pusa Arpita, Arka Pari is more suitable for pot culture due to its dwarf stature, compact growth habit, higher flower production, greater yield, and better overall pot appearance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I, hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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