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Performance assessment of chrysanthemum varieties under hilly condition of Uttarakhand

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Abstract
The present investigation was conducted to evaluate the performance of 11 chrysanthemum varieties on the basis of vegetative and floral attributes under hill conditions of Uttarakhnad. The results showed that with respect to vegetative attributes, Pusa Lohit exhibited tallest plants (56.36 cm), maximum plant spread (33.21 cm), number of leaves per plant (86.93±4.75) and leaf area (41.33 cm^2). With respect to flowering attributes, earliest days taken to 1st bud appearance (66.07), maximum flower diameter (8.06 cm) and individual flower weight (9.05 g) were recorded in Pusa Kesari. The maximum number of flowers per plant was recorded in Pusa Aditya (70.36), while longest flowering duration was recorded in Pusa Shwet (25.60 days). Ravi Kiran recorded the maximum number of ray florets per head (298.45) and longest shelf life (5.53 days), whereas Bidhan Mallika had the longest vase life (19.78 days). The maximum flower yield per plant and per plot was recorded in the Pusa Kesari (479.74 g and 5.76 kg, respectively). Therefore among all the varieties evaluated on an overall basis, Pusa Kesari, Pusa Lohit and Bidhan Mallika may be recommended for commercial cultivation and future breeding programme under hill condition of Uttarakhand.

Keywords: Chrysanthemum, floral attributes, hilly conditions, shelf life, varieties, vase life

Introduction
Chrysanthemum is one of the pinnacle five ranking cut flower in the market. It is one of the most widely cultivated flowers globally, valued for its versatile applications as a cut flower, loose flower, in pot culture, and for bedding purposes (Kaushal and Bala, 2019) [9]. The loose flowers of chrysanthemum are commonly used for making garlands, *venis*, gajras, and for religious offerings. In the cut flower trade, cultivars with long, tall, and sturdy stems, attractive flower colour, consistent bloom opening and extended vase-life are preferred. In recent years, the demand for potted chrysanthemums has also grown owing to their suitability as ornamental potted plants (Abrol *et al*., 2018) [1]. In landscaping upright and tall-growing cultivars are ideal for background planting whereas, short plants are used for front row planting in garden borders. In Japan, cut flowers are also commonly used in cemeteries. Additionally, chrysanthemums are known for their anti-inflammatory and antioxidant properties and are frequently used in herbal remedies and teas (Nguyen *et al*., 2023) [20]. Chrysanthemum growth and flowering are affected by light, temperature, and genotype performance. The response of genotypes varies depending on the season, region, and other environmental conditions (Swaroop *et al.,* 2008) [28]. Chrysanthemum exhibits great varietal diversity, with new varieties being introduced each year. Therefore, evaluating these varieties is essential to identify the most suitable ones for specific regions (Kumar and Yadav, 2005) [14]. The choice of appropriate cultivars for a given location determines the final yield, production of high-quality flowers, and resistance to biotic influences. Furthermore, the need for promising cultivars is inevitable to avoid consumer's dissatisfaction for the existing varieties, receptiveness to a range of biotic stresses and conditions. Selection of the appropriate cultivar is essential for successful and market-oriented commercial floriculture. Importantly, varietal performance evaluation can be helpful for the commercial chrysanthemum grower to decide their preferable one (Jamaluddin *et al.,* 2015) [6]. The effective cultivation of chrysanthemums depends largely on selecting the most appropriate variety. Hence, assessing the

performance of various chrysanthemum varieties is essential for optimizing production and ensuring economically viable cultivation (Yumkhaibam *et al*., 2023) [32]. Currently, Uttarakhnad has emerged as one of the major hub of flower cultivation due to its congenial environment conditions, fertile soil and ample of water supply. To enhance farmer's profitability, evaluation studies plays a significant role as the performance of varieties often varies with location. Some varieties perform well in hilly areas while other are suited well to plains. Thus, it is essential to determine best suited varieties to the agro-climatic conditions in hilly area of Uttarakhand for maximizing yield and profit potential. Keeping these considerations in view, the present investigation was conducted at Floriculture and Landscaping Block, College of Horticulture, VCSG UUHF Bharsar.

Materials and Methods

The present study was conducted at Floriculture and Landscaping Block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal. The site is located at an altitude of 1900 meters above mean sea level at Latitudes of 29º20'-29º75' N and Longitudes 78º10'-78º80' E. The soil of the experimental site was acidic having soil pH (4.35), EC (0.123 dS/m), organic carbon (2.414%), available nitrogen (263.072 kg/ha), available phosphorus (8.736 kg/ha) and available potassium (344.96 kg/ha). The experiment consists of 11 chrysanthemum varieties which were laid out in Randomized Complete Block Design with 3 replications under open field conditions. The well rooted uniform size cuttings of chrysanthemum varieties were planted at a spacing of 30 cm x 30 cm accommodating 12 plants per bed. The standard cultural practices were carried out during the course of investigation. The observations on vegetative attributes i.e., plant height, plant spread, number of primary branches and leaves per plants were recorded at the time of full bloom stage. Similarly floral attributes like days taken to first bud appearance, flowering duration (days), flower diameter (cm), individual flower weight (g), number of ray florets per flower, number of flowers per plant, flower yield per plant and plot, shelf and vase life were recorded and analyzed as per statistical procedure given by Gomez and Gomez (1984) [4].

Table 1: Name of the chrysanthemum varieties with source of collection

Variety code	Variety name	Flower head type	Source
V_1	Pusa Lohit	Semi-double	ICAR-IARI, New Delhi
V_2	Pusa Shwet	Semi-double	ICAR-IARI, New Delhi
V_3	Pusa Arunodaya	Semi-double with incurving ray florets	ICAR-IARI, New Delhi
V_4	Garden Beauty	Spoon-type	PAU, Punjab
V_5	Pusa Chitraksha	Single Korean	ICAR-IARI, New Delhi
V_6	Pusa Aditya	Single	ICAR-IARI, New Delhi
V_7	Pusa Kesari	Semi-double with incurving ray florets	ICAR-IARI, New Delhi
V_8	Pusa Guldasta	Semi-double	ICAR-IARI, New Delhi
V_9	Pusa Sundari	Anemone	ICAR-IARI, New Delhi
V_{10}	Bidhan Mallika	Double Korean	BCKV, West Bengal
V_{11}	Ravi Kiran	Decorative	IIHR, Bengaluru

Results and Discussion

Vegetative attributes

The data presented in Table 2 showed a significant variation among the vegetative attributes of the evaluated chrysanthemum varieties. Among the varieties tested, tallest plants along with maximum plant spread were recorded in variety Pusa Lohit (56.36 cm and 33.21 cm, respectively). However, shortest plants in conjunction with maximum number of primary branches per plant were found in Pusa Sundari (24.67 cm and 6.40, respectively). The minimum number of primary branches per plant and plant spread were observed in Ravi Kiran (2.87 and 11.96 cm, respectively). In context to number of leaves per plant (86.93) were recorded highest in Pusa Lohit and found statistically at par with Pusa Kesari (80.98). However, variety Ravi Kiran produced minimum number of leaves per plant (23.20). The variation in vegetative attributes is primarily attributed to the genetic makeup inherent to each genotype (Kumar *et al*., 2020) [13]. Furthermore, these characters are mostly influenced by genetic factors that determine the plant's adaptability and performance across a wide range of environmental conditions (Sharma and Sharma, 2023) [24]. The variation in vegetative traits among the varieties therefore, may be attributed to differences in growth rates and their genetic potential, resulting in varied phenotypic expression (Henny *et al.,* 2021 and Yumkhaibam *et al.,* 2023) [5, 32]. Nair and Shiva (2003) [18] also reported that additive gene effects play a significant role in determining leaf area variability. The above findings are corroborated with the earlier results reported by Kaur and Singh (2023) [8], Yumkhaibam *et al.* (2023) [32], Kashyap *et al.* (2024) [7] and Kavana *et al.* (2024) [10] in chrysanthemum.

Floral attributes

The number of days taken to first flower bud appearance is an important character that indicating the earliness or lateness of flowering, which in turn influences the timing of flower availability. The Table 3 showed that the var. Pusa Kesari recorded minimum number of days taken to first flower bud appearance (66.07 days) and was found statistically at par with Bidhan Mallika (66.13 days), Pusa Arunodaya (66.27 days), Pusa Aditya (66.73 days), Pusa Lohit (66.80 days), Pusa Sundari (67.00 days) and Pusa Guldasta (67.33 days). In contrast, variety Ravi Kiran recorded the maximum number of days taken for first flower bud appearance (80.16 days). The formation and opening of flower buds are directly influenced by the genetic makeup of each variety and its interaction with environmental conditions such as photoperiod, light intensity, temperature, and humidity (Vijayalakshmi *et al*., 2010) [31]. Furthermore, Madhumathi *et al.* (2018) [17] reported that earliness in flower bud appearance is also related with food reserved in the plants, which are closely related to vegetative growth and carbohydrate accumulation, both essential for floral bud development. Similar trends on days taken to bud appearance has been recorded by Thiripurasundari *et al.* (2021) [30], Kashyap *et al.* (2024) [7] and Kavana *et al*. (2024) [10] in chrysanthemum.

The flowering duration was ranged from 16.07 to 25.60 days all

evaluated varieties of the chrysanthemum as embodied in Table 3. However, the longest flowering duration was recorded in Pusa Shwet (25.60 days) and was statistically at par with Bidhan Mallika (25.20 days) and Pusa Aditya (25.13 days). However, shortest flowering duration (16.07 days) was recorded in Pusa Sundari. Srilatha *et al.* (2015) [27] reported that flowering duration in chrysanthemum is largely determined by inherent potential of the varieties and its responsiveness to climatic conditions. These findings are in validation with the findings of Dey *et al*. (2023) [3], Kaur and Singh (2023) [8], Sharma and Sharma (2023) [24], Yumkhaibam *et al*. (2023) [32] and Kashyap *et al*. (2024) [7] in chrysanthemum. The maximum flower diameter and weight (8.06 cm and 9.05 g, respectively) were recorded in Pusa Kesari as shown in Table 3. The minimum flower diameter was recorded in the variety Bidhan Mallika (2.72 cm) and var. Pusa Sundari registered minimum flower weight (1.02 g). The maximum and minimum flower diameter might be due to inherent genetic characters of the individual varieties and environmental factors. Kashyap *et al*. (2024) [7] reported that varieties having larger flower dimensions, with more pronounced central disc florets and a higher number of ray florets produced heavier flowers. Such variation in flower diameter was earlier reported by Thiripurasundari *et al*. (2021) [30], Dey *et al*. (2023) [3], Kaur and Singh (2023) [8], Yumkhaibam *et al*. (2023) [32] and Kashyap *et al*. (2024) [7] in chrysanthemum.

Data presented in Table 3 also reported that most number of ray florets (298.45) was produced in Ravi Kiran followed by Pusa Kesari (211.33). Whereas, Pusa Sundari recorded minimum number of ray florets per head (31.00). According to Behera *et al.* (2002) [2], the genetic makeup independently plays a pivotal role in governing traits such as flower shape, form, and the number of ray florets. Similar results were also found by Patil *et al*. (2017) [22] and Singh *et al*. (2017) [26] in chrysanthemum. With respect to number of flowers per plant, var. Pusa Aditya recorded highest number of flowers per plant (70.36) and lowest in Ravi Kiran (9.13). The number of flowers per plant is directly depend on vegetative attributes like number of branches per plant, plant spread, number of leaves and leaf area. Greater the branches more will be the number of flowers. Kashyap *et al*. (2024) [7] observed that variation in number of flowers per plant in chrysanthemum varieties might be due to their innate genetic potential as well as their response toward the environmental factors. The similar results were observed by Madhumathi *et al.* (2018) [17], Parmar *et al.* (2019) [21], Kumar *et al*. (2020) [13], Kaur and Singh (2023) [8], Yumkhaibam *et al*. (2023) [32] and Kavana *et al.* (2024) [10] in chrysanthemum.

In addition, a significant variation was observed in flower yield per plant and per plot among evaluated varieties of chrysanthemum as shown in Table 3. The maximum flower yield per plant and per plot were recorded in the Pusa Kesari (479.74 g and 5.76 kg, respectively) followed by Pusa Lohit (166.91 g and 2.00 kg, respectively). Whereas, minimum flower yield per plant and per plot were recorded in Garden Beauty (32.13 g and 0.39 kg). Flower yield per plant is primarily influenced by the number of flowers produced per plant and the weight of individual flowers. According to Kulkarni and Reddy (2004) [11], additive gene effects play a significant role in determining genotype-to-genotype differences in yield potential. The genetic composition of varieties, along with morphological traits, may contribute to increased flower yield. Additionally, environmental factors and their interaction with genotype further influence yield performance. The present results are in close agreement with the observations reported by Kumar *et al*. (2021) [15], Yumkhaibam *et al*. (2023) [32] and Kavana *et al.* (2024) [10] in chrysanthemum.

After harvesting of flower, the period for which it remain in presentable form without losing its grade and quality is considered to be vase (cut flower) and shelf (loose) life. An inquisition of the data in Table 3 shows the shelf and vase life of the different chrysanthemum varieties. Among the 11 varieties tested, longest shelf life was recorded in Ravi Kiran (5.53 days) and was found statistically at par with Pusa Lohit (5.47 days) and Bidhan Mallika (5.00 days). However, shortest shelf life was recorded in Pusa Sundari (1.27 days). The variation in shelf life among the varieties may be attributed to differences in flower form, size, shape and genotype sensitivity to ethylene (Thakur *et al*., 2018) [29]. These findings are in agreement with Negi *et al*. (2019) [19], Shravani *et al*. (2023) [25] and Kashyap *et al*. (2024) [7] in chrysanthemum. The longest vase life was registered in variety Bidhan Mallika (19.78 days) and found statistically at par with Pusa Lohit (17.89 days). However, shortest vase life was registered in Pusa Sundari (11.45 days). The variation in vase life among the varieties may be attributed to their distinct genetic composition and environmental influences, which affect vital physiological functions such as maintaining cell turgidity, regulating transpiration rates, and the breakdown of stored reserves; all of which are crucial for determining post-harvest longevity (Roopa *et al*., 2018) [23]. Similar prior results were reported by Negi *et al*. (2019) [19], Lavanya *et al.* (2022) [16], Yumkhaibam *et al*. (2023) [32] and Kashyap *et al*. (2024) [7] in chrysanthemum.

Table 2: Performance of different chrysanthemum varieties for vegetative attributes (at full bloom stage)

Varieties	Plant height (cm)	Number of primary branches per plant	Plant spread (cm)	Number of leaves per plant
Pusa Lohit	56.36	5.27	33.21	86.93
Pusa Shwet	50.08	4.73	26.92	51.14
Pusa Arunodaya	41.25	4.53	25.74	78.40
Garden Beauty	36.61	4.27	20.26	33.80
Pusa Chitraksha	37.31	3.87	25.54	69.52
Pusa Aditya	44.91	5.67	24.31	59.87
Pusa Kesari	48.11	3.80	29.81	80.98
Pusa Guldasta	49.77	4.00	25.59	72.65
Pusa Sundari	24.67	6.40	22.39	74.40
Bidhan Mallika	36.13	4.07	25.09	76.20
Ravi Kiran	28.93	2.87	11.96	23.20
SE(d)	2.43	0.79	2.07	4.01
$C.D_{(0.05)}$	5.10	1.67	4.35	8.43

Table 3: Performance of different chrysanthemum varieties for floral attributes

Varieties	No. of days taken to 1st flower bud appearance	Duration of flowering (days)	Flower diameter (cm)	Individual flower weight (g)	Number of ray florets per head	Number of flowers per plant	Flower yield per plant (g)	Flower yield per plot (kg)	Shelf life (days)	Vase life (days)
Pusa Lohit	66.80	24.13	5.73	2.62	164.38	63.71	166.91	2.00	5.47	17.89
Pusa Shwet	72.08	25.60	5.13	2.32	149.54	43.85	101.72	1.22	3.73	13.67
Pusa Arunodaya	66.27	17.40	6.32	5.56	95.16	25.47	141.51	1.70	3.80	14.89
Garden Beauty	76.11	22.30	7.28	1.34	54.13	24.04	32.13	0.39	3.87	15.67
Pusa Chitraksha	76.74	18.13	5.63	1.63	37.87	43.44	70.66	0.85	3.20	15.44
Pusa Aditya	66.73	25.13	4.19	1.42	32.73	70.36	99.67	1.20	3.73	14.56
Pusa Kesari	66.07	20.93	8.06	9.05	211.33	53.01	479.74	5.76	4.60	17.33
Pusa Guldasta	67.33	17.63	3.17	1.36	128.54	45.56	61.80	0.74	2.93	15.67
Pusa Sundari	67.00	16.07	4.26	1.02	31.00	41.47	42.43	0.51	1.27	11.45
Bidhan Mallika	66.13	25.20	2.72	2.80	131.56	58.53	164.09	1.97	5.13	19.78
Ravi Kiran	80.16	19.03	8.03	5.31	298.45	9.13	48.47	0.58	5.53	16.44
SE(d)	0.72	0.48	0.19	0.11	0.91	1.03	2.55	0.03	0.36	0.97
$C.D_{(0.05)}$	1.52	1.01	0.40	0.24	1.90	2.17	5.35	0.06	0.76	2.04

Conclusion

The evaluation of chrysanthemum varieties revealed significant variability in vegetative and floral traits in hilly condition. The variety Pusa Lohit performed well in context to vegetative attributes. The variety Pusa Kesari recorded earliness, maximum flower yield, flower diameter and weight. For bedding purpose varieties Pusa Shwet, Bidhan Mallika and Pusa Aditya found superior. For postharvest performance, Ravi Kiran, Pusa Lohit, and Bidhan Mallika showed longer shelf life, whereas Bidhan Mallika and Pusa Lohit recorded longer vase life. Therefore among all the varieties evaluated on an overall basis, Pusa Kesari, Pusa Lohit and Bidhan Mallika may be recommended for commercial cultivation and future breeding programme under hill condition of Uttarakhand.

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