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Varietal assessment of Gladiolus for growth, flowering and yield attributes

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Abstract
A field experiment was conducted during 2022-2023 at Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. Fifty varieties of gladiolus (*Gladiolus* spp.) were evaluated for various growth, flowering and yield parameters. Experiment was laid out in Randomized Block Design with three replications. The varieties differed significantly from one another with regard to growth, flowering and yield characteristics. Maximum number of sprouts per hill was exhibited by variety Arka Amar (2.53). Maximum plant height was recorded by variety Dhanvantari (72.05 cm). The variety Sunayana (3.83 cm) was reported for maximum leaf width. The present study revealed that varieties with more leaf width maintained an upright position, prevented bending or lodging which is especially important in areas with occasionally strong winds like Varanasi region. Minimum days to colour show of 3rd floret was reported by variety Chandni (82.40 days). Variety Chandni (85.59 days) took the minimum number of days to opening of 3rd floret and also minimum days to opening of 5th floret (86.24 days). Maximum days to withering of 3rd floret and 5th floret was observed by the variety Arka Darshan (108.80 days) and (109.80 days) respectively. Maximum number of corms per hill was observed with variety Pusa Shubham (3.00). The maximum weight of corms per hill was observed with variety Sunayana (55.70 g). Variety Urvashi (60.00 mm) was recorded by maximum diameter of corm. The experiment revealed that corms with higher weight and diameter are generally more robust and less susceptible to environmental stresses such as drought and nutritional deficiencies. Whereas, maximum number of cormels per hill was recorded by variety Shubhangini (72.13). The maximum weight of cormels per hill was exhibited by variety Shubhangini (13.37 g).

Keywords: Growth attributes, flowering attributes, yield attributes, corms, cormels

Introduction
Gladiolus (*Gladiolus grandiflorus* L.) is a popular cut flower in both the domestic and international markets (Singh and Sisodia, 2017) [15]. It is renowned for its magnificent spikes, adorned with alluring florets that come in a plethora of captivating colours and mesmerizing shapes. Pliny Elder (A.D 23-79) coined the term Gladiolus, which was derived from the Latin word 'gladius' meaning a sword because of its foliage's sword-like shape and it is also known as Sword lily (Goldblatt *et al*., 1998) [6]. It is one of the largest genera in the Iridaceae family contains about 260 species (Singh, 2014) [16]. The species stands out for being easy to grow, having a low production cost which present a diversity of colours and formats, good post-harvest durability and added value, resulting in a quick financial return (Tomiozzo *et al*., 2018) [21]. Gladiolus is propagated through rounded, symmetrical corms that are encased in several layers of brownish, fibrous tunics. When planting a single corm, it gives rise to 2-3 emerging plants, each bearing its own striking beauty. With each growing season, a new corm grows over the mother corm. Cormels are formed at the tips of branched stolons that develop from buds at the base of the mother corm.

Varanasi region of Uttar Pradesh experienced substantial temperature variations during the experimental period, making it a pivotal factor in gladiolus cultivation. The oscillation between sunny and foggy days had diverse effects on the vegetative and flowering phases of different gladiolus varieties. It is quite necessary to evaluate different gladiolus varieties suitable for this region. Hence, the present experiment was conducted to study the relative performance of fifty varieties of gladiolus for their different growth, flowering and yield parameters.

Materials and Methods

Fifty varieties of gladiolus were evaluated for growth, flowering and yield parameters at the Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the year 2022-2023, which is geographically located at 25.2677° N latitudes and 82.9913° E longitudes and an altitude of 128.93 m above mean sea level. Experiment was laid out in Randomized Block Design with three replications. Varieties used in the experiment were American Beauty, Arka Aarti, Arka Aayush, Arka Amar, Arka Darshan, Arka Kesar, Arka Nazrana, Arka Poonam, Arka Pratham, Arka Tilak, Chandni, Dhanvantari, Flevo Souvenir, Green Star, Gulal, Hunting Song, IIHR, Jyotsana, Lemon Beauty, Malaviya Kiran, Malaviya Kundan, Malaviya Shatabdi, Manorma, MD-1, Mohini, MS-1, Novalux, Pink City, Pink Friendship, Plum Tart, Priscilla, Pusa Kiran, Pusa Manmohak, Pusa Shubham, Pusa Srijana, Pusa Swarnima, Red Beauty, Regency, Shabnam, Shubhangini, SM-1, SM-2, Snow Princess, Sunayana, Tiger Flame, True Love, Urmi, Urvashi, Yellow Jester, Yellow Star. The field preparation process commenced with the incorporation of well-rotted farmyard manure (FYM) @ 5 tonnes/ha. To safeguard against fusarium wilt disease, a preventative measure was taken by thoroughly cleaning the corms. Subsequently, the corms were subjected to a treatment with copper fungicide @ 0.1% SAAF solution for 20 minutes. Planting involved the use of healthy and uniformly sized corms from various gladiolus varieties. These corms were planted at a spacing of 30 cm × 20 cm. Throughout the cultivation period, essential operations such as irrigation and intercultural practices (weeding, earthing up and plant protection measures) were carried out as and when needed. The study involved the systematic collection of data on various growth and flowering attributes which were then subjected to statistical analysis for meaningful insights and conclusions.

Results and Discussion

Significant differences due to varieties was observed for different growth parameters (Table 1). The highest number of sprouts per hill was exhibited by variety Arka Amar (2.53) followed by cultivar IIHR (2.33). These differences can be attributed to variations in the genetic constitution of the varieties as well as the presence of specific promoters and inhibitors of development, considering uniform meteorological conditions and cultivation practices (Baruah and Bora, 2022) [3]. Maximum plant height was recorded by variety Dhanvantari (72.05 cm) which was found to be statistically significant to all other varieties Jyotsana (70.77 cm), Gulal (69.94 cm), Sunayana (69.13 cm), Mohini (68.97 cm). These height differences within varieties were also observed in previous studies conducted by Sumi *et al*. (2021), Bhat *et al*. (2016) [18]. Since, plants may vary in height as they compete for light, space, moisture, nutrition, and ventilation (Azimi, 2020) [1] as well as other environmental factors (Singh *et al*., 2020) [17]. Plant height is an essential trait as it influences spike length and floret numbers, contributing to spike quality (Kadam *et al*., 2014) [7].

The variety Sunayana (3.83 cm) was reported for maximum leaf width which was statistically significant to varieties American beauty (3.67 cm), Snow Princess (3.43 cm) and Shubhangini (3.28 cm). The differences in leaf width can be attributed to genetic makeup variations among the varieties or higher rates of photosynthesis activities which promote cell division, proliferation and enlargement, resulting in larger leaves (Nagar *et al*., 2018) [11]. Similar results have been reported by Kumawat *et al*. (2018) [9] and Swaroop *et al*. (2005) [20]. The differences vary significantly for the flowering characters which is under consideration (Table 2). The minimum days to colour show of 3rd floret was reported by variety Chandni (82.40 days) which was statistically significant to all other varieties Arka Pratham (83.43 days), American Beauty (85.03 days), Plum Tart (86.68 days) and Snow Princess (86.80 cm). Early colour show of 5th floret was reported by variety Chandni (83.17 days) which is statistically significant to rest of the varieties. Variety Chandni took the minimum number of days to opening of 3rd floret (85.59 days) and opening of 5th floret (86.24 days). Late withering of 3rd floret was observed by the cultivar Arka Darshan (108.80 days). The maximum number of days to withering of 5th floret was also recorded under variety Arka Darshan (109.80 days) which was statistically significant to varieties Tiger Flame (109.58 days), Pusa Swarnima (105.80 days), Manorma (104.98 days). Variety American Beauty was recorded for maximum diameter of 3rd floret (10.73 cm) as well as 5th floret (10.51 cm).

For yield attributes, significant difference due to varieties was observed (Table 3). The maximum number of corms per hill was observed with variety Pusa Shubham (3.00), whereas, the maximum weight of corms per hill was observed with variety Sunayana (55.70 g) which was significant to all other varieties. Maximum number of cormels per hill (72.13) and weight of cormels per hill (13.37 g) was recorded by variety Shubhangini. Number, size and weight of cormels produced per plant may vary from variety to variety due to variation in their genetic makeup. Results are in confirmation with the findings of Mehra *et al*. (2016) [10], Kaur and Bajpay (2019) [8], Nalage *et al*. (2019) [12], Safeena and Thangam *et al*. (2019) [13]. The maximum diameter of corm was recorded by variety Urvashi (60.00 mm), followed by Regency (55.33 mm) and American Beauty (53.97 mm) whereas, minimum diameter was observed by the variety Arka Aarti (27.93 mm). Corms with more diameter typically have more stored energy reserves which can provide a strong start for the growing plant. This stored energy helps the plant establish healthy roots and initiate vigorous vegetative and reproductive growth. Corms that are both healthy and have a significant weight can better withstand adverse conditions and recover more effectively after periods of stress. Similar findings observed by the workers Azimi and Banijamali (2019) [1], Nalage *et al*. (2019) [12], Safeena and Thangam (2019) [13], Choudhary *et al*. (2011) [5], Saleem *et al*. (2013) [14] and Kadam *et al*. (2014) [7]. Different varieties responded or interacted differently with different soil and climatic conditions depending on their genetic composition. Since corm size influences corm production, the availability of more nutritional material stored in larger mother corms may have contributed to greater plant growth (Swaroop *et al*., 2019) [19]. Over time, the corms planted may produce daughter corms/cormels that lead to the multiplication of corms and cormels and increased flower production in subsequent years.

Table 1: Performance of gladiolus varieties for growth attributes

Treatments	Number of sprouts per hill	Plant Height (cm)	Leaf width (cm)
American Beauty	1.2	68.04	3.67
Arka Aarti	1.53	54.2	2.1
Arka Aayush	1.33	53.8	2.3
Arka Amar	2.53	65.59	3.19
Arka Darshan	1.87	50.66	3.12
Arka Kesar	1.33	54.69	2.43
Arka Nazrana	1.27	54.65	2.78
Arka Poonam	1.07	53.02	2.27
Arka Pratham	1.33	64.23	3.26
Arka Tilak	1.3	54.92	2.5
Chandni	2.2	59.51	2.55
Dhanvantari	2.13	72.05	2.94
Flevo Souvenir	1.4	59.35	2.95
Green Star	1.33	62.18	3.36
Gulal	1.33	69.94	3.15
Hunting Song	1.8	61.72	2.97
IIHR	2.33	54.04	2.37
Jyotsana	1.27	70.77	2.79
Lemon Beauty	1.4	63.03	2.62
MD-1	1.13	53.02	2.47
Malaviya Kiran	2.33	56.61	2.12
Malaviya Kundan	2	59.01	3.09
Malaviya Shatabdi	1.2	60.33	2.34
Manorma	1.07	51.1	2.63
Mohini	1.47	68.97	2.83
MS-1	1.27	57.6	2.62
Novalux	1.73	64.97	3.26
Pink City	1	54.43	2.82
Pink Friendship	1	57.61	2.27
Plum Tart	1.4	63.52	2.39
Priscilla	1.53	67.7	2.85
Pusa Kiran	1.4	59.61	3.15
Pusa Manmohak	1.33	66.63	2.93
Pusa Shubham	1.4	55.47	2.77
Pusa Srijana	1.07	52.29	3.09
Pusa Swarnima	1.4	69.13	2.99
Red Beauty	1.2	68.13	2.92
Regency	1.2	61.19	3.09
Shabnam	1.42	63.01	2.26
Shubhangini	2.33	53.82	3.28
SM-1	1.2	62.88	2.5
SM-2	1.33	55.63	2.52
Snow Princess	1.8	57.63	3.43
Sunayana	2.2	64.65	3.83
Tiger Flame	1.53	63.75	2.85
True Love	1.33	54.43	3.12
Urmi	1.53	66.55	3.11
Urvashi	1.4	63.52	2.64
Yellow Jester	1.4	54.29	2.84
Yellow Star	1.37	63.41	3.11
C.D. (5%)	0.4	2.087	0.216

Table 2: Performance of gladiolus varieties for flowering attributes

Treatments	Days to colour show of 3rd floret	Days to colour show of 5th floret	Days to opening of 3rd floret	Days to opening of 5th floret	Days to withering of 3rd floret	Days to withering of 5th floret	Diameter of 3rd floret (cm)	Diameter of 5th floret (cm)
American Beauty	85.03	86.07	87.98	88.91	90.61	91.61	10.73	10.51
Arka Aarti	97.45	98.37	100.5	101.56	103.61	104.61	8.19	7.95
Arka Aayush	93.72	94.37	96.17	97.02	98.86	99.93	9.47	9.2
Arka Amar	93.66	94.99	96.82	97.88	99.6	100.6	10.11	9.88
Arka Darshan	102.76	103.68	105.62	106.58	108.8	109.8	10.15	9.83
Arka Kesar	90.48	91.7	93.46	94.23	96	97	9.93	9.67
Arka Nazrana	94.6	95.35	96.31	97.47	99.49	100.49	10.21	9.93
Arka Poonam	97.84	98.9	100.71	101.81	103.97	104.97	10.23	10.13

Arka Pratham	83.43	84.5	86.04	87.46	88.83	90.05	10.41	10.24
Arka Tilak	95.4	96.66	98.58	99.52	101.6	102.6	7.35	7.05
Chandni	82.4	83.17	85.59	86.24	88.72	89.72	9.19	8.97
Dhanvantari	94.69	95.45	97.59	98.26	100.56	101.56	9.37	9.09
Flevo Souvenir	96.97	98.39	100.18	101.43	103.1	104.1	9.95	9.65
Green Star	93.36	94.34	96.08	97.19	99	100.17	10.29	9.83
Gulal	92.36	93.8	95.49	96.57	98.57	99.57	10.21	9.95
Hunting Song	89.24	90.5	91.96	93.21	94.95	95.95	10.2	9.67
IIHR	90.63	91.89	93.92	95.06	96.93	97.93	9.98	9.71
Jyotsana	90.13	91.25	93.11	94.28	96.02	97.02	9.45	9.03
Lemon Beauty	91.77	92.89	95.05	96.07	97.86	98.86	8.86	8.51
MD-1	95.96	96.81	99.1	99.92	101.97	102.08	9.22	8.97
Malaviya Kiran	94.75	95.79	97.48	98.77	100.58	101.58	8.03	7.81
Malaviya Kundan	93.51	94.62	96.36	97.64	99.71	100.71	10.29	9.99
Malaviya Shatabdi	92.83	93.79	95.78	96.79	98.87	99.87	8.56	8.26
Manorma	97.05	97.92	100.49	102.39	103.71	104.98	10.03	9.73
Mohini	90.14	91.32	93.2	94.05	96.09	97.09	10.33	10.06
MS-1	96.43	97.44	99.35	100.58	102.28	103.28	9.85	9.59
Novalux	96.77	97.46	99.41	100.59	102.5	103.5	10.13	9.6
Pink City	92.17	94.02	96.76	97.41	99.28	100.28	9.71	9.53
Pink Friendship	95.41	96.53	98.59	99.81	101.61	102.61	9.9	9.63
Plum Tart	86.68	87.28	89.26	90.59	92.63	93.63	9.31	9.02
Priscilla	90.81	91.94	93.8	95	97.08	98.08	10.22	9.54
Pusa Kiran	90.71	92.04	93.85	94.83	96.72	97.72	10	9.43
Pusa Manmohak	94.47	96.25	97.92	99.14	101.43	102.43	9.46	9.17
Pusa Shubham	93.48	94.48	96.57	97.31	99.72	100.72	9.56	9.31
Pusa Srijana	89.18	90.17	92.24	93.09	95.21	96.21	10.15	9.88
Pusa Swarnima	98.78	99.78	101.89	102.94	104.8	105.8	9.65	9.36
Red Beauty	93.36	94.58	96.59	97.64	99.72	100.72	10.04	9.76
Regency	91.74	92.66	94.47	95.56	97.89	98.89	10.37	10.17
Shabnam	97.15	98.12	100.39	101.58	103.68	104.68	9.51	9.42
Shubhangini	91.04	92.29	94.22	95.1	97.18	98.18	10.29	10.06
SM-1	92.79	93.58	95.67	96.57	98.91	99.91	9.6	9.16
SM-2	93.59	94.23	96.71	97.6	99.53	100.53	9.55	9.12
Snow Princess	86.8	87.74	89.89	91.06	93.09	94.09	10.63	10.4
Sunayana	88.03	89.27	91.39	92.28	94.09	95.09	10.25	10.11
Tiger Flame	102.29	103.53	105.39	106.53	108.58	109.58	10.02	9.8
True Love	93.82	94.94	96.88	97.6	99.88	100.88	10.08	9.87
Urmi	91.66	93.2	94.92	95.92	97.98	98.98	10.15	9.89
Urvashi	90.34	91.44	93.2	94.51	96.45	97.45	9.74	9.53
Yellow Jester	91.62	93.13	94.68	95.88	98.23	99.23	10.27	10
Yellow Star	87.18	88.13	90.17	91.16	93.24	94.24	9.95	9.63
C.D. (5%)	1.667	1.773	1.717	1.756	1.772	1.806	0.258	0.274

Table 3: Performance of gladiolus varieties for yield attributes

Treatments	No. of corms/hill	Weight of corms/hill (g)	Diameter of corms (mm)	No. of cormels/hill	Weight of cormels/hill (g)
American Beauty	1.07	48.34	53.97	9.40	1.62
Arka Aarti	1.33	11.13	27.93	4.33	3.69
Arka Aayush	1.20	11.61	32.63	3.33	0.88
Arka Amar	1.60	45.65	44.57	30.40	8.36
Arka Darshan	1.27	11.47	36.33	17.13	8.10
Arka Kesar	1.07	19.77	36.93	18.32	6.26
Arka Nazrana	1.07	20.66	44.60	8.00	2.74
Arka Poonam	1.13	28.17	38.60	1.33	0.15
Arka Pratham	1.30	13.05	42.73	23.75	4.42
Arka Tilak	1.35	16.12	46.27	5.30	1.23
Chandni	1.40	24.90	39.67	17.24	2.59
Dhanvantari	1.33	33.45	47.50	6.53	1.60
Flevo Souvenir	1.17	26.05	37.20	8.78	2.61
Green Star	1.13	16.33	34.33	4.80	1.61
Gulal	1.13	26.13	36.83	1.67	0.12
Hunting Song	1.80	44.48	42.10	24.93	6.09
IIHR	1.33	20.96	36.37	12.33	3.00
Jyotsana	1.13	25.59	37.87	9.07	1.89
Lemon Beauty	1.50	32.13	42.80	6.27	1.70
MD-1	2.37	24.98	29.63	11.89	1.12

Malaviya Kiran	2.07	18.40	33.00	30.33	7.73
Malaviya Kundan	2.93	20.65	37.27	10.53	1.96
Malaviya Shatabdi	1.33	20.08	35.00	1.27	0.09
Manorma	1.13	18.76	42.90	3.25	0.84
Mohini	1.53	48.13	48.40	11.53	4.34
MS-1	1.43	23.99	37.63	9.85	1.81
Novalux	1.67	36.67	47.73	11.73	2.72
Pink City	1.20	19.01	32.70	14.20	1.21
Pink Friendship	1.39	27.34	44.93	5.83	1.63
Plum Tart	1.52	26.63	42.27	3.93	1.90
Priscilla	1.15	25.66	43.37	16.47	3.72
Pusa Kiran	1.33	27.75	40.37	8.00	1.44
Pusa Manmohak	1.27	23.58	38.10	12.13	1.82
Pusa Shubham	3.00	45.51	32.50	4.89	1.57
Pusa Srijana	1.07	16.56	42.03	4.62	1.28
Pusa Swarnima	1.73	48.77	45.13	17.53	2.95
Red Beauty	1.27	33.06	43.70	12.20	1.89
Regency	1.27	37.11	55.33	23.27	9.65
Shabnam	1.21	20.63	42.63	7.31	2.59
Shubhangini	1.13	37.47	47.13	72.13	13.37
SM-1	1.40	20.47	34.37	7.53	2.11
SM-2	1.07	24.19	32.13	13.60	3.12
Snow Princess	1.00	28.87	48.00	25.20	4.81
Sunayana	1.80	55.71	46.27	33.66	3.66
Tiger Flame	1.13	16.89	36.07	7.27	1.31
True Love	1.20	20.08	43.37	3.60	1.47
Urmi	1.60	33.50	46.27	15.20	3.80
Urvashi	1.67	37.82	60.00	14.83	3.21
Yellow Jester	1.40	29.60	45.70	37.33	4.87
Yellow Star	1.23	40.54	42.10	10.67	2.96
C.D. (5%)	0.43	9.47	0.49	4.38	0.84

Conclusion

Considering specific attributes can lead to the development of a prospective gladiolus variety suitable under Varanasi region. It is important to note that more sprouts per hill means more flowering stems and consequently, a higher yield of gladiolus flowers per plant. This is particularly important for commercial growers aiming to maximize their production. Plants with greater height typically produce longer flower spikes and thus are desirable for cut flowers, as they provide more options for floral arrangements and increase the overall value of the gladiolus as a cut flower. Varieties with more leaf width can provide structural support to the plant by capturing more sunlight and wind. Wider leaves generally have a larger surface area for photosynthesis which is critical for producing energy and nutrients that support the growth of the plant. Varieties that provide earlier opening of florets allows to enjoy their vibrant colours sooner and provide the ability to time harvests for peak market demand resulting in higher prices for gladiolus produce. This strategic approach bolsters the economic viability of gladiolus cultivation.

While evaluating growth, flowering, and yield characteristics, it becomes clear that certain gladiolus varieties stand out as ideal choices for commercial production in the Varanasi region. American Beauty, Arka Amar, Chandni, Dhanvantari, Jyotsana, Malaviya Kiran, Malaviya Kundan, Malaviya Shatabdi, Mohini, Pusa Manmohak, Pusa Shubham, Pusa Swarnima, Regency, Shubhangini has shown exceptional promise for commercial production. Their ability to thrive in Varanasi's unique climate makes them top choices for growers pursuing commercial gladiolus cultivation in the region.

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