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Evaluation of ICAR-IIHR-developed Gladiolus Cultivars under Rainy-season Conditions in Hajo, Kamrup District, Assam, India

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Authors' contributions

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

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Abstract

Gladiolus is an important cut-flower crop whose commercial performance depends strongly on cultivar adaptation to the production environment. The present study evaluated six gladiolus cultivars developed by ICAR-Indian Institute of Horticultural Research (ICAR-IIHR)—Arka Amar, Arka Aayush, Arka Kesar, Arka Arati, Arka Tilak, and Arka Gold—against a local cultivar under rainy-season conditions in the Hajo region of Kamrup district, Assam. Planting was undertaken in July 2024 at Kulhati, Pakarkona, and Bongshar, and the study was analysed using a randomised block design with seven treatments and three

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replications, with the three locations serving as replications in the reported analysis. Corms were planted at 30 cm × 20 cm spacing under open-field conditions and managed uniformly. Five floral traits were evaluated: days to spike emergence, spike length, rachis length, number of florets per spike, and floret size. Significant varietal differences were recorded for the measured traits. Arka Amar showed the earliest spike emergence (65.5 days), the longest spike (88.5 cm), the longest rachis (72.4 cm), the highest number of florets per spike (15.4), and the largest numerical floret size (8.9 cm). Relative to the local cultivar, Arka Amar reached spike emergence 26.0% earlier and recorded increases of 37.4% in spike length, 44.2% in rachis length, 35.1% in florets per spike, and 18.7% in floret size. Arka Aayush and Arka Kesar also performed well for several floral traits. No visible Fusarium wilt symptoms were noted during routine field observation; however, no quantitative disease-screening protocol was included, and the observation therefore cannot be interpreted as evidence of resistance. The findings indicate that Arka Amar is a promising cultivar for rainy-season cut-flower production in the tested Hajo locations, while multi-season validation would strengthen recommendations for wider cultivation in Assam.

Keywords: Arka Amar; cut flower; floral traits; floriculture; Gladiolus; rainy season; varietal evaluation.

1. Introduction

Gladiolus (*Gladiolus × grandiflorus* Hort.) is a commercially important geophytic ornamental crop valued primarily for its long flowering spikes, wide range of floret colours, sequential opening of florets, and suitability for cut-flower use. Commercial quality is determined not by a single character but by a combination of earliness, spike length, rachis length, number of florets, floret size, spike straightness, and postharvest performance. Because these traits differ substantially among cultivars, regional evaluation is a necessary step before recommending planting material for commercial production. Studies conducted across India have repeatedly demonstrated significant cultivar-to-cultivar variation in flowering and yield attributes, confirming the practical importance of matching genotype with the production environment (Bhatt *et al*., 2015; Singh *et al*., 2017; Patel *et al*., 2022; Maurya *et al*., 2025).

Cultivar performance in gladiolus is influenced by both genetic constitution and environmental conditions. Large differences in days to spike initiation, spike length, rachis length, floret number, and floret diameter have been documented among genotypes grown under common field conditions (Bhatt *et al*., 2015; Momin *et al*., 2017). At the same time, flowering phenology is responsive to temperature and moisture, and the sensitivity of developing spikes to environmental conditions means that the relative performance of cultivars may change across planting dates and locations. Early experimental work established that temperature and soil moisture affect gladiolus flowering and spike development (Shillo & Halevy, 1976). More recent crop-modelling research has similarly shown that cultivar and daily temperature are major determinants of gladiolus phenology across environments (Uhlmann *et al*., 2017), while field validation under subtropical Indian conditions has confirmed that planting date and temperature modify developmental timing among cultivars (Jhanji & Kaur, 2022). These findings provide a strong basis for location-specific assessment rather than assuming that a cultivar performing well in one region will maintain the same ranking elsewhere.

The northeastern region of India has substantial climatic diversity, and humid rainy-season conditions create a distinct production environment for bulbous ornamentals. Regional evidence also shows appreciable genetic variability in gladiolus. Momin *et al*. (2017), working in Meghalaya, reported wide variation in flowering traits among 22 gladiolus genotypes and found strong relationships among important cut-flower attributes. In Assam, Baruah and Bora (2022) evaluated seven cultivars under a paired-row system and documented cultivar-dependent differences in vegetative, floral, and multiplication characters. Such studies emphasise that varietal selection for northeastern India should be based on local performance data rather than on cultivar descriptions generated under dissimilar climates.

Disease pressure is another consideration in rainy-season gladiolus production. Fusarium wilt and corm rot caused by *Fusarium oxysporum* f. sp. *gladioli* can reduce plant establishment, flowering, corm quality, and survival. The pathogen is sufficiently important that controlled screening has been used to distinguish resistant, tolerant, and susceptible gladiolus genotypes. Taj *et al*. (2016) evaluated ICAR-IIHR genotypes against two geographically distinct Fusarium cultures and identified useful differences in disease response as well as agronomic performance. Kumari *et al*. (2016) further characterised resistant and susceptible material using molecular markers, whereas Kumari *et al*. (2019) quantified disease incidence and plant mortality after controlled inoculation. Field and pot studies have also shown that disease incidence can be modified by production practices such as crop rotation and co-cultivation (Riaz *et al*., 2009). Consequently, absence of visible symptoms in an unscreened field trial should be interpreted cautiously and should not be equated with formal disease resistance.

ICAR-IIHR has developed several gladiolus cultivars with desirable floral characteristics, including Arka Amar, Arka Aayush, Arka Kesar, Arka Arati, Arka Tilak, and Arka Gold. Several of these cultivars have shown strong performance in previous evaluations, but cultivar ranking is not uniform across regions. For example, Arka Amar has been associated with earliness and favourable floral characters in controlled evaluation (Taj *et al*., 2016), whereas a highland assessment in Wayanad reported particularly strong spike length and floret number for Arka Kesar, with Arka Amar ranking closely behind for several traits (Safia *et al*., 2024). Such differences are consistent with genotype-by-environment effects and reinforce the need for evaluation under the humid rainy-season conditions of Assam.

However, location-specific evidence remains limited on the rainy-season performance of ICAR-IIHR-developed gladiolus cultivars under the humid production conditions of Hajo, particularly when compared with a local cultivar using key floral-quality traits. This gap limits cultivar selection based on performance under the tested production environment.

The objective of the present study was therefore to compare six ICAR-IIHR-developed gladiolus cultivars with a local cultivar under rainy-season conditions in the Hajo region of Kamrup district, Assam, focusing on five floral traits directly relevant to cut-flower quality: days to spike emergence, spike length, rachis length, florets per spike, and floret size. The study also recorded the presence or absence of visible Fusarium wilt symptoms as a qualitative field observation, without treating this observation as a formal disease-resistance test.

2. Materials and Methods

2.1 Study Area and Experimental Treatments

The field evaluation was conducted by Krishi Vigyan Kendra (KVK), Kamrup, Assam Agricultural University, under the ICAR-IIHR North Eastern Hill (NEH) programme component. The experiment was undertaken during the rainy season of 2024 at three locations in the Hajo region of Kamrup district: Kulhati, Pakarkona, and Bongshar. The locations occur at approximately 58–87 m above mean sea level and represent the local production environment in which rainy-season gladiolus cultivation was being assessed.

Seven cultivar treatments were included. The six ICAR-IIHR-developed cultivars were Arka Amar (T1), Arka Aayush (T2), Arka Kesar (T3), Arka Arati (T4), Arka Tilak (T5), and Arka Gold (T6). A locally cultivated gladiolus type served as the local check (T0). The experiment was analysed using a randomised block design with seven treatments and three replications, with the three locations serving as replications in the reported analysis.

Planting was carried out in July 2024 under open-field conditions. Corms were planted at a row spacing of 30 cm and an intra-row spacing of 20 cm, corresponding to approximately 16 planting positions per square metre. A uniform package of crop-management practices was followed across treatments during the rainy season so that cultivar comparison was not confounded by differential management.

2.2 Data Collection

Five flowering variables were recorded: (1) days to spike emergence, expressed as days from planting to spike emergence; (2) spike length, measured in centimetres; (3) rachis length, measured in centimetres; (4) number of florets per spike; and (5) floret size, measured in centimetres. These variables were selected because the timing of spike emergence and the dimensional and numerical characteristics of the spike are routinely used to compare gladiolus cultivars for cut-flower performance (Bhatt *et al*., 2015; Singh *et al*., 2017; Patel *et al*., 2022). Visible symptoms consistent with Fusarium wilt were also noted during routine crop observation. Because the study did not include pathogen inoculation, disease-incidence scoring, severity ratings, pathogen isolation, or a susceptible disease-control treatment, this observation was treated only as a qualitative field record.

2.3 Statistical Analysis

The recorded floral data were subjected to analysis of variance within the randomised block design framework. Treatment effects were evaluated by the F test, and critical difference (CD) values at the 5% probability level were used for pairwise interpretation of treatment means. Standard error of difference (SED) values were also calculated. The values reported in Table 1 represent treatment means across the three replications.

3. Results

Varietal effects were evident for all five recorded floral traits (Table 1; Fig. 1). The magnitude and direction of the differences consistently favoured several ICAR-IIHR cultivars over the local check, although the best-performing cultivar depended on the trait considered.

Table 1. Flowering parameters of ICAR-IIHR gladiolus cultivars and the local check under rainy-season conditions in Hajo, Kamrup district, Assam

Cultivar (Treatment)	Spike Emergence (Days)	Spike Length (cm)	Rachis Length (cm)	Florets Per Spike (no.)	Floret Size (cm)
Arka Amar (T1)	65.5	88.5	72.4	15.4	8.9
Arka Aayush (T2)	69.7	87.5	70.2	14.4	8.8
Arka Kesar (T3)	67.5	85.3	69.3	14.1	8.6
Arka Arati (T4)	78.4	72.6	52.3	12.5	7.7
Arka Tilak (T5)	75.5	67.4	51.4	12.3	8.2
Arka Gold (T6)	75.5	68.2	52.5	13.4	8.4
Local (T0)	88.5	64.4	50.2	11.4	7.5
CD (5%)	**0.44**	**0.3**	**0.41**	**0.42**	**0.34**
SED	**0.2**	**0.14**	**0.19**	**0.19**	**0.15**

Note. CD = critical difference; SED = standard error of difference. Values are treatment means across three replications (locations)

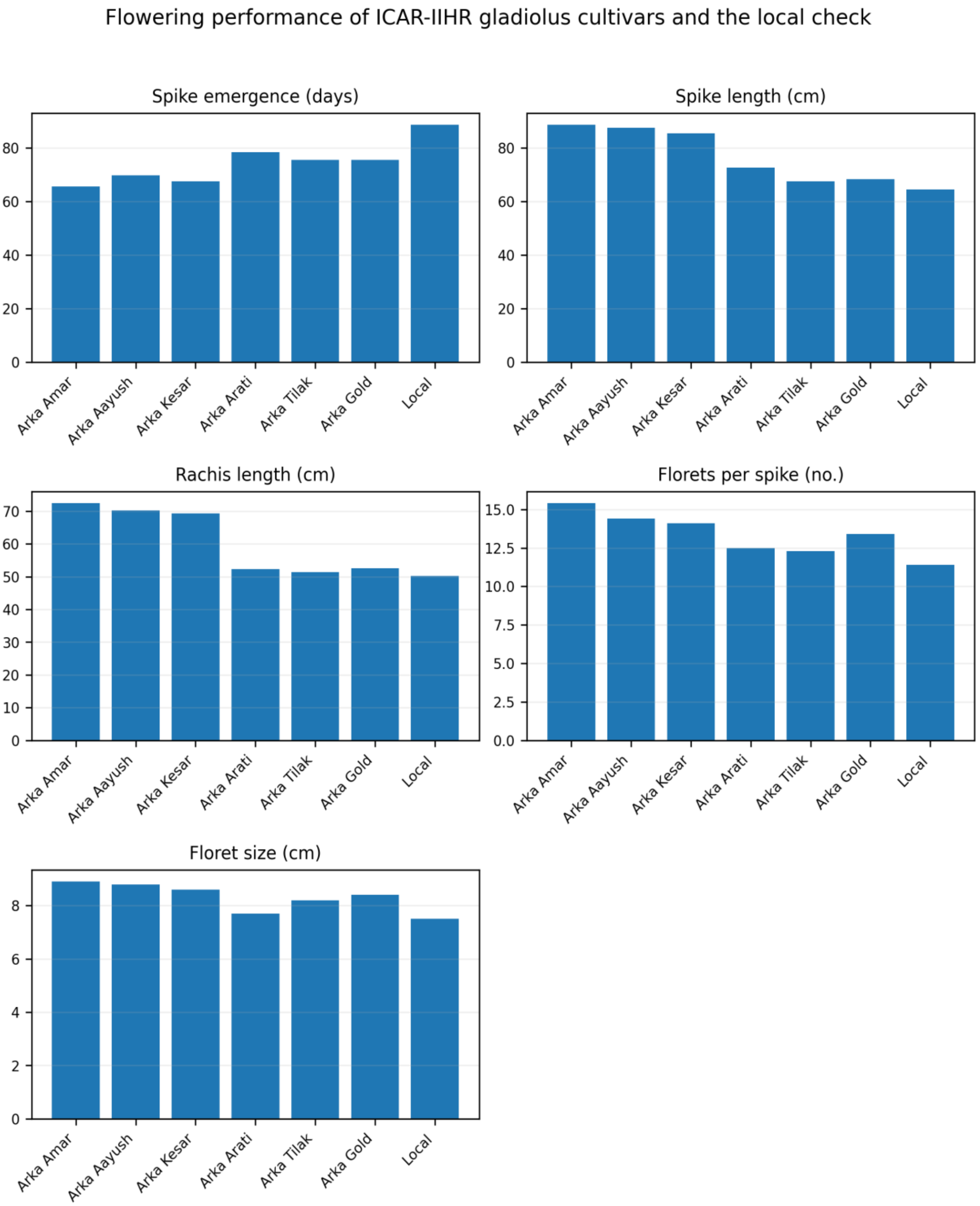

Fig. 1. Graphical representation of flowering parameters of ICAR-IIHR gladiolus cultivars and the local check. Each panel is shown on its own scale to preserve the original variables while improving readability

Days to spike emergence ranged from 65.5 to 88.5 days. Arka Amar was the earliest cultivar, reaching spike emergence in 65.5 days, followed by Arka Kesar at 67.5 days and Arka Aayush at 69.7 days. Arka Tilak and Arka Gold both required 75.5 days and were at par with each other for this trait. Arka Arati required 78.4 days, while the local cultivar was the latest at 88.5 days. Based on the reported CD of 0.44 day, the difference between Arka Amar and each of the other cultivars was significant. Relative to the local cultivar, Arka Amar reduced the time to spike emergence by 23.0 days, equivalent to 26.0% earlier emergence.

Spike length showed a range of 64.4–88.5 cm. Arka Amar produced the longest spikes (88.5 cm), followed by Arka Aayush (87.5 cm) and Arka Kesar (85.3 cm). Arka Arati recorded 72.6 cm, Arka Gold 68.2 cm, Arka Tilak 67.4 cm, and the local cultivar 64.4 cm. With a reported CD of 0.30 cm, the difference between Arka Amar and the other treatments exceeded the threshold for significance. Compared with the local cultivar, Arka Amar produced spikes that were 24.1 cm longer, representing a 37.4% increase.

Rachis length followed a broadly similar pattern. Arka Amar recorded the longest rachis (72.4 cm), followed by Arka Aayush (70.2 cm) and Arka Kesar (69.3 cm). The values for Arka Gold (52.5 cm) and Arka Arati (52.3 cm) differed by only 0.2 cm and were therefore at par at the reported CD of 0.41 cm. Arka Tilak recorded a rachis length of 51.4 cm and the local cultivar 50.2 cm. The rachis of Arka Amar was 22.2 cm longer than that of the local check, an improvement of 44.2%.

The number of florets per spike varied from 11.4 in the local cultivar to 15.4 in Arka Amar. Arka Aayush produced 14.4 florets per spike and Arka Kesar 14.1; the 0.3-floret difference between these two cultivars was below the reported CD of 0.42 and they were therefore statistically comparable. Arka Gold produced 13.4 florets per spike. Arka Arati and Arka Tilak produced 12.5 and 12.3 florets per spike, respectively, and these two treatments were also at par. Arka Amar exceeded the local cultivar by 4.0 florets per spike, corresponding to a 35.1% increase.

Floret size ranged from 7.5 to 8.9 cm. Arka Amar had the highest numerical value (8.9 cm), closely followed by Arka Aayush (8.8 cm) and Arka Kesar (8.6 cm). The pairwise differences among these three cultivars were below the reported CD of 0.34 cm, indicating that they were statistically comparable for floret size. Arka Gold recorded 8.4 cm, Arka Tilak 8.2 cm, Arka Arati 7.7 cm, and the local cultivar 7.5 cm. The numerical advantage of Arka Amar over the local cultivar was 1.4 cm, or 18.7%.

No visible symptoms of Fusarium wilt were observed during routine field inspection of the rainy-season crop. Because Fusarium incidence and severity were not quantified and the causal pathogen was not isolated or experimentally introduced, this observation is reported descriptively and is not used to classify any cultivar as resistant or tolerant.

4. Discussion

The present evaluation demonstrates substantial varietal variation in floral performance under the rainy-season conditions tested in Hajo. The advantage of Arka Amar was especially consistent: it was earliest for spike emergence and had the highest mean values for spike length, rachis length, florets per spike, and floret size. Such simultaneous superiority across several cut-flower characters is agronomically relevant because commercial suitability depends on a combination of phenological and quality traits rather than on a single measurement. Significant cultivar differences for these same classes of characters have been reported in multiple Indian environments, including Gujarat, eastern Uttar Pradesh, Bundelkhand, and the northeastern hills (Bhatt *et al*., 2015; Singh *et al*., 2017; Momin *et al*., 2017; Patel *et al*., 2022). The present results therefore fit the broader evidence that gladiolus cultivars express marked phenotypic differences when grown under a common management regime.

Earliness is particularly useful in cut-flower production because it affects harvest scheduling, market timing, and the possibility of staggering plantings. Arka Amar reached spike emergence in 65.5 days, 23 days earlier than the local cultivar. This result is directionally consistent with the performance reported by Taj *et al*. (2016), who found Arka Amar among the earlier ICAR-IIHR genotypes for spike emergence and first-floret opening. The exact number of days to a developmental stage should not be expected to remain constant across environments. Gladiolus phenology is strongly temperature dependent, and moisture conditions can also influence flowering (Shillo & Halevy, 1976). The PhenoGlad framework developed by Uhlmann *et al*. (2017) explicitly incorporates cultivar-specific temperature responses to predict developmental stages, and Jhanji and Kaur (2022) demonstrated under subtropical Punjab conditions that planting date altered the time required by different varieties to reach phenological stages. Thus, the relatively early performance of Arka Amar in Hajo is best interpreted as a favourable cultivar response within the 2024 rainy-season environment rather than as a fixed cultivar constant.

Spike and rachis lengths are major visual and handling attributes of gladiolus cut flowers. In this study, Arka Amar recorded an 88.5 cm spike and a 72.4 cm rachis, substantially exceeding the local check. Earlier Indian work has likewise shown that both traits are highly cultivar dependent. Bhatt *et al*. (2015) reported significant differences in spike and rachis length among 16 cultivars under south Gujarat conditions, while Singh *et al*. (2017) and Patel *et al*. (2022) documented distinct cultivar rankings under eastern Uttar Pradesh and Banda conditions, respectively. The regional variability in cultivar rankings is important. Safia *et al*. (2024), for example, recorded the longest spike in Arka Kesar under Wayanad highland conditions, with Arka Amar ranking closely behind. In the present rainy-season Hajo evaluation, Arka Amar slightly exceeded Arka Kesar for spike length. The contrast illustrates why cultivar recommendation should be based on performance in the target environment and why results from one agroclimatic region should not be transferred uncritically to another.

The number and size of florets are also central to spike quality because they influence visual fullness and display value. Arka Amar produced the highest number of florets per spike (15.4), while Arka Aayush and Arka Kesar formed the next statistical group. This pattern is broadly compatible with earlier evidence that Arka Amar can combine favourable floral characters with relatively high flower production (Taj *et al*., 2016). However, the Wayanad study by Safia *et al*. (2024) found a higher floret number in Arka Kesar than in Arka Amar. Again, the differing rank order suggests environmental modulation of genotype expression rather than a contradiction between experiments. The present floret-size results also illustrate the importance of statistical rather than purely numerical ranking. Although Arka Amar had the largest numerical floret size at 8.9 cm, Arka Aayush at 8.8 cm and Arka Kesar at

8.6 cm were not significantly different at the reported CD. For cultivar recommendations, these three may therefore be regarded as similarly strong with respect to floret diameter under the tested conditions.

The local cultivar was consistently later and produced shorter spikes and rachises, fewer florets, and smaller florets than the strongest ICAR-IIHR entries. The magnitude of the differences was substantial, especially for spike and rachis length. This comparison is useful because local checks provide a practical benchmark against which introduced cultivars can be judged. Nevertheless, superiority for the five measured floral traits should not be interpreted as complete agronomic superiority. The present experiment did not report marketable spike yield per unit area, vase life, corm and cormel multiplication, lodging, economic returns, or long-term planting-material performance. Other varietal evaluations have shown that cultivars can differ independently for flowering, corm production, and postharvest traits (Baruah & Bora, 2022; Maurya *et al*., 2025). Consequently, the recommendation arising from the present study is specifically about rainy-season floral performance rather than all dimensions of commercial value.

An additional point is that the measured traits should be considered together when interpreting practical value. Earliness alone does not guarantee a high-quality spike, and a long spike is not necessarily accompanied by a long rachis or a high floret count in every genotype. The present dataset is notable because Arka Amar ranked strongly across all five measured characters, whereas several other cultivars showed more trait-specific performance. This multi-trait perspective is consistent with correlation and variability studies in gladiolus, which have shown that flowering and spike characters can be associated but still retain substantial independent genetic variation (Momin *et al*., 2017). It is also consistent with the Assam study of Baruah and Bora (2022), in which cultivar differences were expressed across vegetative, floral, and multiplication traits rather than through a single universal performance index. For growers, this means that cultivar choice should reflect the intended market and production objective. Where early harvest and visually substantial spikes are priorities, the combined performance of days to spike emergence, spike length, rachis length, and floret number becomes especially informative. Where planting-material multiplication or postharvest longevity is the main objective, additional traits not measured in the present trial would need to be considered before a final commercial recommendation is made.

The rainy-season context deserves particular attention. Gladiolus flowering can be affected by temperature, soil-water status, radiation, and interactions among these factors (Shillo & Halevy, 1976; Uhlmann *et al*., 2017). The trial was planted in July, when the production environment differs markedly from the cool-season conditions under which gladiolus is often evaluated elsewhere in India. The ability of Arka Amar, Arka Aayush, and Arka Kesar to maintain relatively long spikes and large florets under these conditions suggests useful adaptability. At the same time, weather variables were not analysed as experimental covariates, so the present data cannot identify which environmental factor caused the observed cultivar differences. Future multi-season evaluations that include temperature, rainfall, relative humidity, soil moisture, and soil characteristics would help distinguish stable cultivar performance from responses specific to a particular season.

The absence of visible Fusarium wilt symptoms should be interpreted separately from the floral-performance results. Controlled studies have established that meaningful assessment of Fusarium resistance requires deliberate pathogen exposure or, at minimum, quantitative disease-incidence and severity data. Taj *et al.* (2016) screened eight gladiolus genotypes against two cultures of *F. oxysporum* f. sp. *gladioli* and identified Arka Amar among genotypes combining useful floral attributes with disease resistance. Kumari *et al.* (2016) reported molecular markers associated with resistant and susceptible responses in gladiolus material that included Arka Amar and Arka Aayush. Kumari *et al.* (2019) subsequently used inoculated corms, replicated pot assays, disease-severity measures, and plant mortality to differentiate tolerance among 30 genotypes. Riaz *et al.* (2009) similarly quantified disease incidence when assessing corm-rot management. In comparison, the present trial recorded only whether visible symptoms appeared under natural field conditions. The lack of symptoms is encouraging from a crop-observation standpoint, but it cannot establish that inoculum was present or that a cultivar was resistant. Retaining this distinction avoids overinterpretation while remaining consistent with the published Fusarium literature.

From a practical standpoint, the results identify Arka Amar as the strongest overall cultivar among those tested for the measured flowering traits. Arka Aayush and Arka Kesar also merit attention because their spike lengths were close to that of Arka Amar and their floret sizes were statistically comparable. Arka Gold showed intermediate performance, while Arka Arati and Arka Tilak were generally later and shorter than the leading three ICAR-IIHR cultivars but still outperformed the local check for several traits. Such cultivar differentiation can support growers who require different combinations of earliness, spike dimensions, and floral display. The results should, however, be applied at the scale supported by the experiment: the three Hajo-area locations and the 2024 rainy season.

The study also has a design-related scope that is important when interpreting the findings. The three locations were treated as replications in the reported randomised-block analysis. This provides a comparative summary across the locations, but it does not constitute a formal multi-environment genotype-by-environment analysis. Repeating the same cultivar set over additional rainy seasons and, where possible, analysing location and season effects explicitly would permit stronger estimates of stability and wider adaptation. Such validation is especially important before extending a cultivar recommendation from Hajo to the whole of Assam. Within the present dataset, however, the direction and magnitude of the floral-trait differences, together with their consistency with several earlier cultivar-evaluation studies, support Arka Amar as a promising rainy-season option for further regional validation.

5. Conclusion

Six ICAR-IIHR-developed gladiolus cultivars and a local check differed significantly in floral performance under the 2024 rainy-season conditions of three locations in the Hajo region of Kamrup district, Assam. Arka Amar combined the earliest spike emergence with the longest spike and rachis, the highest number of florets per spike, and the largest numerical floret size. Arka Aayush and Arka Kesar also showed strong performance and were statistically comparable with Arka Amar for floret size. The local cultivar was later and inferior for all five measured floral traits. No visible Fusarium wilt symptoms were observed, but the absence of a formal disease-screening protocol means that resistance cannot be inferred from this observation. On the basis of the measured floral traits, Arka Amar is a promising cultivar for rainy-season cut-flower production in the tested Hajo locations. Multi-season and broader multi-location validation, together with quantitative disease assessment and additional commercial traits such as marketable spike yield, vase life, and corm multiplication, would strengthen recommendations for wider adoption in Assam.

6. Limitations

The study was conducted during a single rainy season at three Hajo-area locations, which were treated as replications in the reported randomised block analysis. Therefore, the results do not provide a formal multi-environment genotype-by-environment assessment. Weather and soil variables were not analysed as experimental covariates, and commercial traits such as marketable spike yield, vase life, corm multiplication, and economic returns were not evaluated. Fusarium wilt was recorded only through visible field observation without quantitative disease assessment or pathogen confirmation.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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