International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(5): 989-994
www.biochemjournal.com
Received: 02-03-2024
Accepted: 13-04-2024

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Response of herbal *kunapajala* on vegetative, flowering and corm attributes of gladiolus cv. Jessica

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DOI: https://doi.org/10.33545/26174693.2024.v8.i5l.1228

Abstract
Intensive farming in India has led to the deterioration of soil and ecology. Flower crops, with their high nutrient demands, are especially vulnerable to intensive farming methods. However, for sustainable alternatives has spurred a shift to organic practices, including the use of nettle grass and neem-based *Kunapajala*. To explore the efficacy of *Kunapajala*, an experiment was carried out to evaluate the response herbal *kunapajala*, on vegetative, flowering and corm attributes of Gladiolus cv. Jessica at Model Floriculture Centre, GBPUA&T, Pantnagar during 2019-20 and 2020-21. Thirteen treatments, including three *Kunapajala* compositions, were compared to a control (conventional fertilizers). Based on the results, 10% of KJ2 (nettle grass + seasonal weed-based KJ) at a dose of 150 mL/m^2 significantly improved flower yield, spike quality, and corm attributes. These results highlight the potential of ancient organic farming practices to enhance crop health and productivity, reducing reliance on chemical chemicals for sustainable agriculture in India.

Keywords: Herbal *kunapajala*, Nettle grass, Traditional knowledge, Vrikshayurveda, *Gladiolus grandiflorus*

Introduction
Amidst global challenges like environmental degradation and the COVID-19 pandemic, there's a growing inclination towards healthier lifestyles and organic products. Flower producers also seek natural alternatives to chemicals, focusing on environmental sustainability. Due to environmental concerns over excessive use of inorganic fertilizers and pesticides, interest in organic alternatives is rising. Kunapajala, an organic fertilizer from Vrikshayurveda, holds promise in this context. *Kunapajala* contains significant amounts of NPK which is crucial for plant growth and development (Ayangarya, 2008; Nene, 2018) [4, 15]. It enhances crop growth, productivity, disease resistance and soil microbial diversity (Sadhale, 1996) [20]. Nutrients in organic fertilizers are gradually released, ensuring sustained availability to crops (Neff *et al*., 2003) [14]. Incorporating extracts from plants such as *Urtica dioica*, *Azadirachta indica*, and *Clerodendron inermi* further reduces plant resilience and pests while improving soil microbial biomass.
Gladiolus (*Gladiolus grandiflorus*), the second most produced cut flower crop in India, accounts for 177.34 thousand MT out of 854 thousand MT total cut flower production in 2022-23 (Anonymous, 2024). Originally from South Africa, this bulbous flower is now grown across India, including Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, West Bengal, Karnataka, Tamil Nadu, and Maharashtra. Due to its popularity in bouquets and floral arrangements, the demand for gladiolus is steadily rising. However, being a heavy feeder crop, gladiolus has high nutrient requirements. There's limited research on the effects of herbal Kunapajala on flower crops like gladiolus. Therefore, experiment was carried out to evaluate the influence of herbal *Kunapajala* on vegetative and flowering attributes, as well as the production of corms and cormels in cut flowers.

Materials and Methods
The field study was carried out at the Model Floriculture Centre, Department of Horticulture, GBPUA&T, Pantnagar, Uttarakhand during 2019-20 and 2020-21. Gladiolus cv. Jessica corms (8-10 cm circumference) were planted at 30 cm x 20 cm spacing.

Three types of herbal *kunapajala* (KJ) *viz*., *Kunapajala* 1 (KJ1), *Kunapajala* 2 (KJ2) and *Kunapajala* 3 (KJ3) were prepared using various vegetations (Table 1). Ingredients were mixed in a 200L plastic drum, filled with water to about 180L, and stirred twice daily for 20 days until anaerobic fermentation was complete. The final product was filtered and stored for future use in dark place.

The field was prepared following standard gladiolus cultivation practices (Figure I). The research field was laid out in Randomized Block Design (RBD) with 13 treatments were replicated thrice. Before planting, 2 kg/m^2 of well-decomposed farmyard manure was applied to all treatments except the control. The 10% solution of herbal *kunapajala* is used through drenching in plots and corm treatment at planting (shade dried before planting). The foliar application of solutions was also sprayed at 20-25 days interval (Table 2). The control plot (T_{13}) received the recommended dose of fertilizers (RDF) of NPK (40:20:20 g/m^2), with 50% of N applied at planting and the rest 50%, 40 days later.

All the vegetative parameters were taken at 60 and 90 days after planting. Flowering attributes and vase life (days) was observed when lowest floret show colour. Days to flower emergence and flowering duration was taken from planting date and first flower opening date, respectively. All the data were statistically analysed by ANOVA through SPSS ver. 16 and the treatments were compared using the mean of critical difference at a significance level of 5%. The pooled analysis of the attributes of two-year study are presented in results.

Results

Response on Vegetative attributes

Treatment T_7 resulted in the tallest plant height, measuring 56.29 cm and 71.84 cm at 60 and 90 days after planting, respectively, showing significant differences from the control treatment, T_{13}, which had heights of 48.22 cm and 60.89 cm, respectively. Similar tendency was observed for growth parameters such as leaf number, length, and width. Treatment T_7 showed the highest leaf number (7.89), a 11.75% increase compared to the control (7.06) after 90 days. Additionally, T_7 exhibited a 25.64% increase in leaf length, reaching 27.14 cm, while the control had the shortest leaf length at 21.60 cm (Table 3). In treatment T_7, the widest leaf recorded was 21.37 mm and 22.71 mm at 60 and 90 days after planting, respectively, showing a 21.57% increase in length over the control (18.68 mm) by the end of the experiment. However, T_7 was statistically at par with T_8 (20.30 mm and 22.07 mm) at 60 and 90 days of planting, respectively (Table 3).

Response on Flowering attributes

Longer spike length (69.65 cm) was found in treatment T_7 which registered 18.97% increase in spike length compared to control (58.54 cm) having shortest spikes. The length was at par with T_8 with 68.56 cm spike length. Similar trend of results for rachis length was observed as the T_7 treatment shows maximum rachis length of 38.47 cm and control treatment T_{13} found smallest rachis length of 30.36 cm. Treatment T_7 recorded 12.64 florets per spike which were highest compared to all other treatments and was significantly more than the control (T_{13}) with the minimum florets numbers (9.34) (Fig. 2) (Table 4).

Treatment T_7 produced the earliest spike emergence (71.36 days). It was followed by the treatment T_8 (75.07 days) and T_6 (75.45 days). Whereas, delayed spike emergence (82.30 days) was noticed in control T_{13}. Minimum days taken to full bloom (97.39 days) were recorded in T_7, it was statistically at par with T_8 (99.62 days). T_{13} took longest time to reach full bloom (107.15 days). The data with respect to flowering duration that treatment T_7 (13.00 days) led to 33.60% increase in flowering duration than control treatment T_{13} which showed the shorter blooming period (9.73 days) (Fig. 4).

Vase life

T_7 (10.11 days) reported a significant 22.99% increase in vase life than control and found at par with T_8 (9.89 days), T_3 (9.78 days), T_6 (9.56 days) and T_4 (9.44 days). Whereas, control T_{13} exhibited significantly shorter vase life of 8.22 days (Fig. 4).

Response on Corm and Cormel attributes

Different doses of herbal *kunapajala* significantly affected corm weight. Treatment T_7 with 45.31 g corm weight exhibited a 44.80% increase compared to the control (31.29 g). T_7 was at par with T_8 having 44.13 corm weight. Treatment T_7 also resulted in the maximum corm diameter (5.19 cm) followed by T_8 (4.99 cm), whereas the control treatment T_1 had the minimum diameter (4.22 cm) (Table 4). *Kunapajala* treatments significantly influenced the number of cormels per plant (Figure 3). Treatment T_7 had highest cormels number per corm (9.67), significantly higher than rest of treatments. The treatment T_{13} had the lowest number of cormels per corm (5.33).

Discussion

Increase in vegetative growth is ascribed to the beneficial influence of diverse microbial populations such as rhizobium, phosphorus solubilizing bacteria (PSB) found in organic fertilizers (Chakraborty *et al.*, 2019) [9]. These microbial consortia stimulate cell division and elongation, enhancing nutritional assimilation and promoting increased meristematic area and biomass accumulation. Constituents like *Urtica dioca*, rich in micronutrients as iron, vitamins and antioxidants (Jan *et al.*, 2017) [11], along with neem leaves containing secondary metabolites like Azadirachtin and approximately 2.63% nitrogen content (Adeosun *et al*., 2023) [1], are believed to enhance vegetative growth. Nettle-based *Kunapajala* showed the highest chlorophyll content compared to other *Kunapajala* (Naik *et al.*, 2022) [13]. 10% *Kunapajala* led to early germination due to increased α-amylase activity, resulting in accelerated growth and flowering. These findings align with previous studies on ashwagandha and gladiolus, indicating *Kunapajala*'s efficacy in improving vegetative parameters (Ankad *et al*., 2017; Tamrakar *et al*., 2018) [2, 22].

Fermented fertilizers containing active phenolic compounds, which potentially inhibit oxidase activity and increasing the tenacity of IAA in plants, enhancing the florets number per spike in gladiolus (Sankari *et al*., 2015) [20]. *Kunapajala*, recognized as a source of plant growth promoters (Biswas and Das, 2023) [8], improves the crop quality, particularly in terms of stem and rachis length (Rajasree *et al.*, 2022) [17]. Organic fermented fertilizers reduce abscisic acid (ABA) concentration and increase the phosphorus availability (Phengphachanh *et al*., 2012) [16]. Improved flowering quality and fruiting have been observed in various vegetable crops with *Kunapajala* application (Beniwal, 2023) [6].

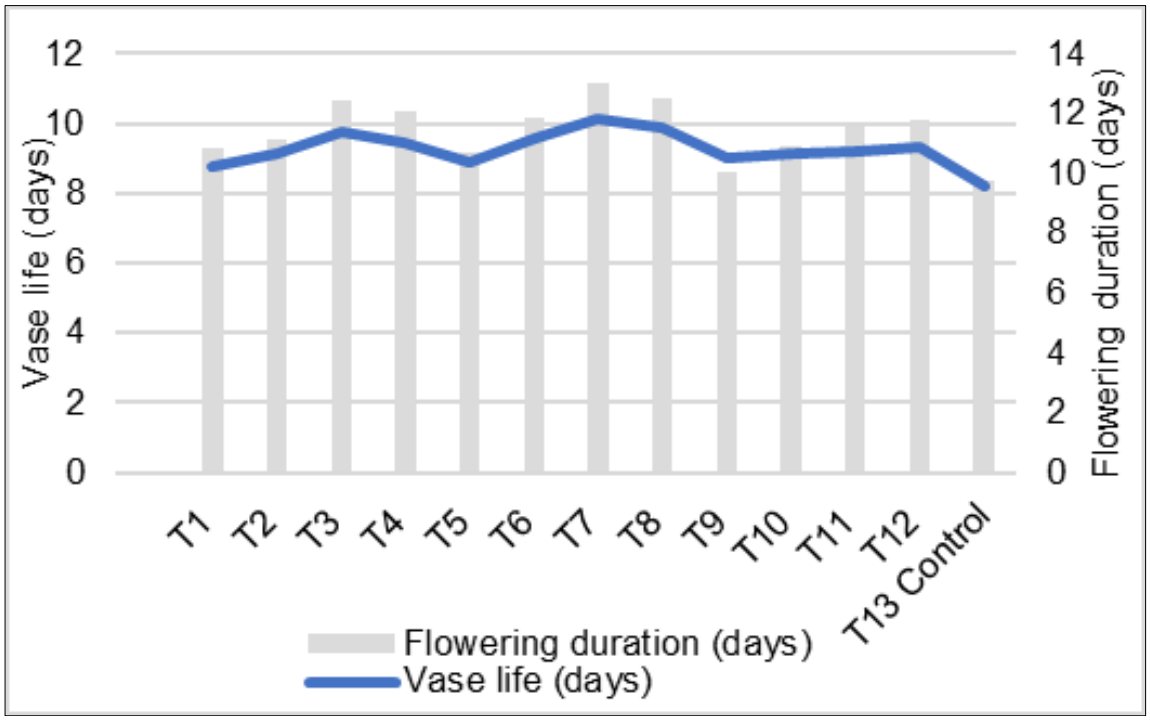
Additionally, increased leaf number results in the accumulation of more photosynthates, facilitating the transition to reproductive phases (Sharifuzzaman *et al.*, 2011) [21]. Kavya and Ushakumari (2020) [12] reported that the foliar and soil application of 2 and 5% non-herbal and herbal *kunapajala* was found better in increasing flower and yield parameters.

Improved nutritional status from biofertilizer inoculation likely prolongs vase life by enhancing nutrient uptake. Higher photosynthatic assimilation enhances reserves and water retention within flower, thereby reducing desiccation (Chandrappa *et al.*, 2006) [10]. Compounds such as hexonoic acid, phenols, etc. known for their antimicrobial properties may also contribute to this effect (Revathi *et al.*, 2023) [18]. These findings align with Bhalla *et al.* (2006) [7], who found that a mixture of manchurian mushroom tea and *panchagavya* increased vase life in Gladiolus cv. Red Beauty. Presence of GA_3 in fermented fertilizers increased leaf number and photosynthetic area, enhancing photosynthetic assimilates in sinks through increased cell division, expansion, and intercellular volume of mesocarpic cells (Baskaran *et al.*, 2014) [5].

Fig 1: Planting of corms

Fig 2: Spike at full bloom stage

Fig 3: Harvested corms



The value of SEm± and critical difference (CD) at 5% confidence limit are:
Vase life: 0.27 and 0.80 days, respectively; Flowering duration: 0.37 and 1.07days, respectively

Fig 4: Pooled response of herbal *Kunapajala* on flowering duration and vase life of gladiolus cv. Jessica during 2019-21.

Table 1: Composition of various types *Kunapajala* formulation

Ingredients						
	***Kunapajala* 1 (KJ1)**		***Kunapajala* 2 (KJ2)**		***Kunapajala* 3(KJ3)**	
Finely chopped (20 kg)	Nettle leaves *Urtica dioica* L	20 kg	Nettle leaves *Urtica dioica* L	10 kg	Neem leaves *Azadirachta indica* A. Juss.	3 kg
			Neem leaves *Azadirachta indica* A. Juss.	2 kg	Clerodendron leaves *Clerodendron inermi*	2 kg
			Clerodendron leaves *Clerodendron inermi*	1 kg	Madar (Arka) leaves *Calotropis gigantea*	2 kg
			Madar (Arka) leaves *Calotropis gigantea*	1 kg	Dhatura leaves *Datura stramonium*	2 kg
			Dhatura leaves *Datura stramonium*	1 kg	Bale leaves *Aegle marmelos*	2 kg
			Bale leaves *Aegle marmelos*	1 kg	Castor leaves *Ricinus communis*	2 kg
			Castor leaves *Ricinus communis*	1 kg	Kaner leaves *Nerium oleander*	2 kg
			Kaner leaves *Nerium oleander*	1 kg	Sharifa leaves *Annona squamosa*	2 kg
			Sharifa leaves *Annona squamosa*	1 kg	Local weeds	3 kg
			Local weeds	1 kg		
Fresh cow dung						20 kg
Cow urine (as old as possible)						10L
Germinated *Vigna mungo* (urd bean)						2 kg
Oilcake of Mustard (*Brassica juncea*)						2 kg
Jaggery						2 kg
Raw milk						1 L
Rice husk water						3 kg
Buttermilk (Sour)						2 L
Extract of 2 cow dung cakes (upla)						4 L
Water						10 L

Table 2: Treatment details of three types of *kunapajala* along with its application rate.

	Soil drenching and corm treatment at planting	**Foliar spray after planting at 20 days interval**		**Soil drenching and corm treatment at planting**	**Foliar spray after planting at 20 days interval**
T_1	1L KJ1	50 mL/ m^2 of KJ1	T_7	1L KJ2	150 mL/m^2 of KJ2
T_2	1L KJ1	100 mL/m^2 of KJ1	T_8	1L KJ2	200 mL/m^2 of KJ2
T_3	1L KJ1	150 mL/m^2 of KJ1	T_9	1L KJ3	50 mL/ m^2 of KJ3
T_4	1L KJ1	200 mL/m^2 of KJ1	T_{10}	1L KJ3	100 mL/m^2 of KJ3
T_5	1L KJ2	50 mL/ m^2 of KJ2	T_{11}	1L KJ3	150 mL/m^2 of KJ3
T_6	1L KJ2	100 mL/m^2 of KJ2	T_{12}	1L KJ3	200 mL/m^2 of KJ3
T_{13}	Control (100% NPK at 40:20:20 g/m^2)				
	**Treatments applied after 10% dilution of the given content				

Table 3: Pooled response of herbal *Kunapajala* on vegetative attributes in gladiolus cv. Jessica at 60 and 90 days of planting for 2019-2021

Treatments	**Plant height (cm)**		**Number of leaves**		**Length of leaves (cm)**		**Width of leaves (mm)**	
	60 DAP	**90 DAP**	**60 DAP**	**90 DAP**	**60 DAP**	**90 DAP**	**60 DAP**	**90 DAP**
T_1	48.71 a	61.36 ab	4.61 ab	7.18 ab	20.65 ab	23.50 b	18.01 ab	19.42 ab
T_2	51.81 cde	64.07 bc	5.02 c	7.29 abc	21.79 bcde	24.18 bcd	18.95 cd	20.78 cde
T_3	53.66 d	67.26 d	5.51 e	7.58 c	23.37 fg	25.58 de	20.08 ef	21.64 de
T_4	52.15 de	65.87 cd	5.23 cde	7.44 bc	22.6 ef	24.61 bcd	19.63 def	21.18 de
T_5	52.44 de	65.90 cd	5.05 c	7.19 ab	21.32 abcd	23.97 bc	19.03 cd	20.7 bcde
T_6	53.38 e	68.02 d	5.49 de	7.48 bc	22.58 ef	25.00 de	19.63 def	21.38 ef
T_7	56.29 f	71.84 e	5.69 e	7.89 d	25.07 h	27.14 f	21.37 f	22.71 f
T_8	53.80 e	70.98 e	5.63 e	7.57 c	24.06 gh	26.49 ef	20.30 def	22.07 de
T_9	49.48 ab	63.02 abc	4.9 bc	7.10 a	21.04 abc	23.79 bc	18.61 bc	19.33 bc
T_{10}	49.93 abc	63.32 abc	5.10 cd	7.21 ab	21.94 cde	24.46 bcd	18.38 bc	19.73 bc
T_{11}	51.03 bcd	64.1 bc	5.05 c	7.30 abc	22.23 cdef	24.75 bcd	19.10 cd	20.41 bcd
T_{12}	51.91 cde	65.16 cd	5.17 cde	7.48 bc	22.46 def	24.51 bcd	19.41 de	20.12 bcd
T_{13} Control	48.22 a	60.89 a	4.43 a	7.06 a	20.35 a	21.60 a	17.57 a	18.68 a

DAP: Date of planting; Values within the same column, denoted by distinct letter(s), signify significant differences as determined by DMRT at the 5% significance level.

Table 4: Pooled response of herbal *Kunapajala* on flowering attributes, vase life and corm attributes in gladiolus cv. Jessica during 2019-21.

Treatments	Days to spike emergence (days)	Days to full bloom (days)	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Weight of corm (g)	Diameter of corm (cm)	No. of cormels / plant
T_1	81.39 fg	104.49 cde	62.175 bc	32.43 ab	9.74 ab	33.08 ab	4.29 ab	5.35 a
T_2	79.19 cdefg	102.8 bcd	63.47 bc	33.43 bc	10.10 bc	35.80 bc	4.425 ab	5.78 ab
T_3	75.73 bc	100.05 ab	67.14 fg	36.48 de	11.12 d	42.85 fg	4.84 cd	8.02 ef
T_4	76.55 bcd	101.39 abcd	66.77 efg	34.91 cd	10.35 c	40.18 ef	4.52 ab	7.11 cd
T_5	78.26 bcdef	103.36 bcde	63.95 cd	33.32 bc	10.22 bc	37.26 cd	4.31 ab	5.81 ab
T_6	75.45 b	100.37 abcd	65.61 cde	35.82 d	10.39 c	39.83 de	4.61 bc	8.17 ef
T_7	71.36 a	97.39 a	69.65 g	38.47 e	12.64 e	45.31 g	5.19 e	9.76 g
T_8	75.07 b	99.62 ab	68.56 g	36.60 de	11.35 d	44.13 g	4.99 de	8.49 f
T_9	80.33 efg	105.09 de	59.97 ab	32.59 bc	9.89 bc	31.96 a	4.27 a	5.63 a
T_{10}	79.71 defg	102.23 bcd	61.21 abc	32.63 bc	10.36 c	32.20 a	4.40 ab	6.22 abc
T_{11}	77.56 bcde	101.97 bcd	63.15 cd	33.46 bc	10.30 c	34.21 ab	4.32 ab	6.88 bcd
T_{12}	77.34 bcde	101.79 bcd	64.02 cde	34.56 bcd	10.42 c	35.56 bc	4.51 ab	7.31 de
T_{13} Control	82.30 g	107.15 e	58.54 a	30.36 a	9.34 a	31.29 a	4.22 a	5.22 a

DAP: Date of planting; Values within the same column, denoted by distinct letter(s), signify significant differences as determined by DMRT at the 5% significance level.

Conclusion

Based on the data collected in the current experiment, it can be inferred that corms treated with 10% dilution of 1L KJ2 and foliar spraying of different doses of KJ2 *viz*., T_7 and T_8, at 20-25 days intervals had found best for improving vegetative growth, flowering, vase life, corm and cormels characters in gladiolus cv. Jessica. However, future research might assure the consistency of results on the response of herbal *kunapajala* for quality production in gladiolus and other crops.

Acknowledgement

The authors acknowledge NMHS, Ministry of Environment, Forest and Climate Change, Govt. of India for their support in preparing herbal *Kunapajala* under the project "Exploring Livelihood Potential of Wild Growing Stinging Nettle (*Urtica dioica*) in Uttarakhand". I acknowledge co-authors Kumar Ajit: Conceptualization, methodology, supervision; Bhuj BD: Review and editing, Pant Kritika: review and editing; Pandey Sunita T.: resources and Pareek Navneet: resources.

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