



Effect of foliar application of vermiwash and potassium nitrate on growth, yield and quality of tuberose cv. Prajwal

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ABSTRACT

Tuberose is an economically important ornamental crop valued for its fragrant flowers used in the cut flower trade and perfume industry. The present study was conducted at the Horticulture Section, College of Agriculture, Nagpur, from May 2022 to March 2023. The experiment was laid out in a factorial randomized block design with four levels of vermiwash (0, 50, 100, and 150 ml/L) and four levels of potassium nitrate (0, 1.0, 1.5, and 2.0%), replicated thrice. Foliar application of vermiwash at 150 ml/L combined with potassium nitrate at 1.5% significantly enhanced plant height, number of leaves, and leaf area at 50% flowering. This treatment also induced early spike initiation, floret opening, and flowering, and recorded the highest spike and floret yield. Floret length and diameter were also significantly improved. The combined treatment V_4P_3 proved most effective for improving growth, yield, and quality of tuberose cv. Prajwal

Key words: Vermiwash, potassium nitrate, growth, flowering, spike length.

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), an ornamental plant from the Asparagaceae family, is known for its fragrant white flowers used in garlands, bouquets, floral arrangements, and perfumes. Optimizing nutrient management is crucial for enhancing flower quality by improving growth, flowering duration, size, and overall quality. Tuberose flowers are also durable, making them suitable for long-distance transport (Mandal *et al.*, 11). Vermiwash, a liquid byproduct derived from vermicomposting, has become increasingly popular in sustainable cultivation owing to its abundance of nutrients, phytohormones, and beneficial microbes. It improves soil structure, nutrient availability, and plant growth, benefiting tuberose growth and flowering (Nayak *et al.*, 13). Potassium nitrate (KNO_3) serves as a key inorganic fertilizer supplying nitrogen and potassium which are macronutrients essential for photosynthetic activity, cellular growth, and flowering. Potassium enhances carbohydrate production and enzyme activation, while nitrogen supports vegetative growth.

Integrated nutrient management (INM) approach, involving a combination of organic and chemical fertilizers, improves nutrient accessibility and thereby enhances plant growth, yield, and overall quality. Organic inputs, such as vermiwash, improve soil health, and their combined application with potassium nitrate (KNO_3) may further optimize tuberose growth and flowering. However, the interactive effects of vermiwash and KNO_3 on tuberose have not been fully

explored. The present study aims to evaluate their influence on growth, flowering, yield, and quality of tuberose, thereby supporting sustainable agricultural practices by reducing chemical fertilizer use and improving cultivation efficiency.

MATERIALS AND METHODS

The present experiment was conducted at Horticulture Section, COA, Nagpur, India, in 2022-2023. The experiment was carried out with sixteen treatment combinations viz; $*V_1P_1$ - Absolute control (water spray); V_1P_2 - Control (0 ml/L) +1% KNO_3 ; V_1P_3 - (0ml/L) +1.5% KNO_3 ; V_1P_4 - (0ml/L) +2% KNO_3 ; V_2P_1 - 50ml/L Vermiwash + 0 % KNO_3 ; V_2P_2 - 50ml/L Vermiwash +1% KNO_3 ; V_2P_3 - 50ml/L Vermiwash +1.5% KNO_3 ; V_2P_4 -50ml/L Vermiwash +2% KNO_3 ; V_3P_1 - 100 ml/L Vermiwash + 0% KNO_3 ; V_3P_2 - 100ml/L Vermiwash +1% KNO_3 ; V_3P_3 - 100ml/L Vermiwash +1.5% KNO_3 ; V_3P_4 -100ml/L Vermiwash +2% KNO_3 ; V_4P_1 - 150ml/L Vermiwash + 0% KNO_3 ; V_4P_2 - 150ml/L Vermiwash +1% KNO_3 ; V_4P_3 -150ml/L Vermiwash +1.5% KNO_3 ; V_4P_4 -150ml/L Vermiwash +2% KNO_3 *

The experimental plot was ploughed thrice, followed by harrowing to achieve fine tilth. Well-rotted FYM (20 t ha⁻¹) was mixed into the soil before final harrowing. The fertilizer dose (NPK 200:300:200 kg ha⁻¹) was applied based on recommendations from PDKV farm. The field was divided into plots with raised beds (15 cm height, 0.6 m width, 1.8 m length) with 20 × 20 cm spacing. Data was analysed using the method by Panse and Sukhatme (15) with

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a factorial randomized block design, under three replications at a 5% significance level. Vermiwash and potassium nitrate were mixed in 1 L of water and applied on foliar basis at 30, 45, and 60 days after planting. Timely observations were recorded at specific intervals.

RESULTS AND DISCUSSION

The data regarding the effect of foliar application of vermiwash and KNO₃ on growth and flowering attributes of tuberose are presented in table 1. Showed that the individual effect of vermiwash and KNO₃ were found significant but the interaction effect of both factors were found non-significant.

At 150 days after planting, significant differences in plant height were observed among vermiwash concentrations. The highest height (74.18 cm) was recorded in V₃ (150 ml/L), followed by V₃ (100 ml/L) and V₃ (50 ml/L), while the lowest (68.99 cm) occurred in the control. The increased growth could be due to improved nitrogen mineralization and phosphatase enzyme activity, which facilitate

better nutrient absorption, as similarly noted by Sivasubramanian and Ganeshkumar (17); Tamrakar *et al.* (19) in gladiolus.

At 150 days after planting, the treatment V₃ – Vermiwash @150 ml/L recorded the highest number of leaves per plant (35.23), closely followed by V₃ – 100 ml/L (35.15) and V₃ – 50 ml/L (33.94), while the minimum (32.60) was observed in control (V₃ – 0 ml/L). The increase in number of leaves might be from the nitrogen, plant growth regulators, and enzymatic components present in vermiwash (Arya and Singh (3)), which enhance leaf formation and enlargement, consistent with the observations of Tamrakar *et al.* (19) in gladiolus.

At 150 days after planting, the treatment V₃ – vermiwash @150 ml/L exhibited the highest leaf area (102.25 cm²), statistically at par with V₃ – 100 ml/L (101.54 cm²) and followed by V₃ – 50 ml/L (99.67 cm²), whereas the lowest (97.05 cm²) was noted in control (V₃ – 0 ml/L). Enhanced nutrient uptake and sustained chlorophyll content under vermiwash application contributed to greater photosynthetic

Table 1: Effect of vermiwash and potassium nitrate on growth and flowering parameters in tuberose at 150 days after planting.

Factors	Growth parameters				Flowering parameters			
	Plant height	Number of leaves plant ⁻¹	Leaf area at 50% flowering (cm ²)	Days to initiation of spike	Days to opening of first floret	Days to 50% flowering	Days to first harvesting	
Vermiwash (V)								
V ₁ - 0 ml/L	68.99	32.60	97.05	72.36	78.03	96.30	103.92	
V ₂ -50 ml/L	72.61	33.94	99.67	68.56	77.55	94.79	102.52	
V ₃ -100 ml/L	73.02	35.15	101.54	67.16	75.66	92.00	101.07	
V ₄ -150ml/L	74.18	35.23	102.25	66.54	75.35	91.54	100.70	
'F' test	p<0.05							
SE (m) ±	0.72	0.66	0.79	0.58	0.73	0.92	1.10	
CD at 5%	2.07	1.90	2.29	1.68	2.10	2.65	3.17	
Potassium nitrate (P)								
P ₁ - (0%) KNO ₃	69.67	32.90	97.76	70.02	78.72	94.98	102.92	
P ₂ - KNO ₃ 1 %	72.74	35.11	100.49	68.39	77.13	94.58	102.44	
P ₃ - KNO ₃ 1.5%	74.60	35.62	103.05	66.38	75.68	91.29	100.3	
P ₄ - KNO ₃ 2%	71.79	33.30	99.19	69.42	77.54	94.79	102.60	
'F' test								
SE (m) ±	0.72	0.66	0.79	0.58	0.73	0.92	1.10	
CD at 5%	2.07	1.90	2.29	1.68	2.10	2.65	3.17	
Interaction VxP	NS	NS	NS	NS	NS	NS	NS	
SE (m) ±	1.44	1.32	1.59	1.16	1.46	1.46	2.20	
CD at 5%	-	-	-	-	-	-	-	

activity and leaf expansion, in agreement with Palagani and Singh (14) in gerbera and Tamrakar *et al.* (19) in gladiolus.

At 150 days after planting, the treatment $P_3 - KNO_3$ 1.5% recorded the maximum plant height (74.60 cm), followed by $P_2 - KNO_3$ 1% (72.74 cm) and $P_4 - KNO_3$ 2% (71.79 cm), whereas the minimum height (69.67 cm) was recorded in the control (P_1). The enhanced plant height observed with potassium treatments could be linked to the nutrient's critical function in stimulating vegetative development, as demonstrated by Bose and Yadav (4) in chrysanthemum and petunia.

At 150 days, $P_3 - KNO_3$ 1.5% recorded the highest number of leaves plant⁻¹ (35.62), which was at par with $P_2 - KNO_3$ 1% (35.11) and followed by $P_4 - KNO_3$ 2% (33.30). The lowest (32.90) was observed in control (P_1). The increase in leaf number with potassium application is due to enhanced enzyme activation, nutrient availability, and photosynthesis, supporting vegetative growth with Mahajan *et al.* (9) in tuberose; Memon *et al.* (12) in gladiolus.

At 150 days, $P_3 - KNO_3$ 1.5% recorded the highest leaf area (103.05 cm²), followed by $P_2 - KNO_3$ 1% (100.49 cm²) and $P_4 - KNO_3$ 2% (99.19 cm²), while the lowest (97.76 cm²) was observed in the control (P_1). KNO_3 enhances leaf expansion by improving K^+ and NO_3^- uptake, reducing Na^+ and Cl^- accumulation, and boosting biomass and nitrogen reductase activity, in agreement with Mahajan *et al.* (9) in tuberose; Memon *et al.* (12) in gladiolus.

At 150 days after planting, the treatment $V_4 -$ vermiwash @150 ml/L recorded the minimum days (66.54) for initiation of the first spike, which was at par with $V_3 - 100$ ml/L (67.16 days) and followed by $V_2 - 50$ ml/L (68.56 days), while the control ($V_1 - 0$ ml/L) took the maximum (72.36 days). The earlier spike emergence might be due to the phosphorus content and growth-stimulating compounds present in vermiwash, which accelerate floral initiation, corroborating the observations of Vidhya and Anburani in jasmine (20) and Palagani and Singh in gerbera (14) (Fig. 1).

At 150 days after planting, the treatment $V_4 -$ vermiwash @150 ml/L recorded the minimum days (75.35) for opening of the first floret, which was at par with $V_3 - 100$ ml/L (75.66 days) and followed by $V_2 - 50$ ml/L (77.55 days), whereas the control ($V_1 - 0$ ml/L) took the maximum (78.03 days). The reduction in days to floret opening might be due to improved phosphorus and micronutrient availability in vermiwash promoting early floral development, consistent with Vidhya and Anburani (20) in jasmine and Palagani and Singh in gerbera (14).

At 150 days after planting, the treatment $V_4 -$ vermiwash @150 ml/L recorded the minimum days

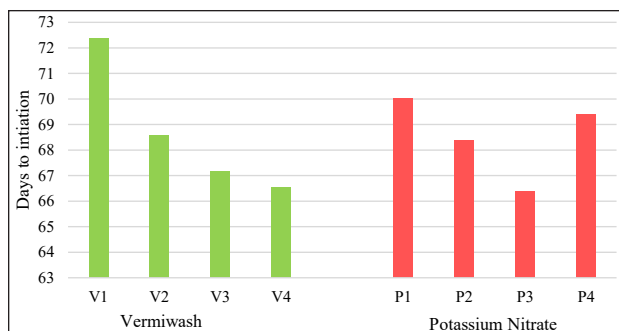


Fig. 1. Days to initiation of spike as influenced by vermiwash and potassium nitrate in tuberose.

(91.54) for 50% flowering, which was at par with $V_3 - 100$ ml/L (92.00 days) and followed by $V_2 - 50$ ml/L (94.79 days), while the control ($V_1 - 0$ ml/L) took the maximum (96.30 days). Earlier flowering observed under vermiwash application may result from the combined influence of macro, secondary and micronutrients stimulating floral differentiation, consistent with the findings of Chattopadhyay *et al.* (6) and Pathak and Kumar (16) in gladiolus.

At 150 days after planting, the treatment $V_4 -$ vermiwash @150 ml/L recorded the minimum days (100.70) to first harvesting, which was at par with $V_3 - 100$ ml/L (101.07 days) and $V_2 - 50$ ml/L (102.52 days), whereas the control ($V_1 - 0$ ml/L) required the maximum (103.92 days). The reduced days to harvesting may be due to growth regulators such as IAA, GA_3 , and cytokinins produced through microbial activity in vermiwash, as also noted by Pathak and Kumar (16) in gladiolus.

At 150 days after planting, the treatment $P_3 - KNO_3$ 1.5% recorded the minimum days (66.38) for initiation of the first spike, followed by $P_2 - KNO_3$ 1% (68.39) and $P_4 - KNO_3$ 2% (69.42), whereas the control ($P_1 - 0\%$ KNO_3) took the maximum (70.02). The early spike initiation may be due to increased potassium and nitrogen availability, which synchronises the bud break with existing floral initials, as reported by Karagüzel *et al.* (8) in gladiolus; Mahajan *et al.* (9) in tuberose; and Memon *et al.* (12) in gladiolus.

At 150 days after planting, the treatment $P_3 - KNO_3$ 1.5% recorded the minimum days (75.68) for opening of the first floret, followed by $P_2 - KNO_3$ 1% (77.13) and $P_4 - KNO_3$ 2% (77.54), while the control ($P_1 - 0\%$ KNO_3) took the maximum (78.72). Foliar application of KNO_3 enhances chlorophyll content, photosynthetic rate, stomatal conductance, and nutrient uptake (P, Mg, S, Cu, Fe), improving flowering quality, consistent with Karagüzel *et al.* (8) in gladiolus; Mahajan *et al.* (9) in tuberose; and Memon *et al.* (12) in gladiolus.

At 150 days after planting, the treatment P₃ – KNO₃ 1.5% recorded the minimum days (91.29) to 50% flowering, followed by P₂ – KNO₃ 1% (94.58) and P₄ – KNO₃ 2% (94.79), whereas the control (P₁ – 0% KNO₃) took the maximum days (94.98). The early flowering may be attributed to foliar-applied KNO₃, a soluble source of K and N, which enhances nutrient absorption and leaf nutrient concentrations, improving floral development, as reported by Karagüzel *et al.* (8) in gladiolus; Mahajan *et al.* (9) in tuberose.

At 150 days after planting, the treatment P₃ – KNO₃ 1.5% recorded the minimum days (100.31) to first harvesting, which was at par with P₂ – KNO₃ 1% (102.44) and P₄ – KNO₃ 2% (102.60), whereas the control (P₁ – 0% KNO₃) required the maximum (102.92). The reduced days to harvesting may be due to improved plant growth and nutrient assimilation under KNO₃ application, in agreement with Karagüzel *et al.* (8) and Mahajan *et al.* (9).

The data regarding the effect of foliar application of vermiwash and KNO₃ on yield and quality of tuberose are presented in Table 2. It showed that the individual effect of factors and the interaction effect of foliar spray of Vermiwash and KNO₃ on yield parameters, i.e., spikes plant⁻¹, spikes plot⁻¹, spikes ha⁻¹, florets spike⁻¹, were found significant.

At 150 days after transplanting, the maximum number of spikes plant⁻¹ (3.25) was recorded in V₄P₃ (Vermiwash @ 150 ml/L + KNO₃ @1.5%), followed by V₃P₃ (2.46), while the minimum (1.71) was observed in control V₁P₁. The combined impact of vermiwash and potassium nitrate could be attributed to the presence of growth-promoting substances such as auxins, cytokinins, humic, and fulvic acids in vermiwash, which enhance plant vigor. Meanwhile, KNO₃ supplementation likely boosts nutrient uptake and organic acid synthesis, thereby promoting spike formation (Suthar, 18; Aghamohammadi *et al.*, 1; Mahajan *et al.*, 9).

At 150 days after transplanting, spikes plot⁻¹ were highest in V₄P₃ (62.81), followed by V₃P₃ (55.97), and lowest in V₁P₁ (36.17). This may be attributed to enzymes and growth-promoting substances in vermiwash combined with KNO₃, which stimulate vegetative growth and crop yield (Sivasubramanian and Ganeshkumar, 17; Pathak and Kumar, 16).

At 150 days after transplanting, spikes ha⁻¹ (lakh) were maximum in V₄P₃ (6.23), at par with V₃P₃ (5.47), and lowest in control V₁P₁ (3.81) (Fig. 2). The interaction likely results from vermiwash enhancing chlorophyll content and photosynthesis, and KNO₃ improving phosphorus and micronutrient

Table 2: Interaction effect of foliar spray of vermiwash and KNO₃ on yield and quality of tuberose.

Treatment	Spike plant ⁻¹	Spikes plot ⁻¹	Spikes ha ⁻¹ (lakh)	Florets spike ⁻¹	Length of floret (cm)	Diameter of floret (cm)
V ₁ P ₁	1.71	36.17	3.81	34.25	4.34	2.99
V ₁ P ₂	1.65	41.14	4.06	41.24	4.87	3.29
V ₁ P ₃	1.72	40.90	4.56	37.71	5.10	3.73
V ₁ P ₄	1.88	48.27	4.75	35.35	4.87	3.59
V ₂ P ₁	1.74	43.17	5.21	38.35	5.22	3.31
V ₂ P ₂	1.78	43.37	4.65	40.04	5.13	3.62
V ₂ P ₃	2.01	49.14	4.58	40.12	5.33	3.82
V ₂ P ₄	1.79	43.67	4.26	40.32	4.77	3.30
V ₃ P ₁	1.73	42.07	4.77	39.41	5.19	3.68
V ₃ P ₂	1.91	47.27	4.82	40.43	5.43	3.58
V ₃ P ₃	2.46	55.97	5.47	43.93	5.82	4.08
V ₃ P ₄	1.85	45.67	4.24	41.82	5.31	3.53
V ₄ P ₁	1.66	41.64	4.50	40.66	5.08	3.47
V ₄ P ₂	2.04	55.20	5.21	41.96	5.43	3.78
V ₄ P ₃	3.25	62.81	6.23	46.61	6.40	4.69
V ₄ P ₄	1.68	48.82	5.26	40.47	5.35	4.33
F test						
SE (m) ±	0.14	3.31	0.30	1.62	0.28	0.20
CD at 5%	0.40	9.57	0.86	4.70	0.78	0.56

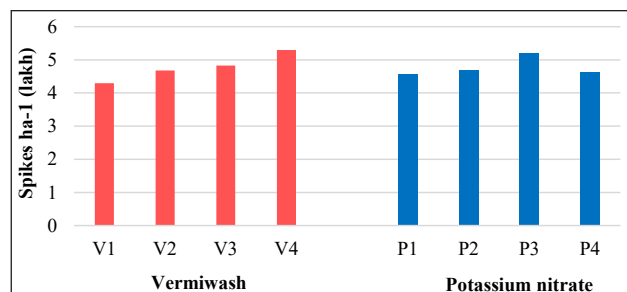


Fig. 2. Spikes ha⁻¹ (lakh) as influenced by foliar application of vermiwash and potassium nitrate in tuberose.

availability, thereby increasing spike yield (Suthar, 18; Aghamohammadi *et al.*, 1; Mahajan *et al.* 9).

At 150 days after transplanting, the maximum number of spikes plant⁻¹ (3.25) was recorded in V₄P₃ (Vermiwash @150 ml/L + KNO₃ @1.5%), followed by V₃P₃ (2.46), while the minimum (1.71) was observed in control V₁P₁. The interaction effect may be due to vermiwash containing auxins, cytokinins, humic, and fulvic acids that improve plant vigor, while KNO₃ enhances nutrient availability and organic acid formation, increasing spike production (Suthar, 18; Aghamohammadi *et al.*, 1; Mahajan *et al.*, 9).

At 150 days after transplanting, spikes plot⁻¹ were highest in V₄P₃ (62.81), followed by V₃P₃ (55.97), and lowest in V₁P₁ (36.17). This may be attributed to enzymes and growth-promoting substances in Vermiwash combined with KNO₃, which stimulate vegetative growth and crop yield (Sivasubramanian and Ganeshkumar, 17).

At 150 days after transplanting, spikes ha⁻¹ (lakh) were maximum in V₄P₃ (6.23), at par with V₃P₃ (5.47), and lowest in control V₁P₁ (3.81). The interaction likely results from Vermiwash enhancing chlorophyll content and photosynthesis, and KNO₃ improving phosphorus and micronutrient availability, thereby increasing spike yield (Suthar, 18; Aghamohammadi *et al.* 1; Mahajan *et al.*, 9).

At 150 days after transplanting, the maximum number of florets spike⁻¹ (46.61) was recorded in V₄P₃ (Vermiwash @150 ml/L + KNO₃ @1.5%), followed by V₃P₃ (43.93), while the minimum (34.25) was observed in control V₁P₁. This increase may be due to Vermiwash containing enzymes, growth hormones (IAA, cytokinin, GA₃), earthworm secretions, and humic acids, which enhance nutrient absorption and floret production (Fig. 3). Similar results were reported by Buckerfield *et al.* (5) in radish and Pathak and Kumar (16) in gladiolus.

The data regarding the effect of foliar application of vermiwash and KNO₃ on flower yield and quality of tuberose revealed that the effect of foliar spray of

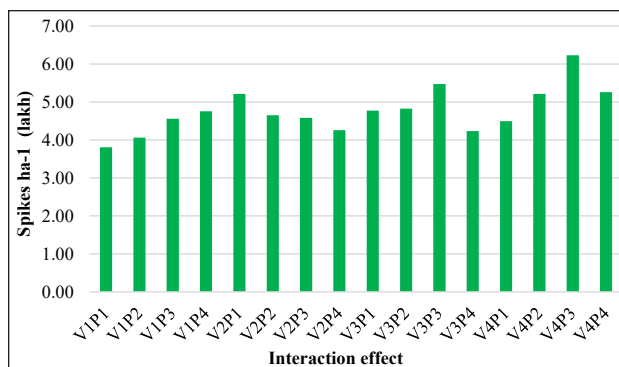


Fig. 3. Interaction effect as influenced by foliar application of vermiwash and potassium nitrate on spikes ha⁻¹.

vermiwash and KNO₃ and their interaction effect on quality parameters like length of floret and diameter of floret were found significant.

At 150 days after transplanting, the maximum floret length (6.40 cm) was recorded in V₄P₃ (Vermiwash @150 ml/L + KNO₃ @ 1.5%), at par with V₃P₃ (5.82 cm), while the minimum (4.34 cm) was observed in control V₁P₁. The interaction effect may be due to vermiwash containing enzymes, growth hormones (cytokinins, GA₃), vitamins, and nutrients, while KNO₃ improves dry matter and flower quality, as reported by Buckerfield *et al.* (5) and Memon *et al.* (12).

At 150 days after transplanting, the maximum floret diameter (4.69 cm) was observed in V₄P₃, followed by V₃P₃ (4.08 cm), while the minimum (2.99 cm) was recorded in control V₁P₁. Vermiwash and KNO₃ enhance nutrient absorption, growth hormones, and dry matter accumulation, improving flower size, color, and smoothness, consistent with Zaller (22), Karagüzel *et al.* (8), Mahajan *et al.* (9) in tuberose, and Memon *et al.* (12) in gladiolus.

The present study demonstrated that vermiwash and potassium nitrate (KNO₃) significantly influenced the growth, flowering, yield, and quality of tuberose cv. Prajwal. Among the treatments, the combination of Vermiwash at 150 ml/L (V₄) with 1.5% KNO₃ (P₃) proved most effective. Vermiwash alone markedly enhanced vegetative growth parameters such as plant height, number of leaves per plant, and leaf area at 50% flowering due to its richness in essential nutrients, enzymes, and plant growth-promoting substances that improved root activity and nutrient uptake. KNO₃ application, on the other hand, significantly influenced floral attributes, leading to early spike initiation, early floret opening, and reduced days to 50% flowering and first harvest by improving photosynthetic efficiency and metabolic functions. The interaction effect of vermiwash and KNO₃ was significant for quality parameters, particularly the

number of florets per spike, floret length, and floret diameter, indicating a synergistic influence on flower quality and yield. The combined treatment (V₄P₃) recorded the highest number of spikes per plant, spikes per plot, and spikes per hectare. Thus, integrated application of vermiwash (150 ml/L) and KNO₃ (1.5%) can be recommended for achieving optimal growth, enhanced yield, and superior flower quality in tuberose cv. Prajwal under sustainable cultivation practices

AUTHOR'S CONTRIBUTION

Original draft preparation, execution of field experiment and data analysis (V.H.); Contribution of experimental materials (R.P.G.); Conceptualization of research and designing of experiments (S.T.); Conceptualization of research (S.S.M.); Resources (C.M.).

DECLARATION

The authors declares no conflict of interest

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