



Determining the Effect of Integrated Nutrient Management (INM) on Growth and Flower Yield of Tuberose (*Polianthes tuberosa* L.) cv. Prajwal

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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

Tuberose (*Polianthes tuberosa* L.) is a highly valued commercial bulbous ornamental plant found in tropical and subtropical climates in the Amaryllidaceae family. It is high demand in both domestic and distant markets due to its long tepels, funnel shape, and strong fragrance. The field experiment was carried out to study the effect of integrated nutrient management on growth and flower yield of tuberose cv. Prajwal during the year of 2021 -2022 at Department of Horticulture, Annamalai University, Annamalainagar, Tamil Nadu. The investigation was laid out in Randomized Block Design with 10 treatments and replicated thrice. The treatments comprised of different levels of

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FYM (25% and 15%), poultry manure (25% and 15%), vermicompost (25 % and 15 %), inoculation of *Azotobacter* (2 kg ha⁻¹) and phosphate solubilizing bacteria (2 kg ha⁻¹) along with RDF (100 % and 75 %). Among the different treatments, T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹) was discovered to be more successful in improving all growth, physiological and flowering characters viz., plant height (51.75 cm), number of side shoots plant⁻¹ (11.23), leaf area (98.76 cm²), chlorophyll content (0.99 mg g⁻¹), dry matter production (42.37 g plant⁻¹) and flowering and yield parameter viz., number of spike plant⁻¹ (3.12), length of spike (105.30 cm), number of florets spike⁻¹ (56.11) and flower yield ha⁻¹ (15.72 t ha⁻¹).

Keywords: INM; RDF; tuberose; polyanthes tuberosa; amaryllidaceae; flower and yield.

1. INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), popularly known as Rajnigandha and member of the Amaryllidaceae family. Among other flower crops, tuberose is a significant commercial bulbous flower crop in India and is well-liked for its highly fragrant and long-lasting spikes [1]. Because of its pleasant scent, longer spike vase life, greater returns, and wide soil and climate tolerance, tuberose is a valuable commercial cut flower crop. It offers significant economic possibilities for the trade in cut flowers and the essential oil industry. Spikes can be used as cut flowers in bouquets and vases, while individual flowers can be used to make crowns, veni, garlands, buttonholes, or garland. Tuberose oil comes from it, and it smells delicious. The pricey raw material for perfume is the natural floral oil of the tuberose. There is a significant economic potential for the trade in loose and cut flowers as well as essential oils [2]. It is a perennial herbaceous bulbous plant that is half-hardy. The leaves are long, thin, and thick, with a pale green color. The base leaves are 1.2 to 1.5 cm wide, 30 to 40 cm long, and occasionally reddish close to the base. The blooming stems are tall, typically reaching a height of 60 to 75 cm, but they can grow as high as 100 cm [3]. The pure white, waxy-textured raceme of flowers is found in the upper part of the stalk. The flowers are 3 to 6 cm long and are borne in pairs on a loose spike. The segments are funnel-shaped, slender, tube-shaped, and 1 to 2 cm long. They bend slightly at the base. The upper section of the corolla has filaments linked to it. Ovary: three-celled, stigmatized, ovate falcate. Fruit with flat seeds and a prolonged perianth at its peak [4]. Commercial tuberose is grown in many places across the world, including Hawaii, South Africa, Taiwan, USA, Egypt, China, India, Kenya, Mexico, Morocco, France, Italy, and many more tropical and subtropical regions. Within India, West Bengal, Tamil Nadu,

Maharashtra, Andhra Pradesh, Karnataka, Assam, Rajasthan, Gujarat, Uttar Pradesh, Punjab, and Chhattisgarh are the states where tuberose cultivation for commercial purposes is most preferred. Districts of Coimbatore, Madurai, and Dindigul in Tamil Nadu are the primary locations for tuberose cultivation. Vegetative development and higher floral quality yields are dependent on plant nutrition. Since tuberose uses a lot of nitrogen, phosphate, and potassium, it reacts favorably to both inorganic and organic fertilizers, especially those that are high in nitrogen. The types of soil and climates have an impact on the need for fertilizers. The problems with the ecology throughout the world have gained more attention recently. In addition to the soil's varied physical, chemical, and biological qualities being disrupted, the soil's fertility is declining as a result of increased and ongoing applications of chemical fertilizers. Following the green revolution, crop production increased its usage of chemical pesticides and fertilizers, endangering the environment and ecosystem. Consequently, it appears that organic farming is the only way to solve this issue [5]. Experience from the past has made it abundantly evident that no one source of input can achieve the dual challenges of maintaining increasing output and protecting the environment. Consequently, it supports the idea of spreading awareness of the "Integrated Nutrient Supply System" (IPNS), which entails utilizing many nutrient sources simultaneously, including chemical fertilizers, organic manures, and biofertilizers. Utilizing organic wastes, farm yard manures, compost, vermicompost, and poultry manures is emphasized by the world's elite society as the most effective way to partially protect the environment. The safest sources of plant nutrients are organic materials, which don't harm soil or crops. Green manure, vermicompost, chicken manure, and farm yard manure are all great sources of organic matter and basic plant nutrients [6]. It has been demonstrated that vermicompost contains high

concentrations of micronutrients, growth regulators, phosphorus, potassium, total and accessible nitrogen, as well as microbial and enzymatic activity [7]. According to Kumaresan et al. [8], vermicompost is a highly effective plant growth medium that accelerates the growth of a wide range of plant species. Spike output and floret quality are significantly impacted by nitrogen, phosphate, and potassium [9]. Due to its high concentration of nitrogen, phosphorus, potassium, and other vital nutrients, poultry dung is a superior organic manure [10]. The most often utilized organic manure is farm yard manure, which enhances the soil's structure and ability to retain water by pulverizing the soil. In addition to improving soil structure by providing food and energy for beneficial soil bacteria to create polysaccharides, increasing microbial activity in the organically supplemented soil facilitates N fixing and P solubilization. Chemical fertilizers alone are insufficient for the crop because major nutrients, particularly nitrogen, can be lost through evaporation or leaching, and P can be fixed in the soil in complex forms. As a result, the crop receives less N and P availability, which may not be enough for the plant to reach its full potential and yield more. Biofertilizers are becoming more and more popular as an additive to mineral fertilizers, and they have the potential to increase agricultural yield and quality. As they don't require non-renewable energy sources during manufacture, biofertilizers are more affordable environmentally benign, and sustainable. Live or dormant microbe cells are the usual component of biofertilizers, which can be used to fix nitrogen biologically, solubilize P, mineralize nitrogen, and convert various elements into forms that are useful. According to Zaredost *et al.* [11], biofertilizers typically used in horticulture crops include phosphate-solubilizing bacteria, *Azotobacter*, VAM fungi, and *Azospirillum*. Therefore, to preserve the fertility condition and health of the soil while also boosting tuberose yield, biofertilizers can be employed as an alternative to the overuse of inorganic fertilizers.

2. MATERIALS AND METHODS

The field investigation was carried out to study the effect of integrated nutrient management on growth and flower yield of tuberose cv. Prajwal at Department of Horticulture, Annamalai University, Anna malainagar, Tamil Nadu. The experimental site is located in the southern region of India at latitude 11°24' N and longitude 74°44' E, at an elevation of + 5.79 m above

mean sea level. During the experiment, the temperature and relative humidity ranged from 28.5 to 38.5°C and 78.0 to 96.0%, respectively. "The experimental farm's soil is categorized as Typic Haplusterts (clay), with characteristics such as neutral reaction (pH 7.4,7.5), organic carbon content 4.6 and 5.8 g kg⁻¹, CEC of 20.7 and 21.4 c mol (P+) kg⁻¹, low available N (227 and 230 kg ha⁻¹), medium available P (1.9 and 21.3 kg ha⁻¹), and high available K (281 and 276 kg ha⁻¹)" [12].

The experimental site's geographic coordinates are 11°24' North latitude and 79°44' East longitude, with an elevation of +5.79 m above mean sea level. The summers are hot and the weather is often warm. 35°C is the mean maximum temperature, and 23.5°C is the mean lowest temperature. The average annual rainfall is 1500 mm, of which 1000 mm occur between October and December during the North East monsoon, 400 mm between June and September during the South West monsoon, and 100 mm during summer showers (March - May). There is a 72% relative humidity on average. The treatments comprised of different levels of FYM (25% and 15%), poultry manure (25% and 15%), vermicompost (25% and 15%), inoculation of *Azotobacter* (2 kg ha⁻¹) and phosphate solubilizing bacteria (2 kg ha⁻¹) along with RDF (100 % and 75%). According to the treatments, the recommended fertilizer dosage has been applied to the chosen plots. When plants were planted, a basal application of two thirds of nitrogen, complete dosages of P and K, were given. Six weeks after planting, one-third of the nitrogen was top-dressed. N, P, and K were supplied, respectively, by urea, super phosphate, and muriate of potash. The observations were recorded at various stages of crop growth. The growth and physiological parameters viz., plant height, number of side shoots plant⁻¹, number of leaves plant⁻¹, leaf area, chlorophyll content, dry matter production and flowering and yield parameter viz., Days to fifty per cent flowering, number of spike plant⁻¹, length of spike, length of rachis, number of florets spike⁻¹, floret length, floret diameter, hundred floret weight, flower yield plant⁻¹, flower yield plot⁻¹ and flower yield ha⁻¹. The statistical analysis of data was carried out for the experiment as suggested by Panse and Sukhatme [13].

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

The plant height at different stages of growth differed significantly. Among all the nutrient management levels, the maximum plant height (58.45cm) was observed in T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹) and minimum (49.72 cm) was found to be in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). The beneficial activity of biofertilizers (*Azotobacter*) may have contributed to the rise in plant height by increasing the availability of nitrogen and certain growth factors such auxins, gibberellins, vitamins, and organic acids released by bioinoculants. The studies conducted by Ajimuddin [14] and Yadav *et al.* [15] also supported the influence of *Azotobacter* on plant height in tuberose. Because nitrogen is a component of protein and is necessary for the formation of protoplasm, which improves cell division and enlargement and ultimately increases plant height, the increase in plant height may have resulted from the increased availability of nitrogen and phosphorus due to the use of biofertilizers [16].

3.2 Number of Side Shoots Plant⁻¹

The number of side shoots plant⁻¹ differed significantly by the effect of various nutrient management treatments. The maximum (11.23) number of side shoots plant⁻¹ was observed in T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹). The minimum number of side shoots (7.27) was recorded in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). The production of cytokinins by *Azotobacter* and PSB, as well as growth regulators like NAA, may be the cause of the significant rise in branches plant⁻¹. These factors have hastened the formation of more branches and broken apical dominance. It is also possible that the process of cell division and differentiation was sped up by the increased nitrogen feeding, which *Azotobacter* corrected. The findings of African marigold and Patil *et al.* [17], as well as those of Sunitha *et al.* [18] and Thumar *et al.* [19], support the prior results. When *Azotobacter* and PSB were combined with 75% nitrogen in marigold plants, Gupta *et al.* [20] observed the highest number of branches per plant as well as yield.

The increased metabolic transport, photo synthesis, and cell multiplication in marigold may

be the cause of the N and P's stimulating influence on plant growth. Yadav *et al.* [15] made a similar observation on tuberose cv. Double. It's possible that the PSB, *Azotobacter*, or *Azospirillum* produced more leaves because they alone or in combination produced growth-promoting compounds like IAA or GA, such as vitamin B12, thiamine, riboflavin (B2), etc. All of these elements support the growth, division, and multiplication of cells, which may have improved photosynthesis and, ultimately, vegetative growth. As a result, compared to the control, the treatment's leaf count greatly rose. Gladiolus cv. American Beauty had more leaves after applying biofertilizers, specifically *Azotobacter* and PSB [21].

3.3 Leaf Area (cm²)

The treatments significantly influenced the leaf area. Larger leaves (98.76 cm²) were observed in the treatment T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹) whereas the smaller leaf area (52.86 cm²) was observed T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). The application of biofertilizers (*Azotobacter* and PSB) may have increased leaf area because they released growth regulators such as cytokinins. These growth-promoting substances may have increased cell division and elongation, which in turn led to enhanced leaf expansion, which in turn increased leaf length and leaf width. These results closely correspond with the marigold research conducted by Kumar *et al.* (2009).

3.4 Chlorophyll Content (mg g⁻¹)

The chlorophyll content was found to be significantly influenced by all the treatments. The highest value (0.992 mg g⁻¹) was recorded in treatment T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹) followed by T₁ (100 % RDF (200:200:200 kg NPK ha⁻¹) which recorded 0.908 mg g⁻¹. The lowest value (0.740 mg g⁻¹) was recorded in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹).

An increase in nitrogen, the main component of protein and protoplasm, causes a rise in chlorophyll content, which in turn increases photosynthetic activity. The production of cytokinin by microbial inoculants may have increased as a sink to draw in nutrients such as magnesium, iron, and potassium, leading to an increase in the synthesis of chlorophyll in tuberose [22].

3.5 Dry Matter Production (g plant⁻¹)

The effect of treatments on dry matter production was found to be highly significant. Among the different treatments, the highest dry matter production (42.37 g plant⁻¹) was recorded in T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹). It was followed by T₄ (39.57). The least dry matter (28.78 g plant⁻¹) was recorded in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). The results of the study are in close conformity with the findings of Sumitha et al. [21] who had recorded significant improvement in dry matter content in marigold due to the application of *Azotobacter* with different levels of chemical fertilizers. The promotive effect of bio and chemical fertilizers on vegetative attributes had also been observed by Kumar et al. (2003) in China aster.

3.6 Number of Spikes Plant⁻¹

The maximum number of spikes plant⁻¹ (3.12) was recorded in T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹), followed by T₄ (75 % RDF + Poultry manure 25 %) recorded 3.09 spikes and the minimum number of spikes (2.92) was observed in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). The increased number of spikes could be attributed to various factors such as atmospheric

nitrogen fixation, improved root proliferation, increased water and nutrient uptake, increased photosynthesis, enhanced food accumulation, and increased capacity for cell division, all of which could have contributed to better plant growth and a subsequent increase in the number of spikes and florets. These results were consistent with gladiolus research by Kathiresan and Venkatesha [23], Godse et al. [24] and Anu et al., 2020 [25] in marigold cv. Pusa Narangai Gaiinda.

3.7 Number of Florets Spike⁻¹

Among the various treatments, T₁₀ (75 % RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹) recorded a greater number of florets spike⁻¹ (56.11) and this was followed by T₄ (54.39). The least number of florets (48.37) was recorded in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹). Higher levels of NPK in the soil may have encouraged the synthesis of more amino acids, the formation of chlorophyll, and better carbohydrate transformation, which in turn led to better growth and longer rachis, which in turn produced more florets per spike, explaining the notable increase in floret count in T₁₀. These conclusions were supported by the findings of Achal et al. [26] and Gopitha et al. [27].

Table 1. Effect of Integrated Nutrient Management on Growth and physiological characters of Tuberose

	Treatments	Plant height (cm)	Number of side shoots plant ⁻¹	Leaf area (cm ²)	Chlorophyll content (mg g ⁻¹)	Dry matter production (g plant ⁻¹)
T ₁	100 % RDF (200:200:200 kg NPK ha ⁻¹)	53.35	10.53	87.03	0.908	37.57
T ₂	75 % RDF + Vermicompost 25 %	51.75	10.08	80.26	0.825	35.77
T ₃	75 % RDF + Vermicompost 15 %	51.22	9.50	74.26	0.793	33.71
T ₄	100 % RDF + Poultry manure 25 %	55.48	11.14	92.88	0.856	39.57
T ₅	75 % RDF + Poultry manure 15 %	51.93	8.00	83.91	0.781	36.77
T ₆	75 % RDF + FYM 25 %	51.45	9.00	71.02	0.820	34.31
T ₇	75 % RDF + FYM 15 %	50.41	8.25	61.76	0.753	30.75
T ₈	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹	51.11	8.85	67.76	0.773	32.75
T ₉	75 % RDF + PSB @ 2 kg ha ⁻¹	49.72	7.27	52.86	0.740	28.78
T ₁₀	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹ + PSB @ 2 kg ha ⁻¹	58.45	11.23	98.76	0.992	42.37
S.Ed		0.16	0.23	2.33	0.006	0.69
CD (P=0.05)		0.30	0.44	4.59	0.012	1.36

Table 2. Effect of Integrated Nutrient Management on flower and yield characters of Tuberose

	Treatments	Spike length (cm)	Number of spikes plant ⁻¹	Number of florets spike ⁻¹	Floret length (cm)	Flower yield hectare ⁻¹ (t ha ⁻¹)
T ₁	100 % RDF (200:200:200 kg NPK ha ⁻¹)	99.58	3.07	53.19	5.74	14.02
T ₂	75 % RDF + Vermicompost 25 %	96.23	3.06	52.15	5.50	13.35
T ₃	75 % RDF + Vermicompost 15 %	89.06	3.03	50.32	5.11	12.47
T ₄	100 % RDF + Poultry manure 25 %	102.40	3.09	54.39	6.08	14.73
T ₅	75 % RDF + Poultry manure 15 %	96.85	3.06	52.18	5.54	13.49
T ₆	75 % RDF + FYM 25 %	93.31	3.04	51.21	5.34	12.90
T ₇	75 % RDF + FYM 15 %	90.16	3.02	49.33	4.87	12.06
T ₈	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹	90.32	3.03	50.25	5.08	12.43
T ₉	75 % RDF + PSB @ 2 kg ha ⁻¹	77.04	2.92	48.37	4.66	11.54
T ₁₀	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹ + PSB @ 2 kg ha ⁻¹	105.30	3.12	56.11	6.73	15.72
S.Ed		2.42	0.15	0.45	0.090	0.24
CD (P=0.05)		2.66	0.26	0.86	0.19	0.51

Table 3. Economics of crop production of tuberose as influenced by different sources of nutrient

	Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross income (Rs. ha ⁻¹)	Net income (Rs. ha ⁻¹)	B:C Ratio
T ₁	100 % RDF (200:200:200 kg NPK ha ⁻¹)	324252	1121600	797348	2.45
T ₂	75 % RDF + Vermicompost 25 %	329436	1068000	738564	2.24
T ₃	75 % RDF + Vermicompost 15 %	325197	997600	672403	2.06
T ₄	100 % RDF + Poultry manure 25 %	321912	1178400	856488	2.66
T ₅	75 % RDF + Poultry manure 15 %	728278	1079200	758278	2.36
T ₆	75 % RDF + FYM 25 %	326437	1032000	705563	2.16
T ₇	75 % RDF + FYM 15 %	323637	964800	641163	1.98
T ₈	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹	319517	994400	674883	2.11
T ₉	75 % RDF + PSB @ 2 kg ha ⁻¹	319517	923200	603683	1.88
T ₁₀	75 % RDF + <i>Azotobacter</i> @ 2 kg ha ⁻¹ + PSB @ 2 kg ha ⁻¹	319597	1257600	938003	2.93

The increased number could be attributed to a variety of factors, including increased photosynthesis, improved food accumulation, improved root proliferation, improved water and nutrient uptake, increased ability to divide cells, and atmospheric nitrogen fixation. All of these factors could have contributed to improved plant growth and a subsequent increase in the number of spikes and florets. These results were consistent with those of the following studies: Barman *et al.* [28], Yadav *et al.* [14] in tuberose, Gayathri *et al.* [29] in statice, Kathiresan and Venkatesha [23], Madinatul-Nisa *et al.* [30] and Godse *et al.* [24] in gladiolus.

3.8 Floret Length (cm)

There was a significant difference between the treatments. Among all the treatments, T₁₀ (75 %

RDF + *Azotobacter* @ 2 kg ha⁻¹ + PSB @ 2 kg ha⁻¹), registered the maximum floret length (6.73 cm) and this was followed by T₄ (75 % RDF + Poultry manure 25 %) which recorded 6.08 cm. The minimum floret length (4.66 cm) was observed in T₉ (75 % RDF + PSB @ 2 kg ha⁻¹).

The increase in flowering parameters may be the result of adequate phosphorus availability during vegetative growth, which has a positive impact on the development of flowering parameters. Similar results were also seen in crossandra by Narasimharaju and Haripriya [31] and in tuberose by Barman *et al.* [28]. *Azotobacter* fixes nitrogen and PSB makes insoluble phosphorus available by secreting organic acids, primarily *Pseudomonas*, the improved floral characteristics may be the result of increased availability of N

and P, which are necessary for flower growth [32].

3.9 Flower Yield Ha^{-1} (t ha^{-1})

Among the treatments, T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}) recorded the highest flower yield (15.72 t ha^{-1}). It was followed by T_4 (14.73 t ha^{-1}) and the lowest yield was observed in T_9 (11.54 t ha^{-1}). The increase in yields ha^{-1} may have resulted from the beneficial actions of *Azotobacter* and PSB in combination with inorganic fertilizers, which aided in the plant's general development and improved yield production. These outcomes agree with those of Yadav *et al.* [15] and Swaminathan *et al.* [33] in relation to tuberose. Similar results were also observed in the studies of Mogal *et al.* [34] in China aster, Gayithri *et al.* [29] in statice, Abhishek *et al.* [35] and Gupta *et al.* [20] in marigold. The impact of integrated nutrient management on the garland chrysanthemum's yield and relative economics was assessed by Angadi [36]. According to the reports, Azospirillum + PSB + 50% vermicompost equivalent to RDN + 50% prescribed NPK resulted in considerably increased yield features, such as number of flowers/plants, flower yield/plant, and flower yield/ha [37,38].

3.10 Economic Analysis

Effect of different sources of nutrient significantly imparted the effect on B:C ratio (Table 3). The maximum B: C ratio (2.93) was recorded in the treatment T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}), the minimum (1.88) was recorded in treatment T_9 (75 % RDF + PSB @ 2 kg ha^{-1}).

4. CONCLUSION

The experiment is concluded that the application of 75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1} was found to be more effective for better performance of all the growth, physiological and flowering characters of tuberose.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hemanta L, Srivastava R, Devi MP. Studies on floral biology of Tuberose (*Polianthes tuberosa* L.) under Tarai regions of Uttarakhand. Journal of Crop and Weed. 2017;13(2): 106-111.
2. Alan O, Gunen Y, Ceylan S, Gunen E. Effect of nitrogen applications on flower yield, some quality characteristics and leaf mineral content in tuberose (*Polianthes tuberosa* L.), Aegean Agric. Res. Ins. Direc., 2007;17(1): 43-57.
3. Bahadoran M, Salehi H. Growth and Flowering of Two Tuberose (*Polianthes tuberosa* L.) Cultivars under Deficit Irrigation by Saline Water, J. Agr. Sci. Tech., 2015;17:415-426.
4. Farooqi AA, Sreeramu BS and Srinivaspa KN. Cultivation of spice crops. Universities press. 2004; 563-570.
5. Rawat V. Organic all the way. Agrl. Today. 2002; 6:55-56.
6. Pieters AJ. Green manuring: principles and practices. Agrobios, Jodhpur, India. 2005;234-37
7. Chaoui I, Zibiliske M and Ohno T. Effect of earthworm casts and compost on soil microbial activity and plant nutrient availability. Soil Biol. Biochem., 2003;35:295-302.
8. Kumaresan M, Nadhiya Devi K, Rajaselvam M. Effect of organic media on growth and rooting performance of medicinal plants. Research Journal of Agricultural Sciences, 2023;14(6):1855–1858.
9. Singh SRP, Dhiraj K, Singh VK, Dwivedi R. Effect of NPK fertilizers on growth and flowering of tuberose cv. single. J. of Hort. Sci., 2005;34(1/2): 84.
10. Garg S, Bahla GS. Phosphorus availability to maize as influenced by organic manures, Biores. Technol., 2008;99: 773-777.
11. Zaredost F, Hashemabadi D, Ziyabari MB, Torkashvand AM, Kaviani B, Solimandarabi MJ and Zarchini M. The effect of phosphate biofertilizer on the growth of marigold. J. Environ. Biol., 2014;35(2): 439-443.
12. Sudhagar R, Rajaselvam M, Kamalakannan S, Kumar S, Maheswari TU. Influence of Integrated Nutrient Management on Growth and Flower Yield of Tuberose (*Polianthes Tuberosa* L.) CV.

- Prajwal. Plant Archives. 2020;20(1):2415-8.
13. Panse VG, Sukhatme PV. Sastical methods for Agricultural workers. ICAR, new Delhi. 1985.
14. Ajimuddin M. Effect of biofertilizers on the growth and yield of tuberose (*Polianthes tuberosa*). M. Sc. Thesis, University of Agricultural Sciences (GKVK), Bangalore, Karnataka. 2002.
15. Yadav BS, Singh S, Gupta AK, Beniwal BS. Effect of nitrogen, plant spacing and biofertilizers on N, P and K content in tuberose cv. Double. Haryana J. Horti. Sci., 2005;34 (1-2): 85-86.
16. Halil Demir, İker Sönmez, Ufuk Uçan, İsmail Hakkı Akgün. Biofertilizers Improve the Plant Growth, Yield, and Mineral Concentration of Lettuce and Broccoli, Agronomy. 2023;13(8), 2031.
17. Patil VS, Agasimani AD. Effect of integrated nutrient management on growth and yield parameters in China aster (*Callistephus chinensis*). Mysore J. Agric. Sci., 2013;47(2):267-272.
18. Sunitha HM, Hunje Ravi, Vyakaranahal BS, Ablad HBB. Effect of plant spacing and integrated nutrient management on yield and quality of seed and vegetative growth parameters in African marigold (*Tagetes erecta* L.). J. Orn. Hort., 2007;10(4): 245-249.
19. Thumar BV, Barad AV, Neelima P, Nilima B. Effect of integrated system of plant nutrition management on growth, yield and flower quality of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi. Asian J. Hort., 2013;8(2):466-469.
20. Gupta NS, Sadavarte KL, Mahorkar VK, Jadhao BJ, Dorak SV. Effect of graded levels of nitrogen and bioinoculants on growth and yield of marigold. J. Soils and Crops. 1999;(1): 80-83.
21. Srivastava R, Govil M. Influence of biofertilizers on growth and flowering in gladiolus cv. American Beauty. Acta Hort., 2007;742:183-188.
22. Sumita P, Mitra M, Sadhukhan R. Response of tuberose cv. Prajwal to integrated nutrient management. Environ. and Ecology. 2017;35(4): 3051-3055.
23. Kathiresan C, Venkatesh J. Effect of biofertilizers with levels of N and P on gladiolus. Floriculture research trend in India. In: Indian Floriculture in the new millennium Proceedings of the National Symposium, Lal Bagh, Bangalore, 25-27, February. 2002; 118-121.
24. Godse SB, Golliwar VJ, Chopde N, Bramhankar KS and Kore MS. Effect of organic manures and bio fertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of gladiolus. J. soils and Crops, 2006;16(2): 445-449.
25. Anu Seng Chaupoo, Sunil Kumar. Integrated Nutrient Management in Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. Int. J. Curr. Microbiol. App. Sci. 2020; 9(5): 2927-2939.
26. Achal SS, Lal D, Seth JN. Effect of different levels of nitrogen and phosphorus on growth, flowering and corm yield of gladiolus cv. Vink's Glory. Progr. Hort., 1984;16(3-4): 304-307.
27. Gopitha G, Kannan M, Sankari A, Santhi R. Effect of integrated nutrient management on flower quality and physiological parameters of Nerium (*Nerium oleander* L.), Journal of Pharmacognosy and Phytochemistry. 2021;10(1):1847-1851.
28. Barman D, Datta M, De LC, Banik S. Efficiency of phosphate-solubilizing and phytohormone-producing bacteria on the growth and yield of tuberose in acid soil of Tripura. Indian J. of Hort., 2003;60(3): 303-306.
29. Gayathri HN, Jayaprasad KV, Narayanaswamy P. Response of biofertilizers and their combined application with different levels of inorganic fertilizers in statice (*Limonium caspia*). J. of Orn. Hort., 2004;7(1):70-74.
30. Madinat-ul-Nisa, KM Malik, Rather ZA. Effect of biofertilizers on growth, flowering and corm yield in Gladiolus (Tourn.) L. cv. Priscilla. Green Farming. 2016;7(5): 1256-1259.
31. Narsimharaju S, Haripriya K. Integrated nutrient management in crossandra (*Crossandra infundibuliformis* L.) cv. Dindigul Local. South Indian Hort. 2001; 49: 181-184.
32. Dave A, Patel HH. Impact of different carbon and nitrogen sources on phosphate solubilization by *Pseudomonas fluorescens*. Indian J. Microbiol. 2003;43(1): 33-36.
33. Swaminathan V, Ramaswamy N, Pillai OAA. Effect of *Azospirillum*, phosphobacteria and inorganic nutrients on the growth and yield of tuberose. South Indian Hort., 1999;47: 331-334.

34. Mogal SA, DKhiratkar S, Chopde NK, Dalvi AM, Kuchanwar OD, Khobragade YR. Effect of organic manures and biofertilizers with reduced doses of nitrogen on growth, yield and quality of China aster. J. Soils and Crops. 2006;16(1): 180-185.
35. Abhishek Kumar Upadhya, Rajeev Singh, Pramod KR Singh, Rohit Kumar Sengar, Mohil Kumar and Nikhil Vikram Singh. Effect of integrated nutrient management on plant growth, flower yield of African marigold (*Tagetes erecta* L.). The Pharma Innovation Journal. 2022;11(5): 2064-2069.
36. Angadi AP. Effect of integrated nutrient management on yield, economics and nutrient uptake of garland chrysanthemum (*Chrysanthemum coronarium* L.) The Asian J. Horticulture, 2014;9(1):132-135.
37. Kumar Sunil, Singh RP. Effect of nitrogen, bulb size and plant density on growth, flowering and yield of tuberose (*Polianthes tuberosa* L.). J. Orn. Hort., 1998;1(1): 6-10.
38. Patil PR, Reddy BS, Patil SR, Kulkarni BS. Effect of community planting and fertilizer levels on growth and flower yield of tuberose (*Polianthes tuberosa* L.) cv. Double. South Indian Hort. 1999;47(1/6): 335- 338.

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