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Determining the Effect of Integrated Nutrient Management (INM) on the Growth of Tuberose (*Polianthes tuberosa* L.) cv. Rajat Rekha

Rohan Tomar [a*], Sunil Malik [a], Mukesh Kumar [a], Satendra Kumar [a], S. P. Singh [b], Bhim Singh [c], Abhishek Chandra [a] and Krishna Kaushik [a]

[a] *Department of Floriculture and Landscaping Architecture, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India.*
[b] *Department of Soil Science, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India.*
[c] *Department of Basic Science, College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India.*

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, a valuable ornamental crop, requires optimized nutrient management to maximize its potential. With increasing concerns about chemical fertilizer usage, integrated nutrient management (INM) offers a sustainable alternative. This study investigated the effects of INM on Tuberose

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**Corresponding author: E-mail: rohantomar97@gmail.com;*

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(*Polianthes tuberosa* L.) cv. Rajat Rekha, exploring combinations of organic and inorganic fertilizers to promote growth and productivity.
The results showed that integrated nutrient management significantly enhanced growth parameters. Specifically, the treatment combining 75% Recommended Dose of Fertilizer (RDF) with 2 kg Farm Yard Manure (FYM)/m², 300g Vermicompost (VC)/m², Phosphate Solubilizing Bacteria (PSB), and Azospirillum (T15) yielded superior results. This treatment reduced days to sprouting (12.10 and 14.18), and improved plant height (40.8 and 41.7 cm), leaf length (48.0 and 48.6 cm), leaf width (1.78 and 1.80 cm), and leaf number (60.8 and 61.4).
These findings suggest that integrated nutrient management can enhance Tuberose productivity while minimizing chemical fertilizer reliance. The identified optimal treatment combination offers a viable strategy for sustainable Tuberose cultivation, contributing to environmentally friendly agricultural practices. Future research can focus on scaling up these results and exploring potential applications in other ornamental crops.

Keywords: Tuberose; FYM; Vermicompost; PSB and Azospirillum.

1. INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) belongs to family Agavaceae and is native of Mexico. It is a one of the most important tropical bulbous flowering plants cultivated for production of long lasting flower spikes. It is popularly known as Rajanigandha. Commercial importance of tuberose is due to beauty of the flower, longer vase-life of spikes and aromatic oil extracted from its fragrant white flower and it has a great economic potential for cut flower trade and essential oil industry [1]. It has great demand for home decoration, garland, flower decoration, bouquets and pots, in addition to the purpose of cutting flowers. It's essential oil is rich in geraniol, nerol, benzyl alcohol, eugenol, benzyl benzoate and methyl anthranilate and methyl salicylate (Hussain, 1986). Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers [2]. INM helps in maintaining or enhancing soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients, improving the stock of plant nutrients in the soils and improve the efficiency of plant nutrients, thus, limiting losses to the environment. In the present investigations, studies have been made to know the effect of integrated nutrient management on the growth of Tuberose (*Polianthes tuberosa* L.) cv. Rajat Rekha.

2. MATERIALS AND METHODS

The experiment was carried out at Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh (India) during seasons of 2021-22 and 2022-23. The experiment was laid out in Randomized Block Design with eighteen treatments and three replications. Bulbs of tuberose cv. Rajat Rekha were planted in a spacing 30 cm × 30 cm. The different treatments were T1 (control), T2 (100% Recommended Dose of Fertilizers, RDF), T3 (50% RDF + 2 kg Farm Yard Manure/m² + Phosphate Solubilizing Bacteria + Azospirillum), T4 (50% RDF + 1 kg Farm Yard Manure/m² + Phosphate Solubilizing Bacteria + Azospirillum), T5 (50% RDF + 300g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T6 (50% RDF + 150g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T7 (50% RDF + 2 kg Farm Yard Manure/m² + 300g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T8 (50% RDF + 1 kg Farm Yard Manure/m² + 300g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T9 (50% RDF + 2 kg Farm Yard Manure/m² + 150g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T10 (50% RDF + 1 kg Farm Yard Manure/m² + 150g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T11 (75% RDF + 2 kg Farm Yard Manure/m² + Phosphate Solubilizing Bacteria + Azospirillum), T12 (75% RDF + 1 kg Farm Yard Manure/m² + Phosphate Solubilizing Bacteria + Azospirillum), T13 (75% RDF + 300g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T14 (75% RDF + 150g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T15 (75% RDF + 2 kg Farm Yard Manure/m² + 300g Vermicompost/m2 + Phosphate Solubilizing Bacteria + Azospirillum), T16 (75% RDF + 1 kg Farm Yard Manure/m² + 300g Vermicompost/m² + Phosphate Solubilizing Bacteria + Azospirillum), T17 (75% RDF + 2 kg Farm Yard Manure/m² +

150g Vermicompost/m^2 + Phosphate Solubilizing Bacteria + Azospirillum), and T18 (75% RDF + 1 kg Farm Yard Manure/m^2 + 150g Vermicompost/m^2 + Phosphate Solubilizing Bacteria + Azospirillum). Manures were applied and mixed into the soil thoroughly. The amount and type of manure applied was as per the treatments of respective plots. Cultural practices were kept uniform for all the treatments and standard practices were adopted to raise the crop successfully. Observation on growth attributes *i.e.* days taken for spouting, plant height (cm), length of leaves (cm), width of leaves (cm) and number of leaves per plant.

3. RESULTS AND DISCUSSION

The minimum days taken for spouting (12.10 & 14.18) was recorded in T_{15} (75% RDF + 2kg FYM/m^2 + 300g VC/m^2 + PSB + Azospirillum) and found statistically at par with T_{16} (14.21 & 15.25 days), T_{17} (14.18 & 15.20 days) and T_{18} (14.12 & 15.16 days). The earliest emergence of bulbs in Vermicompost + RDF might be due to the early absorption of N, P and K increased the availability of micronutrients as well as plant hormones due to which the time taken for emergence of bulbs was reduced significantly. Padaganur et al. [3], Kabir et al. [4] and Hadwani et al., [5] reported similar results in tuberose.

The maximum plant height (40.8 & 41.7cm) was recorded in T_{15} (75% RDF + 2kg FYM/m^2 + 300g VC/m^2 + PSB + Azospirillum), and found statistically at par with T_{11} (38.2 & 39.5cm), T_{12} (37.4 & 38.2cm), T_{13} (39.0 & 39.8cm), T_{14} (38.6 & 39.7cm), T_{16} (40.2 & 41.4cm), T_{17} (39.7 & 40.3cm) and T_{18} (39.4 & 40.1cm). However, minimum plant height (28.4 & 30.6cm) was found in control. The result shows nitrogen and phosphorus had positive correlation with the plant height, it nutrient availability is increased with increase in organic sources viz. FYM, vermicompost and PSB. Nitrogen, a constituent of protein and is essential for formation of protoplasm, cell division and cell enlargement, while phosphorus a part of nucleic acids and also responsible for root development and the combined effect of higher availability of both nutrients in plant vicinity enhance the vegetative growth of the plant [6,7,8].

Table 1. The effect of integrated nutrient management treatment on sprouting of Tuberose

Symbol	Treatments	Ist year	IInd year
T_1	Control	20.17	22.29
T_2	100%RDF	16.14	17.22
T_3	50%RDF+2 kg FYM/m^2+ PSB +Azospirillum	19.16	20.26
T_4	50%RDF+1 kg FYM/m^2+ PSB +Azospirillum	20.17	21.28
T_5	50%RDF+300g VC/m^2+ PSB +Azospirillum	18.15	19.25
T_6	50%RDF+ 150g VC/m^2+ PSB +Azospirillum	19.16	20.26
T_7	50%RDF+2 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	16.14	17.22
T_8	50%RDF+1 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	17.18	18.24
T_9	50%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	17.10	18.20
T_{10}	50%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	18.15	19.25
T_{11}	75%RDF+2 kg FYM/m^2+ PSB +Azospirillum	15.13	16.21
T_{12}	75%RDF+1 kg FYM/m^2+ PSB +Azospirillum	16.14	17.22
T_{13}	75%RDF+300g VC/m^2+ PSB +Azospirillum	15.13	16.21
T_{14}	75%RDF+150g VC/m^2+ PSB +Azospirillum	15.10	16.17
T_{15}	75%RDF+2 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	12.10	14.18
T_{16}	75%RDF+1 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	14.21	15.25
T_{17}	75%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	14.18	15.20
T_{18}	75%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	14.12	15.16
	SEm+	**0.59**	**0.63**
	C.D. (P=0.05)	**1.68**	**1.79**

Table 2. Plant height (cm) in relation to INM treatments at 180 days after planting the bulbs

Symbol	Treatments	I[st] year	II[nd] year
T_1	Control	28.4	30.6
T_2	100%RDF	37.0	38.4
T_3	50%RDF+2 kg FYM/m²+ PSB +Azospirillum	33.9	34.8
T_4	50%RDF+1 kg FYM/m²+ PSB +Azospirillum	33.0	34.4
T_5	50%RDF+300g VC/m²+ PSB +Azospirillum	35.1	36.4
T_6	50%RDF+ 150g VC/m²+ PSB +Azospirillum	34.5	35.6
T_7	50%RDF+2 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	36.9	37.8
T_8	50%RDF+1 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	36.5	37.5
T_9	50%RDF+2 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	36.0	37.1
T_{10}	50%RDF+1 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	35.7	36.4
T_{11}	75%RDF+2 kg FYM/m²+ PSB +Azospirillum	38.2	39.5
T_{12}	75%RDF+1 kg FYM/m²+ PSB +Azospirillum	37.4	38.2
T_{13}	75%RDF+300g VC/m²+ PSB +Azospirillum	39.0	39.8
T_{14}	75%RDF+150g VC/m²+ PSB +Azospirillum	38.6	39.7
T_{15}	75%RDF+2 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	40.8	41.7
T_{16}	75%RDF+1 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	40.2	41.4
T_{17}	75%RDF+2 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	39.7	40.3
T_{18}	75%RDF+1 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	39.4	40.1
	SEm+	**1.32**	**1.36**
	C.D. (P=0.05)	**3.74**	**3.85**

Table 3. Length of leaves (cm) in relation to INM treatments

Symbol	Treatments	I[st] year	II[nd] year
T_1	Control	37.2	37.8
T_2	100%RDF	43.7	44.2
T_3	50%RDF+2 kg FYM/m²+ PSB +Azospirillum	37.7	38.0
T_4	50%RDF+1 kg FYM/m²+ PSB +Azospirillum	37.5	37.8
T_5	50%RDF+300g VC/m²+ PSB +Azospirillum	38.1	38.4
T_6	50%RDF+ 150g VC/m²+ PSB +Azospirillum	38.0	38.4
T_7	50%RDF+2 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	42.8	43.2
T_8	50%RDF+1 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	41.4	42.0
T_9	50%RDF+2 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	38.7	39.0
T_{10}	50%RDF+1 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	38.3	38.7
T_{11}	75%RDF+2 kg FYM/m²+ PSB +Azospirillum	44.7	45.1
T_{12}	75%RDF+1 kg FYM/m²+ PSB +Azospirillum	43.8	44.3
T_{13}	75%RDF+300g VC/m²+ PSB +Azospirillum	45.5	45.9
T_{14}	75%RDF+150g VC/m²+ PSB +Azospirillum	44.8	45.4
T_{15}	75%RDF+2 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	48.0	48.6
T_{16}	75%RDF+1 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	46.8	47.3

Symbol	Treatments	Ist year	IInd year
T_{17}	75%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	45.9	46.4
T_{18}	75%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	45.7	46.1
	SEm+	**1.51**	**1.52**
	C.D. (P=0.05)	**4.28**	**4.32**

Table 4. Width of leaves (cm) in relation to INM treatments

Symbol	Treatments	Ist year	IInd year
T_1	Control	1.48	1.50
T_2	100%RDF	1.67	1.70
T_3	50%RDF+2 kg FYM/m^2+ PSB +Azospirillum	1.56	1.58
T_4	50%RDF+1 kg FYM/m^2+ PSB +Azospirillum	1.54	1.56
T_5	50%RDF+300g VC/m^2+ PSB +Azospirillum	1.60	1.63
T_6	50%RDF+ 150g VC/m^2+ PSB +Azospirillum	1.58	1.60
T_7	50%RDF+2 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	1.65	1.68
T_8	50%RDF+1 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	1.64	1.66
T_9	50%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	1.62	1.65
T_{10}	50%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	1.61	1.63
T_{11}	75%RDF+2 kg FYM/m^2+ PSB +Azospirillum	1.70	1.72
T_{12}	75%RDF+1 kg FYM/m^2+ PSB +Azospirillum	1.68	1.71
T_{13}	75%RDF+300g VC/m^2+ PSB +Azospirillum	1.72	1.75
T_{14}	75%RDF+150g VC/m^2+ PSB +Azospirillum	1.71	1.73
T_{15}	75%RDF+2 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	1.78	1.80
T_{16}	75%RDF+1 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	1.76	1.78
T_{17}	75%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	1.75	1.77
T_{18}	75%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	1.74	1.76
	SEm+	**0.06**	**0.06**
	C.D. (P=0.05)	**0.17**	**0.17**

Table 5. Number of leaves in relation to INM treatments at 180 days after planting the bulbs

Symbol	Treatments	Ist year 2021-22	IInd year 2022-23
T_1	Control	32.1	34.6
T_2	100%RDF	46.3	47.9
T_3	50%RDF+2 kg FYM/m^2+ PSB +Azospirillum	36.7	37.2
T_4	50%RDF+1 kg FYM/m^2+ PSB +Azospirillum	35.6	36.4
T_5	50%RDF+300g VC/m^2+ PSB +Azospirillum	38.9	39.8
T_6	50%RDF+ 150g VC/m^2+ PSB +Azospirillum	37.3	38.4
T_7	50%RDF+2 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	44.8	45.8
T_8	50%RDF+1 kg FYM/m^2 + 300g VC/m^2+ PSB +Azospirillum	42.8	43.6
T_9	50%RDF+2 kg FYM/m^2 + 150g VC/m^2+ PSB +Azospirillum	40.7	42.8
T_{10}	50%RDF+1 kg FYM/m^2 + 150g VC/m^2+ PSB	40.1	41.6

Symbol	Treatments	Ist year 2021-22	IInd year 2022-23
	+Azospirillum		
T_{11}	75%RDF+2 kg FYM/m²+ PSB +Azospirillum	49.5	50.6
T_{12}	75%RDF+1 kg FYM/m²+ PSB +Azospirillum	47.8	48.2
T_{13}	75%RDF+300g VC/m²+ PSB +Azospirillum	53.6	54.8
T_{14}	75%RDF+150g VC/m²+ PSB +Azospirillum	51.9	52.7
T_{15}	75%RDF+2 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	60.8	61.4
T_{16}	75%RDF+1 kg FYM/m² + 300g VC/m²+ PSB +Azospirillum	58.3	60.3
T_{17}	75%RDF+2 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	56.9	57.4
T_{18}	75%RDF+1 kg FYM/m² + 150g VC/m²+ PSB +Azospirillum	56.2	56.8
	SEm+	**1.67**	**1.71**
	C.D. (P=0.05)	**4.74**	**4.85**

The maximum length of leaves (48.0 & 48.6cm) was recorded in T_{15} (75% RDF + 2kg FYM/m² + 300g VC/m² + PSB + Azospirillum) and found statistically at par with T_{11} (44.7 & 45.1cm), T_{12} (43.8 & 44.3cm), T_{13} (45.5 & 45.9cm), T_{14} (44.8 & 45.4cm), T_{16} (46.8 & 47.3cm), T_{17} (45.7 & 46.4cm) and T_{18} (45.7 & 46.1cm). However, minimum length of leaves (37.2 & 37.8cm) was found in control. The results revealed that length of leaves was greater with organic fertilizer application along with chemical fertilizers. These results indicate that application of organic fertilizers had tremendous effects on plant growth and development in tuberose. Further the effect was more pronounce in FYM + vermicompost + PSB combination followed by FYM + PSB`combination. These results have conformity with the result of Padaganur et al. [9] who reported that application of organic fertilizers along with chemical fertilizers enhanced plant growth and development in tuberose. Similar findings were reported by Desai and Thirumala [10].

The maximum width of leaves (1.78 & 1.80cm) was recorded in T_{15} (75% RDF + 2kg FYM/m² + 300g VC/m² + PSB + Azospirillum) and found statistically at par with T_{11} (1.70 & 1.72cm), T_{12} (1.68 & 1.72cm), T_{13} (1.72 & 1.75cm), T_{14} (1.71 & 1.73cm), T_{16} (1.76 & 1.78cm), T_{17} (1.75 & 1.77cm) and T_{18} (1.74 & 1.76cm). However, minimum width of leaves (1.48 & 1.50cm) was found in control. The results showed that organic nitrogen enhanced chlorophyll formation, leading to healthier leaves compared to the control. Kadu et al. [11] reported that the profound effect of nitrogen fertilization on anatomical structure of tuberose. Similar results were also reported by Meena et al. [12].

The maximum number of leaves (60.8 & 61.4cm) was recorded in T_{15} (75% RDF + 2kg FYM/m² + 300g VC/m² + PSB + Azospirillum) and found statistically at par with T_{16} (58.3 & 60.3cm), T_{17} (56.9 & 57.4cm) and T_{18} (56.2 & 56.8cm). However, minimum number of leaves (32.1 & 34.6cm) was found in control. Kabir et al. [4] also noted that the number of leaves was significantly increased with the application of half of chemical fertilizer along with vermicompost in tuberose. These findings are in agreement with Pradhan et al. [13], [14].

4. CONCLUSION

On the basis of finding of two consecutive years of experiments, it can be concluded that treatment T_{15} (75% RDF + 2 kg FYM/m² + 300g VC/m² + PSB + Azospirillum) may be recommended to farmers of Meerut district, Uttar Pradesh for better growth of tuberose.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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