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

Abstract

Tuberose (*Polianthes tuberosa* L.) belongs to the Amaryllidaceae family. It is one of the most important commercial bulbous ornamental plants in tropical and subtropical regions and is always in high demand for the production of attractive and fragrant spikes and loose flowers. 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, Annamalainagar, Tamil Nadu. The experiment was laid out in Randomized Block Design with 10 treatments replicated thrice. 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 %). Among the different treatments, T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}) was found to be more effective for better performance of all growth and physiological parameters *viz*., plant height (51.75 cm), number of side shoots $plant^{-1}$ (11.23), leaf area (98.76 cm^2), 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, Amaryllidaceae, flowering and yield

Introduction

Tuberose (*Polianthes tuberosa* L.) commonly known as 'Rajnigandha' belongs to family Amaryllidaceae. It is one of the most important commercial bulbous ornamentals of sub-tropical and tropical areas and is always in great demand for its attractive and fragrant spikes as well as for producing its loose flowers. It occupies a very selective and special position to flower loving people because of its prettiness, elegance and sweet pleasant fragrance. It has a great economic potential for loose and cut flower trade and essential oil industry (Alan *et al*., 2007). The flowers remain fresh for quite a long time and stand distance transportation and fill a useful place in the flower market (Patil *et al.,* 1999). It is a half-hardy, herbaceous perennial, bulbous plant. The leaves are pale green, long, narrow and very dense. The leaves at the base are 30 to 40 cm long, 1.2 to 1.5 cm in width, sometimes, reddish near the base. The flowering stems are long and can reach a height of upto 100 cm, although 60 to 75 cm is normal. It is approximately top third of the stem which bears pure white waxy textured raceme of blooms. The flowers are borne in pairs on a lax spike and are 3 to 6 cm length. The segments 1 to 2 cm long, tube long, narrow, funnel shaped slightly bent near the base. Filaments are attached to upper part of corolla. Ovary is 3 celled, stigma 3, ovate falcate. Fruit crowned by the persistent perianth, seeds are flat (Farooqi *et al.,* 2004). Tuberose is grown commercially in a number of countries including India, Kenya, Mexico, Morocco, France, Italy, Hawaii, South Africa, Taiwan, USA, Egypt, China and many other tropical and subtropical areas in the world. In India, commercial cultivation of tuberose is popular in West Bengal, Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka, Assam, Rajasthan, Gujarat, Uttar Pradesh, Punjab and Chhattisgarh. In Tamil Nadu, tuberose is mainly cultivated in Coimbatore, Madurai and Dindigul districts. As per the area and production statistic of National Horticulture Board (2017 - 2018), the total area under tuberose cultivation in Tamil Nadu is 1629 ha.

Plant nutrition is an important aspect for good vegetative growth and also to increase the yield with better quality of flowers. Tuberose utilizes nitrogen, phosphorus and potassium in large amount; thus, it responds well to applied organic and inorganic fertilizers particularly the nitrogenous fertilizers. The requirement for fertilizers varies with climatic conditions and soil types. More recently, attention is focused on the global environmental problems. Due to increased and continuous applications of chemical fertilizers, the soil fertility is being decreased besides disruption of its various physico – chemical and biological properties. After green revolution, the use of chemical fertilizers and pesticides increased in crop production which is dangerous to ecology and environment. Therefore, organic farming seems the only solution for this problem (Rawat, 2002). Past experiences clearly indicated that no single source of input can meet out the twin challenge to maintain higher productivity besides, sustaining the environment. Thus, it warrants for popularizing the concept of "Integrated nutrient supply system" (IPNS) which involves the conjoint use of different sources of nutrients such as chemical fertilizers, organic manures and biofertilizers. The world elite society is giving emphasis on utilization of organic wastes, farm yard manures, compost, vermicompost and poultry manures as the most effective measure to save the environment to some extent. Organic materials are the safer sources of plant nutrients which have no detrimental effect to crops and soil. Farm yard manure, poultry manure, vermicompost and green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2005).

Vermicompost has been shown to have high levels of total and available nitrogen, phosphorus, potassium, micronutrients, and growth regulators as well as microbial and enzymatic activities (Chaoui *et al*., 2003). Vermicompost is an extremely efficient plant growth medium that promotes faster growth in a wide variety of plant species (Kumaresan *at al*., 2023). Nitrogen, phosphorus and potassium have a significant effect on spike production and floret quality (Singh and Singh, 2005). Poultry manure is excellent organic manure as it contains high nitrogen, phosphorus, potassium and other essential nutrients (Garg *et al*., 2008). Farm yard manure is the commonly used organic manure, which pulverizes the soil and improves structure and water holding capacity of the soil. It supplies food and energy to beneficial soil microorganisms to produce polysaccharides leading to better soil structure; N fixing and P solubilisation occurs due to improved microbial activity in the organically amended soil. The use of only chemical fertilizers is not sufficient to the crop, because fertilizers containing major nutrients especially N may be lost through leaching or evaporation and P may be fixed in the soil in complex form and thus both N and P availability are in lesser quantity to the crop which may be insufficient for the plant to show its maximum potentiality for producing higher yield. Therefore, integrated nutrient management may be one of the possible solutions to solve this problem. In recent days biofertilizers have emerged as a supplement to mineral fertilizers and hold a promise to improve the yield as well as quality of crop. Biofertilizers are less expensive, eco-friendly and sustainable and they do not require non-renewable source of energy during their production. Biofertilizer usually consists of live or latent cells of micro-organisms which include biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements into available forms. VAM fungi, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria are commonly applied biofertilizers in horticultural crops (Zaredost *et al.*, 2014). Hence, biofertilizers can be used as an alternative to the excessive use of inorganic fertilizers to maintain the soil health, fertility status as well as increasing the productivity of tuberose.

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, Annamalainagar, Tamil Nadu. The experiment was laid out in Randomized Block Design with 10 treatments replicated thrice. 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 %). The recommended dose of fertilizers was applied to the selective plots according to the treatments. Two third of nitrogen along with full doses of P and K were applied as basal at the time of planting. One third of nitrogen was top dressed at one month after planting. Urea, super phosphate and muriate of potash were used to supply N, P and K respectively. 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 (1985).

Results and discussion

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 T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}) and minimum (49.72 cm) was found to be in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The increase in plant height may be due to favorable action of biofertilizers (*Azotobacter*) which resulted in more availability of nitrogen and certain growth substances like auxins, gibberellins, vitamins and organic acids secreted by bioinoculants. The effect of *Azotobacter* on plant height in tuberose was also confirmed by the work carried out by Ajimuddin (2002) and Yadav *et al*. (2005). The increase in plant height might be due to the increased availability of nitrogen and phosphorus by using biofertilizers as nitrogen is a constituent part of protein which is essential for the formation of protoplasm thus improving the cell division, cell enlargement and ultimately increased the plant height Gowda *et al*. (1991).

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 T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}). The minimum number of side shoots (7.27) was recorded in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The significant increase in branches plant^{-1} might be due to the growth regulator like NAA and cytokinins released by *Azotobacter* and PSB which have resulted in breaking of apical dominance and accelerated higher number of branches. The increased nitrogen nutrition (fixed by *Azotobacter*) might also have accelerated the process of cell division and differentiation. The above results are corroborated with the findings of Sunitha *et al*. (2007) and Thumar *et al*. (2013) in African marigold and Patil *et al*. (2013). Similar results were also reported by Gupta *et al.* (1999) who had recorded maximum number of branches plant^{-1} and yield when *Azotobacter* and PSB in combination with 75 per cent nitrogen was applied in marigold. The promotive effect of N and P on plant growth might be due to increased metabolic transport, photosynthesis and cell multiplication in marigold. Similar observation was recorded by Yadav *et al.* (2005) on tuberose cv. Double. The PSB, *Azotobacter* or Azospirillium alone or in combination produces growth promoting substances such as IAA or GA like substances Vit B_{12}, thiamine, riboflavin (B_2) etc, which might have helped to increase number of leaves. All these factors contribute to cell multiplication, cell enlargement and differentiation which could have resulted in better photosynthesis and ultimately exhibited better vegetative growth. Thus, the number of leaves in the treatment increased significantly in comparison to control. Srivastava and Govil (2007) reported increased number of leaves in gladiolus cv. American Beauty with the application of biofertilizers *viz*. *Azotobacter* and PSB.

Leaf area (cm^2)

The treatments significantly influenced the leaf area. Larger leaves (98.76 cm^2) were observed in the treatment T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}) whereas the smaller leaf area (52.86 cm^2) was observed T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The increase in leaf area with application of biofertilizers (*Azotobacter* and PSB) might be due to release of growth regulators like cytokinins by biofertilizers, these growth promoting substances might have resulted in increased cell division and elongation leading to enhanced leaf expantion, thus leading to increased leaf length and leaf width which in turn resulted in higher leaf area. These findings are in close agreement with the findings of Kumar *et al.* (2009) in marigold.

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 T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}) followed by T_1 (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 T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). Increase in chlorophyll content is due to increase in nitrogen content which is the chief constituent of protein and protoplasm resulting in increased photosynthetic activity. Cytokinin produced by microbial inoculants might have become a greater sink to attract nutrients like Mg, Fe and K which, in turn have resulted in greater synthesis of chlorophyll Sumitha *et al*., (2017) in tuberose.

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 T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}). It was followed by T_4 (39.57). The least dry matter (28.78 g $plant^{-1}$) was recorded in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The results of the study are in close conformity with the findings of Sumitha *et al.* (2017) 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.

Number of spikes $plant^{-1}$

The maximum number of spikes $plant^{-1}$ (3.12) was recorded in T_{10} (75 % RDF + *Azotobacter* @ 2 kg ha^{-1} + PSB @ 2 kg ha^{-1}), followed by T_4 (75 % RDF + Poultry manure 25 %) recorded 3.09 spikes and the minimum number of spikes (2.92) was observed in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The increase in number of spikes may be due to possible role of biofertilizers through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, more photosynthesis enhanced food accumulation and increased ability towards cell division which might have resulted in better plant growth and subsequently higher number of spikes and florets. These findings were in line with those of Kathiresan and Venkatesha (2002) and Godse *et al*. (2006) in gladiolus.

Number of florets spike^{-1}

Among the various treatments, T_{10} (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 T_4 (54.39). The least number of florets (48.37) was recorded in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The significant increase in number of florets in T_{10} may be due to higher levels of NPK in soil which had incited the synthesis of more amino acids, chlorophyll formation and better carbohydrate transformation which in turn resulted in to better growth and more length of rachis that ultimately produced more florets per spike. The results obtained by Achal *et al*. (1984) and Gowda *et al*. (1991) confirmed these findings. The increase in number may be due to possible role of biofertilizers through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water, more photosynthesis enhanced food accumulation and increased ability towards cell division which might have resulted in better plant growth and subsequently higher number of spikes and florets. These findings were in line with those of Kathiresan and Venkatesha (2002) and Godse *et al*. (2006) in gladiolus, Barman *et al.* (2003), Yadav *et al.* (2005) in tuberose and Gayathri *et al.* (2004) in statice.

Floret length (cm)

There was a significant difference between the treatments. Among all the treatments, T_{10} (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 T_4 (75 % RDF + Poultry manure 25 %) which recorded 6.08 cm. The minimum floret length (4.66 cm) was observed in T_9 (75 % RDF + PSB @ 2 kg ha^{-1}). The increment in flowering parameters might be due to that proper availability of phosphorus during vegetative growth towards the better effect on developing flowering parameters. Similar findings were also observed by Barman *et al*. (2003) in tuberose and Narasimharaju and Haripriya (2001) in crossandra. The improved floral characters might be due to increased availability of N and P required for flower development as *Azotobacter* fixes nitrogen and PSB makes the insoluble phosphorus available by secreting organic acids, mainly Pseudomonas (Dave and Patel, 2003).

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 (15.72t 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 $hectare^{-1}$ might be due to the favorable action of *Azotobacter* and PSB and their combine interaction with inorganic fertilizers, which helped in overall development of the plant leading to produce better yield. These results are congruent with the results of Swaminathan *et al.* (1999) and Yadav *et al.* (2005) in tuberose. Similar findings were also reported by Gupta *et al.* (1999) in marigold, Gayithri *et al.* (2004) in statice and Mogal *et al.* (2006) in China aster.

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.

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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 + *Azotobacter* @ 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 + *Azotobacter* @ 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 + *Azotobacter* @ 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 + *Azotobacter* @ 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**