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Influence of fertigation and consortium of biological sources on growth and flower yield of tuberose (*Polianthes tuberosa* L.) cv. 'Prajwal'

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Abstract
An experiment was conducted to evaluate the effect of fertigation and consortium of biological sources on growth parameters, yield attributes and flower yield of tuberose during 2015-2016. The treatment consists of three level of recommended dose of fertilizer through fertigation (RDFTF) gradients (125, 100 and 75 % of NPK), recommended dose of microbial consortium (5 kg @ acre^{-1}), foliar spray of panchakavya (3 % and 4 %) and humic acid (0.4 % and 0.5 %) were laid out in randomized block design with two replications. The results revealed that the morphological characters namely plant height and number of leaves plant^{-1} at various growth stages were recorded highest in 100 % RDFTF + microbial consortium @ 5 kg acre^{-1} + 3 % panchakavya and 0.4 % humic acid. The yield attributes *viz.*, number of florets spike^{-1}, spike length, number of spikes clump^{-1}, were registered highest with treatment received 100 % RDFTF + microbial consortium @ 5 kg acre^{-1} +3 % of panchakavya and 0.4 % of humic acid when compared to 100 % recommended dose of fertilizer through soil application. The yield attributes namely single flower weight was noticed highest of 1.81g respectively with 100 % NPK+ microbial consortium @ 5 kg acre^{-1} +3 % panchakavya and 0.4 % humic acid when compared to fertigation alone. The percent increase of flower yield by 100 % NPK+ microbial consortium @ 5 kg acre^{-1} +3 % panchakavya and 0.4 % humic acid was 39 % over soil application of recommended fertilizers. Overall findings concluded that treatment combinations of 100 % NPK+ microbial consortium @ 5 kg acre^{-1} +3 % panchakavya and 0.4% humic acid were recorded higher flower yield and yield attributes besides quality parameters.

Keywords: Fertigation, microbial consortium, growth, yield attributes and yield

Introduction
Tuberose (*Polianthes tuberosa* L.) is one of the popular cut flower commercially grown in many parts of the world. In India, loose flowers are commercially cultivated over an area of 1,48,240 hectare comprised mainly of Tamil Nadu, Karnataka, West Bengal, Andhra Pradesh, Maharashtra, Gujarat, Uttar Pradesh and Delhi (NHB database, 2010) [6]. As of tuberose in particular in Tamil Nadu it flourishes over an area of 1660 hectare (Surendra Nath *et al*., 2016) [14]. It belongs to the family Asparagaceae and originated from Mexico. It was introduced in to India through Europe in 16th century. In India, Tuberose occupies a prime position in floriculture industry because of its beauty, fragrance, wide utility and good keeping quality. The flower spikes are largely utilized for vase decoration and preparation of bouquets, while the loose flowers especially singles are used for making garlands, floral ornamentals and extraction of essential oil. Tuberose has special features like blooms all over the year, give higher returns and wide adaptability to varied climate and soil conditions.
Fertigation allows an accurate and uniform application of nutrients to the wetted area, where the active roots are concentrated. Therefore, it is possible to assess the nutrients quantity and concentration to their demand throughout the growing season of the crop. Consequently, recommendations have been developed for the most suitable fertilizer formulation according to the type of soil, physiological stage, climate and other factors. Special attention should be given to the pH and NO_3/NH_4 ratio, nutrient mobility in soil and salinity conditions. Though fertigation is a new concept in India, it has potential for more accurate and timely crop nutrition leading to increased yield and enhanced quality in gerbera (Palanisamy *et al*., 2015) [7]. Integrated use of inorganic and organic manures has become important for higher agricultural produce as no single source of plant nutrients, either it is chemical, organic or consortium of biofertilizers can meet the entire needs of crop.

The role of organic supplements is more important in maintaining and increasing the long run fertility and sustainability of agriculture, as it is ecologically sound and supportive of higher levels of biological production and productivity of crops. Senthil Kumar *et al.* (2014) [11] reported that, combined application of fertigation and consortium of biofertilizers significantly enhanced the yield attributing characters and yield in banana.

Biostimulants like humic acid and panchakavya have a significant role in increasing the quality attributes and yield in gladiolus (Sankari *et al*., 2015) [10]. Application of humic acid in pot culture enhances the growth and flowering in tuberose (Hadi Ghasemi *et al*., 2016) [2]. Humic acid contain cytokinin and auxin that increased the antioxidant levels (Zhang and Schmidt, 2000) [17]. Inorganic fertilizers are immediately available to plants, but they are subject to leaching, a process that occurs when fertilizers are washed by rain or irrigation water below the level of plant roots. Heavy applications of inorganic fertilizers can burn the plants and build up toxic salt concentrations in the soil, which can create chemical imbalances. Organic fertilizer may also build up concentrations of some nutrients, but buildup of toxicity is unlikely as long as the organic material is able to fully decompose. Hence, the present research work has been undertaken to study the effect of fertigation, microbial consortium, panchakavya and humic acid on growth and yield of tuberose.

Materials and Methods

The field experiment was conducted at T. Pudhupatti village, Reddiyarchatram block of Dindigul district during 2015 - 2016. The research trial consists of 19 treatments as given below were carried out in Randomized Block Design with two replications. The soil was sandy clay loam in texture with a pH of 8.10, EC of 0.19 (dSm^{-1}), available Nitrogen of 320 (kg ha^{-1}), available phosphorus of 18 (kg ha^{-1}), available potassium of 375 (kg ha^{-1}) and organic carbon status of 0.65 (%). Recommended dose of fertigation was applied at vegetative stage, pre flowering and flowering stage of crop. Out of the recommended phosphorus, 75 % of phosphorus was applied as basal dose and remaining 25 % was applied through fertigation at crop demand stage. Microbial Consortium was applied as basal dose during last ploughing. Foliar spray of panchakavya and humic acid at two concentrations were applied at monthly interval from planting to till crop period. Biometrical observations *viz*., plant height (cm) and number of leaves $plant^{-1}$, yield attributes viz., No. of florets $spike^{-1}$, No. of spikes $clump^{-1}$, spike length (cm), single flower weight (g), and flower yield (t ha^{-1}) were measured in randomly selected five plants in each treatments and replication wise and averaged. The data were subjected to statistical analysis as suggested by Panse and Sukhatme, 1985. The critical difference was worked out at five per cent ($p \leq 0.05$) probability level.

Treatment details

Treatments	Details
T_1	125 % recommended dose of fertilizer through fertigation (RDFTF)
T_2	125 % RDFTF + Microbial Consortium (MC) @ 5kg $acre^{-1}$
T_3	125 % RDFTF + MC@5kg $acre^{-1}$ +3 % Panchakavya + 0.4 % Humic acid
T_4	125 % RDFTF + MC@5kg $acre^{-1}$ + 3 % Panchakavya + 0.5 % Humic acid
T_5	125 % RDFTF + MC@5kg $acre^{-1}$ + 4 % Panchakavya + 0.4 % Humic acid
T_6	125 % RDFTF + MC@5kg $acre^{-1}$ + 4 % Panchakavya + 0.5 % Humic acid
T_7	100 % RDFTF
T_8	100 % RDFTF + Microbial Consortium (MC)@5kg $acre^{-1}$
T_9	100 % RDFTF + MC @5kg $acre^{-1}$ + 3 % Panchakavya + 0.4 % Humic acid
T_{10}	100 % RDFTF + MC @5kg $acre^{-1}$ + 3 % Panchakavya + 0.5 % Humic acid
T_{11}	100 % RDFTF + MC @5kg $acre^{-1}$ + 4 % Panchakavya + 0.4 % Humic acid
T_{12}	100 % RDFTF + MC @5kg $acre^{-1}$ + 4 % Panchakavya + 0.5 % Humic acid
T_{13}	75 % RDFTF
T_{14}	75 % RDFTF + Microbial Consortium (MC)@5kg $acre^{-1}$
T_{15}	75 % RDFTF + MC@5kg $acre^{-1}$ + 3 % Panchakavya + 0.4 % Humic acid
T_{16}	75% RDFTF + MC@5kg $acre^{-1}$ + 3 % Panchakavya + 0.5 % Humic acid
T_{17}	75 % RDFTF + MC@5kg $acre^{-1}$ + 4 % Panchakavya + 0.4 % Humic acid
T_{18}	75 % RDFTF + MC@5kg $acre^{-1}$ + 4 % Panchakavya + 0.5 % Humic acid
T_{19}	100 % Recommended dose of fertilizer (Soil application)

Results

Growth parameters

As the growth characteristics of a plant decide the ultimate yield, the results obtained with regard to the result parameters like plant height, number of leaves as influenced by fertigation and biological sources were presented. In the present study, significant increase in plant height was observed in the treatment T_9 at vegetative stages (38.18 cm), pre flowering (44.98 cm) and flowering stage of 56.84 cm (Table.1). The decreased plant height was recorded in conventional practice of T_{19} at all three stages. Maximum number of leaves was observed in T_9 at vegetative, pre flowering and flowering stages. Whereas minimum leaves $plant^{-1}$ was observed in T_{19} in which the entire dose of fertilizer was applied through soil.

Table 1: Effect of fertigation and consortium of biological sources on growth of tuberose (*Polianthes tuberosa* L.) cv. 'Prajwal'

Treatments	Plant height (cm)			No. of leaves per plant		
	Vegetative Stage	Pre Flowering Stage	Flowering Stage	Vegetative Stage	Pre Flowering Stage	Flowering Stage
T_1	33.56	38.73	50.42	17.02	25.45	40.42
T_2	34.42	40.07	51.69	18.14	26.47	42.72
T_3	37.03	43.73	55.28	20.11	28.72	46.14
T_4	36.81	43.01	55.03	19.98	28.56	45.82

T_5	36.53	42.64	54.57	19.76	28.22	45.27
T_6	36.37	42.28	54.08	19.64	27.04	44.93
T_7	33.87	39.33	50.93	17.38	25.78	41.47
T_8	34.85	40.48	52.11	18.46	26.79	43.31
T_9	38.18	44.98	56.84	20.72	29.66	47.68
T_{10}	37.96	44.69	56.56	20.61	29.45	47.57
T_{11}	37.61	44.31	56.03	20.43	29.19	46.97
T_{12}	37.33	44.16	55.73	20.32	29.02	46.71
T_{13}	33.17	37.85	48.31	16.54	24.58	39.04
T_{14}	34.06	39.62	51.23	17.97	26.13	42.28
T_{15}	36.08	41.92	53.62	19.46	26.78	44.47
T_{16}	35.83	41.69	53.38	19.32	27.59	44.92
T_{17}	35.52	41.21	52.92	19.08	27.32	44.38
T_{18}	35.28	41.03	52.65	18.93	27.18	43.87
T_{19}	28.88	33.14	42.05	14.96	22.14	34.91
SEd	0.13	0.15	0.19	0.07	0.10	0.20
CD (0.05)	0.26	0.33	0.41	0.16	0.23	0.42

Yield parameters

Minimum number of days taken for first spike emergence (76.92 days) was observed in T_9 (100 % RDFTF + microbial consortium @ 5 kg acre^{-1} + 3 % panchkavya + 0.4 % humic acid) followed by T_{10} (100 % RDFTF + microbial consortium @ 5 kg acre-^{1} + 3 % panchakavya + 0.5 % humic acid). The treatment T_{19} (100 % recommended dose as soil application) has taken maximum number of days (94.66 days) for first spike emergence. The data pertaining to number of florets spike^{-1} revealed that, all the fertigation treatments in combination with bio stimulants significantly increased the number of florets spike^{-1} over control (Table 2). The maximum (40.47) number of florets spike^{-1} was obtained in T_9 (100 % RDFTF + microbial consortium @ 5 kg acre-^{1} + panchakavya 3% + humic acid 0.4 % followed by T_{10} (40.04). The maximum number of spikes clump^{-1} (3.47) and spike length (89.67 cm) was recorded in T_9. Whereas, minimum number of spikes clump^{-1} (2.44) and spike length (70.06 cm) were recorded in T_{19} (100 % RDF as soil application). Treatment T_9 (100% RDFTF + microbial consortium @ 5 kg acre^{-1} + panchakavya 3% + humic Acid 0.4% was better resulted with regard to single flower weight (1.81 g) when compared to 100% RDFTF. The lowest single flower weight (1.24 g) was recorded in T_{19} (100 % RDF as soil application). The highest flower yield was observed (15.48 t ha^{-1}) in T_9 (100 % RDFTF + microbial consortium @ 5 kg acre^{-1} + 3 % panchakavya + 0.4 % humic acid) followed by 15.39 t ha^{-1} was recorded in T_{10} (100 % RDFTF + microbial consortium @ 5 kg acre^{-1} + 3 % panchakavya + 0.5 % humic acid). The treatment T_9 registered significantly higher yield (15.48 t ha^{-1}) compared to T_1 (125 % RDFTF) of 12.38 t ha^{-1}and T_7 (100 % RDFTF) of 12.64 t ha^{-1} (Table.2).

Table 2: Effect of fertigation and consortium of biological sources on yield parameters of tuberose *(Polianthes tuberosa L.)* cv. 'Prajwal'

Treatments	No. of days taken for Spike emergence	No. of florets/ Spike	No. of spikes per clump	Spike length (cm)	Single flower weight (g)	Flower Yield (t/ha)
T_1	87.23	31.84	2.72	75.89	1.45	12.38
T_2	84.28	33.81	2.86	79.13	1.55	13.11
T_3	81.88	37.83	3.31	86.58	1.73	14.81
T_4	81.37	37.42	3.28	86.12	1.72	14.70
T_5	82.68	36.78	3.22	85.03	1.70	14.46
T_6	82.93	36.37	3.20	84.68	1.69	14.37
T_7	84.65	32.50	2.78	76.98	1.49	12.64
T_8	82 26	34.42	2.94	80.26	1.58	13.38
T_9	76.92	40.47	3.47	89.67	1.81	15.48
T_{10}	77.36	40.04	3.45	89.24	1.80	15.39
T_{11}	79.08	39.26	3.39	88.11	1.77	15.14
T_{12}	79.65	38.55	3.37	87.66	1.76	15.06
T_{13}	85.92	30.94	2.65	74.87	1.40	12.12
T_{14}	80.95	33.12	2.80	78.02	1.52	12.89
T_{15}	74.32	35.64	3.13	83.51	1.66	14.11
T_{16}	74.74	36.28	3.10	83.07	1.65	14.02
T_{17}	75.17	35.56	3.03	81.97	1.62	13.73
T_{18}	75.41	35.24	3.02	81.33	1.61	13.62
T_{19}	94.66	28.28	2.44	70.06	1.24	11.14
SEd	0.58	0.33	0.02	0.46	0.01	0.10
CD (0.05)	1.22	0.68	0.05	1.02	0.02	0.22

Discussion

In the present study, the increased plant height in T_9 plants is attributed to higher level of availability of nitrogen throughout the cropping period and also it might be due to combination of growth promotory effect of recommended dose of fertilizer along with 3 % panchakavya and 0.4 % humic acid, which enhanced protein synthesis resulting in increased plant height at all stages. This finding is in confirmation with the results of Kabir *et al.* (2011) [3] and Palanisamy *et al.* (2015) [7] who have reported that the micronutrient mixture and humic acid combination has enhanced the plant height in gerbera. Leaf is considered as an important functional unit of plant which contributes to the formation of assimilates. Rodrigo and Adams (1972) [9] observed a strong positive correlation

between leaf number and yield of crop plants. The increased number of leaves plant^{-1} and increased leaf length might be due to fertigation along with foliar spray of humic acid and panchakavya which enhanced more number of leaves plant^{-1}. These results were similar with the finding of Sujatha *et al.* (2002) [13] in gerbera. Similarly, Shibles and Weber (1966) [12] suggested that larger leaf area development aids in the effective interception of sun light leading to high dry matter production. Greater leaf width aids the plant to synthesise more metabolites exhibiting high photosynthetic rate during the period of growth and development (Mahadevan, 1988) [5]. Higher availability of nitrogen leads to increased rate of meristamatic activity, resulting in better plant growth parameters (Yathindra *et al.*, 2016) [16].

In the present study, combination of recommended fertilizer along with 3 % panchakavya and 0.4 % humic acid registered maximum number of spikes clump^{-1} and spike length which ensued in higher flower yield. The increased yield in the present study, might be due to the availability of major nutrients throughout the cropping period and the presence of bioactive principles like auxin, gibberellins, cytokinins, vitamins and amino acids in biostimulants. Humic substances present in the biostimulants leads to greater movement and availability of phosphorus and micronutrients might also be a possible reason for higher yield. These findings were in confirmation with the results of Kumerasn and Jawaharlal (2017) [14] as 100 % of recommended dose of fertilizer + 3 % panchakavya + 0.4 % humic acid treated plants recoded higher number of flowers in jasmine. The combined application of fertilization and consortium of biofertilizers significantly enhanced the photosynthesis and yield attributing characters. Present findings also supported the conclusions of Senthil Kumar *et al.* (2014) [11] that fertigation with 100 % recommended dose of fertilizers along with consortium of biofertilizers recorded significantly higher yield compared to 100 % RDF applied through soil. Dhanumjaya Rao *et al.*, (2015) [1] also reported that, 75 % RDF along with organic manure resulted as higher weight of individual floret in tuberose. Palanisamy *et al.* (2015) [7] also reported that, higher number of flower yield sq.m^{-1} (207.9) in 100 % recommended dose of fertilizer (RDF) through fertigation + 0.004 % micronutrient mixture + 0.2 % humic acid when compared to 125 % RDF through fertigation + 0.004 % micronutrient mixture + 0.2 % humic acid (133.1) and 125 % RDF of fertigation (115.7) alone. The findings of Vimalendran *et al.* (2014) [15] also supports these findings that, NPK fertilizer along with 3 % Panchakavya spray at 4 times recorded as higher Green cob yield when compared to NPK fertilizer along with 4 % panchakavya spray at four times in baby corn. Panchakavya has significantly increased the yield due to the presence of useful microorganisms, nitrogen, calcium, cytokinin, gloucose, minerals, etc. These nutrients might have triggered rapid cell division, proliferation and speedy growth.

Conclusion

It could be concluded that application of 100 % recommended dose of fertilizer through fertigation + microbial consortium + 3 % panchakavya + 0.4 % humic acid (T_9) is the most effective nutrient combination in enhancing the yield as well as the quality of flower in tuberose. Similarly 75 % RDF through fertigation + microbial consortium + 3 % panchakavya + 0.4 % humic acid (T_{15}) significantly increased the yield than the 100 % RDF applied through soil (T_{19}), widening the scope of obtaining optimum yield in tuberose.

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