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Influence of Fertigation, Microbial Consortium and Foliar Application of Organic Nutrients on NPK Content in Leaf and Post-harvest Soil Nutrients of Tuberose

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A B S T R A C T

A field experiment on Tuberose was conducted to find out the influence of fertigation, microbial consortium and foliar application of organic nutrients on leaf NPK contents in Tuberose cv. Prajwal and post-harvest soil at T. Pudhupatti village, Dindigul District of Tamil Nadu during 2015-16 and 2016-17. The experiment was laid out in randomized block design (RBD) with nineteen treatments including three levels each of water-soluble fertilizers viz., 125, 100 and 75 per cent of the recommended doses of fertilizers along with microbial consortium, foliar spray of panchagavya and humic acid and the treatments were replicated twice. The results revealed that application of 100 per cent recommended dose of fertilizer through fertigation along with microbial consortium @ 12.5 kg ha$^{-1,}$ panchagavya @ 3.0 per cent and humic acid @ 0.4 per cent (T_9) significantly increased the nitrogen, phosphorus and potassium content in leaf of Tuberose, while application of 125 per cent recommended dose of fertilizer through fertigation along with microbial consortium @ 12.5 kg ha^{-1}, panchagavya @ 3.0 per cent and humic acid @ 0.4 per cent (T_3) recorded the highest available nitrogen, phosphorus and potassium in soil compared to fertigation alone. The increase of nitrogen content in leaves (second year of the experiment) by the T_9 over soil application of recommended dose of fertilizer was 35 per cent.

***Key words*: Fertigation, Organic nutrients, Tuberose, NPK in leaf and available in soil**

Tuberose (*Polianthes tuberosa* L.) a member of the family Amaryllidaceae, is an important tropical ornamental bulbous flowering plant because of its multi-purpose uses as a cut flower as well as loose flower and due to pleasant fragrance, the longer vase life of spikes, higher profit and wide adaptability to different climatic and soil condition. Tuberose oil is highly used in perfumery and cosmetic industries and tuberose concrete is in high demand in international markets with a remunerative price. Furthermore, fragrant flowers are added along with stimulants or sedatives to the favourite beverage prepared from chocolate and served either cold or hot as desired. Tuberose requires a large quantity of organic and inorganic form of fertilizers for higher yield and quality. Under commercial cultivation of Tuberose, indiscriminate and inadequate plant nutrients mainly cause poor growth which may lead to decline of plant vigour and productivity.

Continuous use of inorganic fertilizers, reduces organic matter and increases soil acidity, creates micronutrient deficiencies finally makes the plant susceptible to pest and diseases. During this modern cultivation, the concept of integrated nutrient management has emerged as an essential tool for maintaining soil fertility and the productivity of crops. Integrated use of fertilizer through fertigation, microbial consortium and bio-stimulants like panchagavya and humic acid maintain the soil fertility, higher vegetative growth and yield of crops.

Fertigation ensures availability of nutrients in the crop root zone in a readily available form and therefore, accurate fertilizer application through fertigation increases the fertilizer use efficiency. The associated increase in yield with precise fertilizer application rates, increases return on the fertilizer invested. The microbial consortium is a carrier-based microbial product that contains nitrogen-fixing, phosphorus, zinc solubilizing and plant growth promoting microbes in a single carrier and also exploits the synergistic effects of combined microbes [1]. Panchagavya play the role in promoting growth and providing immunity in the plant system. Foliar application of panchagavya is more efficient than soil application, the uptake of nutrients is more viable by application in the form of foliar spray at all stages of crop growth. Humic acids are an excellent natural and organic way to provide plants and soil with a concentrated dose of essential nutrients. Humic acid contains cytokinin and auxin

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that increased the antioxidant levels [2]. The absorption of humic substances by the plant tissue resulting in various biochemical effects through uplifting the nutrient uptake and maintaining vitamins and amino acid levels in plant tissues. In view of the facts, the present investigation has been carried out to find out influence of fertigation, microbial consortium and foliar application of organic nutrients on NPK content in leaf as well as post-harvest soil nutrients of tuberose.

MATERIALS AND METHODS

The present study was conducted at T. Pudhupatti village of Reddiyarchatram block, Dindigul District. The experimental trial was laid out in randomized block design (RBD) with 19 treatments and replicated two times. The trial consisted of three levels of fertigation viz., 125 per cent, 100 per cent and 75 per cent of recommended dose of fertilizer and was applied at various crop growth stages during the cropping period. The microbial consortium was applied @ 12.5 kg ha^{-1} as soil application and bio-stimulants namely panchagavya (3 per cent and 4 per cent) and humic acid (0.4 and 0.5 per cent) were foliar sprayed at monthly intervals. Nutrient contents sch as nitrogen (%), phosphorus (%) and potassium (%) content in leaf and available nitrogen, phosphorus and potassium in soil were analyzed and expressed in kg ha^{-1}. Standard analytical procedures were adopted for the analysis of soil and plant samples. It was statistically analyzed at 5% level of probability.

Treatments details

Treatments	Details
T_1	125% recommended dose of fertilizer through fertigation (RDFTF)
T_2	125% RDFTF + Microbial Consortium (MC) @ 12.5 kg ha^{-1}
T_3	125% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 3% +Humic acid @ 0.4%
T_4	125% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 3% + Humic acid @ 0.5%
T_5	125% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 4% + Humic acid @ 0.4%
T_6	125% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 4% + Humic acid @ 0.5%
T_7	100% RDFTF
T_8	100% RDFTF + MC @ 12.5 kg ha^{-1}
T_9	100% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 3% + Humic acid @ 0.4%
T_{10}	100% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 3% + Humic acid @ 0.5%
T_{11}	100% RDFTF + MC @ 12.5 kg ha^{-1} +Panchagavya @ 4% + Humic acid @ 0.4%
T_{12}	100% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 4% + Humic acid @ 0.5%
T_{13}	75% RDFTF
T_{14}	75% RDFTF + MC @ 12.5 kg ha^{-1}
T_{15}	75% RDFTF + MC @ 12.5 kg ha^{-1} +Panchagavya @ 3% + Humic acid @ 0.4%
T_{16}	75% RDFTF + MC @ 12.5 kg ha^{-1}+ Panchagavya @ 3% + Humic acid @ 0.5%
T_{17}	75% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 4% + Humic acid @ 0.4%
T_{18}	75% RDFTF + MC @ 12.5 kg ha^{-1} + Panchagavya @ 4% + Humic acid @ 0.5%
T_{19}	100% Recommended dose of fertilizer (Soil application)

RDF: NPK 200:200:200 kg ha^{-1}

RESULTS AND DISCUSSION

Nitrogen and phosphorus content in leaf

Results of the experiment revealed that all the fertigation treatments in combination with the microbial consortium and bio-stimulants significantly increased the nitrogen and phosphorus content in leaves over control (Table 1). The highest nitrogen content (2.543 and 2.722 per cent in first and second year respectively) was recorded at 100 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1} + panchagavya @ 3 per cent + humic acid @ 0.4 per cent (T_9) whereas, the lowest nitrogen content (1.942 cm and 2.014 per cent) was registered at 100 per cent recommended dose of fertilizer application through soil (T_{19}). The maximum phosphorus content (0.511 and 0.526 per cent) was noticed in both the years when the plants received with 100 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1} + panchagavya @ 3 per cent + humic acid @ 0.4 per cent (T_9). The lowest phosphorus content (0.359 and 0.363 per cent) was recorded in T_{19} (100 per cent recommended dose of fertilizer as soil application) in both the years.

Table 1 Effect of fertigation, microbial consortium and biostimulants on leaf nitrogen and phosphorus content (%) in tuberose cv. Prajwal

Treatments	Leaf nitrogen (%)		Leaf phosphorus (%)	
	First year -2015-16	Second year - 2016-17	First year - 2015-16	Second year- 2016-17
T_1	2.143	2.250	0.391	0.395
T_2	2.268	2.416	0.423	0.431
T_3	2.464	2.637	0.486	0.499
T_4	2.450	2.615	0.484	0.497
T_5	2.425	2.594	0.474	0.486
T_6	2.418	2.586	0.471	0.484
T_7	2.184	2.293	0.400	0.406
T_8	2.300	2.458	0.432	0.441
T_9	2.543	2.722	0.511	0.526
T_{10}	2.538	2.716	0.510	0.524

T_{11}	2.504	2.678	0.498	0.512
T_{12}	2.498	2.673	0.496	0.510
T_{13}	2.093	2.196	0.376	0.380
T_{14}	2.229	2.361	0.410	0.418
T_{15}	2.380	2.547	0.456	0.468
T_{16}	2.373	2.539	0.454	0.467
T_{17}	2.341	2.504	0.444	0.455
T_{18}	2.332	2.493	0.441	0.453
T_{19}	1.942	2.014	0.359	0.363
SEd	0.043	0.049	0.008	0.010
CD (p=0.05)	0.092	0.105	0.017	0.020

Potassium content in leaf

The highest potassium content in leaf (2.861 and 3.040 per cent in the first and second year, respectively) was recorded in 100 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1}+ panchagavya @ 3 per cent + humic acid @ 0.4 per cent (T_9 - Fig 1), whereas the lowest potassium content (2.129 cm and 2.214 per cent) was registered in T_{19} (100 per cent recommended dose of fertilizer as soil application) in both the years.

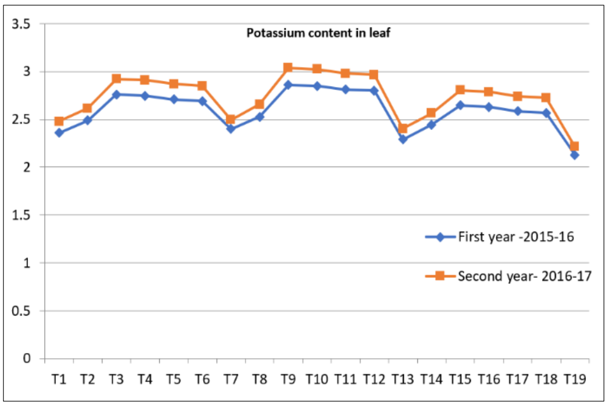

Fig 1 Effect of fertigation, microbial consortium and biostimulants on potassium content (%) in Tuberose cv. Prajwal

Nutrient content plays a major role in imparting higher yield, yield attributing parameters and quality in tuberose. Efficient use of organic and inorganic fertilizers is necessary for optimum growth, yield and quality in addition to saving the production cost.

In the present investigation, it was recorded that the first and second years of leaf NPK content increased by the combined application of a recommended dose of fertilizer through fertigation along with microbial consortium, foliar spray of bio-stimulants as compared to the recommended dose of fertilizer as soil application. The combined application of organic, inorganic and bio-fertilizers greatly increases nitrogen content, which might be attributed to the rapid absorption of these elements by the plant surface and their translocation to the soil as found by Sing *et al*. [3] in gladiolus. The fertigation technique provides consistent moisture regimes in the soil due to which roots remain active throughout the season resulting in optimum availability of nutrients [4-5].

Nitrogen is an important constituent of amino acids, proteins, enzymes, nucleic acids and chlorophyll content. In the present study, the results (first and second year of crop experiment) indicated that the application of 100 per cent of the recommended dose of fertilizer through fertigation along with microbial consortium @ 12.5 kg ha^{-1}, foliar spray of panchagavya @ 3 per cent and humic acid @ 0.4 per cent led to higher nitrogen content in leaves with 2.543 and 2.722 per cent in both the years respectively. This situation was ascribed to the efficient utilization of nitrogen by the developing sink [6-7].

Phosphorus plays a key position in the plant's energy transfer system. In the present investigation, fertigation of 100 per cent water-soluble fertilizers along with microbial consortium @ 12.5 kg ha^{-1}, foliar spray of panchagavya @ 3 per cent and humic acid @ 0.4 per cent resulted in higher leaf phosphorus content with 0.511 and 0.526 per cent in both the years respectively. This could be attributed to the application of phosphorus through fertigation along with microbial consortium and higher nutrient use efficiency. Moreover, higher level of phosphorus application might have helped in the root proliferation and better uptake of available nutrients resulted in more content of phosphorus in leaves. The presence of phosphate solubilizing bacteria in microbial consortia increases the availability of phosphorus in the soil through the secretion of phosphate enzyme which leads to the conversion of organic phosphate to their available forms and therefore increases the absorption and accumulation of phosphorus in plant tissues as stated by Swaminathan *et al*. [8].

Potassium, being a protoplasmic factor is an important plant nutrient. Many enzymes are activated by potassium and it is also involved in photo oxidative phosphorylation, thus enhancing the energy required for growth. The potassium content in the leaf exhibited a similar pattern as that of nitrogen and phosphorus. Fertigation with 100 per cent of the recommended dose of fertilizer along with microbial consortium @ 12.5 kg ha^{-1}, foliar spray of panchagavya @ 3 per cent and humic acid @ 0.4 per cent enhanced the absorption of potassium and increased the potassium level in leaf with 2.861 and 3.040 per cent. Dangler and Lacascio [4] stated that the application of N and K in combination with drip irrigation increased the yield by maximizing the mobility of nutrients around the root zone. The change reactions that took place would have led to greater availability of potassium in the soil and consequently resulted in better utilization by plants. These results are in agreement with those obtained by El-Gizawy *et al*. [9] in tomato.

Available soil nutrients

Available nitrogen and phosphorus in soil

Significant differences were observed (in both the years) between the treatments for the available nutrient content like nitrogen and phosphorus in soil (Table 2). The highest available nitrogen content (349.82 and 352.72 kg ha^{-1}) and available phosphorus content (50.02 and 53.17 kg ha^{-1}) was recorded in 125 per cent recommended dose of fertilizer through fertigation along with microbial consortium

@ 12.5 kg ha^{-1} + panchagavya @ 3 per cent + humic acid @ 0.4 per cent (T_3). The lowest available nitrogen (318.12 and 316.20 kg ha^{-1}) and available phosphorus (30.68 and 29.43 kg ha^{-1}) in soil were recorded in both the years by the application of 75 per cent recommended dose of fertilizer through fertigation alone (T_{13}).

Table 2 Effect of fertigation, microbial consortium and biostimulants on available nitrogen and phosphorus content in soil (kg ha^{-1}) in tuberose cv. Prajwal

Treatments	Soil nitrogen (kg ha^{-1})		Soil phosphorus (kg ha^{-1})	
	First year -2015-16	Second year - 2016-17	First year - 2015-16	Second year- 2016-17
T_1	342.67	343.94	43.68	45.72
T_2	347.22	349.72	48.19	51.36
T_3	349.82	352.72	50.02	53.17
T_4	349.61	352.38	49.64	52.86
T_5	349.16	351.92	49.18	52.47
T_6	348.82	351.64	48.94	52.04
T_7	332.73	334.12	39.68	41.70
T_8	337.54	341.30	45.92	48.68
T_9	341.02	343.49	47. 27	50.28
T_{10}	340.63	343.20	47.05	50.04
T_{11}	340.17	342.76	46.61	49.48
T_{12}	339.72	342.39	46.29	49.10
T_{13}	318.12	316.20	30.68	29.43
T_{14}	326.04	327.85	40.38	42.68
T_{15}	329.57	331.65	41.66	44.31
T_{16}	329.14	331.24	41.31	44.14
T_{17}	328.64	330.71	41.04	43.66
T_{18}	328.22	330.36	40.82	43.24
T_{19}	325.82	327.64	36.92	39.57
SEd	5.83	6.49	0.88	0.94
CD (p=0.05)	12.81	14.25	1.84	1.98

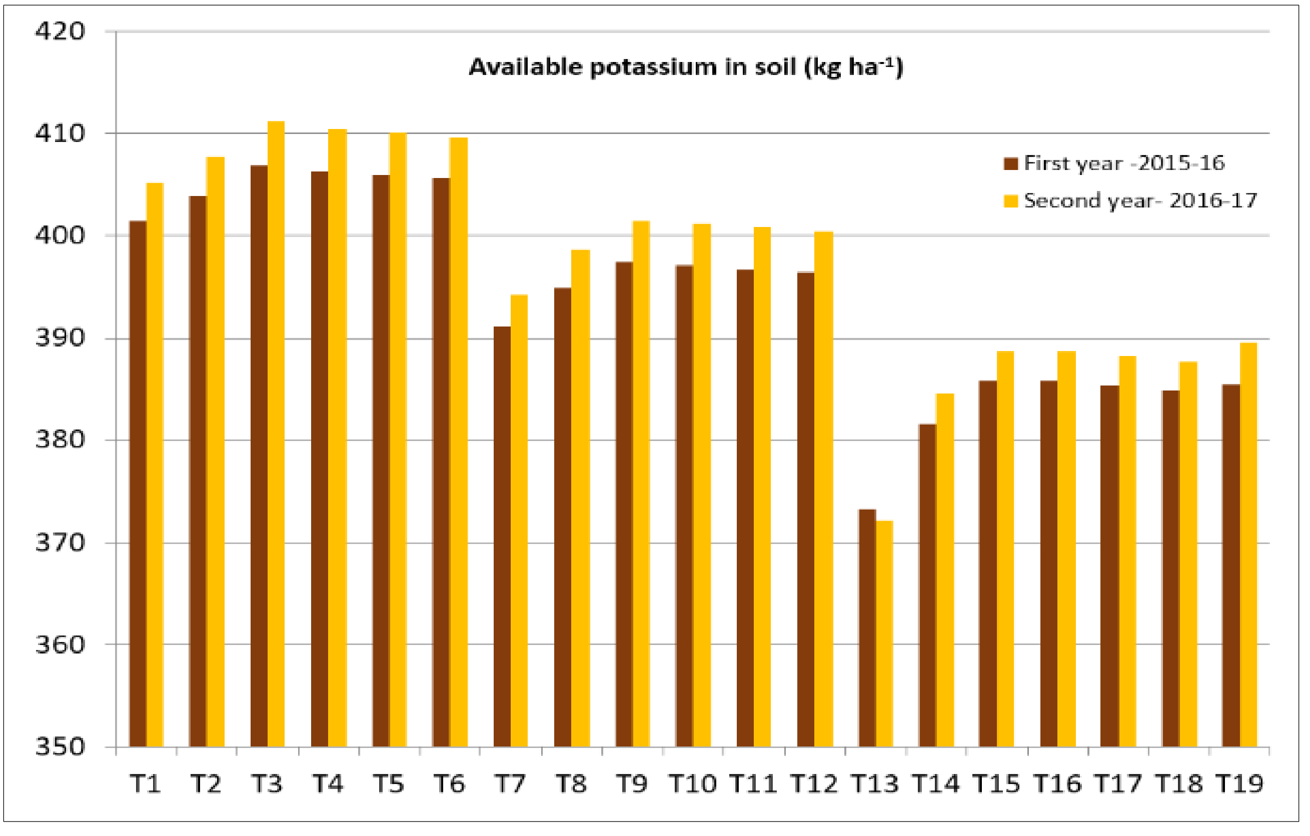

Fig 2 Effect of fertigation, microbial consortium and biostimulants on available potassium in soil of tuberose cv. Prajwal

Available potassium in soil

Available potassium content in soil **(**for both the years) was significantly increased by higher doses of fertigation along with microbial consortium and foliar spray of panchagavya and humic acid (Fig 2). The highest potassium content (406.82 and 411.18 kg ha^{-1}) was recorded by the application of 125 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1} +

panchagavya @ 3 per cent + humic acid @ 0.4 per cent (T_3), whereas the lowest available potassium (373.22 and 372.18 kg ha^{-1}) was recorded in both the years by the application of 75 per cent recommended dose of fertilizer through fertigation alone (T_{13}).

The available nutrient status in the soil is very important for realising higher productivity. In the present study, the variation in nutrient availability is due to different levels of fertigation along with microbial consortium and bio-stimulants including panchagavya and humic acids. Application of 125 per cent of the recommended dose of fertilizer through fertigation along with microbial consortium @ 12.5 kg ha^{-1}, foliar spray of panchagavya @ 3 per cent and humic acid @ 0.4 per cent (T_3) recorded the highest available nitrogen with 349.82 and 352.72 kg ha^{-1}, available phosphorus with 50.02 and 53.17 kg ha^{-1} and available potassium with 406.82 and 411.18 kg ha^{-1}. The treatments comprised of different levels of fertigation along with microbial consortium and bio-stimulant had registered the highest values of soil nitrogen content. The increase in the contents of total nitrogen in the soil might be attributed to the higher availability of nitrogen coupled with related nitrification for a longer period in the soil. These are in line with the findings of Karuthamani *et al*. [10] in coffee. The combined application of inorganic and organic sources may influence the forms and availability of nitrogen through the process of mineralization and also act as a storehouse of nutrients as stated by Hazarika *et al*. [11] in banana. Similarly available phosphorus content in soil was greatly influenced by fertigation, microbial consortium and bio-stimulant treatments. Phosphorus availability in the soil increased with increased application of different levels of nutrients and phosphobacteria in the form of microbial consortium. The phosphobacteria solubilize the immobile phosphorus by secretion of organic acids, thus resulted in higher availability of phosphorus in the soil. The present investigation is in agreement with that of Raghuramalu [12] in coffee and Ravanachandar [13] in black pepper. The highest available soil potassium registered in the treatment that received drip fertigation, microbial consortium and bio-stimulants might be due to the increased level of potassium and organic nutrients and mobilization of potassium due to the exchange reaction with soil particles as reported by Adherkin and Belayer [14].

CONCLUSION

In the present experiment it is concluded that, 100 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1} + panchagavya @ 3 per cent and humic acid @ 0.4 per cent has shown the highest uptake and utilization of nitrogen, phosphorus and potash in leaves of Tuberose. However, available soil nitrogen, phosphorus and potassium were the highest by application of 125 per cent recommended dose of fertilizer through fertigation + microbial consortium @ 12.5 kg ha^{-1} + panchagavya @ 3 per cent and humic acid @ 0.4 per cent.

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