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Effect of integrated nutrient management practices on soil microbes in turmeric

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Abstract
Efficient and rational use of manures and fertilizers is imperative not only for obtaining more yields unit area^{-1} on a sustainable basis, but also to ensure safe food and to conserve the environment. Keeping these aspects in view, the present research work was undertaken to evaluate the organic sources of nutrients on growth and yield of turmeric. Field investigations were carried out at Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in Randomized Block Design replicated thrice. It consisted of fifteen treatments comprising twelve treatments of commercial organic sources of nutrients, two treatments of farm yard manure and one treatment with 100 per cent Recommended Dose of Fertilizers (control). Chemical source of nutrients like N and K were applied in five split doses along with wellgro formulations, while the full dose of P was applied as basal. During both the seasons microbial population was influenced by integrated nutrient management practices and noticed significant difference among the treatments. Among the treatments, the highest microbial population was recorded with 100% RDF along with 40% wellgro soil (T_3). During 2010-2011, T_3 recorded the maximum bacterial and fungal population respectively at 90 (83.3, 67.0), 135 (124.7, 94.3), 180 (169.0, 114.7) and 245 (126.7, 84.0) days after planting. Similar trend was observed during 2011-2012 also. The minimal microbial count was observed under control (100% RDF alone). Hence it is concluded that turmeric responded favourably to wellgro formulations along with chemical fertilizers. Among the different treatments, application of 100% RDF + 40% wellgro soil would be the better practice to enhance the microbial load inturn improves the yield.

Keywords: Bacteria, Fungi, Actinomycetes, wellgro organic manures and farm yard manure and inorganic fertilizers.

1. Introduction
Turmeric (*Curcuma longa* L.) is a perennial rhizomatous herb and regarded as an important spice of Asian cuisine. India is a leading exporter of turmeric and plays important role in earning foreign exchange for the country [17]. Turmeric demands more mineral nutrients and it generally responds to increased soil fertility and quantity of fertilizers applied (organic and inorganic) [18]. Owing to its long duration and high productivity it requires higher quantum of fertilizers [16]. Application of inorganic fertilizers though increases the yield substantially, could not sustain the fertility status of the soil [2] and have caused several undesirable consequences in the fragile soil eco-system, leading to the gradual decline in productivity [15, 19]. Considering the present situation of soil quality and environmental security, it is necessary to go for an integrated nutrient management, involving various sources of organic manures, organic cakes and bio-fertilizers besides using chemical fertilizers in turmeric. In today's cultivation many commercial organic manures are being used because of their application in lesser volume and also enriched with nutrients. One such commercial organic manure used in the study is Wellgro. Wellgro organic manures are a product of Indian Tobacco Company (ITC) and are developed for soil application and foliar spray. Wellgro organic manure is a unique form, a blend of neem and non-timber forest produce, free from harmful chemicals and a rich source of nutrients. This organic based farm input addresses soil fertility and crop nutrition in line with the concept of integrated nutrient management. Across the country, its efficacy was examined in different agro climatic conditions on various crops.
Soil health is referred to as "The soil's fitness to support crop growth without becoming degraded or otherwise harming the environment" [10]. It is determined by physical, chemical and biological properties of soil such as soil texture, amount & type of nutrients available, organic matter content, moisture content, degree of aeration, temperature, pH and microbial diversity. All these properties are affected by certain intrinsic & extrinsic factors like the crop

grown, source of external nutrients provided and abundance of microorganisms. Microorganisms play a definitive and very crucial role in soil fertility. Although soil organisms comprise <1% of the total mass of a soil, they have a vital role in supporting all plants and thus animals. Every gram of a typical healthy soil is home to several thousand different species of bacteria. In addition to bacteria, the soil is home to microscopic fungi, algae, cyanobacteria, Actinomycetes, protozoa and nematodes, and macroscopic earthworms, insects and the occasional wombat. Microorganisms play an important role in the decomposition of organic matter and also help in the decomposition of toxic waste and other pollutants. The diversity and abundance of life are in the soil more copious than in any other ecosystem. Microorganisms play a critical role in soil quality and support development of plants. They stimulate plant growth by facilitating the assimilation of phosphorus and iron, nitrogen fixation, releasing phytohormones, inhibiting root pathogens and synthesizing antibiotics [5]. Application of wellgro organic manures along with inorganic sources of nutrient improves the microbial population in banana under irrigated conditions along with yield increment [13].

The information on effect of integrated nutrient management practices on turmeric with commercial formulations of organic products (*Wellgro*) is new under the soil and climatic conditions of the Western zone of Tamil Nadu. With these ideas, the present research work was undertaken to study the effect of integrated nutrient management practices on the microbial population of turmeric under irrigated conditions.

2. Materials and methods

The field experiment was conducted in field number 11 of Northern block of the Agricultural Research Station, Bhavanisagar, Tamil Nadu Agricultural University during June 2010-2011 – March 2011-2012. It is situated at 11^0 29'at latitude and 77^0 08'E longitude with an altitude of 256 m above mean sea level in Erode district, Tamil Nadu. The normal weather condition at Bhavanisagar is as follows. A mean annual rainfall of 659 mm is received in

57 rainy days. The mean maximum and minimum temperature are 21.54 and 33.43 ^{0}C, respectively. The averages relative humidity is 69.67 per cent and the bright sunshine hour is 4.67 (hrs day^{-1}). The soil of the experimental field was red sandy loam in texture having slightly acidic pH (6.27) with medium soluble salts (0.75 dSm^{-1}), medium in organic carbon content (0.5 per cent), low in available N (205 kg ha^{-1}), medium in available P (15.7 kg ha^{-1}) and high in available K (376 kg ha^{-1}). The field experiment was laid out in Randomized Block Design with three replications.

The experiment consisted of 15 treatments comprising of wellgro formulations T_1:100 % RDF, T_2:100 % RDF + 20% Wellgro Soil, T_3:100 % RDF + 40 %Wellgro Soil, T_4:75 % RDF + 20 % Wellgro Soil, T_5:75 % RDF + 40 %Wellgro Soil, T_6:100 % RDF + 20% Wellgro Pellets, T_7:100 % RDF + 40 % Wellgro Pellets, T_8 :75 % RDF + 20 % Wellgro Pellets, T_9:75 % RDF + 40 %Wellgro Pellets, T_{10} :100 % RDF + 20% Wellgro Grains, T_{11}:100 % RDF + 40 %Wellgro Grains, T_{12}:75 % RDF + 20 % Wellgro Grains, T_{13}:75 % RDF + 40 %Wellgro Grains. Recommended dose of N, P and K was applied at 150 kg, 60 kg and 100 kg ha^{-1}. Planting was done with a spacing of 45 x 15 cm. Farm yard manure was applied at 12.5 t/ha for treatment T_{14} (100 % RDF + FYM) and T_{15} (75 % RDF + FYM).

Fertilizer and wellgro formulations application

Recommended dose of N, P and K was applied at 150 kg, 60 kg and 100 kg ha^{-1}, respectively. Wellgro formulations *viz.*, soil, pellets and grains were applied @ 20% and 40% weight by weight of chemical fertilizer along with RDF as per the treatment schedule. The fertilizer urea, single super phosphate and muriate of potash were the source for N, P and K, respectively. The entire phosphorus was applied as basal at time of planting. Nitrogen and potash were applied along with wellgro formulations in five equal splits at 30, 60, 90, 120 and 150 days after planting (DAP). Farm yard manure was applied @ 12 t ha^{-1} in five equal splits along with RDF. Uniform population of 5 plants plot^{-1} was maintained for all the treatments. The standard recommended cultural practices [3] were followed for raising the crop.

Soil biological properties

Soil samples were procured from the rhizospheric soil of turmeric grown with treatments under the field conditions. Five samples were randomly collected from different areas of the same treatment field and were mixed to get one representative sample. Enumeration of different microbial population viz. Bacteria and Fungi were done in their specific media, sterilized in an autoclave at 15 psi pressure and 121˚C temperature for

20 minutes using serial dilution spread plating technique (at different intervals of time). The population of bacteria and fungi population were specified in nutrient agar and Martin's rose Bengal agar respectively. The standard serial dilution plating techniques [20] was employed for the estimation of microbial population. Soil sample in each treatment was collected replication wise. Ten grams soil of each treatment was mixed separately in 100 ml sterilized water blank to give 10^{-1} dilution and subsequent dilutions were made upto 10^{-6} by transferring serially 1 ml of the dilution into 9 ml sterilized water blanks. The observation on number of colonies of bacteria and fungi were taken at 1 and 3 days after inoculation respectively and expressed as colony forming units per gram of dry weight of soil.

The data were statistically analyzed by the analysis of variance method as suggested Gomez and Gomez (2010). Wherever the treatment differences were found significant, critical differences were worked out at 5 per cent probability level and the values are furnished. Non-significant treatment differences were denoted as NS.

3. Results and discussion

Effect of different treatments on microbial population

The data pertaining to bacterial population recorded at 90, 135, 180 and 245 DAP are furnished in Table 1. Bacterial load in soil at different stages are significantly influenced through application of organic sources of nutrients. Bacterial count increased with ageing of crop and the maximum count was recorded at 180 DAP and slight decline at 245 DAP.

At all intervals of time, bacterial population showed significantly greater values in all treatments over control (Table 1). During 2010-2011, the maximum bacterial count (83.33 x 10^7 cfu g^{-1} dry wt of soil) was observed with application of 100 % RDF along with 40 % wellgro soil at 90 DAP. Similarly at 135 DAP (124.67 x 10^7 cfu g^{-1} dry wt of soil), 180 DAP (169.00 x 10^7 cfu g^{-1} dry wt of soil) and at 245 DAP (126.67 x 10^7 cfu g^{-1} dry weight of soil) also which was on par with 100 % RDF + 40 % wellgro grains/wellgro pellets and farm yard manure. The similar line of results was observed in banana while using wellgro organic manures and

farm yard manure [13]. The application of wellgro soil may increase the friability; promote aggregation of soil and increased the level of humus in soil thereby enhancing the soil microbial activity. The multiplication of microbes significantly improved the N supply of soil. Organic nitrogen and P_2O_5 availability in the soil increased with the application of wellgro soil, due to the increase of decomposition of products of organic matter. This is in confirmation with the previous work [8]. Moreover, wellgro soil helps to retain moisture for a long time. This factor would have led to increased microbial activity in soil. [4] Application of organic manures
(FYM, vermicompost, neem cake, ash) and biofertilizers to turmeric either single or in combination with fertilizers resulted in the positive influence on microbial biomass carbon, N mineralization, soil respiration and enzyme activities. Similarly many researchers [9, 7, 1] opined that application of organic manures increased the microbial population viz. fungi, bacteria and Actinomycetes. The less number was observed with application of 100 % RDF alone (42, 66.67, 88 and 73 x 10^7 cfu g^{-1} dry weight of soil) at 90, 135, 180 and 245 DAP, respectively.

Table 1: Influence of nutrient sources on bacterial population (x10^7 cfu g^{-1}) at different stages of turmeric

Treatments	2010-11				2011-12			
	90 DAS	135 DAS	180 DAS	245 DAS	90 DAS	135 DAS	180 DAS	245 DAS
T_1 - 100 % RDF	42.0	66.7	88.0	73.0	39.3	58.0	78.5	68.5
T_2-100 % RDF + 20% WS	57.7	88.3	124.3	96.0	53.6	82.0	125.0	95.5
T_3 - 100 % RDF + 40% WS	83.3	124.7	169.0	126.7	75.0	119.6	145.3	130.0
T_4-75 % RDF + 20% WS	65.0	111.0	128.0	105.3	65.6	105.3	125.5	108.0
T_5-75 % RDF + 40% WS	72.0	118.3	135.7	113.7	37.2	109.0	130.0	115.5
T_6 -100 % RDF + 20% WP	58.0	92.7	124.3	102.3	55.9	92.5	126.0	104.6
T_7 - 100 % RDF + 40% WP	74.0	105.7	142.7	124.3	72.0	98.0	135.5	126.4
T_8- 75 % RDF + 20% WP	65.0	101.3	139.0	117.0	65.2	102.3	132.0	115.5
T_9 - 75 % RDF + 40% WP	76.7	115.7	150.3	124.3	75.0	112.4	141.0	121.0
T_{10} - 100 % RDF +20% WG	57.7	95.0	143.3	118.7	58.0	96.8	138.0	115.0
T_{11} - 100 % RDF + 40 % WG	74.0	121.0	157.0	122.3	72.5	116.5	149.8	123.5
T_{12}- 75 % RDF + 20 % WG	62.0	94.7	118.0	113.0	63.0	98.6	112.0	115.0
T_{13} - 75 % RDF + 40 % WG	55.7	83.3	118.3	97.3	55.0	85.2	115.0	96.0
T_{14} - 100 % RDF + FYM	70.3	100.0	132.3	92.7	68.5	116.8	140.5	126.0
T_{15} - 75 % RDF + FYM	64.3	94.7	123.7	89.0	63.0	113.0	136.0	121.0
S.Ed	2.48	2.71	2.26	2.54	2.50	3.61	2.35	3.02
CD(P=0.05)	5.08	5.56	4.64	5.28	5.02	7.22	4.71	6.04

WS – Wellgro soil, WP- Wellgro pellets, WG- Wellgro grain, DAS- Days after sowing

Table 2: Influence of nutrient sources on fungal population (x10^4 cfu g^{-1}) at different stages of turmeric

Treatments	2010-11				2011-12			
	90 DAS	135 DAS	180 DAS	245 DAS	90 DAS	135 DAS	180 DAS	245 DAS
T_1 - 100 % RDF	32.7	54.0	63.7	50.7	30.1	52.5	65.5	55.6
T_2-100 % RDF + 20% WS	42.7	65.0	85.7	61.3	35.8	58.8	88.9	62.4
T_3 - 100 % RDF + 40% WS	67.0	94.3	114.7	84.0	55.5	90.3	108.6	80.2
T_4-75 % RDF + 20% WS	53.7	74.0	83.0	61.7	40.2	76.7	87.1	63.1
T_5-75 % RDF + 40% WS	57.0	84.0	93.0	82.3	45.5	88.2	90.2	85.0
T_6 -100 % RDF + 20% WP	47.3	75.7	85.3	73.0	38.4	76.5	85.7	71.6
T_7 - 100 % RDF + 40% WP	57.3	84.0	97.0	76.3	50.7	89.9	92.6	75.8
T_8- 75 % RDF + 20% WP	51.7	78.0	89.0	70.0	45.1	75.6	85.3	72.5
T_9 - 75 % RDF + 40% WP	59.0	84.0	105.3	77.3	48.9	88.4	98.7	75.6
T_{10} - 100 % RDF +20% WG	45.0	75.0	96.3	68.0	38.4	71.2	95.6	67.5
T_{11} - 100 % RDF + 40 % WG	63.0	90.3	103.3	79.3	50.6	92.8	105.2	75.4
T_{12}- 75 % RDF + 20 % WG	55.3	75.0	95.0	70.3	42.2	78.0	96.3	68.7
T_{13} - 75 % RDF + 40 % WG	54.3	75.3	92.3	68.0	45.5	80.3	95.8	65.0
T_{14} - 100 % RDF + FYM	59.7	86.0	98.3	72.0	60.5	90.5	109.3	75.5
T_{15} - 75 % RDF + FYM	56.0	81.3	93.7	70.3	58.7	91.4	105.7	71.6
S.Ed	1.99	2.16	2.29	2.04	2.05	3.01	3.52	2.50
CD(P=0.05)	4.08	4.43	4.7	4.17	4.10	6.02	7.04	5.02

WS – Wellgro soil, WP- Wellgro pellets, WG- Wellgro grain, DAS- Days after sowing

The results on fungal population recorded at 90, 135, 180 and 245 DAP are furnished in Table 2. Fungal load in soil at different stages are significantly influenced through application of organic sources of nutrients. Fungal count increased with ageing of crop and the maximum count was recorded at 180 DAP and slight decline at 245 DAP. At 90 DAP and 135 DAP, maximum fungal count (67, 94.33 x 10^4 cfu g^{-1} dry weight of soil) was observed with application of 100 % RDF + 40 % wellgro soil, which was on par with 100 % RDF + 40 % wellgro grains. At 180 DAP, 100 % RDF + 40 % wellgro soil registered significantly higher fungal load (114.67 x 10^4 cfu g^{-1} dry weight of soil). At 245 DAP, 100 % RDF + 40 % wellgro soil observed higher count (84 x 10^4 cfu g^{-1} dry weight of soil), which was on par with 75 % RDF + 40 % wellgro soil. Similarly [11] application of neem cake, groundnut cake and castor cake increased the fungal population in the rhizosphere and suppressed the number of parasitic fungi as well as phytophagus nematodes. [12] Another research observed that application of vermicompost increased the population of phosphate solubilizing bacteria (*Pseudomonas and Bacillus*) to provide high organic carbon content and caused an increase of the microbial biomass pool.

Application of wellgro organic manures along with inorganic manures favourably increase the soil fertility through microbial population, soil organic matter and nutrient uptake in banana under irrigated conditions [13]. The same trend was followed during 2011-2012 year also. The least microbial count (32.67, 54, 63.67 and 50.67 x 10^4 cfu g^{-1} dry weight of soil) at 90, 135, 180 and 245 DAP, respectively was recorded with application of 100 % RDF (control). Similarly [13] another research also supported the same results that increased microbial biomass under manures and vermicompost based treatments than control.

In the present study, the use of organic sources consists of bulky and concentrated organic manures which provided organic matter and mineral nutrients to soil. These organic manures also greatly increased the soil microbial population. Improved microbial load was observed under

100 per cent RDF along with 40 per cent wellgro soil followed by wellgro grains, wellgro pellet and farm yard manure. Wellgro soil is a neem based organic manure which reduces alkalinity in the soil, as it produces organic acids on decomposition. Being totally natural, it is compatible with soil microbes, improves rhizosphere microflora and hence ensures the fertility of the soil. It is clear that organic manure improved the nutrient status of soil pool in view of slow release effect. The increased available nutrients in wellgro treated plots could have been due to enhanced microbial activity and favourable conditions created in the soil due to the addition of wellgro during crop establishment stage.

4. Conclusion

From the study it could be concluded that integrated nutrient management practice of 100% recommended dose of fertilizer along with 40% wellgro soil enhance the soil biological properties in turmeric under irrigated condition. Hence it is considered to be an ideal option to sustain the soil fertility under the soil and climatic conditions of Western zones of Tamil Nadu.

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