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SOIL PROPERTIES AND NUTRIENT UPTAKE INFLUENCED BY ORGANIC MANURES AND MICROBIAL INOCULANTS IN KASTHURI TURMERIC (*CURCUMA AROMATICA* SALISB.).

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ABSTRACT

The experiment was conducted at the farm attached to the College of Agriculture, Vellayani (Thiruvananthapuram) during 2010-2011 with the main objective of studying the combined effects of organic manures and microbial inoculants on soil properties and nutrient uptake in kasthuri turmeric (Curcuma aromatica Salisb.). The treatments were based on prestandardised doses and included full dose of individual organic manures FYM (40 t ha^{-1}), Vermicomost (25 t ha^{-1}) and Neemcake (6 t ha^{-1}) in combination a common with prestandardised dose of microbial inoculants {Azospirillum + AMF + Trichoderma + Pseudomonas (mi)}, half dose of above organic manures individually in combination with mi, half FYM dose + quarter dose of Vermicompost and Neemcake in combination with mi and half FYM dose + 1/8 th dose of Vermicompost and Neemcake in combination with mi. The above treatments along with control formed the nine treatments which were repeated thrice in RBD. The post experiment study revealed an improvement in the soil physical and chemical properties in all treatments with a general reduction in soil bulk density and an increase in the water holding capacity of the soil, but no appreciable change in soil pH. An increase in the electrical conductivity and in organic carbon was noticed in all treatments including the control. General increase in available N, P and K in soil were noticed in all treatments. The highest values for nitrogen was recorded in higher dose of Neemcake (6 t ha^{-1}) in combination with mi whereas, available Phosphorus and Potassium were recorded in Vermicomost (25 t ha^{-1}) in combination with mi. Plant analysis revealed that Nitrogen uptake was maximum observed in treatment with full dose application of vermicompost with mi (102.48 t ha^{-1}), whereas maximum Phosphorus uptake was noticed with half FYM 40 t ha^{-1} + quarter dose of Vermicompost and Neemcake in combination with mi (59.76 t ha^{-1}). Moreover, uptake of Potassium as observed in the treatment in full dose treatments of vermicompot and neemcake (260.88 t ha^{-1} and 262.56 t ha^{-1} respectively).

KEY WORDS: kasthuri turmeric, microbial inoculants, organic manures, soil properties and nutrient uptake.

I. INTRODUCTION

Kasthuri turmeric (*Curcuma aromatica* Salisb.) belonging to the family Zingiberaceae is a medicinal and aromatic plant with multiple uses. Several commercially produced cosmetics and ayurvedic preparations contain kasthuri turmeric. Skin care is the major domain of application of this aromatic plant. Rhizome of *Curcuma aromatica* are also used in medicines as a stomachic, carminative and emmenogogue, for skin diseases and recently as a health food in Japan (Kojima *et al.,* 1998).

Considering the world demand for organic food, the improvement of soil health and productivity and the availability of local resources, the organic farming practice can be encouraged. Our farmers can take advantage of this opportunity presently available in the international market by offering organically produced spice, aromatic and medicinal products. Use of biofertilizers for crop production is gaining momentum as they are environmentally safe when compared to chemical fertilizers. Though organic manures have beneficial effects on soil health and crop productivity, their limited nutrient content and requirement in large quantity is a constraint for their wider usage. Dwindling availability and huge cost of bulky organic manures warrants the need for reducing their quantity through appropriate substitutes. As a cost effective supplement to chemical fertilizers and as a renewable energy source, microbial inoculants can economize the high investment needed for fertilizer usage of N and P (Pandey and Kumar, 2002). Microbial inoculants like *Azospirillum*, *Phosphobacteria* and AMF are capable of enhancing the fertilizer use efficiently, soil fertility status and thus help in improving the yield and quality of crops. The experiment was undertaken with the main objective of studying the combined effects of organic manures and microbial inoculants on soil properties as well as uptake of major plant nutrients in kasthuri turmeric (*Curcuma aromatica* Salisb.).

II. MATERIALS AND METHODS

The field experiment was conducted at the farm attached to the College of Agriculture, Vellayani, Thiruvananthapuram, Kerala. The area is situated at 8^{o} 30' North latitude and 76^{o} 54' East longitude at an altitude of 29 m above MSL during May 2010 to January 2011. The soil of the experimental site belongs to Vellayani series which comes under the Order Oxisol. The soil type was type was red loam with bulk density 1.28 Mg m^{-3}, Water holding Capacity 22.11 %, pH 6.50, EC 0.22 d S m^{-1}, organic carbon 0.82 %, available N, P and K were 233.35 kg ha^{-1}, 57.01 kg ha^{-1} and 371.28 kg ha^{-1} respectively. The treatments consist of different combinations of three organic manures and four microbial inoculants. The treatments were M_1 d (T_1) - FYM 40.0 t ha^{-1} + mi, M_2 d (T_2) - Vermicompost (VC) 25.0 t ha^{-1} + mi, M_3 d (T_3) - Neemcake (NC) 6.0 t ha^{-1} + mi, M_1 d/2 (T_4) - FYM 20.0 t ha^{-1} + mi, M_2 d/2 (T_5) - Vermicompost 12.5 t ha^{-1} + mi, M_3 d/2 (T_6) - Neemcake 3.0 t ha^{-1} + mi, M_4 d (T_7) - FYM 20.0 t ha^{-1} + VC 6.25 t ha^{-1} + NC 1.5 t ha^{-1} + mi, M_4 d/2 (T_8) - FYM 20.0 t ha^{-1} + VC 3.125 t ha^{-1} + NC 0.75 t ha^{-1} + mi and M_0 d_0 (T_9) - Absolute control with no organic manures and microbial inoculants. The experiment was laid out in a randomized block design with nine replications. IISR accession of kasthuri turmeric were used as a planting material. Full dose of organic manures as per the treatments were applied as basal dose at the time of planting. Commercial inoculum of AMF 2-3 g per pit was applied at the time of planting. In the case of *Trichoderma*, slurry was prepared by dissolving 20 g in 1 liter of water. *Azospirillum* was mixed with the organic manures in a ratio of 1:25 and applied. Two per cent suspension of *Pseudomonas* was applied as soil drenching. The crop was harvested when the above ground portion were completely dried up (at around 230 days after planting). Observations for soil physical and chemical characters were recorded before planting and immediately after the harvest whereas, uptake of major plant nutrients were recorded at the time of harvest. Bulk density and water holding capacity were determined by core and undisturbed core sample method, respectively (Gupta and Dakshinamoorthy, 1980). Soil pH was determined by pH meter with electrodes, soil electrical conductivity was read in Electrical conductivity meter. Soil organic carbon was estimated by Walkley and Black's rapid titration method. Available Nitrogen in soil was determined by Alkaline permanganate method (Subbiah and Asija, 1956) whereas, available phosphorus in the soil was determined by Bray No.1 method using spectro-photometer. Available potassium was extracted using Neutral normal ammonium acetate and available K was read in Flame photometer. Nitrogen uptake was estimated by Microkjeldahl

method, uptake of P was dertermined colorimetrically by Vanedomolybdo phosphoric yellow colour method and K was estimated using flame photometer and expressed in percentage (Piper, 1967). The experimental data were analysed by applying the analysis of variance technique as applied to Randomised Block Design (Panse and Sukhatme, 1985).

III.RESULTS AND DISCUSSION

SOIL PHYSICAL AND CHEMICAL PROPERTIES:

Soil Bulk density, Water holding capacity, pH, EC and Organic carbon:

After the experiment an improvement in the soil physical and chemical properties was recorded in all treatments, but significant differences were not recorded among the different treatments. A general reduction in soil bulk density and an increase in the water holding capacity of the soil was recorded in all treatments after the experiment. However, a significant difference among the treatments was not noticed. Soil pH range of the experimental field remained same after the experiment (6.38-6.59), while an increase in the electrical conductivity was noticed in all the treatments. An increase in organic carbon was noticed in all treatments including control (M_0 d_0) after the experiment.

Available N, P and K (kg ha^{-1}):

After the experiment a significant increase in soil N has been recorded by different treatments over control. Highly significant effect was brought about by full dose application of neemcake + mi (M_3 d) and full dose of FYM + mi (Table 1). Lower dose of organic manures led to a lesser increment in available soil N. Increase in N availability in neemcake treatment may be due to higher N content and its gradual mineralization process. FYM along with microbial inoculants (M_1 d) also play a vital role in increasing the N, P and K availability in the soil by direct contribution as well as indirectly by influencing chemical transformation reaction and microbial activity.

No significant difference in the available P and K content was noticed among the treatments after the experiment. However, after the experiment an increase in P and K content was there in all treatments including control. Substantial increase in soil P and K content was made by vermicompost and neemcake + mi (M_2 d and M_3 d). Combined application of organic manures + mi (M_4 d) also increased the P and K availability in the soil (Table 1). Higher P content in vermicompost due to increased phosphatase activity from the direct action of gut enzymes and indirectly by the stimulation of microorganisms as been reported by Edward and Burrows (1988). Nirmalatha (2009) reported that in kasthuri turmeric available soil P and K content was significantly superior when vermicompost 25.0 t ha^{-1} was applied. The timely and regular cultural practices including mulching might have contributed to an increased N, P and K content in the control also, though the increase is not substantial.

UPTAKE OF MAJOR PLANT NUTRIENTS:

The uptake of nutrients is primarily a function of total biomass production and nutrient content at cellular level.

Uptake of N, P and K (kg ha^{-1}):

Highest N uptake was observed with full dose application of vermicompost, neem cake and combination application (M_2 d, M_3 d and M_4 d) (102.48 kg ha^{-1}, 93.54 kg ha^{-1} and 88.19 kg ha^{-1} respectively) (Table 2). Increase in the soil N availability due to the application of organic manures

and microbial inoculants might have led to higher N uptake. Improvement in major and minor nutrient content in the soil by the use of organic manures has been reported by many scientists (Johnkutty and Menon, 1981; Jenkinson *et al*., 1985). Significant increase in soil N by the incorporation of vermicompost into soils has been reported by Sreenivas *et al*. (2000). The ability of microbial inoculants to mobilize soil nutrient is well documented. In the present study combined application of *Pseudomonas*, *Azospirillum*, *Trichoderma* and AMF was adopted in all treatments. Increase in total N in soil by the combined application of *Azospirillum*, *Trichoderma* and *Pseudomonas* has been reported by Parmar and Dadarwal (1999). According to them the biological N-fixation carried out by *Azospirillum* was responsible for increase in total N content. They also reported the possibility of increased N-fixation by *Azospirillum* sp. with the aid of other agriculturally important microorganisms when inoculated combined. According to them some PGPB secrete some molecules acting as inducers/signals to help the process of N- fixation. Full dose FYM was not as effective as neem cake and vermicompost probably due to comparatively lesser nutrient content and difference in the nutrient release pattern. When the organic manure quantity was reduced to half a reduction in N uptake was noticed probably due to lesser availability of nitrogen compared to higher dose. Increased uptake of N with higher dose of organic manure has been reported by several workers Sudha and Chandani (2002), Preetha *et al*. (2005).

Significantly superior P uptake was noticed with full dose application of organic manures (M_1 d, M_2 d, M_3 d and M_4 d) with the combined application recording the highest value (M_4 d) (59.76 kg ha^{-1}) . Lower dose of organic manures though with microbial inoculants, recorded lower uptake of P (Table 2). The organic acids produced from the degradation of organic materials might have resulted in the solubility and release of native P to result in higher P uptake. High P uptake is also attributable to the increased P mobilization by the action of microbial inoculants. The combination of *Trichoderma*, *Pseudomonas* and AMF can strongly influence the soil phosphorus content and *Pseudomonas* sp. is an efficient solubilizer of complex phosphates releasing inorganic phosphates as reported by Sumathi *et al*. (2011) in turmeric.

Application of organic manures like neemcake and vermicompost along with microbial inoculants either singly or in combination (M_1 d, M_2 d, M_3 d and M_4 d) had significant influence on the uptake of K as observed from the present study. Uptake of Potassium as observed highest in the treatments full dose of vermicompost (25 t ha^{-1}) and full dose of neemcake (6 t ha^{-1}) in combination with mi (260.88 kg ha^{-1} and 262.56 kg ha^{-1} respectively) (Table 2). The effect of vermicompost on plants are not solely attributed to the quantity of mineral nutrition provided but also to its other growth regulating components such as plant growth hormones and humic acids (Arancon and Edwards, 2005). According to Samson and Visser (1989), humic substances modify membrane bound ATPase activity and the relation between membrane ATPase activity, H+ extrusion and the ion uptake suggested that humic substance influence active uptake of potassium by interfering with specific ion carrier. The increase in K availability and uptake in full dose of neemcake applied plants may be due to the action of microbial inoculants particularly *Pseudomonas sp*. Improved bioavailability of N, P and K in soil by the application of neemcake and microbial inoculants has been reported by Murugan *et al*. (2011) in black gram.

Full dose application of organic manures registered comparatively higher K uptake than lower doses. Reduced quantity recorded lesser uptake. As in the case of N and P, the increased uptake of K is also related to its increased availability. In the study, it was noticed that full dose application of organic manures along with microbial inoculants registered higher available K and reduction in the quantity showed a corresponding reduction in the soil available K. Similar trend noticed in the uptake also, is in agreement with the above observation. Sharma and Mittra (1991) reported increased K uptake with higher doses of organic manure.

IV. CONCLUSION

After the experiment a general improvement in soil physical and chemical properties were recorded in all treatments. General increase in available N, P and K was noticed in all treatments with highest values in higher doses of organic manures (M_3 d, M_2 d, M_1 d and M_4 d) applied treatments. Higher N, P and K uptakes were noticed with full dose application of organic manures (M_1 d, M_2 d, M_3 d and M_4 d). Lower dose of organic manures though with microbial inoculants, recorded lower uptake of N, P and K.

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Table 1. Effect of organic manures and microbial inoculants on soil nutrient availability (kg ha^{-1}) after the experiment

Treatments / Manures	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
M_1 d (T_1)	313.99	72.24	456.96
M_2 d (T_2)	305.58	77.97	624.96
M_3 d (T_3)	341.70	70.66	486.08
M_1 d/2 (T_4)	271.75	60.78	377.07
M_2 d/2 (T_5)	281.60	66.13	448.00
M_3 d/2 (T_6)	291.32	61.06	367.44
M_4 d (T_7)	303.82	70.00	477.84
M_4 d/2 (T_8)	265.63	69.52	376.32
M_0 d_0 (T_9)	243.75	56.38	264.32
CD (Treatments)	32.563	12.938	298.249
M_1 (FYM + mi)	292.87	66.51	417.01
M_2 (VC + mi)	293.59	72.05	536.48
M_3 (NC + mi)	316.51	65.86	426.76
M_4 (FYM + VC+ NC + mi)	284.73	69.76	427.08
CD (Manures)	23.025	9.149	210.89
$F_{1,16}$ (M_0T_0 Vs M)	21.308 **	2.484 NS	0.459 NS

Table 2.Effect of organic manures and microbial inoculants on uptake of major plant nutrients (kg ha^{-1})

Treatments / Manures	Uptake of nitrogen (kg ha^{-1})	Uptake of phosphorus (kg ha^{-1})	Uptake of potassium (kg ha^{-1})
M_1 d (T_1)	80.26	54.09	212.02
M_2 d (T_2)	102.48	55.15	260.88
M_3 d (T_3)	93.54	45.04	262.56
M_1 d/2 (T_4)	61.12	23.57	149.57
M_2 d/2 (T_5)	74.87	27.68	187.15
M_3 d/2 (T_6)	64.76	29.49	145.59
M_4 d (T_7)	88.19	59.76	232.92
M_4 d/2 (T_8)	71.23	48.39	192.93
M_0 d_0 (T_9)	40.74	18.84	97.20
CD (Treatments)	17.218	12.115	45.79
M_1 (FYM + mi)	70.69	38.83	180.80
M_2 (VC + mi)	88.68	41.42	224.02
M_3 (NC + mi)	79.15	37.26	204.08
M_4 (FYM + VC+ NC + mi)	79.71	54.08	212.93
CD (Manures)	12.175	8.567	32.381
$F_{1,16}$ (M_0T_0 Vs M)	40.605 **	31.49 **	44.648 **

NS-Not significant **significant at 1 per cent

