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Research Communication

Impact of bio-inoculants and bio-formulations on growth and yield of turmeric (*Curcuma longa*)

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ABSTRACT

An experiment was conducted during 2011–12 at Arabhavi, Karnataka, to study the impact of bio-inoculants and bio-formulations on growth and yield of 'Salem' cultivar of turmeric (*Curcuma longa* L.). Turmeric cv. 'Salem' showed better response to combined application of inorganic fertilizers, bio-inoculants and bio-formulations than other treatments used in the study. Combined application of recommended dose of fertilizer [(RDF), FYM @ 25 t/ha and N:P:K @ 180:90:90 kg/ha) + VA-Mycorrhiza (VAM) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* resulted in higher fresh rhizome yield and growth parameters, viz. plant height, pseudostem diameter, leaf area and leaf-area index, which was at par with the treatment, RDF + VAM + *Trichoderma harzianum*. Similarly, the highest benefit: cost ratio of 4.87 was obtained with the application of RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* compared to the other treatments. Hence planting of turmeric rhizome with combination of RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* was profitable under northern dry zone of Karnataka.

Key words **:** Bio-inoculants, Bio-formulations, Growth, Rhizome yield, Turmeric

Turmeric, herbaceous rhizomatous crop, belonging to the Zingiberaceae, is one of the most valuable spices all over the world. It is used as a spice and condiment, dye stuff and in cosmetic and drug industry. Turmeric carries a wide range of medicinal values, such as a stomachic, blood purifier, antiseptic, wound healing and anti-inflammatory. Being a rhizomatous crop, it requires a heavy dose of fertilizers (Balashangugan and Chezhiyan, 1986). Intensive crop cultivation requires the supplementation of chemical fertilizers with natural bio-fertilizers, bio-inoculants and bio-formulations, as they are most effective, eco-friendly and highly efficient input to produce safer food for consumption. Application of organic manures has been the traditional means of maintaining soil fertility, better water-holding capacity, ecological balance and healthy nutritious food. Of late, there is a great demand for the organically grown produce in western countries. Therefore, chemical free traditional farming technologies such as organic, biodynamics, homa, *Panchagavya*, *Amrit pani*, *Agnihotra*, *Rishi Krishi*, *Jeevamrutha* etc., are gaining a new momentum not only in India, but also world over (Singh *et al.*, 2007). Since studies on bio-inoculants and bio-formulations in turmeric are very meager, an attempt was made to study the effect of bio-inoculants and bio-formulations on growth and yield of turmeric cv. 'Salem'.

A field investigation was carried out during 2011–12 at Department of Plantation, Spices, Medicinal and Aromatic Crops, Kittur Rani Channamma College of Horticulture, Arabhavi at (16°15' N, 74°45' E, 612 m above mean sea level) in northern dry zone of Karnataka. The annual rainfall of this area is about 449.25 mm with temperature ranges between 14.31°C and 36.59°C. The experimental site is having sandy clay loam soil with available N:P:K @ 125:18.2:334.5 kg/ha. The experiment was laid out in randomized block design with 3 replications and 9 treatments. Treatments, viz. T_1, RDF (FYM @ 25 t/ha and NPK @ 180:90:90 kg/ha); T_2, RDF + VAM + *Trichoderma harzianum*; T_3, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*; T_4, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*; T_5, RDF + neem cake (2 t/ha) +

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vermicompost (2.5 t/ha), T_6, VAM + FYM (25 t/ha) + *Trichoderma harzianum;* T_7, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*; T_8, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*; and T_9, vermicompost (2.5 t/ha) + FYM (25 t/ha) + neem cake (2 t/ha). The recommended dose of fertilizers (FYM @ 25 t/ha and N:P:K @ 180 : 90 : 90 kg/ha) were applied as per treatments. The crop was planted in June. Soil application of VAM fungus (*Glomus fasiculatum*) to turmeric was done @ 5 g (soil form) per rhizome, just before planting (Singh *et al.,* 2012). *Panchagavya* and *Amrit pani* were prepared as per Patil (2006). *Trichoderma harzianum* (2.5%) and bio-formulations, viz. *Panchagavya* (3%), *Amrit pani* (3%) and *Agnihotra ash* (1.5%) were applied as per treatments at monthly intervals as soil application. Vermicompost and neem cake were directly incorporated to the soil @ 2.5 t/ha and 2 t/ha respectively. The crop was harvested in the last week of February. Observations on growth attributes at 180 days after planting (DAP), yield (t/ha) and yield attributes and benefit: cost ratio were worked out. Statistical analysis was done by using OPSTAT software package.

The growth, yield and yield attributes differed significantly as influenced by bio-inoculants and bio-formulations (Table 1). The growth parameters, viz. plant height, pseudostem diameter, number of leaves/clump, leaf-area and leaf-area index were significantly higher in RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* (T_3), closely followed by RDF + VAM + *Trichoderma harzianum* (T_2) compared to the lowest recorded in RDF alone. Similarly, the maximum number of rhizomes/clump, rhizome size, yield/clump and yield/ha were recorded from plots that received T_3 (RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*), which was on a par with T_2 (RDF+ VAM + *Trichoderma harzianum*). The lowest was recorded in RDF (T_1).

Significantly higher net income was computed from RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* (T_3) followed by RDF + VAM + *Trichoderma harzianum* (T_2). The lowest recorded in RDF alone. Similarly, the higher benefit: cost ratio of 4.87 was obtained under RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* (T_3), closely followed by RDF + VAM + *Trichoderma harzianum* (T_2). The lowest was recorded in RDF alone (T_1) (Table 2).

The increased growth parameters observed over RDF might be owing to application of VAM fungus, *Tricho-*

Table 1. Effect of bio-inoculants and bio-formulations on the growth, yield and yield attributes in turmeric

Treatment	Plant height (cm)	Pseudo-stem diameter (mm)	Number of leaves per clump	Leaf area (cm^2)	Leaf-area index	Number of rhizomes/ clump	Rhizome size (cm^2)	Yield/ clump (g)	Yield (t/ha)
T_1, RDF (FYM @ 25 t/ha and N:P:K @ 180 : 90 : 90 kg/ha)	66.5	15.0	66.6	414.0	3.4	13.6	128.5	115.4	11.0
T_2, RDF + VAM (*Glomus fasciculatum*) + *Trichoderma harzianum*	78.7	21.1	82.2	672.5	6.4	21.1	206.9	149.7	22.6
T_3, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*	80.7	21.7	93.6	703.2	6.7	23.7	222.2	167.1	25.0
T_4, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*	77.0	18.0	78.2	580.9	5.2	19.3	165.7	141.7	18.5
T_5, RDF + neem cake (2 t/ha) + vermicompost (2.5 t/ha)	79.2	19.3	85.1	627.6	6.3	20.9	177.9	146.7	18.7
T_6, VAM + FYM (25 t/ha) + *Trichoderma harzianum*	74.8	16.1	71.7	528.6	4.7	18.7	146.6	123.9	15.1
T_7, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*	71.3	17.5	71.4	494.2	4.4	19.3	151.4	129.7	12.2
T_8, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*	69.1	15.9	72.8	476.2	4.2	17.4	132.1	132.9	13.6
T_9, Vermicompost (2.5 t/ha) + FYM (25 t/ha) + neem cake (2 t/ha)	76.4	18.8	76.0	539.7	4.9	20.5	156.1	136.7	16.7
SEm±	2.3	0.5	2.9	26.3	0.3	1.4	5.7	7.4	1.2
CD (P=0.05)	6.8	1.4	8.8	78.9	0.8	4.1	17.1	22.2	3.7

Table 2. Effect of bio-inoculants and bio-formulations on the economics of turmeric

Treatment	Estimated cured yield (t/ha)	Total cost of cultivation (×10³₹/ha)	Gross returns (×10³₹/ha)	Net returns (×10³₹/ha)	Benefit: cost ratio
T_1, RDF (FYM @ 25 t/ha and N : P : K @ 180 : 90 : 90 kg/ha)	2.3	59.4	119.2	59.8	1.0
T_2, RDF + VAM (*Glomus fasciculatum*) + *Trichoderma harzianum*	6.7	60.6	338.2	277.6	4.5
T_3, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*	7.4	63.4	372.4	308.9	4.8
T_4, RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*	5.8	63.4	294.1	230.6	3.6
T_5, RDF + neem cake (2 t/ha) + vermicompost (2.5 t/ha)	5.6	76.4	284.4	208.0	2.7
T_6, VAM + FYM (25 t/ha) + *Trichoderma harzianum*	3.6	58.1	182.7	124.5	2.1
T_7, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani*	2.8	60.9	143.3	82.3	1.3
T_8, VAM + FYM (25 t/ha) + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* + *Agnihotra ash*	3.3	60.9	167.3	106.3	1.7
T_9, Vermicompost (2.5 t/ha) + FYM (25 t/ha) + neem cake (2 t/ha)	4.3	74.0	219.6	145.6	1.9
SEm±	0.3	–	16.3	16.3	0.2
CD (P=0.05)	0.9	–	48.7	48.7	0.7

derma harzianum and bio-formulations, viz. *Panchagavya* and *Amrit pani* which mediated to increase root geometry, nutrient translocation, supply of beneficial microflora along with growth regulating hormones and vitamins. Sanjutha *et al.* (2008) reported that application of RDF + *Panchagavya* @ 3% foliar spray increased the growth parameters, nutrient uptake, yield and alkaloid content of *Andrographis*. The fermented solution of Panchagavya contains phytohormones such as cytokinins, auxins and GA-3 (Sharma; Anandaraj, 2003 and Padmapriya *et al.*, 2010). Thus, soil application of bio-formulations had increased the number of functional leaves, leaf area, leaf-area index, which might have led to increased photosynthesis and bio-chemical activities. Similar results were reported by Padmapriya *et al.* (2010) and Kumar *et al.* (2012).

The yield increase owing to combined application of RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* was 2.3 times higher than the RDF alone. The increased fresh rhizome yield and yield attributes was mainly because of adequate supply of required nutrients through chemical fertilizers at the critical crop growth stage and also owing to overall improvement in soil physico-chemical and biological properties due to combined application of organic liquid manures. The better nutrient availability and nutrient uptake increased the growth and yield of crop. The cumulative effect of higher plant growth attributes led to formation of higher sink capacity and accumulation of more carbohydrates in turmeric rhizome. These findings are in agreement with those of Nileema and Sreenivasa (2011) and Munda *et al.* (2013).

It can be concluded that the combined application of RDF + VAM + *Trichoderma harzianum* + *Panchagavya* + *Amrit pani* improved the growth, yield and yield attributes for commercial cultivation of turmeric followed by RDF + VAM + *Trichoderma harzianum* treatment.

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