The Pharma Innovation Journal 2022; 11(7): 2507-2510

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 2507-2510

www.thepharmajournal.com
Received: 01-05-2022
Accepted: 08-06-2022

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Development of organic nutrient management package for black turmeric (*Curcuma caesia* Roxb.) for higher yield in acidic soil

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Abstract
Organic farming is the system of farming which largely excludes the use of synthetic chemical fertilizers, and primarily focus on developing the farm as a system which makes use of its own resources as far as possible and draws on external resources only when necessary and appropriate. Black turmeric is a perennial herb with bluish black rhizomes. It is native to North-eastern part of India. In Meghalaya, black turmeric is cultivated without adding any nutrient sources or sometimes with household waste and farm yard manure (FYM) resulting in low yield with poor quality produce. Therefore, the present investigation was carried out at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam, Ri-Bhoi district of Meghalaya to develop an organic nutrient management package for getting higher production wherein farm yard manure (FYM), vermicompost (VC) and poultry manure (PM) alone and in different combinations were tested through eight treatments *viz.*, T_1: FYM @ 20 t/ha, T_2: VC @ 10 t/ha, T_3: PM @ 5 t/ha, T_4: FYM @ 10 t/ha + VC @ 5 t/ha, T_5: FYM @ 10 t/ha + PM @ 2.5 t/ha, T_6: VC @ 5 t/ha + PM @ 2.5 t/ha, T_7: FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha and T_8: Control. These treatments were replicated thrice in randomized block design. The soil reaction of the experimental plot was acidic. The results revealed that highest plant height, and rhizome yield was obtained in T_7 i.e., combination of FYM, VC and PM @ 10 t/ha, 5 t/ha and 2.5 t/ha, respectively. Therefore, farmers of Meghalaya may be advised to apply FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha for getting higher yield of black turmeric in acidic soils.

Keywords: Black turmeric, organic cultivation, nutrient management, acidic soil, rhizome yield

1. Introduction
Organic agriculture is holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity (Sanjay-Swami, 2017) [13]. It requires at least 3-4 years for an agricultural land to be fully certified as organic. The North Eastern states are by default organic in nature. After Sikkim, the government is aiming to make Meghalaya an organic state, except for few pockets where intensive cultivation of vegetables using inorganic fertilizer and chemicals is preferred (Sanjay-Swami, 2020) [14]. North Eastern Hill (NEH) region is home to some niche spice crops like black turmeric, Lakadong turmeric, King chilli, Assam lemon, etc., which has high market demand for their unique features and is cultivated in organic way (Sanjay-Swami *et al.*, 2022). Turmeric is an important cash crop in the NEH region and shares about 8.30 per cent of the total production in the country. Mizoram, with a total production of 27.82 thousand MT is the leading state in the region followed by Meghalaya (16.63 thousand MT) and Manipur (15.40 thousand MT) (Singh *et al.*, 2020) [16]. Black turmeric is a perennial herb with bluish black rhizomes. It is native to North-eastern part of India. It has been listed as endangered species by Indian Agricultural Department. The plant has been grown as ornamental, but the roots have been used for medicinal and religious purposes. It has anti-fungal, anti-inflammatory properties. The characteristics pungent smell of the rhizome is due to the presence of the essential oil which is rich in eucalyptol (16.43%), camphor (11.56%), starch etc. (Borah *et al.*, 2019) [2].

In Meghalaya, black turmeric is an important crop. It is cultivated by many farmers of the area. They cultivate it without the application of any nutrient sources or sometimes apply household waste and farm yard manure (FYM) and get very low yield with poor quality produce (Sanjay-Swami *et al.*, 2021) [21]. The farmers usually do not use any fertilizers and chemicals. However, to maintain the soil health and sustainability for longer period, organic manures and other organic fertilizers are important (Sanjay-Swami, 2020) [14].

Application of organic manures has various advantages like improving soil physical properties, water holding capacity and organic carbon content apart from supplying good quality of nutrients (Singh *et al.,* 2009; Konyak and Sanjay-Swami, 2018) [17, 8]. Therefore, it is urgent to develop organic nutrient management package for black turmeric, hence a field experiment was carried out to study the performance of black turmeric under various organic manures *viz.*, FYM, vermicompost, and poultry manure along with their combinations.

2. Materials and Methods

2.1 Study location: The field experiment was carried out during *kharif* season of 2021-22 at Research Farm of the School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya. Geographically, the experimental site was located at $91^0$18' to $92^0$18' E longitude and $25^0$40' to $26^0$20' N latitude with an altitude of 950 m above the mean sea level with the agro-climatic zone of mixed subtropical hills (Figure 1). The annual climate of Umiam is divided into three different seasons: pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to February) months. The temperature of this region varies between 10-30 ^{0}C and precipitation of 2410 mm.

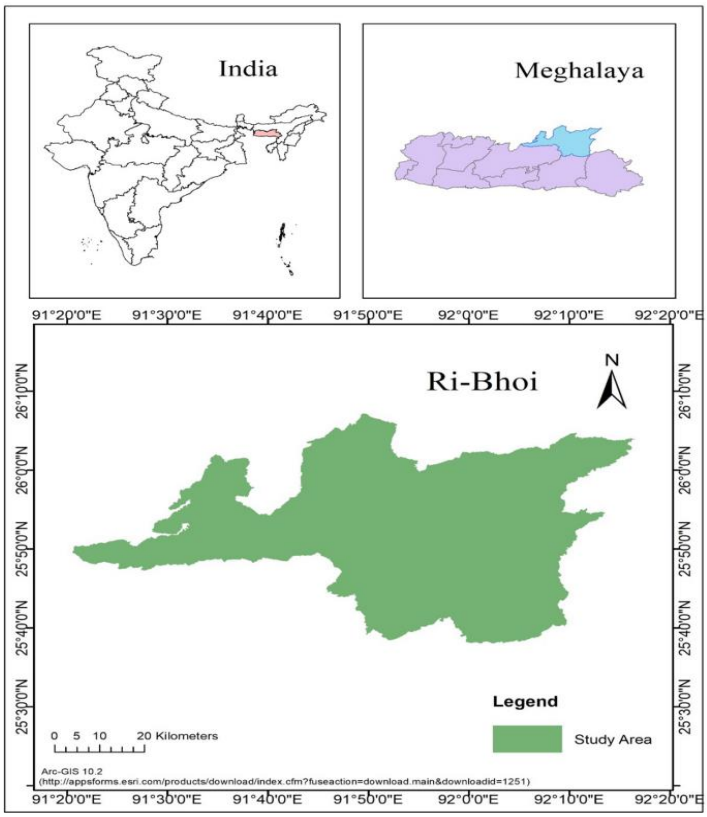

Fig 1: Study location

2.2 Experiment details

The experiment consist of eight treatments: T_1: FYM @ 20 t/ha, T_2: Vermicompost @ 10 t/ha), T_3: Poultry manure @ 5 t/ha), T_4: FYM @ 10 t/ha + Vermicompost @ 5 t/ha), T_5: FYM @ 10 t/ha + Poultry manure @ 2.5 t/ha, T_6: Vermicompost @ 5 t/ha + Poultry manure @ 2.5 t/ha, T_7: FYM @ 10 t/ha + Vermicompost @ 5 t/ha + Poultry manure @ 2.5 t/ha, T_8: Control. The experiment was laid out in a randomized complete block design with three replications.

The composite soil sample of the experimental farm was collected from the surface layer (0-15 cm) before initiation of the trial. The detailed analysis of experimental soil is presented in Table 1.

Table 1: Physico-chemical properties of experimental soil along with methods followed for analysis

Parameters	Values	Methods	References
pH	5.2	Potentiometry	Jackson (1973) [7]
EC(dS/m)	0.43	Conductometry	Jackson (1973) [7]
Available N (kg/ha)	263.00	Alkaline potassium permanganate method	Subbiah and Asija (1956) [18]
Available P_2O_5 (kg/ha)	18.70	Brays No. 1	Bray and Kurtz (1945) [3]
Available K_2O (kg/ha))	231.15	Flame photometer method	Hanway and Heidel (1952) [6]

The farm yard manure and vermicompost used in the study were procured from the Rural Resource and Training Centre, Umran, whereas the poultry manure was procured from the Poultry Farm of ICAR Research Complex for NEH Region, Umiam. The nutrient content of farm yard manure, vermicompost and poultry manure along with the method of analysis are given in Table 2.

Table 2: Nutrient content of farm yard manure, vermicompost and poultry manure used in the study

Parameters	Farm yard manure	Vermicompost	Poultry manure	Methods	References
N (%)	0.60	1.25	2.4	Kjeldahl digestion and distillation method	Jackson (1973) [7]
P_2O_5 (%)	0.23	0.72	0.82	Vanadomolybdate method	Jackson (1973) [7]
K_2O (%)	0.36	0.91	0.34	Flame photometer method	Jackson (1973) [7]

The rhizome seed of black turmeric (Var. Jorlab KH2) were treated with *Trichoderma* @ 10 g/kg of seeds before sowing in the plots. The crop was sown at a spacing of 30 x 30 cm on 10th May 2021. No chemical insecticides, fungicides or herbicides were used in keeping with organic standards. The plant parameters i.e., plant height at 50,100 and 150 days after planting (DAP), and fresh rhizome yield were recorded from the randomly selected 5 plants in each plot.

The data relating to the growth and yield of the crop were statistically analyzed following the analysis of variance method. Statistical analysis and interpretation were done by calculating the value of S.Em (±) and CD at 5% level of significance (Gomez and Gomez, 1984).

3. Results and Discussions

3.1 Plant height

The plant height is an observable character and was recorded at 50, 100 and 150 days after planting (DAP). The data pertaining to plant height of black turmeric depicted an increasing trend up to 150 DAP, irrespective of the treatments (Table 3). Rao *et al*., (2005) [10] also observed increased plant height of turmeric at a faster rate up to 150 days and thereafter it slowed down. The slow growth after 150 days might be attributed to rhizome development due to the source and sink relationship. The maximum plant height (171.80 cm) was recorded at 150 DAP with the application of FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha whereas the lowest plant height (81.86 cm) was recorded with the control.

It was noticed that there was significant increase in plant height at 150 DAP, with the addition of FYM @ 20 t/ha (T_1), Vermicompost @ 10 t/ha (T_2), Poultry manure @ 5 t/ha (T_3) and combination of all the three manures i.e., FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha (T_7) over the control (T_8) by 17.74, 30.40, 34.60 and 52.35%, respectively. Increase in growth parameters can be correlated with the effect of vermicompost and poultry manure, which are a rich source of available nutrients and had narrow C:N ratio. Besides this, vermicompost contains certain growth promoting substances like auxin and enzymes which in turn has resulted in the increased plant height and induction of branches at an earlier stage (Bajeli *et al*., 2016) [1]. The increased plant height with the application of organic manures *viz.*, FYM, VC and poultry manure may be due to narrow C: N ratio which might have produced more humic acid and humic substances form chelates with phosphorus (Yadav and Sanjay-Swami, 2019) [19]. The chelated phosphorous has been reported to be more soluble in water, which could make it easily available to crops. This might have led to increased plant height in turmeric (Kumar *et al.*, 2016) [9]. Sarma *et al.*, (2015) [15] also reported positive influence of organic manure, vermicompost and neemcake on plant height of turmeric (*Curcuma longa* L.) cv. Megha Turmeric-1.

3.2 Fresh rhizome yield

Among all the treatments, highest fresh rhizomes yield of black turmeric was observed with the combination application of all the organic manures i.e., FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha (T_7) (Figure 2). Among all the sole application of manures, poultry manure @ 5 t/ha (T_3) gave the highest rhizome yield (29.67 t/ha) followed by T_2. The fresh rhizome yield was significantly low in the control (T_8). The sole application of poultry manure @ 5 t/ha (T_3) showed increase in rhizome yield by 40.51% over the control whereas application of vermicompost @ 10 t/ha (T_2) showed an increase of 33.00% over the control and combination of various manures i.e., VC @ 5 t/ha + PM @ 2.5 t/ha (T_6) showed a significance increase of 42.82% over the control (T_8). With the application of all the three manures i.e., FYM, VC and PM, fresh rhizome yield was increased by 50.15% over the control. The increased yield due to the application of FYM, vermicompost and poultry manure may be attributed to the instant availability of macro and micro nutrients for longer period of plant growth. Bajeli *et al*., (2016) [1] reported similar results from a study indicating that the combined application of organic manures significantly influenced the biomass and yield of the crops. Increased yield of cabbage (*Brassica oleracea* L. var *capitata*) under combined use of organic manures in acid Inceptisol was also reported by Konyak and Sanjay-Swami (2018) [8] in North East Himalaya whereas Gupta *et al.*, (2019) [5] reported increased yield of okra (*Abelmoschus esculentus* L.) under integrated application of vermicompost and farmyard manure in North West Himalaya.

Table 3: Effect of organic manures on the plant height of black turmeric

Treatments	Plant height (cm)		
	50 DAP	100 DAP	150 DAP
T1: FYM @ 20 t/ha	36.07	82.74	99.52
T2: Vermicompost @ 10 t/ha	42.16	97.54	117.69
T3: Poultry manure @ 5 t/ha	43.64	103.04	125.34
T4: FYM @ 10 t/ha + VC @ 5 t/ha	40.28	95.91	116.05
T5: FYM @ 10 t/ha + Poultry manure @ 2.5 t/ha	40.64	111.34	134.06
T6: VC @ 5 t/ha + Poultry manure @ 2.5 t/ha	49.68	127.20	152.91
T7: FYM @ 10 t/ha + VC @ 5 t/ha + Poultry manure @ 2.5 t/ha	55.94	142.53	171.80
T8: Control	29.90	67.65	81.86
S.Em ±	1.98	4.81	5.86
CD @ 5%	6.03	14.61	17.78

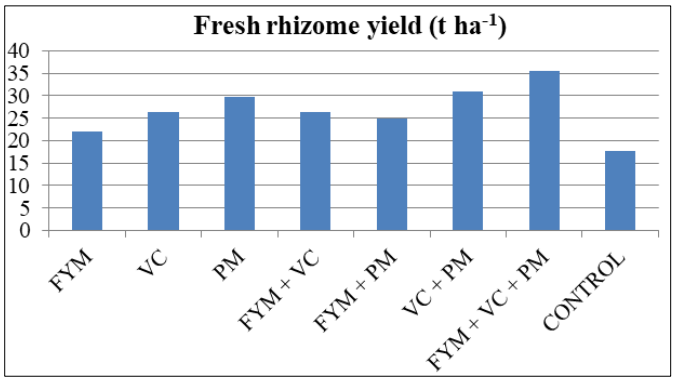

Fig 2: Effect of organic manures on fresh rhizome yield of black turmeric

4. Conclusions

Black turmeric was most responsive to combined treatment of FYM, vermicompost and poultry manure for growth and yield in comparison to various other treatments. Thus, it may be concluded that combined application of all the three organic manures i.e., FYM @ 10 t/ha + VC @ 5 t/ha + PM @ 2.5 t/ha (T_7) may be advised as suitable organic nutrient management package for higher yield of black turmeric in the acidic soil.

5. Acknowledgements

The laboratory facility provided by the School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, CAU, Umiam (Barapani) for carrying out soil and plant analysis is duly acknowledged.

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