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Performance of Lakadong Turmeric (*Curcuma longa* L.) under Integrated Application of Farm Yard Manure, Vermicompost and Chemical Fertilizers

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ABSTRACT: The Lakadong, one of the finest varieties of turmeric (*Curcuma longa* L.), has its uniqueness with a very high curcumin content of about 6-7.5% and volatile essential oil (dry) of about 3.6-4.8%. Being a heavy feeder, it depletes abundant quantity of nutrients from the soil, however farmers of Meghalaya are cultivating it without any nutrient source, or applying household waste resulting continuous decline in yield with poor quality produce. Therefore, a field experiment was conducted at the School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya during 2021-2022 to assess the growth and yield of Lakadong turmeric under integrated nutrient management involving farm yard manure (FYM) and vermicompost (VC). The eight treatment combination *viz.*, T_1 (100% N through FYM), T_2 (100%N through VC), T_3 (75% RDN through urea + 25% N through FYM), T_4 (75% RDN through urea + 25% N through VC), T_5 (50% RDN through urea + 50% N through FYM), T_6 (50% RDN through urea + 50% N through VC), T_7 (50% RDN through urea + 25% N through VC + 25% FYM) and T_8 (100% RDN (120 kg N ha^{-1} through urea) were tested in randomized block design with three replications. The significant higher plant height, clump length and fresh rhizome yield were recorded with the application of 50% RDN through urea + 50% N through VC (T_6), whereas the lowest values for these parameters were recorded with the application of 100% RDN *i.e.*, 120 kg N ha^{-1} through urea (T_8). The findings reflected the supremacy of integrated nutrient management through 50% RDN through urea + 50% N through VC over chemical fertilization alone as well as other combinations with organic manures. Hence, farmers of Meghalaya may be advised to adopt this package for getting higher yield of Lakadong turmeric.

Keywords: Lakadong turmeric, FYM, VC, integrated nutrient management, yield.

INTRODUCTION

Meghalaya, one of the North-Eastern states, is home to a variety of spices of which turmeric (*Curcuma longa* L.) is one of the prominent. The Jaintia hills districts of Meghalaya are native to one of the finest varieties of turmeric in the world, the Lakadong. It is locally known as shynrai or shyrmit Lakadong in Khasi. The variety has its uniqueness with a very high curcumin content of about 6-7.5 % (Shreeranjan, 2006; Jha and Deka 2012) and volatile essential oil (dry) of about 3.6-4.8%. If this uniqueness of the variety is properly exploited, it can change the lives of thousands of small and marginal farmers of Meghalaya. Though the crop is grown to an extent of 1928 ha, Jaintia Hills accounts for 58.0% and West Garo Hills for 20.2% of the total area due to favourable soil and climate. Each of the other five districts has about 4.0% of the area. The state produces around 16 thousand MT of turmeric, of which 72.0% is contributed by Khasi - Jaintia Hills and 28.0% by Garo Hills. Production grew at an annual rate of 2.47% and area at 3.14% per annum, indicating declining trend in yield (GoM, 2018).

One of the possible factors for decline in yield is that majority of the farmers are traditionally growing the Lakadong without adding nutrients, either through organic or inorganic sources. Few farmers are using little quantities of household waste or farm yard manure (FYM) as nutrient sources. Lakadong turmeric, being one of the heavy feeders, extracts abundant quantity of nutrients from the soil (Anuradha *et al*., 2018). Acidity-induced soil fertility constraints coupled with negligible use of chemical fertilizers are generally held responsible for lower crop productivity in Meghalaya (Sanjay-Swami and Yadav, 2021). Therefore, soil health or fertility is the most crucial factor in deciding the agricultural productivity in the region (Lyngdoh and Sanjay-Swami 2018; Sanjay-Swami *et al.,* 2022). Keeping in view the limited availability of organic nutrient sources, it is not possible to meet the high nutrient requirement of the Lakadong turmeric through organic nutrient sources alone. Similarly, use of inorganic fertilizers alone reduces the crop yields over time by affecting the soil properties and depleting soil organic matter (Sanjay-Swami and Singh, 2020). Integrated use of organic and inorganic nutrient sources can improve crop productivity (Mal *et al.,* 2013). The use of chemical fertilizers in combination with organic manure is essentially required to improve soil health (Bajpai *et al*., 2006). Association of organic matter and nutrient availability has been confirmed by the high coefficients of correlation between the soil attributes (Sakal *et al.,* 1996).

It is urgent to develop integrated nutrient management package for Lakadong turmeric involving use of renewable resources of plant nutrients locally available to the farmers. Although FYM is commonly used organic manure but is not adequately available. The huge amounts of farm wastes and weed biomass can be recycled effectively by preparing vermicompost (Sanjay-Swami, 2012). Vermicompost application improves bulk density, water holding capacity, and humic substances of the soil (Sanjay-Swami and Bazaya, 2010). Its application also improves soil biology by increasing population of beneficial microbes and enzyme activities (Sharma and Garg, 2017). Therefore, the present investigation was carried out to study the performance of Lakadong turmeric under integrated application of farmyard manure, vermicompost and chemical fertilizers and develop a suitable integrated nutrient management package to exploit the potential of this variety.

MATERIALS AND METHODS

Study location: The field experiment was conducted at the research farm of the School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Umaim, Meghalaya during *kharif* 2021-2022. Geographically, the experimental site was located at 91°18′ to 92°18′ E longitude and 25°40′ to 26°20′ N latitude with an altitude of 950 m above the mean sea level with the agro-climatic zone of mixed subtropical hills (Fig. 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°C and precipitation of 2410 mm.

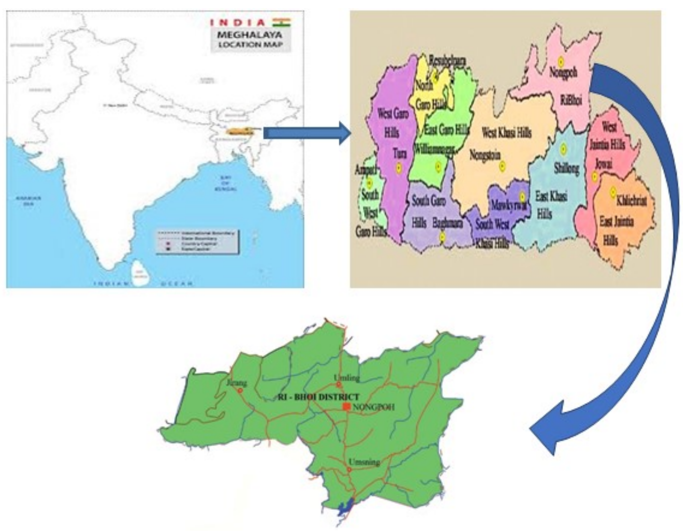

Fig. 1. Study location.

Experiment details: The trial was conducted in randomized block design (RBD) with eight treatments and three replications. The treatments consist of T_1 (100% N through FYM), T_2 (100% N through VC), T_3 (75% RDN through urea + 25% N through FYM), T_4 (75% RDN through urea + 25% N through VC), T_5 (50% RDN through urea + 50% N through FYM), T_6 (50% RDN through urea + 50% N through VC), T_7 (50% RDN through urea + 25% N through VC + 25% FYM) and T_8 (100% RDN (120 kg N ha^{-1} through urea). The plant parameters *i.e*., plant height, clump length, and fresh rhizome yield were recorded from the randomly selected 6 plants in each plot of the different treatments. The data relating to the growth and yield of the crop were statistically analysed 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).

The experimental soil was found to be acidic in reaction having pH 5.2 and medium in available phosphorus (18.70 kg/ha). The detailed analysis of experimental soil is presented in Table 1.

The farm yard manure and vermicompost used in this study were procured from Rural Resource and Training Centre, Umran. The nutrient content of farm yard manure and vermicompost along with the method of analysis are given in Table 2.

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

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

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

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

RESULTS AND DISCUSSION

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 Lakadong turmeric depicted an increasing trend up to 150 DAP irrespective of the treatments (Table 3). Rao *et al.* (2005) also observed increased plant height of turmeric at a faster rate upto 150 days and thereafter it slowed down. The slow growth after 150 days might be attributed to rhizomes development due to the source and sink relationship *i.e.* transportation of more photosynthates from source (leaves) to sink (rhizomes). The maximum plant height (143.84 cm) was recorded at 150 DAP with the application of 50% RDN through urea + 25% N through VC + 25% FYM (T_7), whereas the lowest plant height (82.56 cm) was recorded with 100% RDN through urea (T_8) at 150 DAP. However, maximum significant increase in plant height was observed with the combined use of 50% RDN through urea + 50% N through VC (T_6).

A critical examination of the data further revealed significant increased plant height with 100% N through FYM (T_1), 100% N through VC (T_2) and 50% RDN through urea + 25% N through VC + 25% FYM (T_7) over 100% RDN through urea (T_8) by 6.40, 22.43 and 44.92% at 150 DAP (Table 3, Fig. 2). In contrast to this, non-significant increase in plant height was recorded with 50% RDN through urea + 25% N through VC + 25% FYM (T_7) over 50% RDN through urea + 50% N through VC (T_6) at all the growth intervals *i.e.* 50 DAP (1%), 100 DAP (1.62%) and 150 DAP (2.3%).

Further, scrutiny of plant height data at different growth stages showed increasing trend with the application of 100% N through VC (T_2) over 100% N through FYM (T_1) by 16.94, 17.13 and 16.00% at 50, 100 and 150 DAP, respectively. Similarly, with the application of 75% RDN through urea + 25% N through FYM (T_3), the increase in plant height was recorded to be 20.00, 20.00 and 17.20% over 100% N through FYM (T_1) at 50, 100 and 150 DAP, respectively. The combined use of 75% RDN through urea + 25% N through VC (T_4) also followed the same pattern and the increase in plant height was recorded to be 17.14%, 17.70%, and 14.80% over 100% N through VC (T_2) at 50, 100 and 150 DAP, respectively. The results indicated that 50% RDN through urea + 50% N through VC (T_6) gave maximum significant higher plant height in comparison to all other treatments, including 50% RDN through urea + 25% N through VC + 25% FYM (T_7) followed by 75% RDN through urea + 25% N through VC (T_4), 50% RDN through urea + 50% N through FYM (T_5), 75% RDN through urea + 25% N through FYM (T_3), 100% N through VC (T_2), and 100% N through FYM (T_1). The increased plant height with the application of organic manures *viz.,* FYM and VC 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). 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).

Clump length. The data on clump length of Lakadong turmeric presented in Fig. 3 revealed that the combined use of organic and inorganic fertilizers gave a significant result over the sole use of organic or chemical fertilizers. The highest clump length was recorded under application of 50% RDN + 25% N through VC + 25% FYM (T_7) over the other treatments, however statistically superior clump length was observed with 50% RDN + 50% N through VC (T_6) which was statistically at par with 50% RDN + 25% N through VC + 25% FYM (T_7). Likewise, 18.11% increase in clump length was recorded with 100% N through VC (T_2) over the 100% N through FYM (T_1).

The treatment 50% RDN + 50% N through FYM (T_5) produced 28.31 and 12.10% higher clump length over 100% N through FYM (T_1) and 75% RDN + 25% N through FYM (T_3), respectively. Further it was observed that 100% N through FYM (T_1), 100% N through VC (T_2), 75% RDN + 25% N through FYM (T_3),75% RDN + 25% N through VC (T_4), 50% RDN + 50% N through FYM (T_5), 50% RDN + 50% N through VC (T_6), 50% RDN + 25% N through VC + 25% FYM (T_7) showed increase by 5.83, 22.89, 23.22, 35.21, 48.14, 44.00 and 46.26%, respectively over the sole use of chemical fertilizer 100% RDN (T_8). Pronounced clump length with the application of organic manures might be due to sustained availability of nitrogen throughout the growing phase and also due to enhanced photosynthates and effective translocation of them to the sink *i.e.* rhizome. Singh (2015) also observed beneficial effects of organics in various crops.

Fresh rhizome yield. Harvested rhizomes were cleaned from shoot and root residues, then weighed for yield of fresh rhizome and data are presented in Fig. 4. From the present study, a significant higher fresh rhizome yield was found in all treatments over 100% RDN (T_8). Among the treatments, the significant higher fresh rhizome yield was recorded under the application of 50% RDN + 50% N through VC (T_6) in comparison to other treatments even though the application of 50% RDN + 25% N through VC + 25% FYM (T_7) had been recorded as the highest yield because there is a non-significant increase in yield between them followed by 75% RDN + 25% N through VC (T_4), 50% RDN + 50% N through FYM (T_5), 75% RDN + 25% N through FYM (T_3), 100% N through VC (T_2), and 100% N through FYM (T_1). The sole use of 100% FYM gave 10.25% more fresh rhizome yield (25.4 kg/ha) than sole use of 100% RDN through urea (T_8). Similarly, 100% N through VC also significantly increased fresh rhizome yield by 25.88% yield over 100% RDN through urea (T_8). The application of 100% N through VC (T_2) showed significant increase of 17.35% over the 100% N through FYM (T_1).

The treatment 75% RDN + 25% N through FYM (T_3) produced significant higher fresh rhizome yield over 100% N through FYM (T_1). Similarly, 75% RDN + 25% N through VC (T_4) showed better results with about 17.14% more yield than sole 100% N through VC (T_2). Again, the combined treatment of 50% RDN + 50% N through FYM (T_5) showed significant higher rhizome yield of about 27.5% over the application of 100% N through FYM (T_1). Likewise, 50% RDN + 50% N through VC (T_6) also produced increased yield by 27.53% over 100% N through VC (T_2). These result showed that the combined use of organic and inorganic fertilizers gave more significant results than the sole use of organic or chemical fertilizers. Vermicompost and FYM in integrated nutrient management would have improved the physical, chemical and biological properties of soil which help in better nutrient absorption and utilization by plants resulting in higher rhizome yield as reported by Kanaujia *et al*. (2016). The higher yield might be due to an increase in plant height and clump length and ultimately due to an increased photosynthetic rate. This is also in conformation with the results of Dinesh *et al.* (2010). 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) in North East Himalaya whereas Gupta *et al*. (2019) reported increased yield of okra (*Abelmoschus esculentus* L.) under integrated application of vermicompost and farmyard manure in North West Himalaya.

Table 3: Plant height of Lakadong turmeric (*Curcuma longa* L.) under integrated application of farmyard manure, vermicompost and chemical fertilizers.

Treatments	Plant height (cm)		
	50DAP	**100DAP**	**150DAP**
T_1: 100% N through FYM	37.20	64.60	88.51
T_2: 100% N through VC	44.78	77.96	105.39
T_3: 75% RDN + 25% N through FYM	46.50	80.73	106.90
T_4: 75% RDN + 25% N through VC	54.05	94.68	123.69
T_5: 50% RDN + 50%N through FYM	51.30	94.21	119.60
T_6: 50% RDN + 50% N through VC	61.80	108.00	140.52
T_7: 50% RDN + 25% N through VC + 25% FYM	62.41	109.77	143.84
T_8: 100% RDN through urea (120 kg N ha^{-1})	34.20	60.47	82.56
Mean	392.24	690.42	911.03
S.Em ±	2.41	4.27	5.45
CD ($p \leq 0.05$)	7.32	8.57	8.28

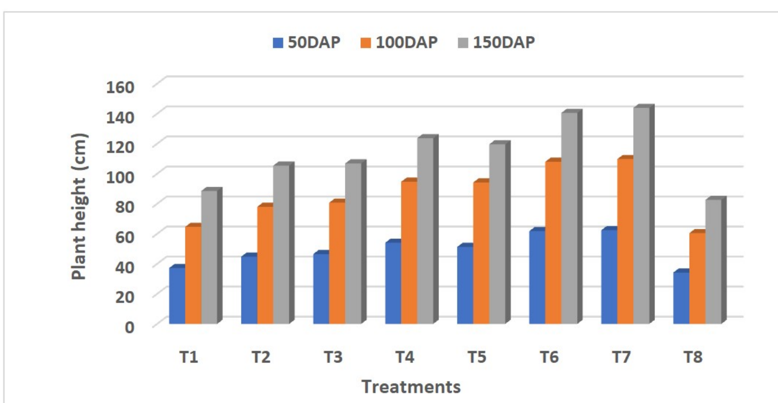

Fig. 2. Plant height of Lakadong turmeric (*Curcuma longa* L.) at different growth stages under integrated application of farmyard manure, vermicompost and chemical fertilizers.

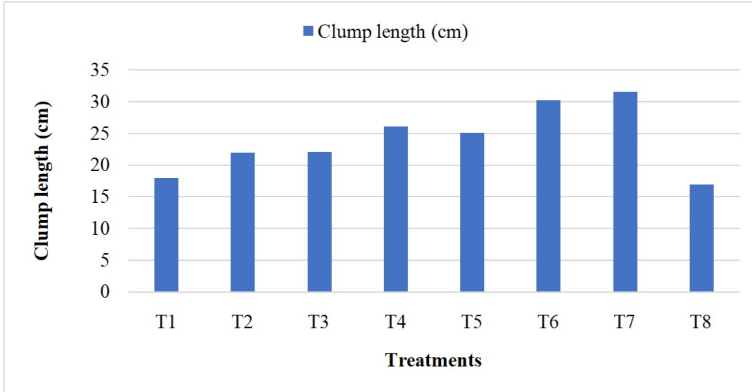

Fig. 3: Clump length of Lakadong turmeric (*Curcuma longa* L.) under integrated application of farmyard manure, vermicompost and chemical fertilizers.

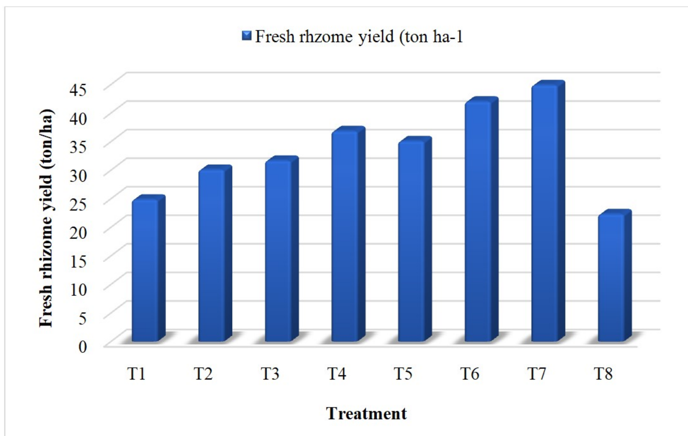

Fig. 4: Fresh rhizome yield of Lakadong turmeric (*Curcuma longa* L.) under integrated application of farmyard manure, vermicompost and chemical fertilizers.

CONCLUSION

Based on the findings of the above investigation, it may be concluded that the plant height, clump length and fresh rhizome yield were significantly superior in plants supplied with 50% RDN + 50% N through VC (T_6) but the highest values of these parameters were recorded with 50% RDN + 25% N through VC + 25% FYM (T_7) which was statistically at par with T_6. Therefore, application of 50% RDN + 50% N through VC (T_6) may be recommended as most appropriate combination for improving fresh rhizome yield of Lakadong turmeric in acid Inceptisol of Meghalaya.

FUTURE SCOPE

The future research may be taken up with the other locally available organic nutrient sources to test and find out their suitability along with quantification of doses for higher yield of black turmeric in acidic soils.

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Conflict of Interest. None.

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