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Assessment of turmeric and chilli under organic cultivation and farmer's practice for doubling farmer's income

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Abstract
The North Eastern Region comprising of states of Assam, Arunachal Pradesh, Sikkim, Manipur, Meghalaya, Tripura, Mizoram, and Nagaland has drawn special attention on the global map due to the quality of organic spices, and spices occupies special recognition and has global demand among the many unique products and features of the region. The region is by default organic in nature and the climatic condition is highly suitable for cultivating a large number of spices like ginger coriander, turmeric, garlic, chilli, bay leaf, cardamom, etc. Among the NER, Assam state is also a major producer of spices like ginger, garlic, turmeric, coriander, chilli, mustard, etc. Turmeric (*Curcuma longa* Linn.) and chilli (*Capsicum annum* L.) are one of the most popular spice crops in Kokrajhar district of Assam. Kokrajhar district is treated as organic by default and every household is intimately associated with the cultivation of turmeric and chilli. A study on the assessment of organic cultivation of turmeric and chilli under different organic sources of nutrients and farmer's practice was carried out with 120 numbers of farmers in Kokrajhar, Dotma, and Gossaigaon blocks of Kokrajhar district of Assam during 2022-2023. In the identified blocks few farmers use different combinations of organic manures *viz.*, FYM, vermicompost neem cake, etc. whereas some farmers cultivate the crops without any organic or inorganic input (absolute control). chilli (var. Surjyamukhi) performed better with organic input in terms of growth, and yield (16.0 q ha^{-1}) compared to absolute control (11.2 q ha^{-1}). Similarly organic turmeric (var. Megha Turmeric-1) cultivation also recorded better performance under combined application of organic inputs *viz.*, vermicompost, neem cake, and FYM in terms of growth as well as rhizome yield (36.50 t ha^{-1}) compared to absolute control (26.55 t ha^{-1}).

Keywords: Turmeric, chilli, organic cultivation, neem cake, FYM, vermicompost

Introduction
India is rightly referred to as the "spice bowl of the world" for producing the highest number of superior quality and variety of spices. In India, spices are low-volume, highly export-focused goods with significant economic value (Sugasini *et al.*, 2018) [12]. The most significant spices crops from tropical regions, in regards to the value of global trade, are pepper, capsicum/chilli, nutmeg/mace, cardamom, cinnamon, vanilla, ginger, cloves, and turmeric, and the most significant spices crops from non-tropical regions are cumin, mint, coriander, oregano, sesame seeds, bay, mustard, and sage (FAO, 2005) [5]. The ISO (International Organization for Standardization) lists 109 varieties, of which about 75 are produced in India. Fennel, cardamom, chili, cumin, ginger, celery, turmeric, fenugreek, coriander, garlic, oleoresins nutmeg & mace, curry powder, and pepper are the most widely exported as well as produced spices. Of these spices, around 76% of the production is comprised of chilli, cumin, turmeric, ginger, and coriander. (Spice Industry and Export in India, 2022). The country is currently the leading exporter, producer, and consumer of spices worldwide, and in recent years, the total production of several types of spices has grown rapidly. India is the world's leading exporter, producer, and consumer of turmeric. Because Indian turmeric has a high curcumin level, it is regarded as the best available worldwide. Approximately 80% of the turmeric produced worldwide is produced in India. India currently supplies the majority of the red chili used in the global market since

Assam produces close to 3.1 lakh metric tonnes of spices annually (Anonymous, 2022) [1]. Turmeric (*Curcuma longa* Linn.) varieties *viz.*, Bombay and Megha Turmeric-1 are the most popularly cultivated and occupy an integral space in the socio-economic well-being of the tribal farmers of Kokrajhar district. Turmeric is grown without the use of inorganic fertilizers under rain-fed conditions. (Chilli (*Capsicum annum* L.) variety Surjyamukhi is also cultivated as a transplanted and direct-seeded crop for fresh consumption and dry chilli. By default, Kokrajhar district is organic as the cultivation of turmeric and chilli is done with the use of organic inputs like FYM, vermicompost, etc. Organic manures improve the drainage, water-holding capacity, and soil texture and structure, all of which are beneficial for the development as well as the growth of rhizomatous crops like turmeric.

In organic production, integrating different organic nutrient sources is crucial for rapid development, higher yield, and improved food quality to sustain soil health and sustainability over a long period. The development and yield of turmeric and chilli are influenced differentially by various organic nutrient sources. Therefore, it is important to know the appropriate source of organic manure which could aid in boosting the growth as well as yield of turmeric. Though turmeric and chilli are cultivated organically in the district by the tribal communities there is a lack of proper knowledge in the usage of organic sources of nutrients and also limited information is available on organic turmeric and chilli cultivation. Keeping these facts in view, the study goal was to assess the impact of various organic nutrient sources on the yield and growth of turmeric and chilli.

Potential of Organic Farming in NE States

Assam and the majority of the Northeastern states have virgin land (i.e. land that has never been explored or developed) without any commercial farming, which is ideal for organic farming of important spices like black pepper, chillies, turmeric, ginger, etc. The following are the potentials of organic spices in Assam and other states of North East India:

- Assam and NE states with their diverse agro-climatic conditions and rich biodiversity, present significant potential for the organic cultivation of turmeric and chili. Both crops have been traditionally grown in the region, and Assam's fertile soils, ample rainfall, and warm temperatures create an ideal environment for their cultivation.
- Minimal utilization of pesticides as well as fertilizers in the region, which is far below the national average, makes the region ideal for organic farming of spices.
- Many agro-ecological zones, ranging from the foothill to the alpine zone, offer excellent opportunities for the production of various spice crops.
- Rich biodiversity offers natural pest control options that are compatible with organic farming. For example, certain species of birds and insects help control pests in an organic system.
- There is a growing market for organic turmeric and chilli, both locally and internationally. Organic certification can help farmers tap into this market and get premium prices for their produce.
- Organic inputs such as compost, biofertilizers, and natural pesticides are increasingly available in Assam, making it easier for farmers to transition to organic cultivation.
- The State government has introduced various schemes and subsidies to promote organic farming, which can benefit farmers interested in cultivating turmeric and chilli organically.

However, challenges such as lack of awareness, access to markets of organic produce, and infrastructure for certification and processing need to be addressed to fully realize the potential for organic cultivation of turmeric and chilli in Assam

Materials and Methods

The study area is Kokrajhar district, which is an administrative district in the Bodoland Territorial Region (BTR), of Assam. BTR is divided into 4 districts, *viz*., Udalguri, Kokrajhar, Baksa, and Chirang. These districts are located in the Brahmaputra River's north bank plain zone. It is located between 89^0 46'E and 90^0 38'E longitudes and 26^0 19'N to 26^0 54'N latitudes. The Bodo tribe is the main inhabitant of the region, while other indigenous people of Assam also inhabit it. The district of Kokrajhar is situated on the Brahmaputra River's northern bank. It serves as a gateway to the Seven Sister States. Additionally, it borders Bhutan and West Bengal. The district lies in Assam's Lower Brahmaputra Valley Zone in terms of agroclimate. The district has a humid subtropical climate with warm, humid summers and cool, dry winters. The district experiences 3127 mm of rainfall on average each year, with typical maximum and lowest temperatures ranging from 33–38°C and 8–10°C, respectively. The uses of organic inputs in turmeric and chilli cultivation in the selected blocks namely Kokrajhar, Dotma, and Gossaigaon of Kokrajhar districts were studied through a semi-structured questionnaire, group meetings with village head man, interaction with farmers, etc. From each block, four villages were selected for the study, and from each village 10 nos. of farmers were selected with a sample size of 120 during 2022-2023.

Variations in soil textural class in the soil of the study site were observed ranging from sandy loam to clay loam and the pH of the soil varied from 4.7 to 7.5 or acidic to neutral. Organic carbon content in the soil ranged from 0.28% to 0.6 %, Available N varied from 54.3 to 238.2 kg ha^{-1}, available P_2O_5 varied from 42.74 to 57.01 kg ha^{-1} and available K_2O varied from 68.03 to 121.0 kg ha^{-1}. Farmers mostly grow local turmeric varieties like Bombay or high-yielding turmeric variety Megha Turmeric-1. In the case of chilli, the popular variety in the district is Surjyamukhi. The organic sources of nutrients applied in the study sites were neem-cake @ 250 kg/ha, FYM @ 5 t/ha, and vermicompost @ 1 t/ha. Before the rhizome planting, the soil was incorporated with all organic manures. The crop was harvested as soon as the above-ground portion dried up entirely. Twenty observational plants from organic and control treatments were selected from the farmer's field of three study sites. Information on plant growth characters and yield of turmeric on plant height (cm), leaves $plant^{-1}$, tillers $plant^{-1}$, fresh aerial biomass (g $plant^{-1}$), fingers $plant^{-1}$, width of rhizome (cm), yield (g $plant^{-1}$), and yield (t ha^{-1}) was recorded at the time of harvest. Similarly, the growth and yield parameters of chilli in terms of plant height (cm), branch no $plant^{-1}$, Leaf area index, dry matter production (g $plant^{-1}$), fruit $plant^{-1}$, avg. fruit weight (g), fruit length (cm), seeds $fruit^{-1}$, 100 fruit weight (g), avg. marketable fruit size (cm^2), yield (g $plant^{-1}$), and yield (t ha^{-1}) were observed from the farmer's field in the study sites. The average data of the three study sites were compiled.

Results and Discussion

The study revealed that the use of organic inputs in chilli cultivation has an impact on the growth as well as yield

characteristics of the crops. Significant differences were noted in the farmer's field among the organically treated and control plants for growth as well as yield characteristics of chilli in terms of plant height (cm), branch no. plant^{-1}, leaf area index, dry matter production(g), fruit no. plant^{-1}, fruit weight(gm), fruit length (cm), seeds fruit^{-1}, average marketable fruit size (cm^2), yield plant^{-1} (kg), and yield ha^{-1} (q) respectively.

Table 1: Growth and yield parameters of chilli (var. Surjyamukhi) under organic cultivation and control

Sl. No.	Parameters	At harvest (Average)	
		Treated	Control
1.	Plant height (cm)	74.50	52.50
2.	No. of branches plant^{-1}	16.20	6.40
3.	Leaf area index (LAI)	7.25	4.28
4.	Dry matter production (g plant^{-1})	87.50	66.90
5.	No. of fruits per plant	115.0	87.40
6.	Avg. fruit weight (g)	4.75	3.50
7.	Fruit length (cm)	5.75	3.80
8.	No. of seeds fruit^{-1}	102.0	67.40
9.	100 fruit weight (g)	350.0	215.00
10.	Average marketable fruit size (cm^2)	11.22	8.70
11.	Yield plant^{-1} (kg)	0.520	0.288
12.	Yield ha^{-1} (q)	16.00	11.20

Among the organic manures, the combined application of vermicompost and FYM along with neem cake was found to be the most effective in chilli cultivation compared to absolute control without any organic manures (Table1.). Maximum plant height (74.50 cm), branch number (16.20), leaf area index (7.25 cm), fruit no. plant^{-} (115.0), fruit weight (4.75 g), fruit length (5.75 cm), seeds fruit^{-1} (102 no.), average marketable fruit size (11.22 cm^2), yield plant^{-1} (520 g) and yield ha^{-1} (16.0 q) was obtained in organically treated plants, while minimum was observed in absolute control. The enhancement in yield parameters as well as growth in chilli under the organic manure application in the farmer's field might be due to the combined application of vermicompost and FYM and neem cake that influenced the biological, physical, and chemical properties of soil through better availability of plant nutrients creating congenial conditions for better plant growth and development.

When compared to the majority of bulky organic manures, vermicompost releases more nutrients, which may account for the higher plant heights (Bhende *et al*., 2013) [3]. Vermicompost is known to have compounds that promote development, increase microbial activity, and stop nitrogen from leaching out of the soil (Shinde *et al*., 1992) [9]. Plant growth parameters and yield of organically treated chilli plants may have improved as a result of increased enzymatic activity, microbial population, and activity, increased water holding capacity, accelerated earthworm population and activity, and easy availability of macro and micronutrients through vermicompost application (Ekinci and Dursun, 2009) [4].

Table 2: Growth parameters of Turmeric (var-Megha Turmeric-1) under organic cultivation and control

Sl. No.	Parameter	At harvest (Avg.)	
		Treated	Control
1.	Plant height (cm)	102.50	65.50
2.	No. of leaves plant^{-1}	12.80	8.40
3.	No. of tillers plant^{-1}	4.50	2.20
4.	Aerial biomass/fresh weight (g plant^{-1})	350.0	260.0
5.	Fingers rhizome^{-1}	20.50	12.57
6.	Width of rhizome (cm)	10.30	7.50
7.	Yield (g plant^{-1})	450.0	300.0
8.	Yield (t ha^{-1})	36.50	26.55

Organically treated turmeric plants in the farmer's field also showed marked differences with the control plants without any organic manures. Significant improvements in growth, as well as yield of turmeric, variety Megha Turmeric-1, was also observed in terms of plant height, leaves plant^{-1}, tillers plant^{-1}, aerial biomass of plant, finger no. rhizome^{-1}, width of rhizome (cm), and yield t ha^{-1}. Analysis of growth and yield attributes of turmeric variety Megha Turmeric-1 under organic cultivation in the farmer's field of Kokrajhar district reveals that with limited application of selected bio-inputs (FYM, vermicompost, and neem cake) profitable cropping of turmeric is possible since the farmer's practice organic cultivation by default without any synthetic fertilizers. Growth parameters in terms of plant height (102.5cm), leaves plant^{-1} (12.80), tillers plant^{-1} (4.50), and fresh aerial biomass plant^{-1} (350 gm) showed marked improvement over absolute control without the use of any organic inputs. Similarly, yield attributes in terms of fingers rhizomes^{-1} (20.50) and width of rhizome (10.30 cm) showed marked improvement with the application of organic inputs compared to control without organic manures. It is demonstrated that the organic treatment recorded significantly higher rhizome yield (450.0 g plant^{-1}) compared to control (300 g plant^{-1}). Organic inputs may be used without causing any harm to the ecosystem for higher production of turmeric (36.50 t ha^{-1}) combined application of FYM, vermicompost, and neem cake over untreated check plots (26.55 t ha^{-1}).

The maximum rhizome production in organic turmeric cultivation may be attributed, in part, to the higher and more easily available nutrient content in vermicompost and its uptake by the plant life. Vermicompost enhances the availability and retention of nutrients in the soil as well as its general health (Sreenivas *et al.*, 2000) [10]. Vermicompost is known for having all the nutrients needed by plants, and it offers a consistent supply of these nutrients for the duration of the entire crop period. Sharma *et al.* (2004) [8] also reported that vermicompost had a favorable influence on the availability of all the important plant nutrients during the crop period. Higher yields in turmeric cultivation conducted organically may have been caused by the higher nutrient content in neem cake as well as their improved availability and uptake enhanced by microbial action. Moreover, neem cake has also been reported to reduce leaching loss and extend the period of availability of N (Sathianathan, 1982) [11]. It has been reported by Sadanandan and Hamza (1997) [7] for ginger and Rao *et al.* (2005) [6] for turmeric that applying neem cake increases yield.

Conclusion

The growth and yield of chilli variety, Surjyamukhi, and turmeric variety, Megha Turmeric-1 recorded marked improvements with the combined application of FYM,

vermicompost, and neem cake. According to the results, all plant growth parameters, yield-attributing characteristics, and overall yield in the farmer's field's organically grown turmeric and chilli were raised by applying FYM, vermicompost, and neem cake in combination. While a minimum of these were produced by absolute control without any input. The highest chilli fruit yield of 16.0 t ha^{-1} and rhizome yield (36.50 t ha^{-1}) was obtained in the treatment combination of FYM, vermicompost, and neem cake indicating the benefit of organic inputs in chilli and turmeric cultivation in the farmer's field at Kokrajhar district of Assam for sustaining the human health and soil as well as the ecosystem.

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