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Impact off INM on Yield and Economics of Turmeric in Gangetic Alluvial Zone of West Bengal

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Abstract: As productivity of turmeric and soil health are reducing day by day due to improper application of chemical fertilizer, so present study was conducted to examine the effect of biofertilizers along with organic and different grades of inorganic nutrients on yield and economics of turmeric var. Suguna. Main objectives of this study were to use multiple sources of nutrients to increase productivity of turmeric rhizome and increase the B:C ratio. 13 treatments combination of nutrient sources like, 100%, 75% & 50% of NPK, 4 organic manures (compost, vermicompost, mustard cake and neem cake) and 3 bio-fertilizers (Nitrogen fixing - *Azotobacter chroococcum*, PSB - *Bacillus polymixa* and Potash mobilizer - *Fraturia aurantia)*. Turmeric rhizomes were harvested from the farm and then yield, and economic parameters were calculated. Treatment combination Vermicompost + NPK (100%) + Biofertilizer significantly superior in clump, primary & secondary rhizome characters, projected yield (38.55 t ha^{-1}), cost of production, gross return, net return (350688 Rs ha^{-1}) and B:C ratio (1.54). 25% of the full NPK can be replaced by organic sources of nutrients, which will improve soil health and productivity.

Keywords: B:C ratio, Economics, INM, Turmeric, Yield

The Zingiberaceae family includes turmeric (*Curcuma Longa* L), a significant ancient spice and medicinal plant with origins in South East Asia. It is a perennial herbaceous crop that is primarily farmed in tropical and subtropical areas of the world (Ronya et al 2020). As a long-term (8-9 months), demanding, and heavy feeder crop, turmeric needs a lot of nutrition to generate huge yield and higher-quality crop. It was found that using chemical fertilisers at high doses continuously has negative impacts on the ecology and the health of the soil (Chanchan et al 2018). Poor soil fertility and ineffective farming techniques result in a turmeric crop with low yield and productivity (Das et al 2020). The rising cost of chemical fertilisers and their negative effects on the environment, human health, and soil quality compelled the farmer to switch to an alternate source of nutrients for the production of spices. There are multiple sources of plant nutrients besides fertilisers, such as organic manures, bio-fertilizers, etc. The role of bio-fertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters (Tinna et al 2020). The gap between potential yield and realized yield in a location can be markedly reduced with an appropriate nutrient management technique. Besides, enhanced rhizome yield, a suitable nutrient management technique can enhance rhizome quality and can also reduce the deleterious impact of fertilization by eliminating nutrient over use. Organic manures and biofertilizers offer an alternative to chemical fertilizers and increasingly used in spice crop production including turmeric (Datta et al 2017, Sahoo et al 2020). Organic source of nutrients is recommended for retaining productivity of soil, reducing usage of chemical fertilizers, improving soil health and minimize environmental pollution. Application of organic manures also quickly increases soil microbial biomass and their activity. Soil microorganisms and their activities play an important role in transformation of plant nutrients from unavailable to available forms and helpful for improvement of soil fertility. The combined use of organic and inorganic fertilizers known as Integrated Nutrient Management, not only increases the yield but also improves the physical, chemical, and biological property of soil which further improves fertility, productivity and water holding capacity of soil. The organic source will help to maintain nutrient equilibrium in soils. Application of different combinations of organic manures like FYM, neemcake, vermicompost also influence the growth and yield of turmeric (Sarma et al 2015). In addition to strengthening productivity and soil health, efficient management of chemical, organic, and biological forms of plant foods have demonstrated encouraging results in fulfilling some of the crop's chemical fertilizer needs (Prasanth et al 2018, Mohanty et al 2022). Integrated plant nutrient system involving a combination of

fertilizers, manures and bio fertilizers are essential to sustain crop production, preserve soil health and biodiversity. This is especially important for developing countries where farming will continue to be in the hands of small farmers (Bhupenchandra et al 2022). Though a lot of trials on varietal, fertilizer, spacing, date of planting, size of planting material, mulching material and irrigation schedule etc. have been conducted to increase the production of turmeric, but till now very little work has so far been undertaken to increase the production. With such a premise, the current research was conducted to determine the effects of bio-fertilizers, manures, and grades of inorganic fertilizer on the yield characteristics and economics of turmeric in the Gangetic alluvial plains of West Bengal.

MATERIAL AND METHODS

The present investigation was conducted at Horticultural Research Station, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Nadia in 2019. Variety of turmeric is Suguna, number of treatments is 13 with 3 replications and followed RBD design (Table 1). Turmeric was fertilized with NPK @ 150:60:150 kg ha^{-1} and four types of organic manure namely Compost @ 25 t/ha, Vermicompost @ 5 t/ha, Neem Cake @ 3 t/ha and Mustard Cake @ 3 t/ha were applied during final land preparation. Three bio-fertilizers namely *Azotobacter chroococcum*, phosphate solubilizing bacteria (*Bacillus polymixa*) and potassic mobilizer (*Fraturia aurantia*) each @ 20 kg/ha was applied with organic manure during final land preparation and thoroughly mix up with soil. The fertilizers were applied in three splits but started 15 days after the application of bio-fertilizer and interval between the splits was same. Urea, SSP, and MOP were used as inorganic source of N, P and K respectively. Fresh turmeric rhizomes were harvested 9 months after planting with the help of spade. Then the roots and dirt material present on the rhizomes were removed. After that weight, length, breadth of the clump, primary and secondary rhizomes were collected. Then yield per plot and projected yield were written. According to the yield parameters, B:C ratio of 13 treatments were calculated.

Table 1. Treatment details

Treatments	Nutrient combinations
T1	Compost + NPK (100%) + Biofertilizer
T2	Compost + NPK (75%) + Biofertilizer
T3	Compost + NPK (50%) + Biofertilizer
T4	Vermicompost + NPK (100%) + Biofertilizer
T5	Vermicompost + NPK (75%) + Biofertilizer
T6	Vermicompost + NPK (50%) + Biofertilizer
T7	Mustard Cake + NPK (100%) + Biofertilizer
T8	Mustard Cake + NPK (75%) + Biofertilizer
T9	Mustard Cake + NPK (50%) + Biofertilizer
T10	Neem Cake + NPK (100%) + Biofertilizer
T11	Neem Cake + NPK (75%) + Biofertilizer
T12	Neem Cake + NPK (50%) + Biofertilizer
T13	NPK 100%

N-Nitrogen, P-Phosphorus, K-Potassium

Benefit: cost ratio: The economic assessment for the different treatment combinations were done based on cost of cultivation, gross return, and net return, considering the cost of inputs and market price of the produce during the period of experimentation (Sahoo et al 2020).

Statistical analysis: To do combined analysis, the mean data were analyzed using MSTAT-C. Various graphical representations have been created using the combined data of the relevant characters. The tables of findings provide the critical difference (C.D.) value to compare the variance between means.

RESULTS AND DISCUSSION

Yield Attributes

Clump: The highest weight of clump was documented under treatment combination of T4 (327.54 g) as compared to lowest clump weight of 205.16 g was associated with treatment of T9 (Table 2). The longest clump (16.31 cm) was in T10 followed by T4 as compared to minimum length (12.28 cm) under T9. The plants raised under T11 exhibited the widest (13.62 cm) clump as compared to minimum breadth (10.87 cm) of clump in T3 combination.

Primary finger: The T7 exhibited maximum (7.63) number of primary fingers as compared to minimum number of finger (4.96) in T3 (Table 3). Maximum weight (176.36 g) of primary finger was T1 as compared to minimum weight (108.24 g) under T11. The maximum length (9.24 cm) of primary finger was in plants grown under T1 as compared to minimum length (6.45 cm) under T9. The plants raised under T1 exhibited the widest (2.54 cm) primary finger as compared to minimum breadth (1.62 cm) of primary finger in T9 combination.

Secondary fingers: The plants raised under T11 exhibited maximum (10.34) number of secondary fingers as compared to minimum number of fingers (3.62) in T3 (Table 4). Maximum weight (135.38 g) of secondary finger was recorded in T4 as compared to minimum weight (38.16 g) under T3. The maximum length (5.83 cm) of secondary finger in T10 as compared to minimum length (4.34 cm) under T9. The maximum breadth of secondary finger (1.92 cm) was associated with T11 and minimum breadth of 1.45 cm under T9. Application of compost along with biofertilizers and NPK

improves the soil tilth and aeration, rises the soil's capacity to hold water, and encourages the activity of microorganisms that makes the plant food elements in the soil readily available to the crop as compared to only NPK (100%) without any organic input. Which in return increase the photosynthesis, then accumulated carbohydrate increase the number of clump, primary & secondary fingers and finally increase total yield. As a result, integrated nutrient management sustain the soil fertility and productivity (Ambala et al 2019, Srinivasan et al 2016).

Yield per plot: The maximum (15.42 kg $3m^{-2}$) plot yield was recorded in T4 (9.84 kg $3m^{-2}$) as compared to minimum yield in T3 (Table 4). The plot yield under only inorganic fertilizer NPK 100% recorded yield of 11.52 kg $3m^{-2}$. C:N ratio narrowed down during vermicomposting, which ensure the release of nitrogen to the crop when applied to the soil (Amala et al 2018).

Projected yield: The maximum projected yield (38.55 t/ha) was observed with T4 as compared to minimum yield (24.60 t/ha) in T3 combination (Table 4). The plot yield under only inorganic fertilizer NPK 100% recorded projected yields of 28.80 t/ha. Bhoomika et al (2018), Anuradha et al (2018) and Tripathi et al (2018) reported identical results. By enhancing the soil aggregates with organic manures, favourable pore

Table 2. Influence of different levels of organic, inorganic and biofertilizers on clump characters of turmeric

Treatment	Weight of clump (g)	Length of clump (cm)	Breadth of clump (cm)
Compost + NPK (100%) + Biofertilizer	285.24	16.14	12.94
Compost + NPK (75%) + Biofertilizer	262.36	15.65	12.46
Compost + NPK (50%) + Biofertilizer	214.18	12.32	10.87
Vermicompost + NPK (100%) + Biofertilizer	327.54	16.24	12.64
Vermicompost + NPK (75%) + Biofertilizer	278.39	15.56	12.18
Vermicompost + NPK (50%) + Biofertilizer	246.52	13.82	11.46
Mustard Cake + NPK (100%) + Biofertilizer	272.84	15.16	13.28
Mustard Cake + NPK (75%) + Biofertilizer	249.32	15.76	12.38
Mustard Cake + NPK (50%) + Biofertilizer	205.16	12.28	10.96
Neem Cake + NPK (100%) + Biofertilizer	304.85	16.31	13.12
Neem Cake + NPK (75%) + Biofertilizer	258.56	15.72	13.62
Neem Cake + NPK (50%) + Biofertilizer	228.38	14.62	11.36
NPK 100%	242.12	15.25	12.92
C.D. (P=0.05)	0.767	0.637	0.531

Table 3. Influence of different levels of organic, inorganic and biofertilizers on primary finger of turmeric

Treatment	Number	Weight (g)	Length (cm)	Breadth (cm)
Compost + NPK (100%) + Biofertilizer	6.51	176.36	9.24	2.54
Compost + NPK (75%) + Biofertilizer	6.32	139.28	8.68	1.92
Compost + NPK (50%) + Biofertilizer	4.96	148.05	6.86	1.67
Vermicompost + NPK (100%) + Biofertilizer	7.12	156.38	8.96	2.34
Vermicompost + NPK (75%) + Biofertilizer	6.24	132.12	8.74	2.14
Vermicompost + NPK (50%) + Biofertilizer	5.36	115.06	7.38	1.89
Mustard Cake + NPK (100%) + Biofertilizer	7.63	136.24	8.76	1.86
Mustard Cake + NPK (75%) + Biofertilizer	7.24	142.18	7.48	1.94
Mustard Cake + NPK (50%) + Biofertilizer	6.33	116.34	6.45	1.62
Neem Cake + NPK (100%) + Biofertilizer	6.82	142.43	8.62	2.08
Neem Cake + NPK (75%) + Biofertilizer	6.34	108.24	7.84	2.32
Neem Cake + NPK (50%) + Biofertilizer	5.46	123.17	6.86	1.82
NPK 100%.	6.24	136.45	7.32	1.84
C.D. (P=0.05)	0.288	5.706	0.336	0.082

geometry was created, increasing soil porosity, and enabling healthy rhizome development beneath the soil. The fact that organic manures after decomposition supply readily available nutrients directly to the plants and had a stabilizing effect on fixed forms of nutrients in soil, in addition to the nutrients supplying capacity, could be attributed to the combination's beneficial effects on yield and yield attributes (Babu et al 2014).

Economics: The maximum cost of production was Rs. 237,562/- recorded in T7 followed by T8 (Rs. 235,717/-) as compared to lowest cost of production Rs. 192,562/- in 100% NPK (Table 5). The highest gross return (Rs. 578,250/-) was observed in T4 as compared to lowest gross return (Rs. 369,075/-) in T3 combination. In case of net return, the maximum value of Rs. 350,688/- was registered under T4 as compared to lowest net return in T9 (Rs. 137,378/-). Highest B:C ratio was noticed in T4 (1.54) as compared to lowest B:C ratio (0.58) in T9 combination. Similar results were presented by Tripathi et al (2021).

Considering gross return, net return, and B:C ratio, the combination of T4 proved best for higher production of turmeric through integrated nutrient management. Though the next best net return (Rs. 298013/-) realized from T10 but for identifying the second-best treatment we should compare

Table 4. Influence of different levels of organic, inorganic and biofertilizers on secondary finger and yield of turmeric

Treatments	Number	Weight (g)	Length (cm)	Yield per plot (kg $3m^{-2}$)	Projected yield (t ha^{-1})
Compost + NPK (100%) + Biofertilizer	6.64	78.62	4.62	13.68	34.20
Compost + NPK (75%) + Biofertilizer	7.32	94.92	4.84	12.30	30.75
Compost + NPK (50%) + Biofertilizer	3.62	38.16	4.56	9.84	24.60
Vermicompost + NPK (100%) + Biofertilizer	9.23	135.38	5.62	15.42	38.55
Vermicompost + NPK (75%) + Biofertilizer	8.64	117.64	5.72	13.38	33.45
Vermicompost + NPK (50%) + Biofertilizer	4.75	94.32	4.76	11.76	29.40
Mustard Cake + NPK (100%) + Biofertilizer	7.92	106.38	5.58	12.96	32.40
Mustard Cake + NPK (75%) + Biofertilizer	9.46	75.62	5.12	11.34	28.35
Mustard Cake + NPK (50%) + Biofertilizer	7.34	54.36	4.34	9.90	24.75
Neem Cake + NPK (100%) + Biofertilizer	6.20	125.44	5.83	14.04	35.10
Neem Cake + NPK (75%) + Biofertilizer	10.34	119.38	5.46	12.72	31.80
Neem Cake + NPK (50%) + Biofertilizer	8.25	72.48	4.82	10.68	26.70
NPK 100%.	6.18	76.38	4.96	11.52	28.80
C.D. (P=0.05)	0.34	3.81	0.21	0.49	1.23

Table 5. Influence of different levels of organic, inorganic and biofertilizers on economics of turmeric

Treatment	Cost of production (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B : C ratio
Compost + NPK (100%) + Biofertilizer	217562	513000	295438	1.35
Compost + NPK (75%) + Biofertilizer	215717	461250	245533	1.13
Compost + NPK (50%) + Biofertilizer	213872	369075	155203	0.72
Vermicompost + NPK (100%) + Biofertilizer	227562	578250	350688	1.54
Vermicompost + NPK (75%) + Biofertilizer	225717	501750	276033	1.22
Vermicompost + NPK (50%) + Biofertilizer	223877	441000	217123	0.96
Mustard Cake + NPK (100%) + Biofertilizer	237562	486075	248513	1.04
Mustard Cake + NPK (75%) + Biofertilizer	235717	425250	189533	0.79
Mustard Cake + NPK (50%) + Biofertilizer	233872	371250	137378	0.58
Neem Cake + NPK (100%) + Biofertilizer	228562	526575	298013	1.30
Neem Cake + NPK (75%) + Biofertilizer	226717	477075	250358	1.10
Neem Cake + NPK (50%) + Biofertilizer	224872	399000	174128	0.77
NPK 100%	192562	432075	239513	1.24

the two-treatment combination of T10 and T1 in respect of cost of production, net return, and B:C ratio. As compared to T1, through incurring the extra expenditure of Rs. 11,000/- in T10 towards cost of production only Rs. 2575/- was realized as net return. Though net return is lower in case of T1, but through consideration of cost of production and B:C ratio, the second-best combination is T1. These organic manures create a reserve of humic substances, which improves the soil's ability to store water and its porosity and structural stability. Therefore, a progress in the physical and chemical conditions of the soil must have aided in the growth of the valuable soil microbial inhabitants, enhanced enzymatic activity, and stimulated the development of new roots, all of which contributed the soil acquire more nutrients and moisture from a larger area. This must be exactly triggered the rhizome production (Singh et al 2012).

CONCLUSION

When manure, biofertilizer, and fertilizer are applied together, the soil's water-holding capacity, photosynthesis, enzyme activity, and friability all increase, which improves yield and productivity and preserves the health of the soil and ecosystem. It also reduces cost of production with increasing net return. Through consideration of yield, cost of production, gross return, and B:C ratio, the best combination was Vermicompost + NPK (100%) + Biofertilizer. Moreover, through comparison of projected yield at 75% NPK level with four organic manures and 100% NPK, there was a chance of substitution of 25% inorganic fertilizer by the application of organic manure and bio- fertilizer. By reducing chemical fertilizer utilization and INM, farmers can reduce the cost of cultivation and environmental pollution as well as ensure sustainable soil fertility and productivity.

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