

STUDIES ON THE IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND QUALITY PARAMETERS OF TURMERIC

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ABSTRACT

The health of the soil is negatively impacted by chemical fertilizer sources, and plants are less able to absorb the readily available nutrients. The current study used several nutrition sources to reduce the negative impacts of chemical fertilizers, boost nutrient availability, and preserve health. The present experiment was conducted in field laboratory during 2017-19. 4 different manures, 3 different biofertilizers, and graded levels of NPK was applied in the form of 13 treatments. Data on the vegetative development of turmeric plants were gathered before to harvesting, and data on quality criteria were obtained after harvesting in the departmental laboratory. Vermicompost + NPK (100%) + Biofertilizers showed the highest results by considering the leaf number (23.64), tiller number (4.25), height of plant (191.74 cm). Higher dry recovery (23.56%), oleoresin (13.48%) and curcumin content (6.16%). Alternative sources of nutrients are reducing the dose of chemical fertilizers application as well as improves the vegetative growth and quality of turmeric rhizome. By this way we can replace 25-50% of chemical fertilizers with organic sources and enhance the soil health for plant growth and production.

Keywords: Curcumin, Dry recovery, Growth, INM, Oleoresin, Turmeric

INTRODUCTION

Turmeric (*Curcuma longa* L.) is a perennial, tropical, monocotyledonous spice plant that has been used medicinally since antiquity. Turmeric rhizome has potential uses in food factory, textile factory or other due to oleoresin and curcumin content causing yellow colour flesh. Rhizomes contain carbohydrate, protein, fiber, minerals, lipids etc (Ojikpong and Undie, 2019). The most secure herb for treating blood diseases is turmeric. Rhizomes are intended to cure many ailments such as diarrhoea, liver problems, fever etc. (Anuradha et al., 2018).

Turmeric is an extremely nutrient-extensive and heavy feeder crop. Applications of organic matter have a positive impact on turmeric's growth, productivity, and quality, and there is experimental data to support this. Organic matter can also be used in conjunction with inorganic fertilisers to improve turmeric's quality. Its capacity to produce a lot of dry matter per unit area and shallow rooting make its nutrient needs quite high. Therefore, it is crucial for optimum growth that plant nutrients are applied as needed with organic and inorganic manures. For the soil to remain fertile and productive, inorganic, and organic manures must be used together. Studies on the effects of organic manures, biofertilizers combined with various rates of NPK fertilisers on turmeric have been documented by Sanwal et al. (2007), Singh (2020), Roy and Hore (2009) and Akamine et al.

(2007). Studies examining how different nutrient management strategies affect turmeric production and quality in addition to their impact on physicochemical and biochemical variables impacting soil quality. Turmeric farmers can earn more money from their produce if they grow it organically because there is an increasing global demand for organic products. Due to improved quality, better market demands, and increased environmental protection, organic farming has become more popular (Yadav et al., 2004). Bio-fertilizers are not just environmentally safe, sustainable, and low-cost input but also given great profits under suitable situation.

The use of biofertilizers, such as Azospirillum, improves soil fertility and aids in the fixation of a significant amount of atmospheric nitrogen for supply to the crop. The uptake of phosphorus, which is easily fixed in the soil, is increased by applying PSB (Khan et. al., 2022). Adopting a strategy for the perceptive amalgamation of chemical fertilizers, organic manures, and bio-fertilizers is necessary to encourage, nurture, and facilitate permaculture for more profitable and healthy production. Recently, biofertilizers have become recognized as a viable nutrient supply element. Numerous researchers have demonstrated the importance of various bio fertilizers, such as Azospirillum and Azotobacter cultures, in fixing atmospheric nitrogen. The soil's microorganisms have the potential to accumulate organic matter, which increases the availability of other nutrients and secretes compounds that promote growth. In several experiments and field tests, the use of phosphate-solubilizing microorganisms has resulted in favourable results (Alori et al., 2017).

METHOD AND MATERIALS

The research was carried out between 2017 and 2019 at the HRS, Bidhan Chandra Krishi Viswavidyalaya, Mondouri, West Bengal. Variety is Suguna, number of treatments is 13 with 3 replications and followed RBD design. Total 13 treatments were Compost + NPK (100%) + Biofertilizer, Compost + NPK (75%) + Biofertilizer, Compost + NPK (50%) + Biofertilizer, Vermicompost + NPK (100%) + Biofertilizer, Vermicompost + NPK (75%) + Biofertilizer, Vermicompost + NPK (50%) + Biofertilizer, Mustard Cake + NPK (100%) + Biofertilizer, Mustard Cake + NPK (75%) + Biofertilizer, Mustard Cake + NPK (50%) + Biofertilizer, Neem Cake + NPK (100%) + Biofertilizer, Neem Cake + NPK (75%) + Biofertilizer, Neem Cake + NPK (50%) + Biofertilizer and NPK 100%. Three biofertilizers were used: Azotobacter chroococcum, a bacterium that fixes nitrogen, Bacillus polymixa, a bacterium that dissolves phosphate, and potassium mobilizer (*Fraturia aurantea*). Five randomly chosen plants were evaluated for growth factors such height, number of leaves per plant, and number of tillers per plant 90, 120, 150, and 180 days after planting.

Dry recovery: Fixed quantity of fresh rhizomes from five randomly selected plants were weighed by using electric balance, then oven dried the harvested rhizome at 550C for 3-5 days until no further change in weight. The dry recovery was expressed in percentage.

Oleoresin content: The dried rhizomes were grinded and sieved. Then turmeric powder was kept in a chromatographic column with acetone for overnight (AOAC, 1975) and filtered out. Oleoresin with acetone was dried and weight was taken.

Curcumin content: Through solvent extraction of turmeric with ethanol and water, the amount of curcumin was estimated (Bagchi, 2012). 2 g of material from each treatment was collected, mixed with 30 ml each of ethanol and water, and then filtered. Each filtrate's concentration is held constant, and a spectrophotometer is used to detect the absorbance at 425 nm. The formula for calculating curcumin content (g/100 g) is as follows:

$$\text{Curcumin content (g/100g)} = \frac{0.0025 \times \text{Absorbance at 425 nm} \times \text{Volume made up} \times \text{Dilution factor} \times 100}{0.42 \times \text{weight of sample} \times 1000}$$

Since 0.42 absorbance at 425 nm = 0.0025 g of curcumin

Statistical analysis: In accordance with Panse and Sukhatme, statistical analysis of variance was performed on the collected data (1985). To perform combined analysis, the mean data from two seasons were combined and analysed using MSTAT-C. Fisher and Snedecor's "F" test was used to determine the significance of various sources of variation at a probability level of 0.05. Fisher and Yates (1979) tables were used to determine the critical difference (C.D.) at a 5% level of significance. The tables of results include the critical difference (C.D.) value and the standard error of the mean [S.Em. (±)] to compare the variance between means.

RESULT AND DISCUSSION

Height of the plant: At various stages of plant growth, organic manures, biofertilizers, and inorganic fertilisers all had a considerable impact on plant height. 90 days after planting, based upon the data given in Table No. 1, the maximum height (118.26 cm) was recorded in plants grown under Neem Cake + NPK (100%) + Biofertilizer (BF) and minimum plant height was recorded under Vermicompost + NPK (50%) + BF (89.47 cm). The plant height with NPK (100%) only was 96.24 cm. At 120 DAP, plants raised under Mustard Cake + NPK (75%) + BF exhibited maximum plant height of 145.82 cm and minimum plant height of 114.86 cm was observed under Mustard Cake + NPK (50%) + BF but plant height of 118.02 cm was recorded under NPK (100%) only, though both of them were statistically not significant. At 150 DAP, the tallest plant (178.30 cm) was observed under Neem Cake + NPK (100%) + BF as compared to shortest plant (132.65 cm) under Mustard Cake + NPK (50%) + BF. The plants raised under only inorganic fertilizer i.e., NPK (100%) exhibited plant height of 137.56 cm. The last two treatment combinations were statistically at par. At 180 DAP, the maximum plant height (193.20cm) was recorded under Neem Cake + NPK (100%) + BF followed by Vermicompost + NPK (100%) + BF (191.74 cm) and Mustard Cake + NPK (100%) + BF (189.35 cm) in contrasted to the minimal plant height of Mustard Cake + NPK (50%) + BF (154.76 cm). The plants raised under only recommended fertilizer (NPK 100%) recorded plant height of 159.38 cm.

Number of tillers per clump: The largest number of tillers per clump (1.61) at 90 DAP was recorded in Neem Cake + NPK (75%) + BF in contrasted to the minimal tiller (0.52) under Mustard Cake + NPK (50%) + BF (table no. 2). At 120 DAP, the plants raised under Vermicompost + NPK (100%) + BF exhibited maximum tiller of 2.36 in contrasted to the minimal tiller (0.93) under Neem Cake + NPK (50%) + BF. The plant grown under only inorganic treatment recorded tiller

number of 1.24. At 150 DAP, maximum number of tiller (3.17) was associated with treatment combination of Neem Cake + NPK (100%) + BF (3.17) as compared to minimum number of tillers (1.58) under Mustard Cake + NPK (50%) + BF. At 180 DAP, as per pooled data the maximum number of tiller (4.25) was observed in treatment combination of Vermicompost + NPK (100%) + BF followed by Neem Cake + NPK (100%) + BF (4.16), as compared to minimum number of tiller in Neem Cake + NPK (50%) + BF (2.35). Plants under NPK (100%) produced tiller number of 2.64.

Table1: Influence of different levels of organic, inorganic and biofertilizers on plant height of turmeric (in cm).

Treatments	90 DAP	120 DAP	150 DAP	180 DAP
C + NPK (100%) + BF	105.62	132.51	167.82	188.36
C + NPK (75%) + BF	99.36	130.38	159.05	180.46
C + NPK (50%) + BF	92.64	122.64	142.62	161.35
VC + NPK (100%) + BF	102.35	134.34	169.82	191.74
VC + NPK (75%) + BF	109.64	136.29	164.13	186.38
VC + NPK (50%) + BF	89.47	117.05	148.05	169.45
MC + NPK (100%) + BF	112.36	142.34	172.82	189.35
MC + NPK (75%) + BF	115.67	145.82	170.26	182.03
MC + NPK (50%) + BF	98.35	114.86	132.65	154.76
NC + NPK (100%) + BF	118.26	145.65	178.30	193.20
NC + NPK (75%) + BF	112.45	136.12	165.12	181.32
NC + NPK (50%) + BF	106.26	128.48	149.36	168.06
NPK (100%)	96.24	118.02	137.56	159.38
S.Em. (±)	1.492	1.859	2.232	2.469
C.D. (P=0.05)	4.380	5.458	6.554	7.250

DAP= Days after planting, C= Compost, VC= Vermicompost, MC= Mustardcake, NC= Neemcake
BF= Biofertilizer

Table no. 2: Influence of different levels of organic, inorganic and biofertilizers on number of tillers of turmeric

Treatments	90 DAP	120 DAP	150 DAP	180 DAP
C + NPK (100%) + BF	1.14	2.02	2.94	3.76
C + NPK (75%) + BF	0.96	1.89	2.68	3.49
C + NPK (50%) + BF	0.65	1.15	2.05	2.86
VC + NPK (100%) + BF	1.26	2.36	3.14	4.25
VC + NPK (75%) + BF	1.42	2.14	2.86	3.92
VC + NPK (50%) + BF	0.82	1.16	2.15	2.74
MC + NPK (100%) + BF	1.18	1.96	2.38	3.87
MC + NPK (75%) + BF	1.46	1.72	2.56	3.45
MC + NPK (50%) + BF	0.52	0.96	1.58	2.49
NC + NPK (100%) + BF	1.25	1.56	3.17	4.16
NC + NPK (75%) + BF	1.61	2.23	2.86	4.02

NC + NPK (50%) + BF	0.63	0.93	1.92	2.35
NPK (100%)	0.72	1.24	1.65	2.64
S.Em. (\pm)	0.016	0.024	0.034	0.048
C.D. (P=0.05)	0.046	0.071	0.099	0.142

Table no. 3: Influence of different levels of organic, inorganic and biofertilizers on number of leaves of turmeric.

Treatments	90 DAP	120 DAP	150 DAP	180 DAP
C + NPK (100%) + BF	10.45	14.31	17.12	20.16
C + NPK (75%) + BF	10.15	13.16	16.56	19.30
C + NPK (50%) + BF	9.30	11.45	13.28	16.45
VC + NPK (100%) + BF	10.12	13.46	18.15	23.64
VC + NPK (75%) + BF	10.80	14.12	16.86	21.32
VC + NPK (50%) + BF	8.32	10.85	14.12	18.35
MC + NPK (100%) + BF	9.64	12.84	15.64	20.74
MC + NPK (75%) + BF	10.24	13.17	16.28	19.36
MC + NPK (50%) + BF	8.12	11.28	13.16	16.45
NC + NPK (100%) + BF	10.56	12.56	16.84	22.13
NC + NPK (75%) + BF	9.86	12.42	15.17	20.36
NC + NPK (50%) + BF	8.34	10.32	14.32	19.14
NPK (100%)	8.90	12.25	15.26	18.36
S.Em. (\pm)	0.139	0.184	0.226	0.281
C.D. (P=0.05)	0.408	0.541	0.664	0.825

Table 4: Influence of different levels of organic, inorganic and biofertilizers on quality parameters of turmeric

Treatment	Dry recovery (%)	Oleoresin (%)	Curcumin (%)
C + NPK (100%) + BF	27.84	13.28	5.76
C + NPK (75%) + BF	21.62	12.62	5.32
C + NPK (50%) + BF	21.76	12.24	5.06
VC + NPK (100%) + BF	23.56	13.48	6.16
VC + NPK (75%) + BF	22.39	12.80	5.94
VC + NPK (50%) + BF	22.60	11.62	5.72
MC + NPK (100%) + BF	23.86	13.06	6.28
MC + NPK (75%) + BF	22.34	12.38	5.86
MC + NPK (50%) + BF	21.92	12.72	6.04
NC + NPK (100%) + BF	24.62	13.76	6.34
NC + NPK (75%) + BF	24.28	13.34	6.18
NC + NPK (50%) + BF	23.64	12.56	5.98
NPK (100%)	22.84	11.84	5.82

S.Em. (±)	0.324	0.179	0.083
C.D. (P=0.05)	0.952	0.524	0.245

C= Compost, VC= Vermicompost, MC= Mustardcake, NC= Neemcake BF= Biofertilizer (Azotobacter chroococcum, Bacillus polymyxa and Frateuria aurantia)

Number of leaves per clump: The maximum leaf number (10.80) was recorded in plants raised under Vermicompost +NPK (75%) + BF as compared to minimum leaf number (8.12) under Mustard Cake + NPK (50%) + BF (table no. 3). At 120 DAP, the maximum number of leaf (14.31) was associated with plants grown under treatment combination of Compost + NPK (100%) + BF as compared to minimum number of leaves (10.32) under Neem Cake + NPK (50%) + BF. The plants raised under NPK (100%) only produced leaf number of 12.25. At 150 DAP, plants raised under Vermicompost + NPK (100%) + BF recorded largest leaf number (18.15) as compared to minimum leaf number (13.16) under Mustard Cake + NPK (50%) + BF. At 180 DAP, like 150 DAP the same treatment combination i.e., Vermicompost + NPK (100%) + BF recorded maximum leaf number of 23.64. The next best treatment combination in respect of leaf production was Neem Cake + NPK (100%) + BF (22.13), Vermicompost + NPK (75%) + BF (21.32) and Neem Cake + NPK (75%) + BF (20.36) as compared to minimum leaf number (16.45) under Compost + NPK (50%) + BF. The plants under only inorganic fertilizer NPK (100%) recorded leaf number of 18.36. similar plant growth results also shown by Dikey et al. (2019), Kumar et al. (2018), Lohar and Hase (2021). Diverse organic nutrient sources, such as biofertilizers and manures, are applied in stages to foster beneficial microorganisms and enhance humus content within the soil, hence increasing nutrient availability and promoting soil health by restoring soil physicochemical qualities (Amala et al., 2019; Lohar and Hase, 2021). The availability of nutrients in the soil promotes plant development.

Dry recovery: Dry recovery of rhizome increased from 21.62% to 24.62%. The maximum dry recovery (24.62%) was observed in treatment combination Neem Cake + NPK (100%) + BF followed by Mustard Cake + NPK (100%) + BF (23.86%) as compared to minimum dry recovery (21.62%) in Compost + NPK (75%) + BF combination. The dry recovery was 22.84% under NPK (100%). In Mustard and Neem Cake combination, dry recovery decreased with the decreasing level of inorganic (100 to 50%).

Oleoresin content: Oleoresin content increased from 11.62% to 13.76%. The results showed that combining bio-inoculants and organic manure with 100% NPK (inorganic) enhanced oleoresin content compared to 75% and 50% inorganic NPK. It also exhibited that the maximum oleoresin content (13.76%) was observed in treatment combination Neem Cake + NPK (100%) + BF followed by Vermicompost + NPK (100%) + BF (13.48%) as compared to minimum oleoresin (11.62%) in Vermicompost + NPK (50%) + BF combination. Except the Mustard Cake combination the decreasing trend in the oleoresin content was noticed with decreasing the quantity of inorganic NPK i.e., 100% to 50%. The oleoresin content is 11.84% under NPK (100%) treatment.

Curcumin content: Curcumin content increased from 5.06% to 6.34%. The results showed that the concomitant application of bio-inoculants and 100% NPK boosted the curcumin content (inorganic). The maximum curcumin content (6.34%) was observed in treatment combination Neem Cake + NPK (100%) + BF followed by Mustard Cake + NPK (100%) + BF (6.28%) as compared to minimum curcumin (5.06%) in Compost + NPK (50%) + BF combination. In Compost, Vermicompost and Neem Cake combination the curcumin content decreased with decreasing level of inorganic. Similar findings were examined and presented by Kumar et al. (2018), Tripathi et al. (2018), and Jabborova et al. (2021).

By raising the biofertilizer applications enhanced the quality of the root system and the rhizome's oleoresin content. Azotobacter, in addition to their capacity to fix nitrogen, also create anti-fungal antibodies that prevent the growth of several harmful fungi in the root area, hence enhancing root development and crop nutrition, which in turn enhances the final product's quality (Subba Rao, 2001). Additionally, they create growth-regulating compounds like phytohormones, vitamins, and other chemicals that balance the crop's nutrition and enhance the quality of the plant (Arun, 2007). Like this, Phosphatica enhances crop quality by increasing physiological activities through improved P nutrition and aids in the solubilization of soil accessible and local P through the creation of organic acids (Mahdi et al., 2010). The increased availability of nutrients in the root zone due to increased microbial activity in the biofertilizer treatment's good influence on rhizome quality may improve crop nutrition (Bijaya and Ado, 2005). When compared to NPK (100%) inorganic fertilizer, it was discovered that the quality parameters—dry recovery, oleoresin, and curcumin content—were raised by the all-organic and bio-fertilizer combination. These results agree with past research by Mridhula and Jayachandran (2001), as well as Velmurugan et al. (2008). All organic and biofertilizer combinations boost quality aspects because they include micro- and macronutrients and enhance the physical, chemical, and biological characteristics of the soil, which encourage the proliferation of roots and promote nutrient uptake by the crop (Sidhu and Sekhon, 2000). In addition to increasing P availability, PSB is also known to produce vitamins, amino acids, and growth-promoting compounds including IAA and GA, which aid in improved plant development. This could have caused the PSB-inoculated plots in the current investigation to expand more rapidly. Increased levels of nutrients like nitrogen, phosphorus, and potassium in plants result in an increase in the production of plant metabolites that assist to construct the tissues of plants, which can be linked to an increase in growth characteristics because of increased fertilizer application (Chanchan et al., 2018).

CONCLUSION

Integrated nutrient management with multiple sources of nutrients amplify the plant growth. Better plant growth of turmeric produce and accumulate more amount of photosynthates in the producing parts like, rhizome. This accumulated photosynthates will improve the qualitative characters of the rhizome. Treatments with vermicompost + NPK (100%) + Biofertilizers shows the highest results based on growth and quality parameters. But we can reduce the use of chemical fertilizers by 25-

30 % of organic sources, which will prevent the soil from pollution and maintain the soil health & productivity.

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