**Influence of integrated nutrient management on growth, yield and soil chemical parameters of turmeric (*Curcuma longa* L.)**

**Abstract**

A field study was carried out at the Regional Research Station (Vegetable Science) of CCS Haryana Agricultural University, Karnal, during the cropping season of 2022-2023 (June-March) to study the effect of integrated nutrient management on soil fertility and yield of turmeric on clay loam soil to assess the effect of integrated nutrient management on yield and economics in turmeric (*Curcuma longa* L.). The experiment was laid out in Randomized Block Design with three replications. The experiment consisted of ten treatments *viz.,* Control, Recommended Dose Fertilizer (N:P:K-100:50:50), 50% Recommended Dose Fertilizer, 75% Recommended Dose Fertilizer, FYM @25 t/ha, 50% Recommended Dose Fertilizer + FYM @25 t/ha, 75% Recommended Dose Fertilizer + FYM @25 t/ha, Vermicompost@5t/ha, 50% Recommended Dose Fertilizer + Vermicompost@5t/ha and 75% Recommended Dose Fertilizer + Vermicompost@5t/ha. Significantly more number of tillers per plant (3.67) reported in 75 % Recommended dose of fertilizer + FYM @25t/ha. Maximum plant emergence ((84.66%), leaf area index, height of plant (14.04) and yield were recorded with 75 % recommended dose of fertilizer (N:P:K-100:50:50) + vermicompost @ 5 t/ha. The physico-chemical properties *i.e.,* bulk density, electrical conductivity, organic carbon and pH of soil didn’t influence significantly with various integrated nutrient management treatments. Available nitrogen and phosphorous was found significantly highest i.e.192.60 Kg/ha and 25.8 kg/ha, respectively 75 % Recommended dose of fertilizer + vermicompost @ 5 t/ha. While, available potassium was reported maximum (186.81 kg/ha) in 75 % Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha. Based on the findings, it is recommended that 75 % recommended dose of fertilizer (N:P:K-100:50:50) along with vermicompost @ 5 t/ha should be adopted for enhancing turmeric productivity and nutrient use efficiency without adversely affecting soil health.

**Key words:** integrated nutrient management, fertilizer, manure, growth, turmeric

**Introduction**

Turmeric (*Curcuma longa* L.) belongs to family Zingiberaceae is one of the important herbaceous plant grown and used in India since ancient times as spice or condiment. India is the largest producer and consumer of turmeric in the world with an area of 3.24 lakh hectare and production of 11.61 lakh metric tonnes according to first advanced estimates of 2022-23 (Anonymous, 2023). In Haryana, turmeric is cultivated in 1.27 thousand hectare area having production of 3.17 thousand metric tonnes (Anonymous 2022). Commercial turmeric is a dried subterranean rhizome that is mostly utilized in the textile, cosmetic, pharmaceutical, and culinary industries. According to Choudhary and Rahi, (2018), turmeric's curcuminoids have anti-inflammatory, antimutagen, anticancer, antibacterial, anti-oxidant, antifungal, antiparasitic, and detoxifying qualities. 1.8–5.4 percent curcumin, 69.49 percent carbohydrates, 6.30 percent protein, 5.10 percent oil, 3.50 percent minerals, and other significant components are found in its rhizome (Bulbula, 2021). These substances provide the plant its antibacterial, anti-inflammatory, and antioxidant qualities, which have been thoroughly investigated for possible medical uses

Although turmeric takes a long time to mature (8–9 months), it reacts well to feeding. Peter et al. (2000) have reported turmeric to be an exhaustive crop that responds well to judicious application of fertilizers and manures. Therefore, getting an appropriate amount of nutrients is crucial for a healthy production. Balanced plant nutrition including micronutrients *viz*. Zn and B increases the rhizome yield, growth and curcumin content (Halder *et al.,* 2007). After rhizome sprouting, the crop undergoes phases of moderate growth, active growth, slow growth, and a phase-approaching senescence (Sivaraman, 2007).

The continuous use of high dose of chemical fertilizer has an adverse effect not only on soil health and but also on environment. The combined use of organic and inorganic fertilizer 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. FYM is an organic fertilizer rich in nutrients such as nitrogen, phosphorus, and potassium, and it also improves the soil's physical and biological properties, including soil structure, water-holding capacity and microbial activity. A study conducted in India reported that the application of FYM at a rate of 10 t ha-1 significantly increased the turmeric yield compared to chemical fertilizers alone (Jena *et al.,* 2016). Vermicompost is a nutrient-rich organic fertilizer produced by the process of decomposition of organic waste by earthworms. Vermicompost contains a wide range of beneficial microorganisms and nutrients, making it an ideal organic fertilizer for turmeric cultivation. a study conducted in India found that the application of vermicompost at a rate of 5 t ha-1 significantly increased the turmeric yield compared to the control (Sharma *et al.,* 2017). Similarly, another study in Iran reported that the application of vermicompost at a rate of 10 t ha-1resulted in higher turmeric yield and quality compared to chemical fertilizers (Hosseini *et al.,* 2020).

Exogenous application of nutrients to turmeric usually involves either exclusive application of chemical fertilizers (conventional method) or organic manures (organic method) or a combination of organic manures and chemical fertilizers (integrated method). Integrated nutrient management envisaging conjunctive use of inorganic and organic sources of nutrient is a novel system of plant nutrient use for sustaining soil health and crop productivity. The integrated nutrient management ensures the better and sustainable yield while correcting some secondary and micronutrients deficiencies and also increases the nutrient use efficiency. Moreover, integrated nutrient management is of immense importance in high value crop like turmeric and by improving the productivity and quality of this crop, socioeconomic status of farmers of the state can be improved further. In view of the above facts the present investigation was conducted to evaluate the impact of integrated nutrient management on growth, yield and soil chemical parameters of turmeric (*Curcuma longa* L.).

**Materials and Methods**

The field experiment was carried out at the Research Farm of the Department of Vegetable Science, Regional Research Station, Karnal situated at 29o 43' N latitude, 76o 58' longitude at an elevation of 245 m above mean sea level during the cropping season of 2022-2023 (June-March). The climate of village Uchani, Karnal is semi-arid and sub-tropical with dry and hot winds during summer months, warm and humid in monsoon and dry and cold weather in winter. Both, summers & winters are generally harsh to hold. The mean maximum and minimum temperatures during cropping season were 43.7oC and 2.0oC, respectively. Most of the precipitation falls between July and September, with only a few showers falling between December and the start of summer. Soil of the study area was clay-loam. At the start of the experiment, electrical conductivity was 0.27 dSm-1 soil organic carbon (SOC) was 0.42 %, and the content of available N,P,K were 168, 7.1 and 156 kg ha-1 and were estimated using conductivity bridge, rapid titration, micro kjeldahl, calorimetry and flame photometry, respectively. The field experiment was laid out in a randomized complete block design with ten treatments *viz.,* Control, Recommended Dose Fertilizer (N:P:K-100:50:50), 50% Recommended Dose Fertilizer, 75% Recommended Dose Fertilizer, FYM @25 t/ha, 50% Recommended Dose Fertilizer + FYM @25 t/ha, 75% Recommended Dose Fertilizer + FYM @25 t/ha, Vermicompost@5t/ha, 50% Recommended Dose Fertilizer + Vermicompost@5t/ha and 75% Recommended Dose Fertilizer + Vermicompost@5t/ha. The turmeric variety Punjab Haldi-1 was planted on 1st June, 2022 with a planting rate of 15 q ha-1 and spacing of 60 cm x 15 cm. One-third of dose of nitrogen along with full doses of P2O5 and K2O were applied at the time of planting. Remaining two-third of nitrogen was applied at an interval of one month. All other agronomic practices like earthing up, weeding (manual), *etc*., were done during the crop growth. Germination percentage was calculated by counting the total germinated rhizomes per plot in comparison to number of rhizomes planted at 60 days after planting. The side shoots (tillers) arising from the basal portion of the pseudo stem were counted and expressed as total number of tillers per plant. The leaf area index (LAI) was computed using the formula given below (Sesta et al., 1971).

LAI

The crop was harvested on 12th March, 2023 and data on yield was recorded. Soil samples (0-15 cm) were taken before starting the experiment and after the harvest of turmeric. The soil samples were air dried and ground to pass through a 2 mm sieve and were analyzed for pH, organic carbon and available N, P and K by standard method.

**Statistical analysis**

The data generated were statistically analyzed following the technique of analysis of variance for randomized block design as suggested by Gomez and Gomez (1984).

**Results and discussion**

**Plant emergence at 60 days after planting**:

The perusal of data that integrated nutrient management has influenced the plant emergence recorded at 60 days after planting (table 1). The outcome revealed that the integrated nutrient management had significant impact on the plant emergence at 60 days after planting. The plant emergence at 60 days after planting for different treatments was noted in the range of 69.33 to 84.66%. It has been noted significantly maximum for the 75% recommended dose of fertilizer (N:P:K-100:50:50) + vermicompost @ 5 t/ha (84.66%) which was statistically at par with recommended dose of fertilizer (N:P:K-100:50:50) (78.66%), 50% recommended dose of fertilizer (RDF) + FYM @ 25 t/ha (79.33%), 75% recommended dose of fertilizer(RDF) + FYM @ 25 t/ha (82.00%) and 50 % recommended dose of fertilizer + vermicompost @ 5t/ha (80.33%). This might be due to the Vermicompost + recommended dose of fertilizer enhancing the germination of turmeric by providing essential nutrients, improving soil structure, increasing water-holding capacity, promoting beneficial microbial activity, and stimulating hormonal effects in most optimum way as compared to the other treatments. The lowest plant emergence at 60 days after planting (69.33%) was reported from the control. The results are in unison with the findings of Sahoo et al.(2020).

**Number of tillers per plant**

The data regarding number of tillers per plant lies in a range of 2.51 to 3.67 (table 1). The outcome revealed that the integrated nutrient management had significant impact on the number of tillers per plant. The maximum number of tillers per plant (3.67) reported in 75 % recommended dose of fertilizer + FYM @ 25 t/ha which was at par with 75% recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha (3.51). The minimum number of tillers per plant (2.51) was found in control. After 60 days of planting the maximum number of tillers per plant were registered in 75 % recommended dose of fertilizer (RDF) + FYM @ 25 t/ha. The number of tillers per plant increased with application of chemical fertilizers along with organic manures such as FYM in turmeric. This might be due to the positively influence of FYM + RDF on number of tillers per plant. FYM provides essential nutrients, improves soil structure, supports microbial activity, and potentially influences hormonal effects, all of which contribute to increase tillering in plants. Amala et al. (2022) also reported similar findings.

**Table 1. Effect of integrated nutrient management on plant emergence (%) and number of tillers per plant**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Plant emergence at 60 days after planting (%)** | **Number of tillers per plant** |
| **T1: Control** | 69.33 | 2.51 |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 78.66 | 2.97 |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 74.00 | 2.73 |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 76.66 | 2.84 |
| **T5: FYM @ 25t/ha** | 72.66 | 2.67 |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 79.33 | 3.33 |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 82.00 | 3.67 |
| **T8: Vermicompost @ 5t/ha** | 72.66 | 2.73 |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 80.33 | 3.33 |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 84.66 | 3.51 |
| **C.D.at 5% level of significance** | 6.53 | 0.25 |

## Leaf area index

The data pertaining to leaf area index (LAI) was recorded at different stages (60, 90, 120 and 150 days after planting) of crop growth. Leaf area index had significant difference among the treatments in all the growth stages of 60, 90, 120 and 150 days after planting. The data furnished in table 2, regarding leaf area index revealed that general trend of leaf area index was increased with increase in age of plant. At treatment 75 % recommended dose of fertilizer + vermicompost @ 5 t/ha, maximum leaf area index was recorded at all the growth stages which lies in the range of 0.99 (60 DAP) to 3.01 (150 DAP). Significantly highest (3.01) leaf area index was recorded in 75 % recommended dose of fertilizer (RDF) + vermicompost @5 t/ha and lowest (2.4) in T1: Control at 150 DAP. The likely cause for the increase in the number of leaves per plant and leaf area index (LAI) in turmeric could be attributed to improved soil properties, specifically organic carbon content, and optimal availability of plantn utrients. These factors acted as growth enhancers for turmeric by providing a continuous supply of essential nutrients throughout the growth period. As a result, the soil fertility and nutrient use efficiency were enhanced, leading to an increase in the number of leaves and LAI in turmeric. Kumar *et al.,* (2016), Kamal and Yousuf (2012), Amala *et al*. (2022) also reported higher LAI of turmeric plants treated with organic manures such as vermicompost.

**Table 2. Effect of integrated nutrient management on leaf area index**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Leaf area index** | | | |
| **60 DAP** | **90 DAP** | **120 DAP** | **150 DAP** |
| **T1: Control** | 0.71 | 1.14 | 2.21 | 2.4 |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 0.90 | 1.44 | 2.40 | 2.81 |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 0.83 | 1.32 | 2.34 | 2.72 |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 0.87 | 1.37 | 2.36 | 2.77 |
| **T5: FYM @ 25t/ha** | 0.75 | 1.21 | 2.28 | 2.65 |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 0.91 | 1.48 | 2.43 | 2.80 |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 0.96 | 1.52 | 2.55 | 2.90 |
| **T8: Vermicompost @ 5t/ha** | 0.78 | 1.25 | 2.32 | 2.68 |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 0.93 | 1.48 | 2.44 | 2.81 |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 0.99 | 1.62 | 2.62 | 3.01 |
| **C.D.at 5% level of significance** | 0.07 | 0.11 | 0.19 | 0.22 |

**Plant height (cm)**

The data obtained during the experiment in table 3, indicated that plant height was significantly influenced by different integrated nutrient management. The data regarding plant height revealed that plant heights in all the treatments increased with increase in the age of the plant upto 150 DAP. Among all the treatments, the plant height at 60 days after planting was noted in the range of 14.04 to 17.21 cm. It has been seen that plant height increased with the increased dose of fertilizers. The height of plant at 60 days after planting was significantly maximum in the 75 % Recommended dose of fertilizer + vermicompost @ 5 t/ha followed by 75 % recommended dose of fertilizer + FYM @ 25 t/ha, i.e., 17.21 and 16.66 cm, respectively. The plant height at 60 days after planting was noticed minimum in control (14.04). At treatment 75 % Recommended dose of fertilizer + vermicompost @ 5 t/ha, maximum plant height was recorded at all the growth stages which lies in the range of 17.21 (60DAP) to 38.26 (150DAP). Significantly highest (38.26cm) plant height was recorded in 75% recommended dose of fertilizer + vermicompost @ 5 t/ha and the lowest (33.07cm) in control at 150 DAS. The potential reason for the increase in plant height in turmeric could be attributed to the application of organic fertilizers such as FYM and Vermicompost. Organic fertilizers with a narrow carbon-to-nitrogen (C: N) ratio have the ability to produce more humic acid and humic substances. These substances have the capability to form chelates with phosphorus. Chelated phosphorus is reported to be more soluble in water, which increases its availability to the crop. This improved availability of phosphorus may have contributed to the increased plant height observed in turmeric. Kumar *et al*. (2016) also reported higher plant height of turmeric plants treated with organic manures such as vermicompost.

**Table 3. Effect of integrated nutrient management on plant height (cm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Plant height (cm)** | | | |
| **60 DAP** | **90 DAP** | **120 DAP** | **150 DAP** |
| **T1: Control** | 14.04 | 19.81 | 31.03 | 33.07 |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 15.79 | 23.21 | 34.14 | 34.52 |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 14.64 | 22.87 | 33.89 | 34.07 |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 14.87 | 23.10 | 33.99 | 34.21 |
| **T5: FYM @ 25t/ha** | 14.57 | 22.38 | 33.64 | 33.88 |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 16.11 | 23.44 | 34.54 | 34.77 |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 16.66 | 24.01 | 34.98 | 35.17 |
| **T8: Vermicompost @ 5t/ha** | 14.62 | 22.51 | 33.76 | 33.98 |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 16.24 | 23.65 | 34.72 | 34.92 |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 17.21 | 24.85 | 35.97 | 38.26 |
| **C.D.at 5% level of significance** | 1.28 | 1.88 | 1.09 | 2.40 |

**Total yield**

Adequate nutrient management in turmeric either with inorganic sources and organic sources or their combined use significantly enhanced rhizome yield of turmeric compared to no nutrition. The data on yield per hectare revealed that there was significant difference among treatments of integrated nutrient management (fig. 1). Application of 75 % recommended dose of fertilizer + vermicompost @ 5 t/ha produced the maximum and significantly higher yield over the control but was statistically on par with recommended dose of fertilizer (N:P:K-100:50:50), 50% recommended dose of fertilizer + FYM @ 25 t/ha, 75 % recommended dose of fertilizer (RDF) + FYM @ 25 t/ha, 50 % recommended dose of fertilizer + vermicompost @ 5 t/ha. The increase in yield might be due to the increased growth and yield traits. However, vermicompost is rich in N, P, K, Mg, and Ca, which enhances plant growth and development, increasing yield, which in turn causes increased biomass accumulation and further rhizome diversion. A similar result was reported by Sreekala and Jayachandran, 2006 in case of baby corn. These results are in close conformity with the findings of Sadanandan and Hamza (1998) and Nirmalatha *et al.* (2010).

**Fig. 1 Graphical representation of effect of integrated nutrient management on yield of turmeric**

Where,

T1: Control, T2: Recommended dose of fertilizer (N:P:K-100:50:50), T3: 50 % Recommended doseoffertilizer, T4: 75 % Recommended dose of fertilizer, T5: FYM @ 25 t/ha, T6: 50 % Recommended dose of fertilizer (RDF) + FYM @25 t/ha, T7: 75 % Recommended doseoffertilizer + FYM @ 25 t/ha, T8: Vermicompost @ 5 t/ha, T9: 50 % Recommended dose of fertilizer + vermicompost @ 5 t/ha, T10: 75 % recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha.

**Bulk density (g/cm3), pH, electrical conductivity (dSm-1) and soil organic carbon (%)**

A perusal of data presented in Table 4, shows that application of different integrated nutrient management practices failed to bring about significant variation in bulk density, electrical conductivity, pH and organic carbon of soil. After the harvest of crop, all the physico-chemical properties of soil were statistically similar under various integrated management practices. Similar findings were reported by Joshi *et al*. (2018).

**Table 4. Effect of integrated nutrient management on bulk density, pH, EC and O.C**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Soil physio-chemical properties** | | | |
| **Bulk density** | **pH** | **EC** | **O.C** |
| **T1: Control** | 1.21 | 8.1 | 0.27 | 0.43 |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 1.18 | 8.1 | 0.28 | 0.44 |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 1.19 | 8.1 | 0.27 | 0.43 |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 1.20 | 8.1 | 0.28 | 0.43 |
| **T5: FYM @ 25t/ha** | 1.11 | 8.0 | 0.27 | 0.45 |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 1.10 | 8.0 | 0.27 | 0.44 |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 1.10 | 8.0 | 0.27 | 0.43 |
| **T8: Vermicompost @ 5t/ha** | 1.14 | 8.0 | 0.26 | 0.45 |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 1.13 | 8.0 | 0.27 | 0.44 |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 1.12 | 8.0 | 0.27 | 0.44 |
| **C.D.at 5% level of significance** | NS | NS | NS | NS |

**Available nitrogen, available phosphorus and available potassium**

Available nitrogen, available phosphorus and available potassium were significantly influenced by integrated nutrient management as shown in Table 5. After the harvest of the crop maximum (192.60 kg/ha) available nitrogen was reported in 75 % recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha. The increase in available nitrogen in the soil after harvest was likely a result of fact that plants being able to utilize only 50 % of the nitrogenous fertilizers applied under optimal circumstances. The minimum (160.00 kg/ha) available nitrogen recorded in control. Similar trend was noted for available phosphorus (25.8 kg/ha) which was recorded highest from treatment 75 % Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha. However, maximum available potassium (186.81 kg/ha) was noted at 75 % Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha. These results corroborate the findings of Satyanarayana *et al*., (2002), who reported that integrated application of organic and inorganic fertilizers certified enhanced soil health and its fertility.

**Table 5. Effect of integrated nutrient management on available nitrogen, phosphorus and potassium (kg/ha)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Available nitrogen (kg/ha)** | **Available phosphorus (kg/ha)** | **Available potassium (kg/ha)** |
| **T1: Control** | 160.0 | 10.47 | 152.00 |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 175.0 | 15.06 | 161.12 |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 166.0 | 11.02 | 156.23 |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 171.8 | 12.56 | 159.63 |
| **T5: FYM @ 25t/ha** | 177.5 | 17.36 | 167.96 |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 182.3 | 21.3 | 183.44 |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 187.6 | 25.5 | 186.81 |
| **T8: Vermicompost @ 5t/ha** | 181.6 | 19.45 | 171.11 |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 186.8 | 23.4 | 177.64 |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 192.6 | 25.8 | 121.82 |
| **C.D.at 5% level of significance** | 14.77 | 1.66 | 12.74 |

**Nutrient use efficiency**

The data concerning to nutrient use efficiency have been demonstrated in Table 6. Data pertaining to nitrogen, phosphorus, potassium use efficiency shows that with different nitrogen, phosphorus, potassium management practices, nutrient use efficiency was influenced significantly. Significantly higher nitrogen, phosphorus, potassium use efficiency was observed in treatment recommended dose of fertilizer (N:P:K-100:50:50), while minimum nitrogen, phosphorus and potassium use efficiency was recorded in treatment FYM @ 25 t/ha.

**Table 6. Effect of integrated nutrient management on nutrient use efficiency (NUE)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **NUE-N** | **NUE-P** | **NUE-K** |
| **T1: Control** | - | - | - |
| **T2: Recommended dose of fertilizer (N:P:K- 100:50:50)** | 40.21% | 80.42% | 80.42% |
| **T3: 50% Recommended dose of fertilizer (RDF)** | 39.16% | 78.32% | 78.32% |
| **T4: 75% Recommended dose of fertilizer (RDF)** | 35.97% | 71.94% | 71.94% |
| **T5: FYM @ 25t/ha** | 6.77% | 12.54% | 6.77% |
| **T6: 50%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 16.32% | 30.88% | 19.04% |
| **T7: 75%Recommended dose of fertilizer (RDF) + FYM @ 25 t/ha** | 16.27% | 30.99% | 20.02% |
| **T8: Vermicompost @ 5t/ha** | 10.40% | 31.22% | 20.81% |
| **T9: 50% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 21.30% | 56.80% | 42.60% |
| **T10: 75% Recommended dose of fertilizer (RDF) + vermicompost @ 5 t/ha** | 20.90% | 53.81% | 42.57% |

**Conclusion**

The present study clearly demonstrated that integrated nutrient management significantly influenced the growth, yield and nutrient use efficiency of turmeric. Among all integrated nutrient management treatments 75 % recommended dose of fertilizer + vermicompost @ 5 t/ha, resulted in markedly maximum plant emergence, leaf area index, height of plant, yield and available nitrogen and phosphorus. In contrast, control treatment recorded the lowest values of these parameters. However, soil physico-chemical properties such as bulk density, electrical conductivity, organic carbon and pH remained unaffected by the treatments. Based on the finding it is recommended that 75% recommended dose of fertilizer (N:P:K-100:50:50) + vermicompost @ 5 t/ha should be adopted for enhancing turmeric productivity and available nitrogen, phosphorus and potassium in soil. These results would help the precise planning and efficient nutrient management for turmeric.

**Conflict of interest:** The authors have no conflict of interest.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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