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Effect of Fertilizer Doses on Turmeric at Madhupur Tract under AEZ-28

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Authors' contributions

This work was carried out in collaboration among all authors. The field trial was done by close cooperation with the authors. First draft was ready by the corresponding author. All the authors read, incorporated their ideas and thoughts, proof read the final paper and agreed it for submission.

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ABSTRACT

A field experiment was conducted at MLT site, Madhupur (AEZ-28), Tangail during 2020-21 and 2021-22 to find out an optimum fertilizer dose of turmeric in Madhupur tract and increase productivity and economic return of the farmers. The experiment was laid out in a randomized complete block design with five compact replications. The tested six treatment combinations were as T_1: STB as per FRG' 2018 (116-27-77-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_2 : T_1 + 20% extra NK (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3 :T_1 + 20% extra NKS (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}), T_4 :T_1 + 20% extra NKSZn (139-27-92-8-1.8-1.2 kg NPKSZnB ha^{-1}), T_5 : IPNS basis fertilizer with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) and T_6 : Farmers' practice (115-50-125 kg NPK ha^{-1}). BARI Halud-5 was used as test crop in this experiment. The unit plot size was 8m × 5m and spacing was maintained as 50 cm apart rows with plant to plant 25 cm. Seeds (rhizome) were planted @ 2000 kg ha^{-1} during 14-20 April, 2020 and 10-15 April 2021.

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The treatments showed significant differences in terms of yield and yield contributing characters. The highest fresh rhizome yield (17.13 t ha^{-1}) was recorded from IPNS basis fertilizer with 5 t ha^{-1} cow dung i.e. (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) treatment combination. The highest gross return (Tk.256950 ha^{-1}) and gross margin (Tk.136740 ha^{-1}) were recorded from the (T_5) same treatment The marginal benefit cost ratio (3.79) was also highest in IPNS basis fertilizer with 5 t ha^{-1} cow dung i.e. (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) which further indicated the superiority among the treatments.

Keywords: Organic manure; yield parameters; soil fertility; farmers' field; productivity.

1. INTRODUCTION

"Turmeric (*Curcuma longa* L.) is rhizomatous erect herb. It's belonging to family from the Zingiberaceae. Turmeric is being used as a spice to enhance flavor, aroma and color in dishes in every day and every home of our country. Turmeric is an important medicinal plant in traditional medicinal system. In recent times, turmeric powder is used for the treatment of biliary disorders, anorexia, coryza, cough, diabetic, hepatic disorders, rheumatism and sinusitis" [1]. "Turmeric has antiseptic, antioxidant, hepatoprotective, anticarcinogenic, antidiabetic and antidepressant properties" [2]. Turmeric holds a prominent position among the spices, and it is believed that turmeric oil has anti-inflammatory and anti-arthritic properties [3]. Curcumin is a main coloring substance of turmeric and two related compounds, desmethoxycurcumin (DMC) and bis-desmethoxycurcumin are altogether known as curcuminoid which has been used for potential treatment of an array of diseases, including cancer, alzheimer disease, allergies, arthritis, reduces intestinal gas formation and other chronic illnesses.

"Turmeric is an important and common spice crop in Bangladesh. Among the spices crops turmeric is a popular and is used in huge numbers of food items. Besides this, it is used in preparing cosmetics and is a raw material of dyeing industries. Turmeric has fourth rank in area after onion, chilli and garlic as well as fourth position in production after onion, garlic and chilli. In Bangladesh turmeric is cultivated in 26411 hectares of land and produces 217738 metric tons among which it is cultivated in 1326 hectares of land and produces 3661 metric tons in Tangail District" [4]. In dry weight basis, its average yield at the farmer's level is 2.06 t/ha. The reasons behind those lower yield are lack of high yielding varieties, improved production technology and improper use of fertilizers and manures. Turmeric can be grown in various types of soil but it prefers to grow in light textured soil with well-suited shady places.

It is widely grown in such countries as India, China, Nigeria, Pakistan, Myanmar, Indonesia, Bangladesh, Sri Lanka, Taiwan, etc. The key importing countries are Japan, Singapore, Iran, the United Arab Emirates (UAE), the Netherlands and Sri Lanka which account for almost 80% of the world's turmeric trade [5]. The farmer will boost his economic status by adopting turmeric cultivation [6]. Besides, the crop has a long growing period (up to 9 months), therefore, the nutrient requirement period also becomes prolonged [4] that exhausted the soil fertility level rapidly and to maintain soil fertility for viable crop production is inevitable. Nitrogen is often the element most restricting to crop production. Several studies indicated that the application of nitrogen had a significant effect on growth and yield of turmeric [7]. It has also been documented that nitrogen application not only increases the turmeric yield but also improves the quality attributes [8]. Application of nitrogen also improves the fertilizer use efficiency of P and K fertilizers to improve turmeric yield [9]. Application of NPK @120:60:120 kg ha^{-1} recorded the highest yield of fresh rhizome (28.17 t ha^{-1}) and found superior in turmeric plant growth, yield, and economy reported by [6]. "The favorable response of NPK fertilization in quality of turmeric reported" by Rao and Swamy [10]. "Crops respond differently to different fertilizer elements, and proper fertilizer management for a plant species is important for increasing yield and quality. Nitrogen (N), phosphorus (P) and potassium (K) are the three major nutrients, which individually and/or together maintain growth, yield and quality of plants" [11]. Nitrogen is responsible for 26-41% of crop yields, K plays catalytic roles in the plant rather than becoming an integral part of plant components. Plants with an inadequate supply of K show poor fruit or seed formation, yellowing of the leaves, poor growth, and low resistance to coldness and drought. A sufficient supply of K promotes N

uptake efficiency of plants due to its stimulant effect on plant growth. Phosphorus indirectly promotes plant growth and absorption of K as well as other nutrients.

The lack of fertilizer requirement is one of the main barriers for turmeric production in Bangladesh. As a result, farmers do not get the maximum benefit from turmeric cultivation. Therefore, this study was conducted at this standing point to find out an optimum fertilizer dose of turmeric production and economic return of farmers in Madhupur tract and suggested a solid adequate fertilizer dose for turmeric production.

2. MATERIALS AND METHODS

The experiment was conducted at the farmers' field of MLT site Madhupur (AEZ-28) under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Tangail during 2020-21 and 2021-22 to find out an optimum fertilizer dose of Turmeric and to increase productivity and economic return of farmers in Madhupur tract. The initial composite soil samples from a depth of 0-15 cm were collected from the experimental plots and were analyzed by ASI method [12]. The initial soil analysis values are presented in Table 1. Soil test values indicate that the soils of experimental plots are acidic in nature. So, 4 kg per decimal agricultural lime ($CaCo_3$) was used to maintain soil acidity 15 days prior to planting the turmeric rhizome.

The experimental site situated at approximately $24^0 64'$N latitude and $90^0 09'$E longitude with the altitude of 19 m above sea level. Mean annual precipitation was 2212 mm, most of which (90%) was received during May to September due to monsoon. The experiment consisted of six treatments viz. T_1 : STB as per FRG 2018 (116-27-77-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_2 : T_1 + 20% extra NK (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3 :T_1 + 20% extra NKS (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}), T_4 : T_1 + 20% extra NKSZn (139-27-92-8-1.8-1.2 kg NPKSZnB ha^{-1}), T_5 : IPNS basis fertilizer with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_6 : Farmers' practice (115-50-125 kg NPK ha^{-1}). The BARI Halud-5 was used as the test crop in this experiment. The experiment was laid out in a randomized complete block design with five compact replications. The unit plot size was 8m × 5m and spacing maintained for turmeric was 50 cm apart rows with plant to plant 25 cm. The seeds (rhizome) were planted @ 2000 kg ha^{-1} during 14-20 April, 2020 and 10-15 April, 2021. Entire cow dung, one half of K and all other fertilizers except N were applied during final land preparation. The remaining K and N were applied in three equal splits at 50, 80 and 120 days after planting under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Weeding, irrigation and other crop management practices were done properly for normal growth of the crop. The crop was harvested during 15-20 March, 2021 and 11-15 March, 2022 in two consecutive years. Necessary data were recorded from randomly selected 10 plants of each treatment in both the years. Pooled analysis was done as because there was no significant difference in yield, growth parameters and yield contributing characters between two years. The collected data on different parameters were statistically analyzed using analysis of variance technique with the help of computer package MSTAT-C and mean comparison among the treatments was made by Duncan's Multiple Range Test at 5% level of significance [13].

Economic analysis was done on the basis of prevailing market price of the commodities. The inputs used included seed, fertilizer, labour and insecticides. Two years' average results were analyzed for economic benefits using the methodology prescribed by CIMMYT [14].

Marginal Benefit Cost Ratio (MBCR) =

$$\frac{\text{Gross return } (E) - \text{Gross return } (F)}{\text{TVC } (E) - \text{TVC } (F)} = \frac{MVP}{MVC}$$

Table 1. Chemical properties of initial soil (0 -15 cm depth) of the experimental field at MLT site, Madhupur during 2020-21

	pH	OM	Total N	K	Ca	Mg	P	S	Zn	B
		(%)	(%)	meq/100 g soil			µg g^{-1} soil			
Soil test value	5.1	1.39	0.01	0.25	1.7	1.8	8.08	22.18	0.46	0.30
Interpretation	acidic	Low	Low	Medium	Low	High	Low	Medium	Low	Low

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The effects of different fertilizer doses showed insignificant variation on the growth parameters of turmeric namely plant height, leaf length, leaf width, collar diameter and days to 50% sprouting but significant variation showed only in tillers plant^{-1} and area of leaves (Table 2).

3.1.1 Plant height

The data revealed that the increase fertilizer doses of T_1: (116-27-77-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_2 : (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3 : (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4 : (139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) increased plant height progressively, whereas the IPNS based treatment T_5 : (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1} +CD 5 t ha^{-1}) which was combination of organic and inorganic fertilizer was not significantly increased plant height as compared to other treatments. This results are in agreement with the finding of Tiwari et al. [15]. Farmers practices recorded the lower number of plant height (116.42 cm).

3.1.2 Average length and width of leaves

The data revealed that the increase fertilizer doses of T_1 :(116-27-77-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_2:(139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3 :(139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4: (139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) increased average length and width of leaves progressively, whereas the IPNS based treatment 91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1} + 5 t CD ha^{-1} which was combination of organic and inorganic fertilizer was not significantly increased average length and width of leaves as compared to other treatments. These results have been supported by Mujumdar et al. [16]. Farmers practices recorded the minimum average length and width of leaves at 120 days (27.50 and 10.03 cm).

3.1.3 Number of tillers per plant

Data on number of tillers per plant is presented in Table 2. The number of tillers per plant of turmeric was found statistically significant under different treatments with 120 days after sowing. The data revealed that the increase fertilizers combinations T_2: (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3: (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4: (139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) and T_5: IPNS with 5 t ha^{-1} cowdung (91-20-66-8-1.5-1.2 kg ha^{-1} of NPKSZnB) increased tillers plant^{-1} whereas the T_6: Farmers' practice (115-50-125 kg ha^{-1} of NPK). which had used only NPK fertilizers was not significantly increased number of tillers plant^{-1}. The result showed that number tillers plant^{-1} was significantly different among the treatment combinations but T_5 treatment gave the higher number of tillers plant^{-1} (3.33) which followed by T_4, T_3 and T_2 treatment combinations. The lower number of tillers plant^{-1} (2.52) was obtained from T_6 treatment followed by T_1 treatment at 120 days. Similar results have been reported by Mohan [17].

3.1.4 Area of leaves (cm^2)

Data on area of leaves is presented in Table 2. The area of leaves of turmeric was found statistically significant under different treatments with 120 days after sowing. The average data revealed that the increase fertilizers combinations in treatments T_2, T_3, T_4 and T_5 increased area of leaves. The result showed that area of leaves was significantly different among the treatment combinations but T_5 treatment gave the highest area of leaves (811.35 cm^2) which followed by T_4, T_3, T_2 and T_1 treatment combinations. The lower area of leaves (626.43 cm^2) was obtained from T_6 treatment followed by T_1 treatment.

3.1.5 Collar diameter

The collar diameter of turmeric crop was observed insignificant under different treatments with 120 days. Numerically higher collar diameter of turmeric was recorded in (T_5) IPNS treatment with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg ha^{-1} of NPKSZnB) and it was about (13.00 cm). While minimum collar diameter (11.00 cm) was recorded in (T_6) Farmers' practice (115-50-125 kg ha^{-1} of NPK).

3.1.6 Days to 50% sprouting

The days to 50 % sprouting of turmeric crop was observed insignificant under different treatments (Table 2). Numerically lower days to 50% sprouting of turmeric was recorded (24.33) in (T_5) IPNS treatment with 5 t ha^{-1} cow dung (i.e., 91-20-66-8-1.5-1.2 kg ha^{-1} of NPKSZnB). While higher days to 50% sprouting (27.66 cm) was recorded in treatment (T_6) which is practiced by Farmers' (115-50-125 kg NPK ha^{-1}).

Table 2. Effect of nutrient management packages on growth parameters of turmeric at MLT site Madhupur during 2020-21 and 2021-22 (pooled data of 2 years)

Treatments	Plant height (cm) at 120 days	Leaf length (cm) at 120 days	Leaf width (cm) at 120 days	Tillers plant^{-1} at 120 days(no.)	Area of leaves (cm^2)	Collar diameter at 120days	Days to 50 % sprouting
T_1	126.79	29.00	11.22	2.73b	660.42bc	11.70	25.66
T_2	127.48	28.45	11.20	2.96a	719.22ab	12.28	25.66
T_3	126.47	28.13	11.18	3.18a	743.71ab	12.52	25.56
T_4	127.48	30.20	11.62	3.25a	760.93ab	12.84	25.40
T_5	130.09	30.75	11.65	3.33a	811.35a	13.00	24.33
T_6	116.42	27.50	10.03	2.52b	626.43c	11.00	27.66
CV (%)	4.89	5.10	4.09	4.80	5.72	4.22	4.87

Figures in a column followed by same letter (s) do not differ significantly at 5% level of significance by DMRT test.

Note: T_1= STB as per FRG 2018, T_2= T_1 + 20% extra NK, T_3= T_1 + 20% extra NKS, T_4= T_1 + 20% extra NKSZn, T_5= IPNS basis fertilizer with cowdung (5 t ha^{-1}), T_6= Farmers' practice

3.2 Yield Parameters

Data regarding the effects of different fertilizer doses showed significant variation on the yield parameters of turmeric namely number of tillers per hill, number of leaves per plant, number of primary fingers per plant, secondary finger per plant and fresh finger weight per plant significant are presented in Table 3.

3.2.1 Number of tillers per hill

The number of tillers per hill was found statistically significant among different treatments (Table 3). The average data revealed that the increase fertilizers combinations T_2: (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3: (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4 :(139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) and T_5 : IPNS with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) increased the number of tillers per hill. The result showed that number of tillers per hill was significantly different among the treatment combinations but T_5 treatment gave the highest tillers hill (7.33) which followed by T_4, T_3 and T_2 treatment combinations. The lower number of tillers per hill (3.82) was obtained from T_6 treatment followed by T_1 treatment (Table 3).

3.2.2 Number of leaves per plant

Data on number of leaves per plant is presented in Table 3. The average data revealed that the increase fertilizers combinations T_2:(139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3 :(139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4 :(139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) and T_5 :IPNS with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) increased number of leaves per plant but they are statistically at par. Whereas the T_5 treatment recorded significantly maximum number of leaves per plant (10.27), closely followed by T_4 (10.15). The T_2 and T_3 treatments were recorded (8.40 and 9.20) leaves per plant, respectively. Number of leaves per plant increased with the increase in level of nutrients in turmeric plants reported by [18]. The Treatment T_6 (Farmer's practices) recorded significantly minimum number of leaves per plant (6.25) followed by T_1 treatment.

3.2.3 Number of primary fingers per hill

The number of primary fingers per hill was found statistically significant under different treatments (Table 3). The average data revealed that the increase fertilizers combinations T_2: (139-27-92-8-1.5-1.2 kg NPKSZnB ha^{-1}), T_3: (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4: (139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) and T_5 : IPNS with 5 t ha^{-1} cowdung (91-20-66-8-1.5-1.2 kg ha^{-1} of NPKSZnB) increased the number of primary fingers per hill but they are statistically similar. The result showed that number of primary fingers per hill in T_5 treatment gave the higher number (9.81) which was followed by T_4 and T_3 treatment combinations. The lower number of primary fingers per hill (7.10) was obtained from T_6 treatment followed by T_1 and T_2 treatment.

3.2.4 Number of secondary fingers per hill

The number of secondary fingers per hill was found statistically significant under different treatments (Table 3). The average data revealed that the increased fertilizers combinations T_2: (139-27-92-8-1.5-1.2 kg

NPKSZnB ha^{-1}), T_3: (139-27-92-9.6-1.5-1.2 kg NPKSZnB ha^{-1}) and T_4 : (139-27-92-9.6-1.8-1.2 kg NPKSZnB ha^{-1}) and T_5 :IPNS with 5 t ha^{-1} cowdung (91-20-66-8-1.5-1.2 kg ha^{-1} of NPKSZnB) increased the number of secondary fingers per hill but they are statistically at par. The result showed that number of secondary fingers per hill in T_5 treatment gave the higher number (9.31) which was followed by T_4, T_3 and T_2 treatment combinations. The lower number of secondary fingers per hill (6.71) was obtained from T_6 treatment followed by T_1 treatment.

3.2.5 Fresh fingers weight per hill

The maximum fresh fingers weight per hill was found statistically significant under different treatments (Table 3). The fresh fingers weight per hill varied from 241.62 to 173.39 g hill^{-1} in the different treatments. The maximum fresh fingers weight was recorded in treatment (T_5) IPNS with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) which was statistically identical with T_4 Treatment. Similar results have been reported by Tiwari et al. [15]. The minimum weight of fresh fingers weight per hill (173.39 g) was obtained from T_6 treatment followed by T_3, T_2 and T_1 treatment.

3.2.6 Fresh rhizome yield

The fresh rhizome yield was found statistically significant under different treatments (Table 4). The fresh rhizome yield varied from 17.13 to 15.37 t ha^{-1} in the different treatments. The maximum rhizome yield was recorded from T_5 (17.13 t ha^{-1}) treatment which was statistically at par with T_4 (16.53 t ha^{-1}) it may be due to number of fingers per hill and rhizome weight per hill were higher in T_5 treatment. The lower rhizome yield (15.37 t ha^{-1}) was recorded in T_6 treatment (Farmers' practices) which was statistically identical with T_3, T_2 and T_1 treatments.

Application of cow dung 5 t ha^{-1} might increase the physical properties of soil which was again enhanced by the use of IPNS basis fertilizers

Table 3. Effect of nutrient management packages on yield contributing characters of turmeric at MLT site Madhupur during 2020-21 and 2021-22 (pooled data of 2 years)

Treatment	Tillers hill^{-1} (no.)	Leaves plant^{-1} (no.)	Primary finger hill^{-1} (no.)	Secondary finger hill^{-1} (no.)	Fresh Finger wt. hill^{-1} (g)
T_1	4.19bc	7.20ab	7.18b	6.49b	185.20bc
T_2	5.16ab	8.40a	7.28b	8.30a	187.14bc
T_3	5.20ab	9.20a	7.75ab	8.78a	193.33bc
T_4	5.37ab	10.15a	8.15ab	8.93a	215.61ab
T_5	7.33a	10.27a	9.81a	9.13a	241.62a
T_6	3.82c	6.25b	7.10b	6.71b	173.39c
CV (%)	6.27	6.40	7.27	7.20	6.87

Figures in a column followed by same letter (s) do not differ significantly at 5% level of significance by DMRT test.

Note: T_1= ST B as per FRG 2018, T_2= T_1 + 20% extra NK, T_3= T_1 + 20% extra NKS, T_4= T_1 + 20% extra N K S Zn, T_5= IPNS basis fertilizer with cowdung (5 t ha^{-1}), T_6= Farmers' practice

Table 4. Effect of nutrient management packages on the yield of turmeric at MLT site Madhupur during 2020-21 and 2021-22 (pooled data of 2 years)

Treatments	Fresh rhizome yield (t ha^{-1})	Dry yield (t ha^{-1})	Dry recovery (%)
T_1	15.47b	3.87b	25.02
T_2	15.87b	4.09b	25.77
T_3	15.97b	4.19b	26.24
T_4	16.53a	4.47a	27.04
T_5	17.13a	4.78a	27.90
T_6	15.37b	3.84b	24.98
CV (%)	5.41	6.24	6.35

Figures in a column followed by same letter (s) do not differ significantly at 5% level of significance by DMRT test.

Note: T_1= ST B as per FRG 2018, T_2= T_1 + 20% extra NK, T_3= T_1 + 20% extra NKS, T_4= T_1 + 20% extra NKSZn, T_5= IPNS basis fertilizer with cowdung (5 t ha^{-1}), T_6= Farmers' practice

resulting the increased growth and yield of turmeric. It is also revealed from the experiment that only chemical fertilizer could not supply the proper soil environment for yield maximization of turmeric. The combined application of chemical and organic fertilizer is effective for higher yield of turmeric. Nitrogen applied alone or in combination with KSZnB resulted in a significantly higher plant height and number of leaves and tillers. Nitrogen is the principal nutrient of plant which significantly increases vegetative growth parameters of turmeric than any other nutrients (Rahman et al., 2010). The highest yield was obtained from the turmeric grown with IPNS treatment along with 5 t ha^{-1} cow dung because the plants with these treatments remained green longer and they had higher shoot biomass, which ultimately contributed to higher yield [8].

3.2.7 Dry yield

The results of dry turmeric rhizomes yield per hectare are also provided in Table 4. The dry rhizomes yield varied from 3.84 to 4.78 t ha^{-1} in the different treatments. The maximum dry rhizomes yield (4.78 t ha^{-1}) was recorded from IPNS treatment with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) which was statistically identical with T_4 (4.47 t ha^{-1}) it may be due to number of fingers per hill and rhizome weight per hill were higher in T_5 treatment. Treatment T_6 (Farmers' practices) resulted minimum dry rhizomes yield (3.84 t ha^{-1}) which was statistically identical with T_3, T_2 and T_1 treatments. [6] reported that growth and dry yield potential of the turmeric can be increased by applying IPNS treatment along with 5 t ha^{-1} cow dung because the plants with these treatments remained green longer and they had higher shoot biomass, which ultimately contributed to higher yield.

3.2.8 Dry recovery %

The results are present in Table 4. In this study, insignificant increase in dry recovery % was seen in different treatments. The dry recovery % ranged from 24.98 to 27.90 and numerically higher yield of dry recovery (27.90%) was recorded from T_5 treatment. Similar results have been recorded by Tiwari et al. [15]. All results clearly showed that all growth and yield parameters gave higher returns in treatment IPNS with 5 t ha^{-1} cow dung (91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) due to application of cow dung might be increase the physical properties of soil which was again enhanced by the use of IPNS basis fertilizers resulting the high growth and metabolism for rhizome development.

3.3 Profitability Analysis

The cost and return analysis was done on the basis of prevailing market price during the crop season are shown in Table 5. The gross return, gross margin and marginal benefit cost ratio (MBCR) varied in different treatments. Mean maximum gross return (Tk. 256950 ha^{-1}) and gross margin (Tk. 136740 ha^{-1}) were recorded from (T_5) treatment which received IPNS based fertilizer i e. 91-20-66-8-1.5-1.2 kg NPKSZn ha^{-1} with 5 t ha^{-1} cow dung and minimum in treatment T_6 (Farmers' practice). The mean gross return of treatment T_5 (IPNS practice) was 11.45% higher than farmers' practice and it might be due to judicial use of fertilizers as well as maximum rhizomes yield. The mean total variable cost of the treatment T_5 (IPNS) and T_6 (Farmers' practice) was Tk. 120210 and Tk. 113243 ha^{-1}, respectively. About 17% higher gross margin (Tk. 136740 ha^{-1}) was calculated at T_5 (IPNS) over farmer's practice (Tk. 117307 ha^{-1}). The mean MBCR was found 3.79 which indicated the superiority of treatment T_5 (IPNS) over farmer's practice.

Table 5. Cost and return analysis of BARI Halud-5 as influenced by different nutrient management packages during 2020-21 and 2021-22 (average of 2 years data)

Treatments	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
T_1	232050	114650	117400	1.07
T_2	238050	115926	122124	2.80
T_3	239550	116025	123525	3.24
T_4	247950	118674	129276	3.20
T_5	256950	120210	136740	3.79
T_6	230550	113243	117307	-

Note: Input and output price (kg Tk.$^{-1}$): - Rhizome as seed = 25/-, Urea = 16/-, TSP = 2/-2, MoP = 15/-, Gypsum = 12/-, Boric acid = 440/-, Zinc sulphate =250/- and Fresh rhizome =15/-

4. CONCLUSION

From the study, it may be concluded that the fertilizer levels significantly affected the yield of fresh turmeric rhizomes. The results showed that the maximum plant growth, yield parameters, fresh rhizome yield and economics of turmeric crop was obtained from the application of fertilizer in IPNS (i.e., 91-20-66-8-1.5-1.2 kg NPKSZnB ha^{-1}) treatment with 5 t ha^{-1} cowdung. So, the application of NPKSZnB @ 91-20-66-8-1.5-1.2 kg ha^{-1} along with 5 t ha^{-1} cow dung can therefore ensure maximum fresh rhizome yield and can be suggested/recommended for growing of turmeric at Madhupur under AEZ-28 in respect of yield and economic return.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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