Effects of different doses of micro-organic and phosphorus fertilizers on growth and yield of red turmeric (*Curcuma longa* L.)

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ABSTRACT

The objective of the study was to determine the appropriate doses of micro-organic and phosphorus fertilizers for good growth, high rhizomes yield and enhancing the economic efficiency of red turmeric cultivated in gray soil in Thu Duc city. The two-factor experiment was laid out in a split-plot design with three replications. The main plots consisted of four doses of phosphorus fertilizer as 30, 60 (control), 90, & 120 kg P_2O_5/ha. The sub-plots included three doses of micro-organic fertilizer (2, 4, & 6 tons/ha) and a control with cow dung of 10 tons/ha. A common dose of 500 kg lime, 90 kg N, 120 kg K_2O/ha was applied in all treatments The results showed that red turmeric was applied at the dose of 120 kg P_2O_5 combined with 6 tons of micro-organic fertilizer/ha exhibited the highest growth, yield and economic outcomes including a plant height of 41.2 cm, stem diameter of 16.2 mm, leaf length of 24.4 cm, leaf width of 8.5 cm, leaf count of 7.0, soil-plant analysis development index of 35.6, the profit of VND 386.32 million/ha, and the benefit cost ratio of 2.4.

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1. Introduction

Turmeric (*Curcuma* sp.) is a large genus in the Ginger family (Zingiberaceae) and an annual plant with tuberous roots that can regenerate new shoots for many years. Turmeric has been widely used as a spice, fabric dye as well as medicine (Ravindran et al., 2007). In Vietnam, red turmeric (Curcuma longa L.) is commonly grown on different soils mainly for its tuberous roots and used in food processing and treated of some diseases according to traditional experience (Do, 2004).

In intensive farming of red turmeric, fertilization is an important technique that not only affects growth and yield but also determines economic efficiency, especially when cultivated on nutrient-poor soils. Therefore, in order to improve the efficiency of red turmeric yield and quality when cultivating this plant on infertile gray soil, the combination of organic and inorganic fertilizers to enhance water retention, porosity, quality, and soil nutrients is necessary.

In addition, the application of organic fertilizer before planting offers a great effect on plant growth (Kamal & Yousuf, 2012) because it helps the soil increasing the ability of the soil to retain macro-minerals from chemical fertilizers, prevent fertilizer loss, creating aeration for roots to thrive, supporting the soil retain moisture better and create a living environment for beneficial microorganisms. Thus, applying organic fertilizers when growing red turmeric is crucial to foster the absorption efficiency of inorganic fertilizers such as N, P and K during the period of plant growth and development.

Stemming from the practical requirements of local production, the study was carried out to determine the appropriate combination rates between two organic fertilizers (cow manure fertilizer and micro-organic fertilizer) and phosphorus fertilizer, which would have the most positive effect on growth, rhizomes yield, and quality, and economic efficiency of red turmeric.

2. Materials and Methods

2.1. Materials

The red turmeric tuberous roots were collected from a farm in Bu Gia Map district, Binh Phuoc province, Vietnam. Red turmeric rhizomes were then treated with 0.5% chlorine for 30 min before dried and incubated for 2 weeks. When the red turmeric seedlings reached 10 - 15 cm in height and were produced with 1 - 3 leaves, each plant was separated before growing (Mai et al., 2000).

Fertilizers used in the experiment included cow manure fertilizer (1% N, 2% P_2O_5, 1% K_2O); La Nga micro-organic fertilizer (hereafter referred to as MOF) (2% N; 1.67% P_2O_5; 1.12% K_2O_{hh}; macro and micro element: 1.63% Ca, 20.2% SiO_2, 67.7 mg/kg Cu; 0.39% Mg; 1070 mg/kg Mn; 211 mg/kg Zn; 7660 mg/kg Fe; 3.7 x 10^8 CFU/g bacterial cellulose; 6.3 x 10^8 CFU/g bacterial phosphorus; 35.3% organic content; 5.72% acid humid; humidity 28.6%); Phu My urea fertilizer (46.3% N); Lam Thao superphosphate fertilizer (16% P_2O_5, 10% S, 12 mg Cd/kg); Canadian potassium chloride fertilizer (61% K_2O, 16% S).

Soil sample was analysed by Forestry Science Institute of Southern Vietnam, 2021.

Table 1. Physical and chemical properties of soil sample used in the experiment

Texture (%)			pH_{KCl}	Organic matter (%)	Total N (%)	Total P_2O_5 (%)	Total K_2O (%)
Clay	Silt	Sand					
68	28	4	5.9	3.71	0.1	0.417	3.5

The main characteristics of soil sample were presented in Table 1. The data showed that the soil is classified as clay texture, moderately acidic, high in soil organic matter, and low in total nitrogen but high in total phophorus and potassium.

2.2. Experimental design

The experiment was carried out at the Agronomy Research Station in Nong Lam University, Ho Chi Minh City, Vietnam from December 2020 to October 2021.

Two-factor experiment was arranged in a split-plot design (SPD) with three replicates. The main-plots were four doses of phosphorus fertilizer as 30, 60 (control), 90, & 120 kg P_2O_5/ha. The sub-plots were three doses of MOF (2, 4, & 6 tons/ha) and a cow dung of 10 tons/ha as control. All treatments were fertilized with the same dose of 500 kg lime, 90 kg N, 120 kg K_2O/ha. Entire amount of cow dung and MOF were applied in respective plots as per treatment during the final land preparation. The amount of nitrogen and potassium was split into three installments: 2/4 N + 1/4 K_2O (30 DAP), 1/4 N + 1/4 K_2O (90 DAP), 1/4 N +2/4 K_2O (150 DAP).

The plot size was 6.3 m^2 (4.5 m in length, 1.4 m in width). The health primary rhizomes of red turmeric were planted at the distance of 35 cm x 25 cm. The spacing between blocks and plots was 1.0 and 0.5, respectively.

2.3. Data collection and analysis

The data on growth parameters were recorded from 10 randomly selected plants per plot. The plant height, the main stem diameter per plant, the leaf length and the leaf width were recorded at 180 days after planting (DAP). The average chlorophyll content was determined before harvest using the Top IDAC ruments SPAD-502PLUS handheld chlorophyll meter at 60 and 120 DAP. The fresh and dry weight of rhizome and roots per plant was recorded at harvest (270 DAP). Regarding the fresh weight of rhizomes per plant, the theoretical fresh rhizomes yield and the actual fresh rhizomes yield of red turmeric were collected at the time of harvest. Fresh rhizomes yield was calculated based on per plant yield and per net plot yield and then converted onto an ha basis, and the data expressed as tons per ha. Economic efficiency included total expenditure, total revenue, profit and benefit cost ratio were computed.

All variables were subjected to analysis of variance (SPD) using mixed models of SAS version 9.1 (SAS Institute Inc., Cary, NC, USA, SAS Institute, 2004).

3. Results and Discussion

3.1. Effects of micro-organic and phosphorus fertilizers on growth and yield of red turmeric

At 180 DAP, the amounts of phosphate fertilizers had a statistically significant effect on the plant height and diameter of the red turmeric. Detailedly, the height of the red turmeric plants at 90 & 120 kg P2O5/ha of phosphorus fertilizer obtained the high stem height, and there were statistically significant differences as compared to 30 & 60 kg/ha treatments. In terms of different MOF levels, applied 4 and 6 tons/ha obtained the highest (37.4 and 38.8 cm, respectively) and significantly different from the others. The interaction between mirco-organic and phosphorus fertilizers has not prevailed (Table 2).

The diameter of the red turmeric stem was highest (14.7 and 15.2 mm), when fertilized with 90 & 120 kg P_2O_5/ha, respectively, there were statistically significant differences compared

Table 2. Effects of micro-organic and phosphorus fertilizers on plant height and diameter of red turmeric at 180 days after planting

Parameters	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
Stem height (cm)	Cow dung [(1)]	34.0	34.7	35.5	35.5	34.9^{b}
	2	34.3	35.0	35.5	38.0	35.7^{b}
	4	35.0	35.5	39.5	39.5	37.4^{a}
	6	36.5	38.0	39.5	41.2	38.8^{a}
	Average (P)	35.0^{b}	35.8^{b}	37.5^{a}	38.6^{a}	
	CV (%) = 4.6		$F_P = 32,6^{**}$	$F_O = 18,7^{**}$	$F_{P*O} = 1,7^{ns}$	
Stem diameter (mm)	Cow dung [(1)]	12.8^{e}	13.0^{de}	13.0^{de}	14.1^{cde}	13.2^{b}
	2	13.2^{cde}	13.4^{cde}	14.7^{a-d}	14.3^{b-e}	13.9^{b}
	4	13.5de	14.1^{cde}	15.0^{abc}	16.1^{ab}	14.7^{a}
	6	14.4^{b-e}	14.1^{cde}	16.0^{ab}	16.3^{a}	15.2^{a}
	Average (P)	13.5^{b}	13.7^{b}	14.7^{a}	15.2^{a}	
	CV (%) = 7.1		$F_P = 27.4^{*}$	$F_O = 28.4^{*}$	$F_{P*O} = 3.6^{**}$	

Within a group of means, values followed by the same letter are not significantly different at 5% level. **: significant at 1% level; *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control); [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

with those in 30 & 60 kg/ha. Regarding the effect of different MOF applications, the red turmeric plants applied with 4 & 6 tons/ha achieved the largest plant diameter and there were statistically significant differences compared with other treatments (Table 2). There was an interaction between the applied rates of MOF and phosphate fertilizer on the stem diameter of red turmeric at 180 DAP. Red turmeric plants were applied 6 tons of MOF and 120 kg of P_2O_5/ha produced the largest stem diameter (16.3 cm), however, there was not significantly different from those fertilized with 6 tons of MOF + 90 kg P_2O_5/ha and 4 tons of MOF at 90 and 120 kg P_2O_5/ha. The results were consistent with the study of Hossain & Ishimine (2007) that there were differences in growth parameters when growing red turmeric in different types of soil such as plant height, the number of leaves, leaf biomass, and especially using on gray soil and red-brown soil achieved the best results compared to the remaining soil types. In addition, by reporting of Chanchan et al. (2018) also concluded that when the applied rates of organic fertilizers, nitrogen, and phosphorus could affect the growth of leaves of red turmeric.

At 180 DAP, red turmeric plants at most applied rates of microbial organic and phosphate fertilizers did not significantly affect the length and width of red turmeric leaves. It can be figured out that did not interact between the doses of phophorus and MOF (Table 3).

Table 3. Effects of micro-organic and phosphorus fertilizers on the length and width of red turmeric leaves at 180 days after planting

Parameters	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
Leaf length (cm)	Cow dung [(1)]	20.1	20.3	21.1	21.5	20.8[d]
	2	21.3	21.8	21.9	22.0	21.8[c]
	4	21.7	22.3	22.4	23.9	22.6[b]
	6	22.5	22.9	23.8	24.4	23.4[a]
	Average (P)	21.4	21.8	22.3	23.0	
	CV (%) = 7.1		$F_P = 8.4^{ns}$	$F_O = 0.8^*$	$F_{P*O} = 1.3^{ns}$	
Leaf width (cm)	Cow dung [(1)]	7.4	7.9	8.0	8.1	7.9
	2	8.0	8.1	8.1	8.1	8.1
	4	8.0	8.1	8.2	8.2	8.1
	6	8.1	8.2	8.4	8.4	8.3
	Average (P)	7.9	8.1	8.2	8.2	
	CV (%) = 4.8		$F_P = 1.7^{ns}$	$F_O = 0.7^{ns}$	$F_{P*O} = 1.0^{ns}$	

Within a group of means, values followed by the same letter are not significantly different at 5% level. *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control); [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

However, red turmeric at the treatment with 6 tons per ha of microbial organic fertilizer recorded the longest leaves (23.4 cm), and there statistically varied those in the other treatments (Table 3). According to MOF, amount of nitrogen helped leaf of red turmeric became generative growth during the period of plant (180 DAP), this appropriate statement also proved by Barker & Pilbeam (2007), mineral element plays important role to growth and development that enhance the yield of crops dramatically. Mazid (1993) also indicated that the combination of organic and in-organic fertilizers or the substances of N, P, K mixed enables turmeric enormously improve growth capacity.

Amount of phosphorus fertilizers affected to soil-plant analysis development (SPAD) index, its gradually increased from 60 to 120 DAP at all treatments, however, there were no statistically significant differences among levels of P application (Table 4). In the comparison with micro-organic and phosphorus fertilizer applications, the recorded data figured out that did not interact SPAD index during the red turmeric growth period. However, the difference of cow dung fertilizer statical significantly improved the SPAD index. In which, the treatment with 6 tons of MOF per ha had the highest average SPAD index of 31.7 and 34.4 at the time of 60 and 120 DAP, respectively. Trinh (2015) assumed that macro and micro elements had tremendously contributed to the material transformation in the plant, and that includes chlorophyll content. The main reason that leads to this significance could be that MOF was added NPK nutrient and other elements which enables red turmeric to reinforce chlorophyll content what could accumulate matters for plants.

Table 4. Effects of micro-organic and phosphorus fertilizers on soil-plant analysis development index of red turmeric leaves

Observed time	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
60 DAP	Cow dung [(1)]	30.1	30.3	30.3	31.3	30.5[c]
	2	30.4	30.6	31.2	31.4	30.9[b]
	4	30.6	31.0	31.0	31.4	31.0[b]
	6	31.2	31.6	31.9	31.9	31.7[a]
	Average (P)	30.6	30.9	31.1	31.5	
	CV (%) = 1.9		$F_P = 5.5^{ns}$	$F_O = 0.7^*$	$F_{P*O} = 1.1^{ns}$	
120 DAP	Cow dung [(1)]	32.7	32.9	33.5	33.6	33.2[d]
	2	33.5	33.9	34.0	34.2	33.9[c]
	4	33.6	34.0	34.3	34.7	34.2[b]
	6	33.8	34.1	34.6	34.9	34.4[a]
	Average (P)	33.4	33.7	34.1	34.4	
	CV (%) = 2.5		$F_P = 20.1^{ns}$	$F_O = 0.3^*$	$F_{P*O} = 1.3^{ns}$	

Within a group of means, values followed by the same letter are not significantly different at 5% level. *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control); [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer; DAP: days after planting.

At the period of 180 DAP, in term of stem fresh weight, the phosphate fertilizer factor did not significantly affect the criteria of the fresh stems, rhizomes, and roots of red turmeric in the experiment, and no significant interaction between the applied rates of microbial organic and phosphate fertilizer was observed.

However, applying different amounts of MOF, a statistical difference in the fresh weight of stems, rhizomes and roots were recorded. Particularly, the red turmeric plants applied 6 tons/ha indicated the highest fresh stem weight (1908.3 g), rhizomes (293.8 g), and roots (255.2 mg) (Table 5).

At the different applied rates of phosphate fertilizer, the dry weight of red turmeric stems, rhizomes and roots were not a statistically significant difference, and the combination of different applied rates of microbial organic and phosphorus fertilizers recorded no significant effect on these parameters in the experiment. The resemblance of the fresh weight indicators, the experiment prevailed that there was a statistically significant difference in the stem dry weight (308.4 g) when applying 6 tons of MOF per ha as compared with the other treatments (Table 6).

Table 5. Effects of micro-organic and phosphorus fertilizers on the fresh weight of red turmeric stems, rhizomes and roots at 180 days after planting

Parameters	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
Stem fresh weight (g)	Cow dung [(1)]	1166.7	1233.3	1333.3	1366.7	1275.0[c]
	2	1233.3	1333.3	1466.7	1533.3	1391.7[b]
	4	1333.3	1333.3	1433.3	1600.0	1425.0[b]
	6	1733.3	1900.0	1866.7	2133.3	1908.3[a]
	Average (P)	1366.7	1450.0	1525.0	1658.3	
	CV (%) = 17.0		$F_P = 0.1^{ns}$	$F_O = 9.2^*$	$F_{P*O} = 0.7^{ns}$	
Rhizomes fresh weight (g)	Cow dung [(1)]	195.9	236.4	236.4	256.7	231.4[c]
	2	236.4	243.2	263.4	276.9	255.0[b]
	4	270.2	290.4	303.9	310.7	287.1[a]
	6	256.7	263.4	297.2	331.0	293.8[a]
	Average (P)	239.8[c]	258.4[b]	275.3[b]	293.8[a]	
	CV (%) = 13.7		$F_P = 2.3^*$	$F_O = 2.6^*$	$F_{P*O} = 0.5^{ns}$	
Root fresh weight (mg)	Cow dung [(1)]	128.0	136.7	149.3	165.3	144.8[b]
	2	172.7	196.7	222.3	231.0	205.7[a]
	4	199.3	210.7	354.0	256.7	246.7[a]
	6	214.7	225.3	229.0	317.7	255.2[a]
	Average (P)	178.7	192.4	238.7	242.7	
	CV (%) = 15.4		$F_P = 1.3^{ns}$	$F_O = 3.7^*$	$F_{P*O} = 0.9^{ns}$	

Within a group of means, values followed by the same letter are not significantly different at 5% level. *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control), [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

Table 6. Effects of micro-organic and phosphorus fertilizers on the dried weight of stems, rhizomes, and roots of red turmeric at 180 days after planting

Parameters	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
Stem dry weight (g)	Cow dung [(1)]	166.7	200.0	200.0	233.3	200.0[c]
	2	200.0	200.0	200.0	233.3	208.3[c]
	4	233.3	233.3	233.3	266.7	241.7[b]
	6	266.7	300.0	300.0	366.7	308.4[a]
	TB (P)	216.7	233.3	233.3	275.0	
	CV (%) = 15.5		$F_P = 0.1^{ns}$	$F_O = 10.8^{*}$	$F_{P*O} = 1.0^{ns}$	
Rhizomes dry weight (g)	Cow dung [(1)]	31.4	35.9	37.4	41.5	36.6
	2	36.5	40.0	42.0	47.9	41.6
	4	38.2	40.9	43.9	48.4	42.9
	6	39.9	41.5	46.0	51.2	44.7
	Average (P)	36.5	39.6	42.3	47.3	
	CV (%) = 17.2		$F_P = 2.4^{ns}$	$F_O = 2.5^{ns}$	$F_{P*O} = 0.7^{ns}$	
Root dry weight (mg)	Cow dung [(1)]	19.3	20.7	24.0	26.7	22.7[c]
	2	27.3	31.0	33.7	37.3	32.3[b]
	4	28.3	35.0	38.7	39.0	35.3[ab]
	6	34.0	34.0	35.0	45.7	37.2[a]
	Average (P)	27.2	30.2	32.9	37.2	
	CV (%) = 12.1		$F_P = 1.2^{ns}$	$F_O = 3.3^{*}$	$F_{P*O} = 0.5^{ns}$	

Within a group of means, values followed by a same letter are not significantly different at 5% level. *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control), [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

3.2. Effects of micro-organic and phosphorus fertilizers on yield of red turmeric

In terms of the correlation between the microbial organic and phosphorus fertilizers, a statistically nonsignificant difference in the theoretical fresh yield of red turmeric was recorded when applied these fertilizers at different rates (Table 7). Particularly, the treatment with 120 kg P_2O_5/ha achieved the highest average theoretical fresh yield of 34.3 tons per ha, whereas the treatment with 30 kg of P_2O_5 per ha had the lowest average theoretical fresh yield of 27.6 tons/ha. The treatment with 6 tons of MOF per ha produced the highest average theoretical fresh yield of 32.7 tons/ha.

The effect of phosphorus fertilizer on the actual fresh yield of red turmeric was also statistically significant between different treatments at the time of harvest. The experimental application of 120 kg P_2O_5/ha obtained the highest actual fresh yield of 24.3 tons/ha, a statistically significant difference compared with the other treatments.

Table 7. Effects of micro-organic and phosphorus fertilizers on theoretical and actual fresh yield of red turmeric

Parameters	MOF dose (tons/ha) (O)	Phosphorus dose (kg P_2O_5/ha) (P)				Average (O)
		30	60[(2)]	90	120	
Theortical fresh rhizomes yield (tons/ha)	Cow dung [(1)]	26.3	27.0	27.0	29.3	27.4[b]
	2	27.7	30.0	31.6	34.7	31.0[a]
	4	27.0	30.8	33.1	35.4	31.6[a]
	6	29.3	30.0	33.9	37.7	32.7[a]
	Average (P)	27.6[c]	29.5b[c]	31.4[b]	34.3[a]	
	CV (%) = 13.7		F_P = 2.3*	F_O = 2.6*	F_{P*O} = 0.5[ns]	
Actual fresh rhizomes yield (tons/ha)	Cow dung [(1)]	15.3	18.9	19.7	20.7	18.7[b]
	2	19.4	21.3	21.5	25.1	21.8[a]
	4	18.4	21.7	22.9	24.0	21.8[a]
	6	20.7	21.1	23.9	27.5	23.3[a]
	Average (P)	18.5[c]	20.8[b]	22.0[b]	24.3[a]	
	CV (%) = 15.5		F_P = 2.7*	F_O = 2.8*	F_{P*O} = 0.6[ns]	

Within a group of means, values followed by a same letter are not significantly different at 5% level. *: significant at 5% level; [ns]: non significant; [(1)] 10 tons/ha (control), [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

In terms of the amount of MOF, the collected data showed that the treatment with 6 tons MOF achieved the highest average actual fresh yield of 23.3 tons/ha, which was statistically significant for the control treatment. These result was in concordance with the study of Banwasi & Singh (2010) that the application of 100 and 150 kg P_2O_5/ha recorded the highest red turmeric yield growing in light clay soil, with the increasing level of phosphorus up to 200 kg/ha, the yield of red turmeric was tended to decrease. Besides, the study results of Padmapriya & Chezhiyan (2009) prevailed the effect of fertilizers (organic, inorganic) on the yield and quality of red turmeric concluded that applying microbial organic fertilizers and NPK significantly increased the yield of red turmeric, and relatively consistented with the contemporary study.

The results showed that red turmeric plants were treated at 120 kg P_2O_5/ha combined with 6 tons of MOF per ha achieved the highest revenue of VND 550 million/ha, the highest cost of VND 163.68 million per ha, the highest profit of VND 386.32 million/ha, and highest benefit-cost ratio of 2.4 (Table 8).

Table 8. Effects of micro-organic and phosphorus fertilizers on economic efficiency of red turmeric

Phosphorus dose (kg P_2O_5/ha)	MOF dose (tons/ha)	AFY (ton/ha)	Total revenue	Total costs	Profit	BCR
			(million VND/ha)			
30	Cow dung [(1)]	15.3	306	155.42	150.58	1.0
	2	18.9	378	144.42	233.58	1.6
	4	19.7	394	153.42	240.58	1.6
	6	20.7	414	162.42	251.58	1.5
60[(2)]	Cow dung [(1)]	19.4	388	155.84	232.16	1.5
	2	21.3	426	144.84	281.16	1.9
	4	21.5	430	153.84	276.16	1.8
	6	25.1	502	162.84	339.16	2.1
90	Cow dung [(1)]	18.4	368	156.26	211.74	1.4
	2	21.7	434	145.26	288.74	2.0
	4	22.9	458	154.26	303.74	2.0
	6	24.0	480	163.26	316.74	1.9
120	Cow dung [(1)]	20.7	414	156.68	257.32	1.6
	2	21.1	422	145.68	276.32	1.9
	4	23.9	478	154.68	323.32	2.1
	6	27.5	550	163.68	386.32	2.4

AFY: Actual fresh yield; BCR: Benefit-Cost ratio, [(1)] 10 tons/ha (control), [(2)] 60 kg P_2O_5/ha (control); MOF: micro-organic fertilizer.

4. Conclusions

The experiment clearly indicated that on the gray infertile soil at Thu Duc city, red turmeric applied with 120 kg P_2O_5/ha combined with 6 tons of MOF/ha (a common dose of 500 kg lime, 90 kg N, 120 kg K_2O/ha) obtained the outstanding results in the growth, development and yield. The yield and yield components of red turmeric were also highest in this treatment with weight of fresh rhizomes (331.0 g), fresh root weight (317.7 mg), theoretical fresh yield (37.7 tons/ha), and actual fresh yield (27.5 tons/ha). Red turmeric was applied at the dose of 120 kg P_2O_5/ha combined with 6 tons of MOF/ha achieving the highest revenue of VND 550 million/ha and highest cost-benefit ratio of 2.4.

Conflict of interest

The authors declare no conflict of interest.

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