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Effect of Partially-burnt Paddy Husk as a Supplementary Source of Potassium on Growth and Yield of Turmeric (*Curcuma longa* L.) and Soil Properties

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Abstract

An experiment was conducted at the Intercropping and Betel Research Station, Narammala, Dampelessa to study the effects of partially-burnt paddy husk as a supplementary source of potassium on growth and yield of turmeric (*Curcuma longa.*L*)* and soil properties during the year 2017. Seven treatments were prepared by using two sources of potassium, namely Muriate of Potash (MOP) and Partially Burnt Paddy Husk (PBPH). The treatments included T1 (zero potassium fertilizer as control), T2 (recommended rate of MOP 100%), T3 (75% MOP+25% PBPH), T4 (50% MOP+50% PBPH), T5 (25% MOP+75%PBPH), T6 (PBPH alone 100%) and T7 (recommended rate of 100% MOP+50% PBPH). For treatment, the percentages of MOP and partially-burnt paddy husk were calculated based on weight

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basis. This experiment was laid out in a Randomized Complete Block Design with three replications. Local type of turmeric was used as planting material and data were collected on soil, growth and yield parameters of turmeric. Parameters were recorded at monthly intervals after planting. Results revealed that most of the growth and yield parameters have increased in a similar pattern (T7>T2=T3>T4>T5>T6>T1). Soil parameters also showed significant differences among the treatments due to the application of PBPH. Quality of the rhizome was evaluated based on colour intensity of the rhizome. There was no significant difference between treatments using colour intensity, except in control treatment (T1). The results obtained by the study showed that combined use of MOP (100%) with PBPH (50%) has beneficial effects on turmeric cultivation. Therefore partially- burnt paddy husk can be used as a supplementary source of K for turmeric cultivation to maximize the yield.

Key words: Turmeric, Potassium, partially burnt paddy husk, Fertilizer

Introduction

Curcuma longa L. (Turmeric) is a perennial rhizomatous herb which belongs to Zingiberaceae family. Turmeric is widely used worldwide as a medicine, condiment, dye, and disinfectant and cosmetic. Due to its economic importance, 800 000 tons of turmeric is annually produced in the world, but Sri Lanka only produces 8304 tons (DEA, 2012). Furthermore, there is a good local and export market for turmeric which is grown in Sri Lanka because of its higher curcumin level, especially for organically cultivated turmeric (DEA, 2012). Sri Lanka has the potential to expand turmeric cultivation and earn foreign exchange.

Annually 15-20 tons of turmeric yields can be obtained from 1ha of turmeric cultivation (DEA, 2012). It removes considerable amounts of nutrients from the field.Fertilizer application is essential in order to obtain a sustainable yield from the field and also previous researches have shown that turmeric plant is sensitive for organic manure and potassium fertilizer (DEA, 2012).

Problem statement

Farmers use higher amount of potassium fertilizer than other fertilizer for turmeric cultivation because turmeric plants show a positive response to it (Amarawansha, 2006). There are several disadvantages of using an inorganic fertilizer, including the increased cost of production. Government is involved in a programme to minimize the utilization of inorganic fertilizer and to promote organic farming (Ministry of Agriculture, 2012) due to the unpopularity of agrochemicals due to perceived health hazards. Therefore, the demand for organic food products has increased. There is a good demand for organically-cultivated turmeric in local and export markets but the production is insufficient. It is important to study the effect of locally available low-cost materials which can be used as supplementary sources of potassium to reduce the total dependence on inorganic fertilizer in turmeric cultivation. It will help to improve organic turmeric cultivation in Sri Lanka. Lack of research and extension programs on organic farming is the principal constraint to the development of productive and profitable organic farming in Sri Lanka (Sangakkara & Katupitiya., 1989).

Research justification

Partially-burnt paddy husk is a locally available low-cost organic material which can be used as a supplementary source of potassium. Partially-burnt paddy husk contains a higher amount of potassium when compared to the organic material (Alwis, 2004). The other benefit of adding partially-burnt paddy husk is its good water holding capacity which helps to retain soil moisture enabling cultivation to proceed even under drought conditions (Amarawansha, 2006). Therefore, the objectives of this study are to investigate the merits/demerits of partially-burnt paddy husk as a supplementary source of potassium for growth, yield and quality of turmeric and on soil parameters.

Materials and Methodology

Location

The study was conducted at a field belonging to the Intercropping and Betel Research Station, Department of Export Agriculture, Narammala, Dampelessa.

Treatments

Table 1 shows the seven treatments prepared using two sources of potassium: Muriate of Potash (MOP) and partially-burnt paddy husk (PBPH). Each of the treatment description is given in Table 1. Percentages of Muriate of Potash (MOP) and the partially burnt paddy husk (PBPH) were decided based on DEA (2012) recommendations.

Table 1. Treatment description

Treatment	MOP amount (g/m^2) (%)	Partially burnt paddy husk amount (g/m^2)	Amount of DEA recommended potassium requirement supply by potassium sources g/m^2	
			MOP%	Partially burnt paddy husk%
T1 (Control)	-	-	-	-
T2 (DEA recommendation)	20	-	100	-
T3	15	230	75	25
T4	10	450	50	50
T5	5	680	25	75
T6	-	900	-	100
T7	20	450	100	50

Experimental design

One factor in the RCBD with three replicates were used as the design. The field layout is given below.

Land preparation

Land was cleared, ploughed and after that harrowing was done. Twenty-one beds having dimensions of 2.4 m in length and 1.2 m in width were prepared.

Selection of planting materials and field establishment

Well matured rhizomes of local type of turmeric, free from pests and diseases were selected. 35-40g parts of rhizomes (seed turmeric rhizomes) were treated with commended fungicide (Mancoseb) and established in the field.

Fertilizer application

Partially-burnt paddy husk was prepared by controlled burning. Total amount of partially-burnt paddy husk of each treatment was applied with recommended TSP amount as basal application before field establishment of rhizomes. First application of the MOP amounts of each treatment was done with recommended urea amounts, 45 days after planting. Second application of MOP with recommended urea amount was done 90 days after planting.

Irrigation
Plants were watered daily during germinating period except in rainy days. Watering was done manually. In rainy days once a week watering was done to fulfill 1/5 amount of field capacity of the soil. Volume basis method was used to determine the field capacity of one pot.

Data collection
Data were collected 1, 2, 3, 4, 5 and 6 months after planting based on plant parameters and soil parameters. Plant parameters were measured using randomly selected two plants from each replicate. Quality parameter of the rhizome was evaluated six months after planting.

One month after planting, only plant height and number of emerged plants were measured as plant parameters as the plants were sprouting at that stage.

Data were collected based on plant parameters and soil parameters according to the following methods. Plant parameters are given in Table 2.

Table 2. Methods of measuring plant parameters

Parameter	Method
Plant height	Taken from the ground level to the tip of the longest shoot.
Number of plants emerged from the soil	Counted in each replicate.
Number of leaves per clump	Counted in randomly selected two plants from each replicate.
Stem diameter	Measured by using a Vernier Caliper at the top, middle, and bottom of stem and the average was calculated and expressed in centimeters.
Fresh and dry weight of the rhizome	Rhizome was cleaned and the fresh weight immediately measured while dry weight was obtained by keeping the rhizome at 70˚C until a constant weight was seen.
Number of rhizome fingers	Two rhizomes were taken from each replicate and the numbers of rhizome fingers were counted.
Fresh total biomass weight	Two plants from each replicate were taken and fresh weight of the total plant was immediately measured by using electronic balancer.
Number of roots	Counted using two plants from each replicate.
Quality of the rhizome	Color intensity of the rhizome was measured using a spectrophotometer (CT-5100 UV/VIS Spectrophotometer). Pure turmeric juice samples (3ml) were prepared using 25g of fresh turmeric rhizome from each sample. The wave length at which maximum absorbance (λ max) took place in UV detector (430 nm) was selected for further analysis. The absorbance of each sample was then measured at 430nm against distilled water as blank. Six samples were analyzed for each treatment and the mean values of absorbance were taken to compare color intensity of rhizomes.

Soil parameters

(i) N, P, K content of soil samples

N and K content of soil samples were measured using the Kjeldahl method and Ammonium Acetate extraction method at the Cinnamon Research Station Matara. P content of soil samples was measured using the Vandatemolybdate method at the Soil and Water Laboratory of the Department of Agricultural and Plantation Engineering, The Open University of Sri Lanka.

(ii) Soil moisture content

Two soil samples were taken from each replicate by using a soil core sampler at 10-30cm depths. Wet weights of the soil samples were taken and samples were kept at 105°C temperature in oven until weight became constant. The dry weight was subtracted from wet weight to obtain moisture content of the soil and then it was converted to a percentage.

(iii) Soil pH and Soil EC

Soil pH was measured using a pH meter. Soil EC was measured using the HANNA digital EC meter.

Data analysis

All of above-mentioned data were subjected to Analysis of Variance (ANOVA) using the SAS software package. Mean separation was done by Least Significant Difference Test (LSDT) at 0.05 level of probability.

Results and Discussion

1. Soil parameters

Soil moisture content

During every month the highest moisture content percentage was observed in treatments T5 (75% PBPH+25%MOP) and T6 (100%PBPH) and the lowest moisture content percentage was observed in the treatment T1 (Control) and T2 (100% MOP). Significantly, the highest percentage of moisture content was observed in treatment T6 (100% PBPH) and the lowest value in treatment T1 (Control) at the sixth month (Table 3). However, there is no significant difference between treatment T6 and T5 at the sixth month. Moisture content has increased in accordance with the amounts of partially-burnt paddy husk applied. The reason may be the higher water holding capacity of partially-burnt paddy husk (Amarawansha, 2006).

Soil EC

The highest EC values were observed in the 2nd month probably due to the first application of inorganic fertilizer at 45 days after planting. Significantly highest EC value was observed in treatment T7 (100% MOP + 50% PBPH) and the lowest EC value was observed in treatment T6 (Table 3) at the sixth month. Treatment T7 is significantly different from treatment T6 but not significantly different from treatment T2 (100% MOP). Initial PBPH sample showed higher EC value of 2.21 and PBPH may have an effect on soil EC alone but Lehmann and

Joseph (2009) reported that biochar increases nutrient retention on the top soil by lowering the amount of nutrient leached into lower layers of soil or into ground water and it supports the result of T7 having higher EC than T6.

Table 3. Soil parameters measured at the sixth month afterplanting

Treatments	**Soil Moisture Content (%)**	**Soil electrical conductivity (mS/m)**	**Soil pH**	**Soil N (%)**	**Soil P (ppm)**	**Soil K (%)**
T1(Control)	4.87[d]	0.5[de]	6.41[cd]	0.17[a]	285 [a]	0.012[e]
T2 (100%MOP).	5.12[d]	1.0[ab]	6.28 [d]	0.18 [a]	289 [a]	0.025[ab]
T3 (75% MOP +25% PBPH)	8.94[c]	0.9[bc]	6.53[bcd]	0.18 [a]	290 [a]	0.024[abc]
T4 (50% MOP + 50% PBPH	10.65[b]	0.73[c]	6.7[abc]	0.17 [a]	276 [a]	0.021[bcd]
T5 (75%PBPH+ 25%MOP)	15.65[a]	0.7[cd]	6.73[ab]	0.18 [a]	300 [a]	0.017[ade]
T6 (100% PBPH)	15.8[a]	0.4[c]	6.84[a]	0.18 [a]	294 [a]	0.016[de]
T7 (100%MOP+ 50%PBPH)	10.66[b]	1.2[a]	6.68[abc]	0.18 [a]	298 [a]	0.029[a]

Soil pH

Soil pH showed decreasing trend from the 1st month up to the 6^{th,} but when compared with the initial value of soil pH (6.26), pH values have slightly increased (Table 3). Initial PBPH sample showed higher pH value of (8.1). Application of partially-burnt paddy husk increases soil pH (AICOAF, 2001) and this may be the reason for the increased pH values in treatments.

In the sixth month the highest pH value was observed in treatment T6 (100% PBPH) and the lowest pH value in treatment T2 (100% MOP) (Table 3). Treatment T6 is significantly different from treatment T2. pH values of treatments with higher amount of PBPH (T5 and T6) have shown significant differences from the treatments which did not involve PBPH (T1 and T2). Reason for the decreasing trend of pH values may be due to the application of urea, 45 days and 90 days after planting and soil pH decreases after application of the urea due to acidification resulting from dissociation of urea to produce H^+ ions.

Available Nitrogen

There is no significant difference among the treatments applied to soil with available nitrogen six months after planting (Table 3), but when compared to the available N in the initial soil (0.16%), N values of all the treatments have slightly increased. The reason for the increased N level may be due to the application of urea, 45 and 90 days after planting. All the treatments received equal amounts of nitrogen fertilizer (urea) in the same manner and this may be the reason for no significant differences among the treatments.

Available Phosphorus

There is no significant difference among the treatments applied to soil with available phosphorus six months after planting (Table 3), but when compared to the initial soil available P value (270ppm), P values of all the treatments have slightly increased. The reason for the increased P level may be due to the application of TSP, 45 and 90 days after planting. All the treatments received equal amount of phosphorus fertilizer (TSP) in the same manner and this may be the reason for no significant differences among the treatments.

Available Potassium

Soil with available potassium shows significant differences among treatments six months after planting (Table 3), but when compared to the initial soil potassium content (0.015%), potassium content of all the treatments, except T1(Control), have increased slightly (Table 3). The reason for the increased potassium levels may be due to the potassium fertilizers and PBPH contained in those treatments. In the 6^{th} month the highest available potassium value was observed in treatment T7 (100%MOP+50%PBPH) and the lowest available was observed in treatment T1 (Control). Treatment T7 is significantly different from treatment T1. Treatment T7 contained the highest amount of potassium and treatment T1 contained no potassium. This may be the reason for the above observation. The reason for the variation of potassium content among the other treatments may be due to the different ratios of potassium sources (MOP: PBPH) contained in the individual treatments.

2. Growth parameters

Number of emerged plants

Number of emerged plants showed an increasing trend. Treatment T6 (100% PBPH) showed the significantly highest number of emerged plants in the 1^{st} and the 2^{nd} months. Treatments T1 (Control) and T2 (100%MOP) have showed the lowest number of emerged plants. In the second month, treatment T6 showed the significantly highest number of emerged plants (Table 4). There is a significant difference between treatments which have applied PBPH and treatments which have not. Soil moisture is important for germination and soil moisture content vary depending on the amount of added partially-burnt paddy husk. Treatment T6 contains the highest amount of PBPH and it may be the reason for the highest number of emerged plants.

Plant height

Plant height showed an increasing trend from the 1st month up to 6th. Plant height has increased in a similar pattern as follows: T7>T2=T3>T4>T5>T6>T1. Significantly the highest plant height was observed in treatment T7 (50%PBPH+100%MOP) and the lowest was observed in treatment T1 (Control) the sixth month (Table 4). Treatment T7 is significantly different from treatment T1. The reason for the increasing trend of plant height may be due to the quick response in the application of inorganic fertilizer, 45 days and 90 days after planting. The plant height has increased proportionally to the amount of MOP contained in the treatments. Noor *et al* (2014) have reported that the increased plant height in turmeric crop could be due to increasing K fertilizer. Treatments T2 and T7 contains the same amount of MOP, but the additional amount of PBPH in treatment T7 may be the reason for the significant difference between treatments T2 and T7. Furthermore, treatment T6 (100%PBPH) showed higher plant height than treatment T1 (Control) because treatment T6 has PBPH and Graber (2010) has reported increased plant height in tomato crop due to biochar application.

Table 4. Growth parameters measured on the 6th month afterplanting.

Treatments	**Emerged plants (%)**	**Plant height (cm)**	**Number of Leaves**	**Stem diameter (cm)**
T1(Control)	56.3^{c}	127.7^{d}	9.3^{d}	2.6^{d}
T2 (100%MOP).	59.4^{c}	149.4^{b}	11.0^{b}	3.2 ^{b}
T3 (75% MOP +25% PBPH)	71.9^{b}	148.8^{b}	10.8^{bc}	3.1 ^{b}
T4 (50% MOP + 50% PBPH	75^{b}	139.5^{c}	10.0$^{bc d}$	2.9 ^{c}
T5 (75% PBPH+25%MOP)	78.1^{b}	137.9^{c}	9.8$^{bc d}$	2.9 ^{c}
T6 (100% PBPH)	90.6^{a}	136.7^{c}	9.7^{cd}	2.9 ^{c}
T7 (100%MOP+50%PBPH)	75^{b}	157^{a}	12.3^{a}	3.5 ^{a}

Number of leaves

The number of leaves showed an increasing trend from the 2nd month up to the 6th. Significantly the highest number of leaves was observed in treatment T7 (50%PBPH+100%MOP) and the lowest in treatment T1 (Control) on the sixth month (Table 4). Treatment T7 is significantly different from treatment T1. The reason for the above observation may be due to the quick response of application of inorganic fertilizer, 45 days and 90 days after planting.

The number of leaves has increased proportionally to the amount of MOP contained in the treatments. Annie *et al* (2002) have recorded increased number of leaves in turmeric crop due to increasing potassium fertilizer. Treatments T2 and T7 contained the same amount of MOP but the additional amount of PBPH in treatment T7 may be the reason for the significant difference between treatments T2 and T7.

Pseudo diameter

Pseudo stem diameter showed an increasing trend from the 2nd month up to the 6th. Significantly the highest pseudo stem diameter was observed in treatment T7 (50%PBPH+100%MOP) as shown in Table 4. The reason for the above observation may be due to the quick response in the application of inorganic fertilizer, 45 days and 90 days after planting. Pseudo stem diameter has increased proportionally to the amount of MOP contained in the treatments. Annie *et al* (2002) have recorded an increased pseudostem girth in turmeric crop correlating with the K fertilizer level.

3. Yield Parameters

Number of rhizome fingers

The number of rhizome fingers shows an increasing trend from the 2nd month up to the 6th month. The number of rhizome fingers has increased in a similar pattern as follows: T7>T2=T3>T4>T5>T6>T1 (Table 5). Treatment T7 is significantly different from treatment T1. The reason for the above observation may be due to the quick response of the application of inorganic fertilizer, 45 days and 90 days after planting. The number of rhizome fingers has increased proportionally to the amount of MOP contained in the treatments. Annie et al. (2002), Karthikeyanet al. (2009) have recorded increased number of rhizome fingers in turmeric crop due to increased K fertilizer.

Table 5. Yield parameters measured on the 6th month after planting

Treatments	Number of rhizome fingers	Fresh weight of rhizome (g)	Dry weight of rhizome (g)	Fresh Biomass weight of plant (g)
T1(Control)	11.5^{d}	139.5^{d}	18.1^{d}	339.5^{d}
T2 (100%MOP).	14.0^{b}	172.1^{b}	22.4^{b}	372.1^{b}
T3 (75% MOP +25% PBPH)	13.9^{b}	171.3^{b}	22.3^{b}	371.3^{b}
T4 (50% MOP + 50% PBPH	13.0^{c}	164.2^{c}	21.3^{c}	364.2^{c}
T5 (75% PBPH+25%MOP)	13.0^{c}	163.5^{c}	21.3^{c}	363.5^{c}
T6 (100% PBPH)	12.7^{c}	162.5^{c}	21.1^{c}	362.4^{c}
T7 (100%MOP+50%PBPH)	15.0^{a}	177.6^{a}	23.1^{a}	377.6^{a}

Fresh weight of the rhizome

Fresh weight of the rhizome showed an increasing trend from the 2^{nd} month up to the 6^{th}. The fresh weight of the rhizome has increased in a similar pattern as follows: T7>T2=T3>T4>T5>T6>T1(Table 5). Significantly the highest fresh weight of rhizome (177.6 g) was observed in treatment T7 and the lowest weight (139.5g) in control treatment T1. The reason for the above observation may be due to the quick response of the application of inorganic fertilizer, 45 days and 90 days after planting. The fresh weight of rhizome has increased proportionally to the amount of MOP in the treatments. This result agrees with the results of Annie *et al* (2002) as the fresh weigh increased with increased potassium fertilizer. Furthermore, fresh weight of the rhizome has increased according to the method of using, zero fertilizer (T1) < organic fertilizer alone (T6) < chemical fertilizer alone (T2) < combined use of organic and chemical fertilizer (T7). These results agree with the results of HARTI (2013).

Dry weight of the rhizome

The dry weight of the rhizome also followed the same pattern as the fresh weight of rhizomes. The dry weight of the rhizome has increased in a similar pattern to the fresh weight of the rhizome (T7>T2=T3>T4>T5>T6>T1(Table 5). The significantly highest dry weight of rhizome (23.1g) was observed in T7 with 100% MOP and 50% of PBPH. The lowest dry weight of rhizome (18.1g) was observed in control treatment T1. The reason for the above observations may be due to the quick response of the application of inorganic fertilizer, 45 days and 90 days after planting. Dry weight of the rhizome has increased proportionally to the amount of MOP in the treatments and this result is supported by the results of Karthikeyan *et al* (2009). PBPH may also have an effect on dry weight of the rhizome. Priyadarshini & Seran (2009) reported that increased dry weight of cowpea pods due to application of PBPH.

Fresh biomass weight of plant

The fresh biomass weight showed an increasing trend from the 2nd month up to the 6th. The fresh biomass weight has increased in a similar pattern as follows: T7>T2=T3>T4>T5>T6>T1(Table 5). Significantly the highest fresh biomass weight of plant (377.6g) was observed in treatment T7 and the lowest (339.5g) in control treatment T1. The reason for the above observations may be due to the quick response of the application of inorganic fertilizer, 45 days and 90 days after planting. The fresh biomass weight of plant has increased proportionally to the amount of MOP in the treatments. Karthikeyan et al. (2009) reported that increasing the application rate of potassium in the form of KCl enhanced the growth of turmeric. Priyadarshini & Seran (2009) reported increased fresh biomass weight of cowpea plant except their roots due to the application of PBPH. There may be a combined effect of MOP and PBPH on the fresh biomass weight of turmeric as observed in this study.

4. Quality parameter

Colour intensity of the rhizome

There is a significant difference between treatment T1 (Control) and all the other treatments (T2, T3, T4, T5, T6, T7) (Fig. 1). HARTI (2003) mentioned that the quality of the turmeric rhizome differs with its colour and the reason for the yellow colour of the rhizome is curcumin. These results indicate that there is no significant difference among the treatments on the quality of turmeric except in treatment T1. When compared with all the other treatments, treatment T1 might have contained relatively a lower curcumin amount and all the other treatments might have contained nearly equal amounts of curcumin but higher than the control treatment. This may be due to the fact that treatment T1 (control) did not contain any potassium source and Akamine et al.(2007) reported that potassium is the principal element involved in curcumin formation in turmeric.

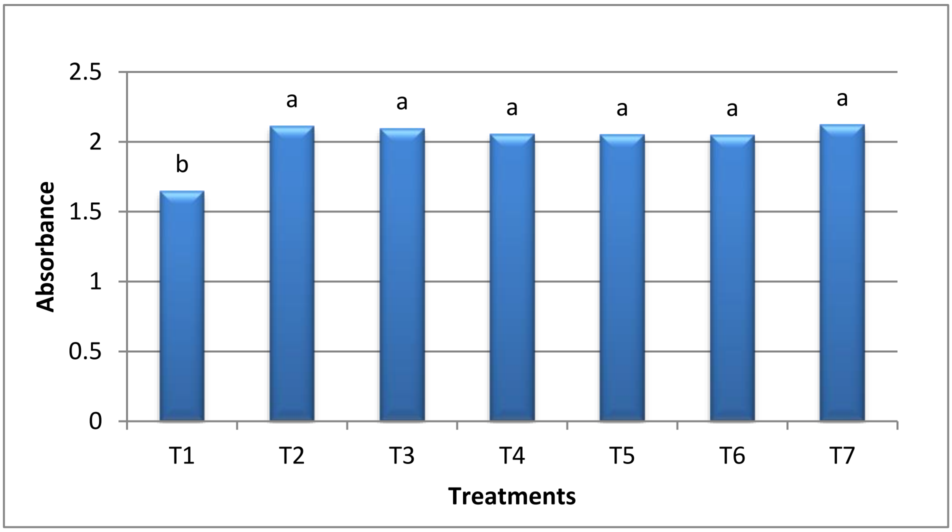

Figure 1. Absorbance of curcumin (means with the same letter is not significantly different)

Conclusions and Recommendations

According to the above observations, the combined use of MOP with PBPH has shown beneficial effects on turmeric cultivation. Partially-burnt paddy husk has beneficial effects as a supplementary source of potassium for growth of turmeric and it enhances the effects of MOP on the growth, yield and quality of turmeric. Therefore, farmers are advised to use partially-burnt paddy husk to dissolve and retain inorganic fertilizer in the soil. It also helps to improve the efficiency of applied inorganic fertilizer in order to increase the yield.

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