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Effect of planting material, mulch and farmyard manure on weed density, rhizome yield and quality of turmeric (*Curcuma longa*)

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ABSTRACT

A field experiment was conducted during 2007-08 and 2008-09 at Ludhiana to study the effect of different cultural practices on weeds, yield and economy of turmeric (*Curcuma longa* L.). Mother rhizome planting material resulted in significantly less weed population than primary and secondary finger planting material. The plant height, tillers/plant, leaves/plant, number of rhizomes/plant and mother, primary and secondary rhizome yields were also significantly more with mother rhizome planting material as compared to primary and secondary finger planting material. Increase in the paddy straw mulch levels from no mulch to 6.25 t/ha and then from 6.25 to 9.38 t/ha significantly decreased weed population and resulted in better growth parameters, yield attributes and mother, primary and secondary rhizome yield. On the other hand increase in farmyard manure levels from 30 to 45 t/ha significantly increased weed population, but growth parameters, yield attributes and mother, primary and secondary rhizome yield increased due to increased availability of nutrients and water. Oil and curcumin content in turmeric was not significantly affected by the planting materials, mulch or FYM application. However, oil and curcumin yield was higher when mother rhizomes were used and also increased with mulching and FYM application during both the years. Mother rhizome planting material, 9.38 t/ha mulch and 45 t/ha FYM resulted in the highest net return and benefit: cost (B: C) ratio.

Key words: Curcumin, Mulching, Turmeric, Weeds

Turmeric is a major field spice crop of India. It is grown for its rhizomes, which are mainly used as a spice for flavouring and colouring many foods. Essential oils, curcumin and oleoresin are also extracted from turmeric. India is major producer, consumer and exporter of turmeric; a major part of its produce is consumed within the country and export accounts only for about 5.9 percent of total production. During 2007-08, the turmeric export from India was 49,250 tonnes valued at 1.57 million Rupees and was 11 percent of total spices export (Selvan, 2009). Though India leads in the production of turmeric but average productivity is quite low. Competition offered by weeds is one of the major factors responsible for its lower productivity. Delayed emergence, slow initial growth, poor canopy development of turmeric provides ideal environment for weeds to grow and cover the ground quickly and compete with the crop. Yield losses of turmeric due to weeds vary from 30-75 percent (Krishnamurthi and Ayyaswamy 2000). Farmers have to go for repeated weedings which add to the cost of its cultivation. Herbicide use may not provide a long lasting and effective weed management in a long duration turmeric crop. Turmeric is propagated vegetatively using both mother as well as finger rhizomes. The type of planting material used affects the vigour of the plant, yield as well as the cost of production of turmeric (Kumar, 2005). Application of straw mulch and FYM is reported to influence water evaporation loss, weed population and soil temperature and thereby the yield and cost of production of turmeric (Gill *et al* 1999). Keeping this in view, the present investigation was undertaken to study the effect of planting material, mulch and FYM application on the yield and quality of turmeric cultivation at Ludhiana.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 2007-08 and 2008-09 at research farm, department of agronomy, Punjab Agricultural University, Ludhiana. The soil of the experimental field was loamy sand, low in available nitrogen (185.0 kg/ha) and organic carbon (0.21 %), medium in available phosphorus (13.3 kg/ha) and potassium (200.0 kg/ha) with pH 7.8. Treatments com-

prised of three planting materials (mother rhizomes: 25-30 g, primary fingers: 15-20 g and secondary fingers: 5-10 g), three mulch levels (no mulch, 6.25 and 9.38 t/ ha) and two farmyard manure levels (30 and 45 t/ha). The experiment was carried out in randomized block design (factorial) with four replications. During both the years, healthy rhizomes of different sizes viz. mother (14.8 q/ha), primary (12.3 q/ha) and secondary (9.8 q/ha) fingers were planted on 2 May at 30 x 20 cm spacing. Farmyard manure was applied before and paddy straw mulch immediately after planting as per treatment. Light irrigations were applied frequently till the crop sprouted and 24 irrigations were applied during the crop season. The crop was harvested on 30 January during both the years. Two hand weedings were given at 70 and 100 days after planting (DAP). Population of weeds and dry weight were recorded at 60 and 150 DAP with the help of a quadrant (0.5 x 0.5 m) and then converted into per square metre. Growth parameters were recorded at the interval of 30 days. Rhizome number and weight per plant were recorded at harvest. Fresh rhizomes yield was calculated based on per plot yield expressed in t/ha. The essential oil content (% w/v) was estimated by hydro-distillation using Clevenger's apparatus. The curcumin content (%) was calculated by using the formula of Thimmaiah (1999). N, P and K (kg/ha) uptake by turmeric were estimated at harvest stage. The economics was worked out based on prevailing input and output costs.

RESULTS AND DISCUSSION

Growth attributes

The data pertaining to plant height, number of leaves and tillers per plant recorded at different stages of crop growth revealed that all these growth parameters increased with the increase in age of crop upto 200 days after planting (DAP) and decreased thereafter. The decrease in growth parameters was due to leaf senescence. All the growth parameters were significantly more with mother rhizome planting material and decreased significantly with a decrease in size of planting material from mother rhizome to primary finger and secondary finger (Table 1). The better growth parameters with mother rhizome planting material can be attributed to more reserve food material, which resulted in quick emergence and more vigorous growth of the plant which led to smothering effect on weeds. The data on leaf senescence of crop was recorded at 200 and 230 days after planting. The data revealed that different planting materials had non-significant effect on the senescence of leaves though the leaf senescence tended to increase with decrease in the size of planting material from mother rhizome to primary and then from primary finger to secondary finger at 200 and 230 DAP

Table 1. Effect of different planting material, mulch and farmyard manure levels on periodic plant height, leaves/plant, tillers/plant and leaf senescence of turmeric

Treatment	Plant height (cm)				Leaves/plant				Tillers/plant				Leaf senescence (%)			
	110 days after planting		At harvest		110 days after planting		200 days after planting		200 days after planting		At harvest		200 days after planting		230 days after planting	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Planting material																
Mother rhizome	41.7	45.3	72.5	71.3	6.6	6.4	14.5	14.0	5.6	5.2	2.9	2.8	33.5	37.6	80.8	82.3
Primary fingers	37.6	35.3	65.3	60.3	6.3	6.0	12.0	12.3	4.9	4.6	2.3	2.5	35.2	38.3	83.3	84.6
Secondary fingers	31.3	30.0	50.3	45.0	5.2	5.6	11.4	11.0	4.4	4.2	1.9	1.6	35.0	39.2	83.9	85.1
SEm±	2.31	1.90	1.83	1.44	0.13	0.07	0.18	0.33	0.20	0.11	0.09	0.08	0.76	1.01	1.71	2.11
CD (P=0.05)	5.78	5.18	5.19	4.73	0.37	0.18	0.48	1.00	0.49	0.26	0.20	0.16	NS	NS	NS	NS
Mulch (t/ha)																
No mulch	25.1	27.8	48.8	40.8	4.1	4.2	9.9	9.2	3.4	2.7	1.5	1.6	43.2	45.9	86.8	89.0
6.25	38.6	37.6	65.5	65.0	6.0	6.0	13.0	13.2	5.5	5.2	2.5	2.3	33.0	37.0	83.0	84.0
9.38	46.9	45.2	73.5	70.8	8.0	7.8	15.0	14.9	6.0	6.1	3.1	3.0	27.0	32.0	78.0	79.0
SEm±	2.31	1.90	1.83	1.44	0.13	0.07	0.18	0.33	0.20	0.11	0.09	0.08	0.76	1.01	1.71	2.11
CD (P=0.05)	5.78	5.18	5.19	4.73	0.37	0.18	0.48	1.00	0.49	0.26	0.20	0.16	2.14	2.90	3.41	4.58
FYM (t/ha)																
30	33.9	33.6	55.2	49.7	5.7	5.2	12.2	11.6	4.7	3.9	2.2	2.0	37.6	39.9	85.3	88.0
45	39.8	40.1	70.0	68.0	6.3	6.8	13.0	13.2	5.2	5.4	2.5	2.6	31.5	36.8	80.0	80.0
SEm±	2.31	1.90	1.83	1.44	0.13	0.07	0.18	0.33	0.20	0.11	0.09	0.08	0.76	1.01	1.71	2.11
CD (P=0.05)	5.78	5.18	5.19	4.73	0.37	0.18	0.48	1.00	0.49	0.26	0.20	0.16	2.14	2.90	3.41	4.58

during both the years. Similar results have been reported by Kumar (2005).

Application of paddy straw mulch @ 9.38 t/ha produced significantly taller plants and more tillers and leaves per plant than application of mulch @ 6.25 t/ha, which in turn was significantly superior to no mulch. Similar result were reported by Junior *et al.* (2005) and Verma and Surnaik (2006). Leaf senescence in turmeric at 200 and 230 DAP decreased significantly with each successive level of mulch.

Application of farmyard manure @ 45 t/ha produced significantly taller plants and more leaves and tillers per plant as compared to 30 t/ha of farm yard manure at both stages of crop growth during both the years. Increased availability of water and nutrients could be responsible for these results. Leaf senescence with 45 t/ha of farmyard manure was significantly lesser than 30 t/ha farmyard manure at 200 as well as 230 DAP. The leaves with higher level of mulch and FYM remained photosynthetically active for longer period, which had favourable effect on growth parameters and yield of crop

Weed population and dry weight

The most common weeds observed in the experimental plots were *Cyperus rotundus* (*Motha*), *Cynodon dactylon* (*Khabbal*), *Eleusine aegyptiacum* (*Madhana*) and *Euphorbia hirta* (*Dodhak*). The weed population and dry weight decreased with age of crop due to two hand weedings given at 70 and 100 days after planting (DAP). The weed population and dry weight was the highest with secondary finger planting material treatment, significantly more than primary and mother rhizome planting materials at 150 DAP. At 60 DAP (Table 2), the weed population and dry weight tended to increase with each decrease in size of planting material, though the difference was non significant during both the years. This might be due to smothering effect of quick and early emergence of crop and vigorous seedlings produced by mother rhizome and primary finger planting material. The weed population and dry weight with 9.38 t/ ha mulch were significantly less as compared to 6.25 t/ha mulch, which in turn recorded significantly lesser weed population and dry weight than no mulch at 60 as well as 150 DAP during both the years. The beneficial effect of mulching in controlling weeds was due to delayed emergence of weeds and smothering effect on weed seedlings. Similar results were reported by Mahey *et al* (1986) and Phihar *et al* (1975). However, the reverse was true with the application of farmyard manure. With an increase in the level of farm yard manure from 30 to 45 t/ha, there was a significant increase in weed population and dry weight at both the stages of crop growth. It is because farmyard manure acts as a seed bank for most of weeds and also provides optimum conditions for their growth.

Yield attributes and yield

Rhizome number and weight per plant decreased with each decrease in size of planting materials from mother rhizome to primary finger and from primary to secondary finger during both the years. Mother rhizome as a planting material produced maximum number and weight of rhizome per plant (Fig. 1 and 2). Effective weed control,

Table 2. Weed density (no/m^2) and weed dry weight (g/m^2) in turmeric as influenced by different cultural practices

Treatment	Weed density				Weed dry weight			
	60 days after planting		150 days after planting		60 days after planting		150 days after planting	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Planting material								
Mother rhizome	118	125	13	14	596	643	95	81
Primary fingers	125	133	18	16	625	673	242	291
Secondary fingers	131	141	27	29	688	742	410	501
SEm±	3.3	3.6	2.8	3.2	10.2	8.5	30.2	24.9
CD (P=0.05)	NS	NS	6.1	8.5	NS	NS	91.2	72.5
Mulch (t/ha)								
No mulch	136	148	32	30	639	771	504	477
6.25	125	132	17	20	585	659	192	323
9.38	113	119	9	9	685	628	51	73
SEm±	3.3	3.6	2.8	3.2	10.2	8.5	30.2	24.9
CD (P=0.05)	9.3	9.1	6.1	8.5	30.5	28.3	91.2	72.5
FYM (t/ha)								
30	119	126	15	15	604	671	94	152
45	130	140	24	24	669	701	404	430
SEm±	3.3	3.6	2.8	3.2	10.2	8.5	30.2	24.9
CD (P=0.05)	9.3	9.1	6.1	8.5	30.5	28.3	91.2	72.5

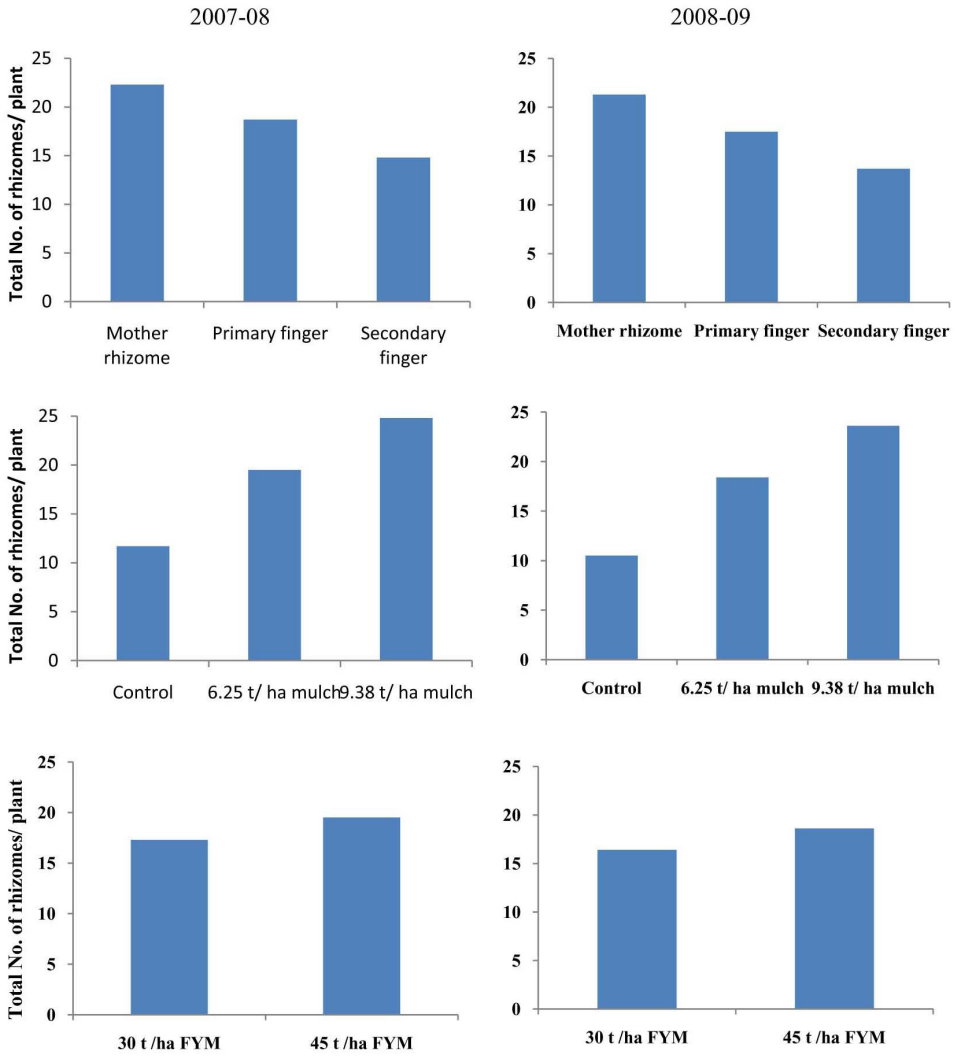

Fig. 1. Effect of different planting material, mulch levels and FYM levels on total rhizome number per plant

more tillers and leaves per plant might be the reason for increase in number and weight of rhizomes per plant with mother rhizome planting material. The increase in number and weight of rhizomes per plant with increased mulch and FYM levels might be due to better weed control, increased availability of water and nutrients to crop. Increase in the number and weight of rhizomes per plant due to mulch has been reported by Junior *et al* (2005). The use of mother rhizome as planting material resulted in higher mother (16.4, 15.3 t/ha), primary (8.3, 7.9 t/ha) and secondary (2.4, 2.4 t/ha) fresh rhizome yield than the primary and secondary finger planting material during both the years. The mother, primary and secondary fresh rhizome yield also increased with an increase in mulch and farm yard manure levels during both the years.

The use of primary and secondary fingers as planting material resulted in 22.6 and 52.5 per cent reduction in total fresh rhizome yield as compared to mother rhizome planting material (Table 5). The highest fresh rhizome yield was obtained with 9.38 t/ha mulch, which was significantly higher than 6.25 t/ha, which in turn was superior to no mulch. This might be due to better weed control under increased mulch levels. Farmyard manure application @ 45 t/ha significantly increased the fresh rhizome yield over 30 t/ha level by 10%. In spite of significant increase in weed population with increase in farmyard manure levels from 30 to 45 t/ ha, there was significantly more fresh rhizome yield with 45 t/ha farmyard manure. This was due to increased water and nutrient availability resulting in better crop growth, which had a smothering effect on weeds.

Oil and curcumin content

Oil and curcumin content in turmeric was not signifi-

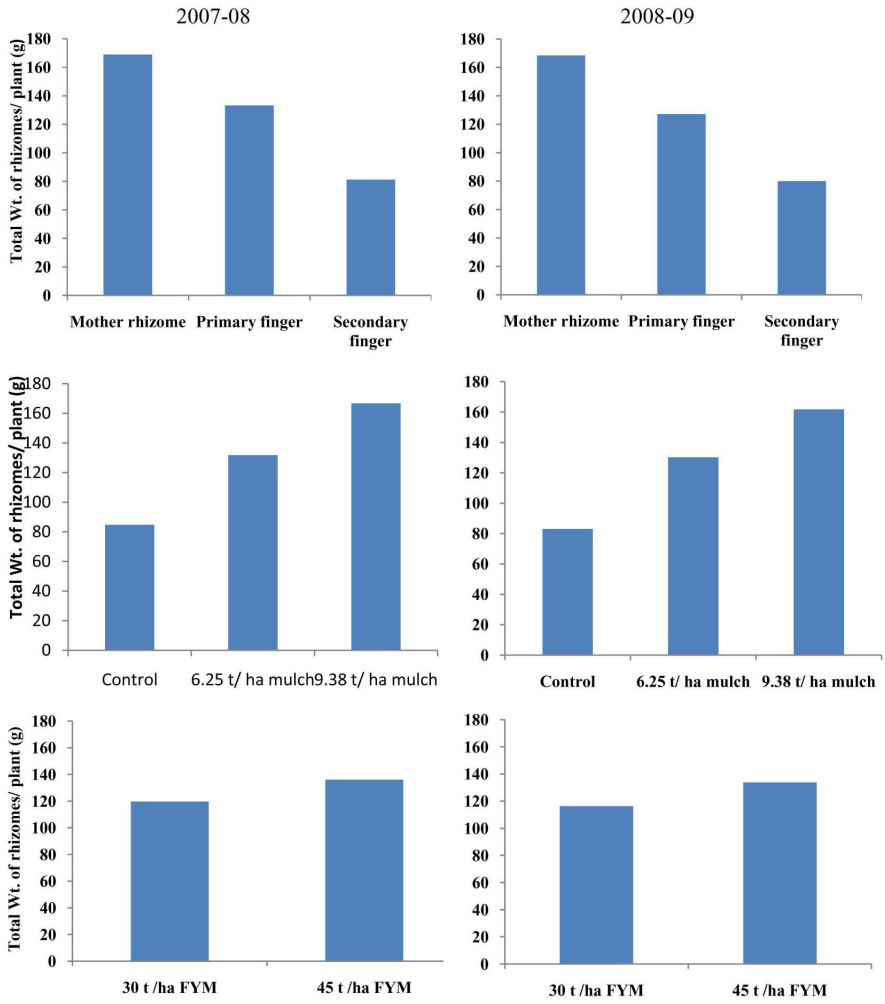

Fig. 2. Effect of different planting material, mulch levels and farmyard manure levels on total weight of rhizomes per plant

Table 3. Effect of different planting material, mulch and farmyard manure levels on quality parameters.

Treatment	Oil content (%)		Oil yield (litre/ha)		Curcumin content (%)		Curcumin yield (kg/ha)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Planting material								
Mother rhizome	7.6	7.3	436.2	394.9	2.6	2.7	149.2	146.1
Primary fingers	7.4	7.1	329.3	301.7	2.5	2.5	111.3	106.3
Secondary fingers	7.3	7.1	192.1	166.1	1.9	1.7	50.2	39.8
SEm±	0.20	0.11	12.93	8.10	0.09	0.07	6.86	10.61
CD (P=0.05)	NS	NS	29.30	25.41	NS	NS	15.40	18.13
Mulch (t/ha)								
No Mulch	7.1	6.9	210.8	191.1	1.9	1.9	56.4	52.6
6.25	7.5	7.2	328.5	291.6	2.5	2.4	109.5	97.2
9.38	7.7	7.4	421.5	383.3	2.6	2.6	142.2	134.7
SEm±	0.20	0.11	12.93	8.10	0.09	0.07	6.86	10.61
CD (P=0.05)	NS	NS	29.30	25.41	NS	NS	15.40	18.13
FYM (t/ha)								
30	7.3	7.1	296.4	271.2	2.2	2.1	89.3	80.2
45	7.5	7.2	336.0	300.9	2.4	2.5	107.5	104.5
SEm±	0.20	0.11	12.93	8.10	0.09	0.07	6.86	10.61
CD (P=0.05)	NS	NS	29.30	25.41	NS	NS	15.40	18.13

Table 4. Effect of different planting material, mulch and farmyard manure levels on nutrient uptake by turmeric at harvest

Treatment	Nutrient uptake (kg/ha)											
	Above ground parts (leaves)						Rhizomes					
	N		P		K		N		P		K	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Planting material												
Mother rhizome	75.3	59.9	8.7	8.1	71.3	62.6	92.0	86.0	11.0	11.0	148.0	139.0
Primary fingers	58.9	40.1	6.2	4.9	55.2	46.1	69.0	65.0	8.0	7.0	114.0	107.0
Secondary fingers	47.8	34.25	4.5	4.0	42.5	38.0	38.0	33.0	5.0	4.0	67.0	58.0
SEm±	2.3	1.9	0.6	0.3	3.1	2.7	3.0	2.5	0.4	0.2	4.6	3.7
CD (P=0.05)	6.2	5.6	1.3	0.7	8.1	5.8	5.0	6.2	1.7	1.3	10.4	9.0
Mulch (t/ha)												
No Mulch	50.9	35.0	5.1	4.0	47.0	39.0	45.0	41.0	5.0	5.0	76.0	69.0
6.25	59.8	42.9	6.6	5.7	55.3	47.4	68.0	62.0	8.0	7.0	113.0	71.0
9.38	68.9	55.1	7.9	7.1	64.1	60.0	85.0	81.5	11.0	11.0	142.0	133.0
SEm±	2.3	1.9	0.6	0.3	3.1	2.7	3.0	2.5	0.4	0.2	4.6	3.7
CD (P=0.05)	6.2	5.6	1.3	0.7	8.1	5.8	5.0	6.2	1.7	1.3	10.4	9.0
FYM (t/ha)												
30	53.8	38.6	5.4	4.7	47.8	43.4	62.0	58.0	7.0	7.0	104.0	98.0
45	66.7	49.8	7.6	6.7	63.2	53.4	68.0	65.0	9.0	10.0	116.0	108.0
SEm±	2.3	1.9	0.6	0.3	3.1	2.7	3.0	2.5	0.4	0.2	4.6	3.7
CD (P=0.05)	6.2	5.6	1.3	0.7	8.1	5.8	5.0	6.2	1.7	1.3	10.4	9.0

Table 5. Effect of different planting material, mulch and farmyard manure levels on pooled yield (t/ha) and economy of turmeric crop (Data pooled over 2 years)

Treatment	Fresh rhizome yield (t/ha)	Cultivation cost ($\times 10^3$ /ha)	Net return ($\times 10^3$ /ha)	B:C ratio
Planting material				
Mother rhizome	26.5	36.4	149.1	4.10
Primary finger	20.4	33.9	116.5	3.42
Secondary finger	12.8	31.5	68.7	2.19
SEm±	0.56	0.36	3.41	0.06
CD (P=0.05)	1.82	0.90	12.80	0.26
Mulch (t/ha)				
No mulch	14.5	31.8	67.3	2.12
6.25	20.0	34.4	111.4	3.21
9.38	25.3	35.6	155.6	4.36
SEm±	0.56	0.36	3.41	0.06
CD (P=0.05)	1.82	0.90	12.80	0.26
FYM (t/ha)				
30	19.0	33.4	104.1	3.11
45	20.9	34.5	118.8	3.44
SEm±	0.56	0.36	3.41	0.06
CD (P=0.05)	1.82	0.90	12.80	0.26

Fresh rhizome @ 10 ₹/kg; planting material: mother rhizome 14.8 q/ha, primary finger 12.3 q/ha secondary finger 9.8 q/ha; FYM @ 80₹/t; Mulch @ 400 ₹/t

cantly influenced by plant material, mulch and farmyard manure application. (Table 3). These results are in accord with those of Sanwal *et al*. (2007).

Oil and curcumin yield

As the size of the planting material decreased from mother rhizome to primary fingers and then to secondary fingers, there was a significant reduction in the oil and curcumin yield. The use of primary and secondary finger as planting material resulted in 24.5 and 55.8 percent reduction in oil yield, respectively during the first year and 23.6 and 57.9 percent during the second year as compared to mother rhizome planting material (Table 3). Each successive increase in mulch level increased the oil and curcumin yield significantly, and the highest oil and curcumin yield was obtained with the mulch application @ 9.38 t/ha, which was significantly higher than mulch application @ 6.25 t/ha and no mulch (Table 3). Application of 45 t/ha farmyard manure produced significantly higher oil and curcumin yield as compared to 30 t/ha farm yard manure.

Nutrient uptake

The N, P and K uptake by leaves and rhizomes of turmeric decreased significantly with a decrease in size of planting material from mother rhizome to primary and secondary fingers (Table 4). Increased mulch and FYM levels significantly increased N, P and K uptake by leaves and rhizomes of turmeric (Table 4). Similar results were reported by Gill *et al* (1999).

Economics

The maximum net returns and benefit: cost (B:C) ratio were obtained with mother rhizome planting material; significantly higher than primary and secondary finger planting material (Table 5). There was a significant increase in net return and B: C ratio with each increase in mulch level and the maximum net return and B: C ratio were obtained with 9.38 t/ha mulch, significantly higher than mulch application at 6.25 t/ha and no mulch. Application of 45 t/ha FYM resulted in significantly higher net return and B: C ratio as compared to 30 t/ha FYM (Table 5).

Mother rhizome planting material and application of 9.30 t/ha mulch and 45 t/ha FYM were the best for higher productivity and profitability in turmeric.

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