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Influence of different nutrient sources and mulching on yield attributes, Rhizome yield and profitability of turmeric crop

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Abstract
In the present study, A two year field experiment was conducted at the Agronomy Research Farm of A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya, U.P during Kharif seasons of 2017-18 and 2018-19 to evaluate the effect of different nutrient sources and mulching on yield attributes, yield and profitability of turmeric crop. The experiment was conducted in Randomized Block Design with 12 treatments and three replications. Two Treatments comprised of chemical fertilizer inputs [T_1 (100% NPK through Recommended Dose of Fertilizers) and T_4 (100% NPK + 40 kg S/ha)]; four comprised of organic inputs [T_2 (100% N {through FYM}), T_3 (100% N {through Vermi Compost}), T_8 (100% N {FYM}+ mulch) & T_9 (100% N {VC}+ mulch)] and six comprised of a mixture of Inorganic & organic inputs [T_5 (100% N {FYM}+ 40 kg S/ha), T_6 (100% N {VC}+ 40 kg S/ha), T_7 (100% NPK + mulch), T_{10} (100% NPK + 40 kg S/ha + mulch), T_{11} (100% N {FYM}+ 40 kg S/ha + mulch) & T_{12} (100% N {VC}+ 40 kg S/ha + mulch)].
The data revealed that the number of rhizomes, weight of rhizomes, fresh and dry rhizome yield increased significantly with mulch and sulphur combined application over no mulch treatments. The application of mulch conserves moisture and lowers soil temperature as compared to pure crop of turmeric and this might have contributed to better growth of plant which leads to improved crop yield. Maximum benefit:cost ratio was observed with T_{12} followed by T_{11} with the ratio of 2.61 and 2.88 during both the years of 2017-18 and 2018-19, respectively. The minimum (1.38) benefit:cost ratio was recorded in T_3 during 2017-18 and was minimum (1.63) in T_2 during 2018-19. The results showed that application of mulch proved to be more profitable in turmeric cultivation.

Keywords: Turmeric, yield, rhizome, benefit:cost ratio, mulching, organic nutrient source

Introduction
Turmeric (*Curcuma longa* L.) is a perennial herbaceous plant of the family, Zingiberaceae, having its importance as a spice, flavoring agent, colorant and its use in most of the systems of medicine in the treatment of various diseases. It is native to southeast India. Turmeric (*Curcuma longa* L.) is an important spice crop of India and many other Asian countries. Turmeric grows well in Andhra Pradesh, Maharashtra, Orissa, Tamil Nadu, Karnataka, Kerala and some parts of North East India including Assam. Turmeric is widely cultivated mainly for its rhizomes. It is used both as spice and as a raw material for dye making and cosmetic industries. Turmeric rhizome contains around 3% curcumin, 2.2% α–phellandrene, 1.5% terpinolene and other essential oils. These essential oils/ alkaloids have very good medicinal properties (Khanna, 1999) [4]. Curcumin, the primary pigment of turmeric, is generally used in various food industries as a food colourant.
Turmeric being a long duration (8-9 months) exhaustive crop, reacts well to nutrition. Therefore, optimum dose of nutrients is essential to get good yield. Chemical fertilizers, herbicides and pesticides used in agriculture for increasing yield and controlling weeds and pests can contaminate the water, air and food, decrease soil fertility, inhibit growth of soil microorganisms and can cause human health hazards. This negative effect of agricultural practices could be upturned by the correct utilization of manures and/ or crop residues within cropping system either alone or in combination with organic fertilizer (Mandal *et al.*, 2007) [5]. The application of different organic sources such as the farm yard manure, vermicompost and neemcake results in to high yield and quality rhizomes. It will not only be useful for sustainable agricultural practices but will also avoid chemical- based farming. Consistent and indiscriminate use of inorganic fertilizers has caused serious damage to the soil and ecology.
In modern years, organic agriculture has been gaining considerable importance and many farmers are switching over to this traditional method of cultivation as a means to produce safe

foodstuff and conserve the environment. Application of organic manures has various advantages like improving soil physical properties, water holding capacity and organic carbon content apart from supplying good quality of nutrients (Singh *et al*., 2009) [10]. Mulching is an important component in the management practices of turmeric. In the dry months, it conserves the moisture in the soil and enhances soil temperature for proper germination of the rhizome. In addition, it improves physical properties of soil and minimizes weed competition by checking weed growth. It also enriches the fertility of soil after its *in situ* decomposition through carbon enrichment. Organic mulches are efficient in reduction of nitrate leaching, improvement of soil physical properties, prevention of erosion, improving nitrogen balanceas well as enhancing soil biological activity (Bhardwaj, 2011) [1]. After decomposition, organic mulches return organic matter and plant nutrients to the soil and improve its physical, chemical and biological properties after decomposition, which in turn increases the crop yield. Further it prevents washing out of soil and nutrients during heavy rains (Mohanty, 1991) [7]. Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops (Kumar *et al*., 1990). Hence, considering these facts, the present study was undertaken to evaluate the effect of different nutrient sources and mulching on yield attributes, yield and economics in turmeric cultivation.

Materials and methods

The two years field experimentation was conducted at the Agronomy Research Farm of A.N.D. University of Agriculture and Technology, Kumarganj, Ayodhya, U.P during 2017-18 and 2018-19. Climate of the area is sub-tropical and sub-humid with an average annual rainfall of around 1040 mm. The planting of turmeric (var. Narendra Haldi-1) was done in the 3rd week of March during both the years. The soil of the experimental field is alluvial, developed from the alluvium deposited by river, partially reclaimed sodic soil belongs to the order Inceptisol with silt loam texture. The analyzed data of soil revealed that the soil was low in organic carbon, available nitrogen, medium in available phosphorus, high in available potassium and low in available sulphur and with alkaline in reaction. The experiment was conducted in Randomized Block Design with 12 treatments and three replications. The experiment consists of 12 treatments *viz.*T_1 -100% NPK(RDF), T_2- 100% N (through FYM), T_3- 100% N(VC), T_4- 100% NPK + 40 kg S/ha, T_5- 100% N (FYM) +40 kg S/ha, T_6- 100% N(VC) +40 kg S/ha, T_7- 100% NPK + mulch, T_8- 100% N (FYM) + mulch,T_9 - 100% N(VC) + mulch, T_{10}- 100% NPK+40 kg S/ha+ mulch, T_{11}- 100% N (FYM) +40 kg S/ha+ mulch,T_{12}- 100% N(VC) +40 kg S/ha+ mulch. The recommended dose of fertilizer was 150-60-120 and paddy straw mulch was applied @ of 10 t/ha. Sulphur was applied @ 40kg/ha. The data were recorded after harvesting on number of primary and secondary rhizome per plant, weight of mother, primary and secondary rhizome in gram per plant. The total yield of rhizomes obtained from different were calculated and converted to per hectare yield.

Result and discussion

Yield and yield attributes

The rhizome yield and yield parameters of turmeric crop are presented in Tables 1, 2 and 3 for 2017-18 and 2018-19. The data were recorded after harvesting of the crops. The data revealed that the fresh rhizome yield increased significantly with mulch and sulphur combined application, which was 18.7% and 18.6% higher over no mulch during 2017-18 and 2018-19 over no mulch treatment (T_1). Among the effect of different nutrient sources individually, it was observed that the application of organic N sources in the form of FYM (T_2) and Vermicompost (T_3) resulted in significantly higher rhizome yields during both seasons, 2017-18 (21.9 t/ha and 21.6 t/ha respectively) and 2018-19 (24.3 t/ha and 23.4 t/ha respectively). Almost similar trend was observed in case of dry rhizome yield during both the years. The data revealed that in general, the number of primary and secondary rhizomes increased significantly with the application of mulch over non-mulch treatments and was maximum in T_{12} receiving nutrients through vermicompost and sulphur along with paddy straw mulch @10 t/ha which was 7.9 and 8.3 primary rhizomes/plant and 14.7 and 15.0 secondary rhizomes/plant during 2017-18 and 2018-19, respectively. This might have enhanced the fresh rhizome yield. Similarly weight of mother, primary and secondary rhizome per plant was significantly higher with mulch application as compared to no mulch during 2017-18 and 2018-19.

Table 1: Effect of different nutrient management practices and mulching on number of primary and secondary rhizome of turmeric per plant

Treatment	Primary rhizome/plant		Secondary rhizome/plant	
	2017-18	2018-19	2017-18	2018-19
100% N NPK (150-60-120)	4.1	4.5	8.7	8.6
100% N FYM	5.0	5.3	9.6	9.8
100% N VC	4.9	5.5	9.4	10.2
100% NPK + 40 kg S/ha	5.9	5.7	10.0	10.4
100% N(FYM) + 40 kg S/ha	5.8	6.3	10.7	11.5
100% N(VC) + 40 kg S/ha	5.7	6.2	10.9	11.3
100% N NPK + paddy straw mulch @ 10t/ha	6.5	6.4	11.8	12.0
100% N (FYM) + paddy straw mulch @ 10t/ha	7.2	7.5	13.3	13.7
100% N (VC)+ paddy straw mulch @ 10t/ha	6.8	7.2	13.2	13.9
100% N NPK+ mulch + 40 kg S/ha	6.7	7.0	12.7	13.0
100% N (FYM) + mulch+40 kg S/ha	7.6	8.0	14.4	14.6
100% N (VC) + mulch+40 kg S/ha	7.9	8.3	14.7	15.0
SE (m) ±	0.2	0.1	0.4	0.5
CD (p=0.05)	0.5	0.4	1.3	1.5

Table 2: Effect of different nutrient management practices and mulching on weight of rhizome (g) / plant of turmeric

Treatment	Mother rhizome(g)		Primary rhizome(g)		Secondary rhizome(g)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
100% N (through NPK) (150-60-120)	38.1	41.3	112.6	120.4	17.1	20.1
100% N (Through FYM)	40.4	44.8	120.3	125.3	20.4	23.2
100% N (Through VC)	43.2	47.2	125.8	133.2	22.3	25.8
100% NPK+ 40 kg S/ha	44.6	48.6	124.1	132.2	25.5	27.4
100% N (FYM) + 40 kg S/ha	48.3	54.5	137.4	147.3	29.8	30.6
100% N(VC)+ 40 kg S/ha	49.2	53.8	135.7	145.6	26.9	31.8
100%N (NPK) + Paddy straw mulch @ 10t/ha	50.5	54.1	137.6	148.8	30.4	32.6
100% N (FYM) + paddy straw mulch @ 10t/ha	56.8	61.1	146.3	158.8	35.1	37.5
100% N (VC)+ paddy straw mulch @ 10t/ha	58.9	62.8	141.6	152.4	32.7	34.8
100% N NPK+ mulch + 40 kg S/ha	55.2	59.4	146.8	157.5	33.8	35.8
100% N (FYM) + mulch + 40 kg S/ha	63.5	68.2	152.3	165.2	35.2	38.3
100%N (VC) + mulch + 40 kg S/ha	60.2	65.6	160.4	170.4	38.6	40.7
SE (m) ±	2.8	2.9	4.5	4.4	1.6	1.6
CD (p=0.05)	8.2	8.6	13.1	12.8	4.6	4.8

Table 3: Effect of different nutrient management practices and mulching on fresh and dry rhizome yield (t/ha) of turmeric

Treatment	Fresh yield (t/ha)		Dry yield (t/ha)	
	2017-18	2018-19	2017-18	2018-19
100% N (NPK) (150-60-120)	19.9	21.6	5.1	5.4
100% N (FYM)	21.9	23.4	5.6	5.9
100% N (VC)	21.6	24.3	5.6	6.2
100% NPK + 40 kg S/ha	23.9	25.4	6.1	6.4
100% N (FYM) + 40 kg S/ha	24.6	27.0	6.6	6.8
100% N(VC) + 40 kg S/ha	25.2	26.7	6.2	6.7
100% N NPK + paddy straw mulch @ 10t/ha	26.1	27.4	6.7	6.9
100% N(FYM) + paddy straw mulch @ 10t/ha	28.5	30.8	7.3	7.8
100% N (VC) + paddy straw mulch @ 10t/ha	27.3	29.7	7.0	7.5
100% N NPK+ mulch + 40 kg S/ha	27.3	29.1	7.0	7.4
100%N (FYM) + mulch+40 kg S/ha	29.7	31.8	7.7	8.1
100% N (VC) + mulch+40 kg S/ha	30.7	33.0	7.9	8.4
SE (m) ±	0.6	0.8	0.14	0.2
CD (p=0.05)	1.92	2.41	0.42	0.63

The application of mulch conserves moisture and lowers soil temperature as compared to pure crop of turmeric (Singh 1992) [9] and this might have contributed to better growth of plat which leads to improved crop yield. The beneficial effect of mulch application on rhizome yield, number and weight of rhizome per plant have also been reported by Junior *et al*. (2005) [3], Gill *et al.* (1999) [2], Manhas (2009) [6], Verma and Sarnaik (2006) [11]. Among the different nutrient sources application of S@ 40kg/ha also shows beneficial effect on the number and weight of rhizomes during both the years. However, least number of primary and secondary rhizome and lowest weight of rhizomes per plant was recorded in treatment T_1 receiving only recommended dose of nutrients through chemical fertilizer.

Economics

The economics for effect of different nutrient sources and mulching was also worked out and is represented in table 4. The maximum cost of cultivation (Rs 201.4 $\times 10^3$) was observed with 100% N through VC along with S @40kg/ha, followed by 100% N through VC (Rs 199.9×10^3) and minimum (Rs 166.6×10^3) cost of cultivation is recorded in 100% N through chemical fertilizer along with paddy straw mulch and sulphur application, this might be due to the reduced cost of chemical fertilizer and also reduced weeding cost because of mulch application. In case of net return treatment with mulch application i.e. T_{12} and T_{11} higher net return of Rs 488.5×10^3 and Rs 539.1×10^3during 2017-18 and 2018-19, respectively. Similarily, maximum benefit:cost ratio was also observed with T_{12} followed by T_{11} with the ratio of 2.61 and 2.88 during both the years of 2017-18 and 2018-19, respectively. The minimum (1.38) benefit:cost ratio was recorded in T_3 during 2017-18 and was minimum (1.63) in T_2 during 2018-19. The results showed that application of mulch proved to be more profitable in turmeric cultivation The cost of cultivation can be reduced substantially if the farmers resort to produce FYM and vermicompost by themselves using available organics wastes/plant residues etc. rather than purchasing the readymade one. If so, these treatments can turn out to be the most cost effective (Shamrao *et al.* 2013) [8].

Table 4: Effect of different nutrient management practices and mulching on economics of turmeric

Treatment	Cost of cultivation (Rs/ha ×10^3)	Gross Return (Rs/ha ×10^3)		Net Return (Rs/ha ×10^3)		B:C	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
100% N NPK (150-60-120)	177.3	437.8	475.2	260.5	297.9	1.47	1.68
100% N FYM	195.4	481.8	514.8	286.3	319.4	1.46	1.63
100% N VC	199.9	475.2	534.6	275.2	334.7	1.38	1.67
100% NPK+ 40 kg S/ha	178.8	525.2	558.8	347.2	380.0	1.94	2.12
100% N (FYM) + 40 kg S/ha	196.9	561.0	594.0	364.0	397.1	1.84	2.02
100% N(VC) + 40 kg S/ha	201.4	532.4	587.4	330.9	386.0	1.64	1.92
100% N NPK + paddy straw mulch @ 10t/ha	165.1	574.2	602.8	409.1	437.7	2.48	2.65
100% N (FYM) + paddy straw mulch @ 10t/ha	180.9	627.0	677.6	446.1	496.7	2.47	2.74
100% N (VC) + paddy straw mulch @ 10t/ha	185.4	600.6	653.4	415.2	468.0	2.24	2.52
100% NPK+ mulch + 40 kg S/ha	166.6	600.6	640.2	434.0	473.6	2.60	2.84
100% N (FYM) + mulch + 40 kg S/ha	182.4	653.4	699.6	471.0	517.2	2.58	2.83
100% N (VC) + mulch+40 kg S/ha	186.9	675.4	726.0	488.5	539.1	2.61	2.88

Conclusion

The rhizome yield, yield attributing characters and profitability of turmeric were influenced by the application of paddy straw mulch along with organic nutrient sources. Much improvement in soil physical, chemical and biological properties can be achieved through mulching and organic manuring in turmeric. Highest rhizome yield with highest benefit cost ratio was obtained in treatment T_{12} receiving 100% N through vermicompost with sulphur and mulch appplication during both the years.

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