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Effect of humic acid (potassium humate) on growth and yield of turmeric (*Curcuma longa* L.) in an *alfisol*

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Abstract

A field experiment was conducted at Mattuvarayapuram (Coimbatore District, Tamil Nadu) to evaluate the effect of lignite humic acid (HA) on growth and yield of turmeric (*Curcuma longa*) in an *alfisol*. The study revealed that application of 100% NPK (150:60:108 kg ha^{-1}) with HA applied to soil (10 kg ha^{-1}) + foliar spray (HA 0.1%) + rhizome dipping (HA 0.1%) significantly enhanced the growth and yield attributes, fresh and cured rhizome yield of turmeric.

Key words: *Curcuma longa*, humic acid, potassium humate, turmeric, yield.

Introduction

Turmeric (*Curcuma longa* L.) being a long duration crop, consumes greater amount of nutrients both from the soil and applied fertilizers and also requires heavy application of organic manures. Sadanandan & Hamza (1998) and Krishnamurthy *et al.* (1999) reported that the productivity of turmeric and its quality can be enhanced by application of organic manure. However, scarcity of farmyard manure (FYM) and other organic manures necessitates the use of other alternative sources in conjunction with chemical fertilizers for supplementing plant nutrients. The present investigation was therefore conducted to study the effect of humic acid (HA) as a supplementary source of nutrient, on turmeric, in an alfisol.

Materials and methods

The study was conducted at a farmer's field at Mattuvarayapuram (Coimbatore District, Tamil Nadu) during 2001. The soil at the site was sandy clay loam with pH 8.3 and EC of 0.23 dS m^{-1}, low in organic carbon (0.47%) and available nitrogen (200 kg ha^{-1}), medium in available phosphorus (11 kg ha^{-1}) and high in available potassium (420 kg ha^{-1}). The experiment was laid out in split plot design with three levels of fertilizers as main plot treatments (M_1-control, M_2-100% recommendation of N, P_2O_5 and K_2O (150:60:108 kg ha^{-1}) and M_3-75% recommendation of N, P_2O_5 and K_2O) and nine levels of HA treatments (S_1-control, S_2-0.1% HA as foliar spray (FS) on 90 and 120 days after sprouting (DAS), S_3-0.1% HA as rhizome dipping (RD), S_4, S_5, S_6 and S_7 as soil application of HA @ 10, 20, 30 and 40 kg ha^{-1} respectively, S_8-combination of S_2 and S_4 and S_9-combination of S_2, S_3 and S_4 as sub-plot treatments with three replications. The turmeric variety BSR-2 was sown

in the last week of May 2001. One sixth of N and K_2O and full dose of P_2O_5 were applied as basal and the remaining quantities of N and K were top dressed @ 25 and 18 kg ha^{-1} respectively, at 30, 60, 90,120 and 150 days after planting. Light and frequent irrigations were given till the rhizomes sprouted and subsequent irrigations were given as per crop need.

The application of four graded levels of HA as potassium humate was applied to soil prior to sowing after mixing with sand. Rhizome dipping was done with potassium humate 0.1% solution for 30 min prior to sowing. Foliar spray of HA 0.1% was given during 90 and 120 DAS by dissolving the required quantity of potassium humate in water.

The data on yield and yield attributes, number and weight of mother, primary and secondary rhizomes were recorded at harvest. Fresh weight of rhizomes was recorded immediately after harvest and curing percentage of rhizomes and the cured rhizome yield were also calculated.

Results and discussion

Among the treatment combinations, 100% NPK + soil application of HA @ 10 kg ha^{-1} + 0.1% foliar spray at 90 and 120 DAS + 0.1% rhizome dipping (M_2S_9) was significantly superior to other treatment combinations in improving plant height (Table 1).

Treatments receiving HA in combination with NPK fertilizers recorded higher range of yield attributes with respect to number of mother, primary and secondary rhizomes $plant^{-1}$ (2.70 to 3.56, 8.40 to 11.93 and 13.70 to 17.35 rhizomes $plant^{-1}$, respectively) than those receiving NPK fertilizer treatments only (2.53 to 3.02, 7.55 to 9.40 and 13.20 to 14.34 rhizomes $plant^{-1}$ respectively) (Table 2).

The weight of mother, primary and secondary rhizomes of turmeric was significantly influenced by the application of HA fertilizers and their interactions (Table 3). The best treatment combination was M_2S_9 in which 195, 426 and 181 g $plant^{-1}$ of mother, primary and secondary rhizomes, respectively, were obtained. These results may be attributed to the formation of carbonic acid owing to the dissolution of CO_2 in soil moisture which might have loosened and flocculated the soil leading to better aeration with greater water availability and encouraging plant growth. Similar findings were also reported by Velmurugan (2002).

Table 1. Influence of humic acid and NPK fertilizers on plant height of turmeric

Treatment	Plant height (cm)															
	90 DAS				120 DAS				150 DAS				180 DAS			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	41.8	54.0	53.0	49.6	46.4	58.5	58.2	54.3	53.9	63.3	61.3	59.5	57.2	70.8	68.5	65.5
S_2	41.8	54.0	53.4	49.7	50.7	60.0	59.5	56.7	54.8	65.5	63.3	61.2	59.5	74.0	71.5	68.3
S_3	43.8	54.5	54.0	50.8	51.3	61.6	59.0	57.3	55.0	65.8	63.4	61.4	59.9	74.7	71.3	68.6
S_4	44.5	55.6	55.0	51.7	52.5	60.6	60.1	57.7	55.5	66.3	64.4	62.0	60.8	76.3	72.5	69.9
S_5	44.8	56.0	55.2	52.0	53.0	61.2	60.5	58.2	54.7	65.6	64.5	61.6	60.6	76.4	73.1	70.0
S_6	44.7	55.8	55.2	51.9	52.9	61.0	60.3	58.1	55.5	66.4	64.4	62.1	59.3	75.7	72.9	69.3
S_7	44.2	55.1	54.5	51.3	52.1	60.3	59.7	57.4	55.3	66.1	63.8	61.7	60.3	75.4	71.6	69.1
S_8	44.9	56.1	55.5	52.1	53.2	61.4	61.0	58.5	55.9	66.6	64.6	62.4	61.2	76.8	73.4	70.4
S_9	45.0	56.5	55.8	52.4	53.7	61.9	61.3	59.0	56.3	67.2	64.9	62.8	61.4	77.5	74.3	71.0
Mean	43.9	55.3	54.6	51.3	51.7	60.7	60.0	57.5	55.2	65.8	63.8	61.6	60.0	75.3	72.1	69.1
	M	S	MxS		M	S	MxS		M	S	MxS		M	S	MxS	
CD (P=0.05)	0.7	0.3	0.8		0.8	0.4	0.8		1.0	0.5	1.2		1.1	0.6	1.3	

M_1=Control; M_2=100% NPK; M_3=75% NPK

S_1=Control; S_2=0.1% HA foliar spray at 90 and 120 DAS; S_3=0.1 % HA as rhizome dipping; S_4=Soil application of HA @ 10 kg ha^{-1}; S_5=Soil application of HA @ 20 kg ha^{-1}; S_6=Soil application of HA @ 30 kg ha^{-1}; S_7=Soil application of HA @ 40 kg ha^{-1}; $S_8 = S_2 + S_4$; $S_9 = S_2 + S_3 + S_4$

M=Main plot; S=Sub plot; DAS=Days after sprouting

Table 2. Influence of humic acid and NPK fertilizers on production (number) of mother, primary and secondary rhizomes in turmeric

Treatment	No. of mother rhizomes plant^{-1}				No. of primary rhizomes plant^{-1}				No. of secondary rhizomes plant^{-1}			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	1.00	3.02	2.53	2.18	2.85	9.40	7.55	6.60	4.10	14.34	13.20	10.55
S_2	1.28	3.29	2.72	2.43	3.70	10.62	8.42	7.58	5.27	15.45	13.72	11.58
S_3	1.24	3.26	2.70	2.40	3.68	10.58	8.40	7.55	5.24	15.25	13.70	11.40
S_4	1.30	3.37	2.77	2.48	3.80	10.89	9.55	8.08	5.43	16.00	14.90	12.11
S_5	1.39	3.47	2.83	2.56	3.91	11.24	10.72	8.62	5.60	16.88	15.25	12.58
S_6	1.34	3.42	2.80	2.52	3.86	11.06	9.64	8.19	5.52	16.41	15.06	12.33
S_7	1.28	3.35	2.73	2.45	3.71	10.75	9.49	7.98	5.35	15.75	14.81	11.97
S_8	1.43	3.50	2.88	2.60	4.00	11.59	10.84	8.81	5.69	17.10	15.42	12.74
S_9	1.48	3.56	2.91	2.65	4.10	11.93	10.95	8.99	5.80	17.35	15.65	12.93
Mean	1.30	3.36	2.76		3.73	10.90	8.51		5.33	16.06	12.97	
	M	S	M x S		M	S	M x S		M	S	M x S	
CD (P=0.05)	0.36	0.12	0.36		0.83	0.40	0.91		1.38	0.37	1.51	

M_1=Control; M_2=100% NPK; M_3=75% NPK
S_1=Control; S_2=0.1% HA foliar spray at 90 and 120 DAS; S_3=0.1 % HA as rhizome dipping; S_4=Soil application of HA @ 10 kg ha^{-1}; S_5=Soil application of HA @ 20 kg ha^{-1}; S_6=Soil application of HA @ 30 kg ha^{-1}; S_7=Soil application of HA @ 40 kg ha^{-1}; S_8 =S_2 + S_4; S_9=S_2 + S_3 + S_4
M=Main plot; S=Sub plot

Table 3. Influence of humic acid and NPK fertilizers on production (weight) of mother, primary and secondary rhizomes in turmeric

Treatment	Weight of mother rhizome plant^{-1} (g)				Weight of primary rhizome plant^{-1} (g)				Weight of secondary rhizome plant^{-1} (g)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	95	169	140	135	175	365	290	277	80	154	135	120
S_2	96	175	144	138	186	395	318	300	83	162	144	126
S_3	97	176	146	140	188	397	316	300	83	161	145	126
S_4	100	180	150	143	189	403	323	305	85	166	150	130
S_5	103	184	154	147	199	412	309	307	89	172	155	135
S_6	101	182	152	145	196	410	314	307	87	169	153	133
S_7	98	178	148	141	191	403	320	305	84	163	147	128
S_8	105	185	155	148	200	413	330	314	90	171	157	136
S_9	106	195	158	153	208	426	338	324	95	181	162	139
Mean	100	180	150		193	403	318		86	166	139	
	M	S	M x S		M	S	M x S		M	S	M x S	
CD (P=0.05)	7	4	9		10	7	12		7	3	8	

M_1=Control; M_2=100% NPK; M_3=75% NPK
S_1=Control; S_2=0.1% HA foliar spray at 90 and 120 DAS; S_3=0.1 % HA as rhizome dipping; S_4=Soil application of HA @ 10 kg ha^{-1}; S_5=Soil application of HA @ 20 kg ha^{-1}; S_6=Soil application of HA @ 30 kg ha^{-1}; S_7=Soil application of HA @ 40 kg ha^{-1}; S_8 =S_2 + S_4; S_9=S_2 + S_3 + S_4
M=Main plot; S=Sub plot

The fresh rhizome yield of turmeric was significantly influenced by the application of HA and fertilizers (Table 4). In HA treatments, S_9 (soil application of HA @ 10 kg ha^{-1} + 0.1% foliar spray at 90 and 120 DAS + 0.1% rhizome dipping) recorded the maximum mean yield of fresh rhizome (21.7 t ha^{-1}), followed by S_8 (soil application of HA @ 10 kg ha^{-1} + 0.1% foliar spray at 90 and 120 DAS) (21.4 t ha^{-1}) and S_5 (soil application of HA @ 20 kg ha^{-1}) (21.2 t ha^{-1}). These three treatments were significantly superior to other HA treat-

Table 4. Influence of humic acid and NPK fertilizers on yield of fresh rhizomes, curing percentage and cured rhizome yield of turmeric

Treatment	Fresh yield (t ha^{-1})				Curing %				Cured rhizome yield (kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	9.8	21.7	20.3	17.3	18.6	20.3	19.2	19.3	1824	4401	3898	3374
S_2	10.5	23.5	21.6	18.5	19.0	20.9	20.0	20.0	1989	4908	4311	3736
S_3	10.5	23.7	21.8	18.7	19.1	21.0	20.0	20.0	2007	4984	4364	3785
S_4	11.0	26.2	22.6	19.9	19.4	21.5	20.4	20.4	2138	5640	4618	4132
S_5	11.5	27.5	24.6	21.2	19.5	21.9	20.7	20.6	2249	6023	5092	4455
S_6	11.3	26.3	23.6	20.4	19.5	21.5	20.5	20.5	2204	5663	4852	4240
S_7	10.9	24.7	22.4	19.3	19.3	21.3	20.2	20.3	2104	5261	4525	3963
S_8	11.6	27.8	24.9	21.4	19.6	21.9	21.0	20.8	2274	6088	5222	4528
S_9	11.8	28.1	25.2	21.7	19.7	22.0	21.2	21.0	2318	6182	5342	4614
Mean	11.0	25.5	23.0		19.3	21.3	20.4		2124	5454	4695	
	M	S	M x S		M	S	M x S		M	S	M x S	
CD (P=0.05)	0.5	0.3	0.7		0.5	0.4	0.5		103	43	135	

M_1=Control; M_2=100% NPK; M_3=75% NPK

S_1=Control; S_2=0.1% HA foliar spray at 90 and 120 DAS; S_3=0.1 % HA as rhizome dipping; S_4=Soil application of HA @ 10 kg ha^{-1}; S_5=Soil application of HA @ 20 kg ha^{-1}; S_6=Soil application of HA @ 30 kg ha^{-1}; S_7=Soil application of HA @ 40 kg ha^{-1}; S_8 =S_2 + S_4; S_9=S_2 + S_3 + S_4

M=Main plot; S=Sub plot

ments. Among the interactions, M_2S_9 (28.1 t ha^{-1}), M_2S_8 (27.8 t ha^{-1}) and M_2S_5 (27.5 t ha^{-1}) were significantly superior over other combinations.

Application of HA significantly improved curing percentage and S_9 (soil application of HA @ 10 kg ha^{-1} + 0.1 % foliar spray at 90 and 120 DAS + 0.1% rhizome dipping) and S_8 (soil application of HA @ 10 kg ha^{-1} + 0.1% foliar spray at 90 and 120 DAS) recorded higher mean values (21.0% and 20.8%, respectively). Among the treatment combinations, M_2S_9 (22.0%) M_2S_8 (21.9%) and M_2S_5 (21.9%) were significantly superior to other treatment combinations.

All the HA treatments were significantly superior to no HA in improving the cured rhizome yield. Among the treatment combinations, the yield of cured rhizome was significantly higher in M_2S_9 (6182 kg ha^{-1}), M_2S_8 (6088 kg ha^{-1}) and M_2S_5 (6023 kg ha^{-1}). Sellamuthu (2002) reported similar higher yield in sugarcane with the combined application of NPK + soil application of HA in *alfisol* and *inceptisol*. Schnitzer (1978) reported that the favourable effect of humic substances in stimulating growth, yield and yield attributes could be attributed to the presence of auxin like properties in HA. In the present investigation, the stimulated growth and yield attributes were observed at lower levels of HA (10 and 20 kg ha^{-1}) beyond which (30 and 40 kg ha^{-1}) a negative effect was noticed even though the growth and yield attributes were enhanced. Similar findings were reported by Rao *et al.* (1987) in sorghum where an increased shoot weight with application of HA was observed at 20-30 kg HA ha^{-1} and though the highest level of HA application (40 kg ha^{-1}) increased the shoot weight, it showed a significant negative effect when compared to that of 30 kg ha^{-1} level, indicating that the HA level of 30 kg ha^{-1} was optimum for sorghum.

It can be concluded that, application of 100% NPK with HA applied to soil (10 kg ha^{-1}) + HA foliar spray (0.1%) + HA rhizome dipping (0.1%) in *alfisol* boosted the yield of cured rhizome in turmeric. Among the methods of humic acid application, soil application of HA was superior in improving the fertility status as compared to foliar spray and rhizome dipping. Therefore, the treatment that received 100 % NPK + 20 kg HA ha^{-1} as soil application would be the best treatment for adoption.

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