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Growth, Yield, N uptake of Turmeric (*Curcuma longa* L.) in Alfisol as affected by lignite humic acid.

K. BASKAR

Associate Professor (SS &AC), Agricultural Research Station, Tamil Nadu Agricultural University, Kovilpatti, Tamil Nadu, 628 501. Email : kolappanbaskar@rediffmail.com

The importance of soil organic matter both as a direct or indirect source of plant nutrient elements has been very well stressed and highlighted. In plant nutrition, organic matter level plays a significant role in deciding the availability status of essential nutrients. Considering the importance of soil humus in stimulating the plant growth and influencing the soil physical environment, it has become necessary to apply humus matter extracted from coal, peat and lignite apart from other organics (FYM, composted coir pith, sludge, *etc.)* to soil in order to sustain the soil fertility and productivity. Several scientists tested the usability of lignite which contains high content of humic acid substances (Stevenson, 1994 and Schnitzer, 2000). Narayanan (1989) revealed that the Neyveli lignite with the very low ash content was the best suited for production of humic acids.

Turmeric being a long duration crop, it removes greater amount of nutrients both from the soil and as well as the applied fertilizers. For a healthy crop of turmeric, 20-25 t ha^{-1} of organic manure is needed.

Table 1. Plant height (cm) of turmeric in Alfisol as influenced by humic acid.

(Mean of three replications)

Treatment	90				120				150				180			
	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	670.6	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	61.5	61.0	58.5	55.9	66.7	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	

Information on the use of organics on the production of high quality turmeric and curcumin is limited. The availability of FYM and other organic manures is becoming scarce which forced the use of humic acid in conjunction with chemical fertilizers. Application of composted coir pith plus NPK had given the highest rhizome yield of 28 t ha^{-1} followed by press mud plus NPK (27.3 t ha^{-1}) and FYM plus NPK (24.2 t ha^{-1}) (Selvakuinari and Baskar, 1998). Thus the present investigation was taken up to evaluate organic product (lignite humic acid) in the form of potassium either alone or in combination with inorganics in alfisol turmeric.

The field experiment was conducted in farmer's holding at Mattuvarayapuram of Coimbatore district, Tamil Nadu. The test crop of turmeric (BSR 2) was planted during June 2001 and harvested on March 2002. The soil of the experimental site belonged to Somayanur series and according to USDA soil taxonomy it could be classified as fine, loamy, mixed isohyperthermic, calcareous, Udic Haplustalf having the following general characteristics: sand 60.1 per cent, silt 17.2 per cent and clay 22.7 per cent, water holding capacity 41.2 per cent, pH (1: 2.5 w/v; H_2O) 8.3, electrical conductivity 0.23 dSm^{-1}, cation exchange capacity 15.2 cmol (p+) kg^{-1}, available nitrogen 200 kg ha^{-1} available phosphorus 11 kg ha^{-1} and available potassium 420 kg ha^{-1}.

The experiment was laid out in a split plot design having three levels of NPK (M_1- control, M_2 - 100 per

Table 2. Influence of humic acid on cured rhizome yield (kg ha^{-1}) of turmeric in Alfisol.

(Mean of three replications)

Treatment	Cured rhizome yield (kg ha^{-1})			
	M_1	M_2	M_3	Mean
S_1	1824	4401	3898	3374
S_2	1989	4908	4311	3736
S_3	2007	4984	4364	3785
S_4	2138	5640	4618	4132
S_5	2249	6023	5092	4455
S_6	2204	5663	4852	4240
S_7	2104	5261	4525	3963
S_8	2274	6088	5222	4528
S_9	2318	6182	5342	4614
Mean	2124	5454	4695	
	M	S	M x S	
SEd	51	21	65	
CD (p= 0.05)	103	43	135	

cent NPK and M_3 - 75 per cent NPK) in the main plots and nine levels of humic acid (HA) *viz.,* S_1 - control, S_2 - 0.1 per cent HA as foliar spray (FS) on 90 and 120 days after sowing (DAS), S_3 - 0.1 per cent HA as rhizome dipping (RD). S_4 -soil application (SA) 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_s - soil application of HA @ 10 kg ha^{-1} plus 0.1 per cent HA as foliar spray on 90 & 120 DAS and S_9 - soil application of HA @ 10 kg ha^{-1} plus 0.1 per cent HA as foliar spray on 90 & 120 DAS plus rhizome dipping each replicated three times. The recommended fertilizer dose for turmeric was applied @150:60:108 kg of N, P_2O_5 and K_2O ha^{-1}, supplied through urea, single super phosphate and muriate of potash respectively. One sixth of N and K_2O and full dose of P_2O_5 were applied basally. 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 sowing.

Humic acid was applied in different modes *viz.,* soil application, rhizome dipping and foliar spray. The application of HA as potassium humate comprised four graded level of HA (10, 20, 30 and 40 kg ha^{-1}) which were applied to soil prior to sowing after mixing with sand. The rhizome dipping was done with 0.1 per cent potassium humate

Table 3. Nitrogen uptake (kg ha^{-1}) by Turmeric rhizome at 90 DAS, 180 DAS and harvest as influenced by humic acid in Alfisol.

(Mean of three replications)

Treatment	90 DAS				180 DAS				Harvest			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S1	3.45	8.28	6.91	6.21	15.5	35.8	31.3	27.54	28.7	59.3	53.3	47.1
S2	3.43	8.26	6.87	6.19	17.6	37.7	32.8	29.39	31.5	62.5	57.0	50.3
S3	3.65	8.92	7.18	6.58	17.4	37.2	32.5	29.05	31.5	62.8	57.0	50.4
S4	3.93	9.55	7.45	6.98	19.0	40.9	34.7	31.53	34.0	68.6	61.2	54.6
S5	4.09	9.70	7.64	7.14	19.0	41.1	34.9	31.65	3.2	68.9	62.2	55.1
S6	3.86	9.32	7.44	6.87	18.4	39.9	33.7	30.65	32.8	66.3	59.5	52.9
S7	3.77	9.12	7.31	6.74	17.8	38.3	33.2	29.77	31.9	63.8	62.3	52.7
S8	3.93	9.22	7.37	6.84	19.2	41.1	34.9	31.71	33.7	68.9	64.8	55.8
S9	4.28	10.15	7.66	7.36	19.6	42.2	35.8	32.53	35.2	71.2	68.1	58.2
Mean	3.82	9.17	7.31		18.17	39.35	33.75		32.6	65.8	60.6	
	M	S	MxS		M	S	MxS		M	S	MxS	
CD(p=0.05)	0.40	0.24	0.44		1.7	1.1	1.9		2.1	1.4	2.4	

solution for 30 minutes prior to sowing. While the foliar spray of HA @ 0.1 per cent was given during 90 and 120 DAS of turmeric by dissolving the required quantity of potassium humate in water. Plant height was recorded in five randomly selected plants for each plot at different stages of growth *viz.,* 90, 120, 150 and 180 DAS. The cured rhizome yield was calculated by multiplying the fresh rhizome weight with the mean curing percentage and it was expressed as kg ha^{-1} (Natarajan and Lewis, 1980). At harvest, yield of turmeric was recorded and plant samples were collected and analysed for N (Humphries, 1956) and N uptake was calculated and statistically analysed for split plot design.

Influence of humic acid on growth of turmeric

The plant height ranged from 41.8 to 56.5 cm at 90 DAS, 46.4 to 61.9 cm at 120 DAS, 53.9 to 67.2 cm at 150 DAS and from 57.2 to 77.5 cm at 180 DAS in turmeric. At all stages of crop growth, there was improvement in the height of plants owing to the application of fertilisers, HA and their combinations. Among the treatment combinations, the treatment receiving 100 per cent NPK with 0.1 per cent foliar spray + 0.1 per cent rhizome dipping + 10 kg HA ha^{-1} as soil application (M_2S_9) was significantly superior in improving the plant height in turmeric by recording 56.5, 61.9, 67.2 and 77.5 cm followed by M_2S_8 (56.1, 61.5, 66.7 and 76.8 cm). The plant height recorded in the treatment combination M_2S_1 (receiving only 100 per cent NPK) was significantly lower when compared with the plant heights of the treatments receiving 75 per cent NPK with different modes of humic acid application. Similar effects of HA was observed by Sathiya Bama (2002) for the combined method of application *viz.,* soil application with foliar spray and root dipping in promoting root proliferation, nutrient absorption, higher growth and yield attributes in rice.

Influence of humic acid on cured rhizome yield

The yield of cured rhizome ranged from 1824 to 6182 kg ha^{-1} (Table 2). The beneficial effect of fertilizers and HA and their interactions were evident. At graded levels of NPK, M_3 (75 per cent NPK) recorded significantly lower cured rhizome yield of 4695 kg ha^{-1} as against 5454 kg ha^{-1} for M_2 (100 per cent NPK). The lowest yield of 2124 kg ha^{-1} was recorded in control (M_1). It was noteworthy to record that all the HA treatments were significantly superior to no HA application in improving the cured rhizome yield. Among the treatment combinations, the yield of cured rhizome (6182 kg ha^{-1}) obtained under M_2S_9 was comparable with M_2S_8 (6088 kg ha^{-1}) and $M_2 S_5$ (6023 kg ha^{-1}) and these three were significantly superior to the other combinations. It was also evident from the table that the treatment combinationsM_3S_9, M_3S_8, M_3S_5, and M_3S_6 (HA application with 75 per cent NPK) recorded significantly higher yield of cured rhizome (5342, 5222, 5092 and 4852 kg ha^{-1} respectively) when compared to M_2S_1 (4401 kg ha^{-1}). Similar result was reported by Baskar and Sankaran (2005b) in turmeric.

Influence of humic acid on rhizome nutrient uptake

N uptake

The uptake of N by turmeric rhizome ranged from 3.45 to 10.15 kg ha^{-1} at 90 DAS and fertilization with NPK improved the N uptake significantly (Table 3). At 180 DAS, it varied from 15.5 to 42.2 kg ha^{-1} and at harvest it increased from 28.7 to 71.2 kg ha^{-1}. In all the three stages, the uptake of N by rhizome was significantly influenced by the application of HA as compared to no HA. Among the HA treatments, S_9 and S_5 recorded at par values of 7.36 and 7.14 kg ha^{-1} respectively at 90 DAS, S_9, S_8, S_5 and S_4 registered comparable values of 32.53, 31.71, 31.65 and 31.53 kg ha^{-1} respectively at 180 DAS and S_9 recorded a value of 58.2 kg ha^{-1} of N uptake at harvest. With respect to treatment combinations, M_2S_9 was significantly superior to other combinations in respect of N uptake and registered 10.15, 42.20 and 71.20 kg ha^{-1} at 90, 180 DAS at harvest. The highest N uptake was associated with HA application at 10 kg ha^{-1} through soil along with foliar spray plus rhizome dipping each at 0.1 per cent HA concentration and this could be attributed to supplementation of soil reservoir / mineralization of organic N from HA. Similar observation with FYM was made by Bhandari *et al.* (2000) who opinioned that enhanced microbial activity of ammonifiers and nitrifiers in particular might have increased microbial mineralization of organic N and carbon. Similar result was observed in turmeric by Baskar and Sankaran (2005a).

The results of the present investigation thus indicate that application of lignite humic acid (potassium humate) in general, and combination with fertilizer in particular augmented plant growth and induced the availability of N in the turmeric rhizosphere soil resulting in greater N uptake by rhizome and increased the cured rhizome yield in turmeric.

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