adras Agric. J. 90 (10-12) : 665-670 October-December 2003

ffect of humic acid on nutrient release pattern in an Alfisol (Typic aplustalf)

. SATHIYA BAMA, G. SELVAKUMARI, R. SANTHI AND P. SINGARAM

ept. of Soil Sci. and Agrl. Chemistry, Tamil Nadu Agrl. University, Coimbatore - 641 003, Tamil Nadu

Abstract: An incubation experiment was conducted to study the influence of Humic Acid (HA) on nutrient release, organic carbon (OC) content and cation exchange capacity (CEC) of the soil. The humic acid as potassium humate was added at graded doses (20 to 80 kg ha^{-1}). A linear trend in the release of N,P and K was observed for the application of HA. The release of N was significant upto 20 kg of HA ha^{-1}, whereas for P and K it extended upto 40 kg ha^{-1}. The N and P were released for a longer period of 60 days, while K release attained a plateau on 45 days after incubation. At the end of incubation period, there was a steep and significant increase of organic carbon and CEC upto 40 kg HA ha^{-1}.

Key words : Humic acid, Release pattern of N, P, K, Organic carbon, CEC.

ntroduction

The organic matter rich soils have a timulating tendency in the process of nitrification s well as in the availability of P and K Tyler *et al.* 1974). The high content of OC nd CEC confer upon the soil, the capacity o hold the essential plant nutrients in sufficient mounts so as to provide the nutrient demanded y the crops. The increased OC and CEC could e made possible through effective management f soils. Inclusion of organic materials such s humic acid found to bring about conducive hanges in nutrient availability. To test the ffect of humic acid on nutrient release pattern he study was undertaken.

Materials and Methods

Incubation experiment was conducted with humic acid in Alfisol (Typic Haplustalf). The texture of soil was clay loam in texture with the pH and EC of 8.0 and 0.32 dSm^{-1} respectively. The organic carbon content and CEC of the soil were 0.706 per cent and 26.7 C mol (p+) kg^{-1} respectively. The soil had a low $KMnO_4$-N (238 kg ha^{-1}), medium Olsen-P (19 kg ha^{-1}) and high NH_4OAcK (670 kg ha^{-1}). The humic acid as potassium humate was added at graded doses (20 to 80 kg ha^{-1}) to the soil. A 500 g soil sample was taken in the glass bottle and the humic acid was mixed thoroughly with soil. The treated soils were replicated four times in completely randomized block design and incubated for a period of 90 days by maintaining the soil moisture at submerged condition. The soil samples were drawn at fortnight intervals and $KMnO_4$-N, Olsen-P and NH_4OAc-K were estimated. The organic carbon and CEC were estimated by adopting standard procedures. The pH, EC and Eh (Redox potential) were determined by immersing the electrode directly in the glass bottle at 90th day of incubation.

Results and Discussion

Humic acid, the main fraction of soil organic matter is a vital factor for maintenance of soil fertility. In the present investigation, an incubation experiment was conducted with different doses of HA in the form of potassium humate to find out its effect on N,P and K availability at definite intervals during incubation period and CEC and organic carbon at the end of incubation period.

Nitrogen availability

The nitrogen availability was increased with increasing doses of HA (80 kg ha^{-1}) and till 60 days after incubation (DAI). The significant increase was observed at 20 kg HA ha^{-1} and beyond that level, any further increase in HA exhibited a decrease in the increasing period (Table 1). The decrease in the increment of

Table 1. Effect of humic acid on $KMnO_4$-N content (kg ha^{-1}) in Alfisol

Treatments HA (kg ha^{-1})	Days after incubation (S)							
	0 (S_1)	15 (S_2)	30 (S_3)	45 (S_4)	60 (S_5)	75 (S_6)	90 (S_7)	Mean
0 (L_1)	240	246	250	260	267	272	275	259
20 (L_2)	240	251	263	275	277	282	284	267
40 (L_3)	240	255	264	277	279	282	286	269
60 (L_4)	240	257	266	278	282	285	288	271
80 (L_5)	240	258	266	277	283	285	287	271
Mean	240	253	262	273	278	281	284	267

CD (P=0.05)	
L	2.5
S	3.5
L at S	8.5

Table 2. Effect of humic acid on Olsen-P content (kg ha^{-1}) in Alfisol

Treatments HA (kg ha^{-1})	Days after incubation (S)							
	0 (S_1)	15 (S_2)	30 (S_3)	45 (S_4)	60 (S_5)	75 (S_6)	90 (S_7)	Mear
0 (L_1)	14.5	15.0	15.4	16.3	17.0	19.6	18.0	16.3
20 (L_2)	14.5	15.3	16.5	17.6	18.6	18.9	18.8	17.2
40 (L_3)	14.5	15.7	16.9	17.8	19.5	20.1	20.5	17.9
60 (L_4)	14.5	16.2	17.3	18.5	19.8	20.5	21.2	18.3
80 (L_5)	14.5	16.8	17.9	18.7	19.8	20.9	21.8	18.6
Mean	14.5	15.8	16.8	17.8	19.0	19.6	20.1	17.6

CD (P=0.05)	
L	0.6
S	0.7
L at S	1.7

Table 3. Effect of humic acid on NH_4OAc-K content (kg ha^{-1}) in Alfisol

Treatments HA (kg ha^{-1})	Days after incubation (S)							
	0 (S_1)	15 (S_2)	30 (S_3)	45 (S_4)	60 (S_5)	75 (S_6)	90 (S_7)	Mean
0 (L_1)	440	450	455	469	472	475	477	464
20 (L_2)	440	460	471	479	479	483	485	471
40 (L_3)	440	465	477	485	486	487	487	475
60 (L_4)	440	468	479	485	487	485	485	476
80 (L_5)	440	470	482	486	486	486	486	476
Mean	440	463	475	481	482	484	484	473

CD (P=0.05)	
L	10
S	12
L x S	22

Table 4. Effect of humic acid on soil organic carbon content and cation exchange capacity in Alfisol

HA (kg ha^{-1})	CEC (C mol (p+) kg^{-1})	Organic carbon (%)
(L$_1$)	28.3	0.672
0 (L$_2$)	30.9	0.678
0 (L$_3$)	32.5	0.685
0 (L$_4$)	34.5	0.690
0 (L$_5$)	35.8	0.689
CD	1.5	0.004

Table 5. Effect of humic acid and fertilizer on nutrient availability in Alfisol-Pot experiment

Treatments	Available N				Available P				Available K			
	M$_1$	M$_2$	M$_3$	Mean	M$_1$	M$_2$	M$_3$	Mean	M$_1$	M$_2$	M$_3$	Mean
S$_1$	185	212	218	205	12.0	16.2	16.6	14.9	452	675	735	621
S$_2$	194	217	221	211	12.4	16.4	16.9	15.2	485	701	759	648
S$_3$	201	222	229	217	13.0	16.6	17.5	15.7	502	725	775	667
S$_4$	205	227	231	221	13.4	16.9	17.9	16.1	510	740	787	679
S$_5$	211	230	240	228	13.9	17.1	18.2	16.4	517	750	799	689

CD (P=0.05)	Available N	Available P	Available K
S	8.5	0.4	18
M at S	8.8	1.1	23
S at M	9.2	0.4	22

Table 6. Effect of humic acid and fertilizer on organic carbon and cation exchange capacity in Alfisol-Pot experiment

Treatments	Organic carbon (%)				CEC (C mol (p+) kg^{-1})			
	M$_1$	M$_2$	M$_3$	Mean	M$_1$	M$_2$	M$_3$	Mean
S$_1$	0.700	0.710	0.712	0.707	20.5	26.8	27.5	24.9
S$_2$	0.722	0.730	0.732	0.728	23.1	29.8	30.3	27.9
S$_3$	0.755	0.762	0.765	0.757	25.1	32.6	33.1	30.3
S$_4$	0.787	0.790	0.790	0.786	27.5	34.8	35.2	32.5
S$_5$	0.809	0.817	0.818	0.811	28.2	36.9	37.2	34.1

CD (P=0.05)	Organic carbon (%)	CEC (C mol (p+) kg^{-1})
S	0.02	2.6
M at S	0.01	3.8
S at M	0.04	3.0

available N at HA levels higher than 20 kg ha^{-1} might be due to reduced microbial activity in the presence of some high content of phenolics produced by HA in the soil. The increase in available N might be attributed to the N contributed from the native N by the enhanced microbial activities induced by the humic acid (Deepa, 2001). Similar increase in N availability was reported by Govindasamy *et al.* (1989) for the application of HA @ 50 kg ha^{-1} and by Prasad *et al.* (1991) by the released HA from the added tree leaves.

Phosphorus availability

A linear trend in P availability was observd for graded doses of HA till the end of incubation period. However the increase was marked for 40 kg ha^{-1} and upto 60 DAI. Beyond that level, the magnitude of increase was reduced (Table 2). The increase in the availability of P could be attributed to the chemical and biochemical processes involved. The humic acids might have helped in solubilizing P from insoluble to soluble form resulting in its increase. Similar increase was reported by Khan *et al.* (1997) for the application of metal humates upto 50 ppm. Fokin and Sinha (1969) proposed that, the derived benefits of the addition of organic matter to the soils might be due to the anion replacement or competition between humate from added OM and phosphate ions on adsorbing surfaces which in turn would have increased the P availability. Sinha (1972) indicated that fulvic acids and intermediate products of organic matter decomposition had played a significant role in mobilizing fairly soluble phosphates. Pal and Sengupta (1985) observed that when black soil was incubated with humic acid, the P availability increased. The reason attributed was phosphate ions were expected to interact with humic acid more through its phenolic and hydroxyl groups which might have changed the behaviour of P. The presence of such functional groups as assessed by infrared spectra analysis would confirm similar action in the treated soil leading to increased P availability. David *et al.* (1994) found that, humus would form protective coating over sesquioxides and thereby reducing the fixation of any phosphate, which made them available in the soil. The increase in available P might also be due to the mineralisation of soil organic P (Dusberg *et al.* 1989) as well as humic acid (Vaughan and Ord, 1985). Thangavelu and Manickam (1989) reported that, the P availability was increased with application of manure due to less fixation and release of P by humic substances released during mineralisation of organic matter. These results lent support to the finding of increased P availability due to HA noticed in the present study.

Potassium availability

The availability of K increased with increasing the level of HA from 0 to 80 kg ha^{-1}. But significant increase was observed upto 40 kg ha^{-1} and beyond which the magnitude of increase was reduced as in N and P. With regard to incubation period, the significant increase was observed upto 45th DAI (Table 3) and thereafter the increase in K availability started declining. The humic acids and fulvic acids are believed to play a definite role in liberating fixed K because of their high complexing power. In addition, the lower molecular weight fractions of humic compounds are capable of penetrating the intermicellar spaces of expanding types of clays and reach the specific sorption sites for K, where they might react or compete for sites with K and increase its availability in soil (Tan and McCreery, 1975; Schnitzer and Kodama, 1972). The enhanced microbial activity due to humic acid application would also have paved way for the increased availability o K through reducing its fixation in the so and dissolution of fixed K. Further, the that contained (6.25%) in the potassium humate which was applied as a source of humic acid in the present study, would also have contributed for the increase of soil K under submerged condition. With the increasing period of incubation, the K availability increased significantly. The probable exchange between hydronium ions and exchangeable K might be a reason for the increase in K availability. Tan (1978) reported that, at pH 7.0, humic and fulvic acids were capable of dissolving small amounts of K from the minerals by chelation, complex reactions or both. The amount released was reported to increase with time and reach a maximum at 800 to 8000 hours. A steady increase in the available K from 15th to 90th day migh be due to solubilising effect caused by humic acid coupled with the release from exchangeable sites by other cations (Khan *et al.* 1997).

Organic carbon

The changes that occur in organic carbon (OC) would influence the soil fertility. Hence it is quite relevant to study the influence o HA on organic carbon content of soil. The result on present study clearly showed the profound effect of application of humic acid upto 80 kg ha^{-1} on organic carbon, but the significan increase was noticed at 40 kg ha^{-1} (Table 3) Beyond 40 kg ha^{-1}, there was a depressive nfluence of HA on OC content and it might e due to the reduced microbial population t higher level of HA (Deepa, 2001). The ositive effect might be due to the high content f organic carbon (289 g/kg) in the potassium umate itself. The accentuated biotic activity Deepa and Govindarajan, 2002) by HA application nd greater increase in soil microbial biomass ight have been paved way for concomitant ncrease in the organic carbon content.

ation exchange capacity

The profound increase in CEC due to A in the present study highlighted the beneficial ffect of HA on CEC. There was a steady ncrease in CEC with increased levels of HA. owever, significant increase was upto 60 kg f HA ha^{-1} (Table 3). The HA was found contain functional groups, that would form e source of negative charge. And they could ave contributed towards the CEC of the soil. his charge might be due in part to the dissociation f hydrogen ions from carboxyl groups and lso probably in part to their dissociation of ydrogen ions from carboxyl groups and also robably in part to their dissociation from phenolic ydroxyls and particularly from groups of the ydroxyls. Similar reports were reported earlier y Lax (1991), who observed that the incorporation f soil organic matter induced the exchange apacity due to the various functional groups amely carboxyl, phenolic etc. present in the umic substances of soil organic substances. he oxidised groups present in HA used in e study migh be responsible for the increase CEC as reported by Roig *et al.* (1988). egarra *et al.* (1987) who established a direct elation with humification and consequent increase the functional groups and CEC. These findings nt support to the increase of CEC by HA pplication in the present study.

The incubation experiment highlighted that, he response of humic acid was observed upto 0 kg ha^{-1} for increasing nutrient availability n Alfisol. To confirm this result in the presence f crop a pot experiment was conducted with ice crop. The treatments tried were three fertilizer evel (0-M_1, 75% NPK-M_2, 100% NPK-M_3) nd humic acid levels tried were 0 (S_1), 10 S_2), 20 (S_3), 30 (S_4) and 40 (S_5) kg HA ha^{-1}. The results showed that, with increasing dose of humic acid, the available nutrients, organic carbon and cation exchange capacity also gets increased (Table 5 and 6).

Conclusions

A linear trend in the release of N, P and K was observed for the application of humic acid. The release of N was significant upto 20 kg of HA ha^{-1}, whereas for P and K it extended upto 40 kg ha^{-1}. The N and P were released for a longer period of 60 days, while K release attained a plateau on 45 DAI. At the end of incubation period, there was a steep and significant increase of organic carbon and CEC upto 40 kg HA ha^{-1}. The result of pot experiment also confirmed that with increasing dose of humic acid from 10 to 40 kg ha^{-1} the soil fertility parameters also enhanced.

References

Cegarra, J., Vazquez, A., Costa, F., Lax, A. and Morgan, E. (1987). Changes undergoes by some characteristics of organic wastes during the composting process. *In*: compost: production quality and use. M.Bertoldi, M.P.Ferranti, P.L.Hermite and F.Zuccoli (eds.), Elsevier, London, pp.776-780.

David, P.P., Nelson, V. and Sanders, D.C. (1994). Humic acid improves growth of tomato seedling in solution culture. *J. Pl. Nutr.* **17**: 173-184.

Deepa, M. (2001). Effect of lignite humic acid on soil microorganisms. *M.Sc.(Ag.) Thesis*, TNAU, Coimbatore.

Deepa, M. and Govindarajan, K. (2002). Effects of lignite humic acid on soil bacterial, fungal and actinomycetes population. *In*: National seminar on recent trends on the use of humic substances for sustainable agriculture, Annamalai University, Tamil Nadu.

Dusberg, J.M., Smith, M.S. and Doran, J.W (1989). *In*: Dynamics of SOM in tropical ecosystems University of Hawaii, Hawaii, USA.

Fokin, A.D. and Sinha, M.K. (1969). Interaction of phosphate with soil humic substances. Izveston Timiryazey Acad. Agric. Sci. 4.

Govindasamy, R., Chandrasekaran, S. and Natarajan, K. (1989). Influence of (lignite) humic acid on ammonia volatilization from urea. *In*: Proc. National seminar on "Humus acids in agriculture". Annamalai University, Tamil Nadu.

Khan, S., Qureshi, M.A., Singh, J. and Praveen, G. (1997). Influence of Ni(ii) and Cr (iii), Humic acid (HA) complexes on major nutrients (NPK) status of the soil. *Indian J. Agric. Chem.* **31**: 1-5.

Lax, A. (1991). Cation exchange capacity induced in calcareous soils by fertilization with manure. *Soil Sci.* **15**: 174-178.

Pal, S. and Sengupta, M.B. (1985). Nature and properties of humic acid prepared from different sources and its effect on nutrient availability. *Pl. Soil*, **88**: 71-91. pp.319-325.

Prasad, A., Totey, N.G., Khatri, P.K. and Bhowmik, A.K. (1991). Effect of added tree leaves on the composition of humus and availability of nutrients in soil. *J. Indian Soc. Soil Sci.* **39**: 429-434.

Roig, A., Lax, A., Cegarra, J., Costa, F. and Hernandez, M.L. (1988). Cation exchange capacity as a parameter for measuring the humification degree of manures. *Soil Sci.* **146**: 311-316.

Schnitzer, M. and Kodama, H. (1972). Differential thermal analysis of metal fulvic acid salts and complexes. *Geoderma*, **7**: 93-103.

Sinha, M.K. (1972). Organo-metallic phosphates. The solvent action of fulvic acids on insoluble phosphates. *Pl. Soil*, **37**: 457-467.

Tan, K.H. (1978). Effects of humic and fulvic acids on release of fixed potassium. *Geoderma*, **21**: 67-74.

Tan, K.H. and McCreery, R.A. (1975). Humic acid complex formation and intermicellor adsorption by bentonite. Proc. Intl. Clay Conf., Mexico City, pp.629-641.

Thangavelu, P. and Manickam, T.S. (1989). Studies on the effect of organic manure on fixation and release pattern of phosphorus and zinc under different moisture regimes. *In*: Proc. National seminar on "Humus acids in agriculture", Annamalai University, Tamil Nadu.

Tyler, G., Mornsio, B. and Nilsson, B. (1974). Heavy metal pollution on soil available nutrients. *Pl. Soil*, **40**: 237-159.

Vaughan, D. and Ord, B.G. (1985). Soil organic matter-a perspective on its nature, extraction, turn over and role in soil fertility. Soil organic matter and biological activity, pp.4-18. Junk Publishers, Werterland.

(Received: December 2002; Revised: September 2003)