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HUMIC SUBSTANCES IN THE GLOBAL ENVIRONMENT AND IMPLICATIONS ON HUMAN HEALTH

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Effect of humic substances on solubilization of rock phosphate incubated with wheat straw

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Abstract.
Wheat straw, amended with molasses and cattle slurry, was incubated alone (control) or with $CaCO_3$ or with Hyperphos without or with $CaCO_3$ for 120 days at 30°C. $CaCO_3$ alone had only a small positive effect (2 %) on the decomposition of straw, while the addition of Hyperphos without or with $CaCO_3$ significantly enhanced the breakdown of the organic matter up to 46 resp. 49 %. The formation of fulvic acids was favoured by phosphate and reached the maximum after 30 days, later on they declined, while humic acids gradually increased up to 120 days even at a lower level with phosphate. The retention of P and Ca released from rock phosphate by fulvic was much higher than by humic acids. The uppermost part of solubilized P was found in the organic P fraction. After 120 days incubation 15.1 % of the Hyperphos P and (in parallel experiments) 26.6 % of Mussoorie P were solubilized. These data demonstrate that the availability of low grade rock phosphates can be improved by composting with straw.

Introduction

Low grade rock phosphates are up to some extent suitable for direct application depending on their reactivity (solubility in 2 % formic acid) and site/crop conditions. By composting organic wastes from plant or animal production with low grade rock phosphates solubility and availability to crops can be improved (Singh and Amberger, 1990 a). During the microbial decomposition process organic acids are produced, which can be chemically differentiated as fulvic and humic acids. The driving force of rock phosphate solubilization is the pH decrease and the chelating effect of organic acids on Ca^{2+} ions from apatitic phosphates.

The objectives of these experiments are to quantify decomposition of organic matter, production of fulvic and humic acids, retention of P and Ca released from rock phosphate by humic substances, production of water soluble and organic phosphate and the solubilization of the low grade rock phosphate Hyperphos during the incubation process with wheat straw.

Material and methods

4 g of wheat straw (0.06 % P) was mixed with 1 g Hyperphos (14.1 % P, reactivity 68 % (= solubility in 2 % formic acid, Hofmann and Mager, 1953), 16.7 % free $CaCO_3$) and 0.5g molasses (as microorganism food) and liquid cattle manure to adjust the C/N ratio of straw from 90 to 30 for quick decomposition, afterwards the mixture was inoculated with 1 ml aqueous extract containing 5 % of soil, dung and old compost each and incubated in 50 ml polyethylen bottles at 30° C over 120 days.

were mixed again after 7, 20, 30 and 90 days of incubation and the moisture kept to the original level (200 % of mixture dry weight) by adding distilled water.

Organic matter was determined by wet oxidation technique (Springer and Klee, 1955). Humic and fulvic acids were extracted with 0.1 N NaOH (Schlichting and Blume, 1966); in these fractions P and Ca were determined by the method of John (1970) for P and by flamephotometer for Ca. The retention of P and Ca released from phosphate by humic and fulvic acids, substracting inorganic P forms, and the final solubilization of rock phosphate P was calculated.

Results and discussion

1. Decomposition of organic matter (fig. 1)

Wheat straw alone was microbially decomposed to 15, 24 and 29 % with incubation time up to 120 days. The addition of 1 g Hyperphos (= 141 mg P and 167 mg $CaCO_3$) enhanced the decomposition significantly up to 46 % finally, while 36 mg $CaCO_3$ to straw alone or to straw + Hyperphos improved the result only by 2 or 3 % respectively. From these data it can be concluded that phosphorus was the limiting factor for microbial decomposition of straw.

2. Production of fulvic and humic acids during incubation of straw and rock phosphate (fig.2)

The initial mineralization of straw is characterized by a high formation of fulvic acids with maximum after 30 days incubation; later on they declined rapidly. However humic acids showed a gradual increase with incubation time. The addition of Hyperphos enhanced fulvic acid but retarded humic acid production. The total humification (humic + fulvic acids) was highest at 30 days, followed by a conversion of fulvic to humic acids.

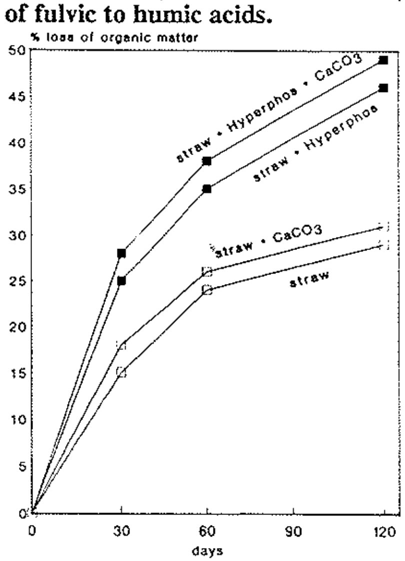

Figure 1. Loss of organic matter (%) during incubation of straw + rock phosphate

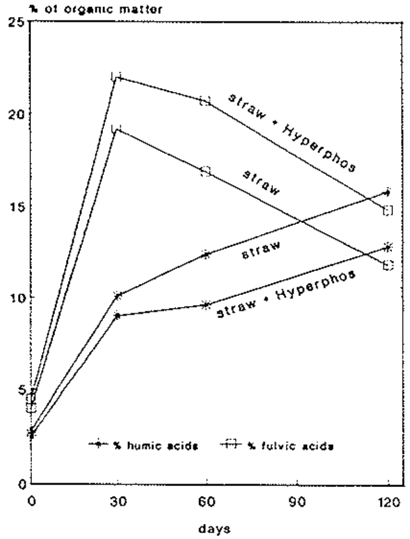

Figure 2. Production of humic and fulvic acids (% of org. m.) during incubation of straw + rock phosphate

3. Retention of P and Ca released by humic substances (table 1)

The retention of P and Ca by humic substances followed the quantitative formatio of these fractions: P and Ca from Hyperphos released by humic acids showed a ver pronounced increase. Compared with humic acids the retention capacity of fulvi acids for P and Ca is much higher again with maximum at 30 days and decrease later on. The uppermost part of total phosphorus and Calcium released by humi substances was found in the fulvic fraction. These results can be explained by th formation of P - Ca - humate complexes (Dormaar, 1972, Fares et al. 1974, Bowma and Cole, 1978) and the greater amounts of carboxylic and hydroxylic groups per uni weight of fulvic acids.

Table 1
Retention of P and Ca released by humic substances during incubation of wheat stra with rock phosphate

Treatment	Incubation period (days)							
	0	30	60	120	0	30	60	120
	µg P/1 g straw				µg Ca/1 g straw			
	released by humic acids							
straw	7	16	20	25	73	130	195	253
+ Hyperphos	5	41	73	208	44	159	281	368
	released by fulvic acids							
straw	56	245	227	197	1029	1215	820	779
+ Hyperphos	54	963	519	498	1074	6713	3159	1674

LSD at 5%: treatm. 3.44, days 3.08

4. Water soluble and organic P (table 2)

During decomposition of straw water soluble and organic P increased graduall with incubation time. In the straw/Hyperphos compost the maximum of water solubl P was reached after 30 days incubation with a declining tendency later on, while th organic P mounted up nearly twenty-fold finally. It demonstrates that the uppermos part of total solubilized P from rock phosphate is converted to the biomass along wit chelated humic substances.

In other experiments (Singh and Amberger, 1990 b) the organic P fraction could be differentiated (according to the method of Bowman and Cole, 1978) to 75 % as labile P, easily available to plants, and only to 25 % as more or less resistant P.

Table 2
Water soluble and organic P during incubation of wheat straw with rock phosphate

Treatment	Incubation period (days) 0	30	60	120
	water soluble P (μg/1 g)			
straw	165	158	196	241
+ Hyperphos	105	187	180	135
LSD at 5%: treatm. 2.25, days 2.01				
	organic P (μg/1 g)			
straw	415	527	553	590
+ Hyperphos	358	3613	5633	6712
LSD at 5%: treatm. 64.9, days 61.3				

5. Effect of incubating straw with rock phosphate on P solubilization

The initial rate of Hyperphos solubilization was high along with maximum fulvic acid production at 30 days and increased finally up to 15.1 % of total added P. In a parallel experiment Mussoorie phos, a very low grade rock phosphate, was solubilized up to 26.6 %.

Table 3
Effect of composting wheat straw + rock phosphate on P solubilization

Treatment	Incubation period (days) 30	60	120
	solubilized in % of added P		
straw + Hyperphos (14.1 % P - 16.7 % $CaCO_3$)	10.0	14.6	15.1
straw + Musoorie phos (8.7 % P - 20.3 % $CaCO_3$)	18.2	24.7	26.6

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References

1 C.P. Singh and A. Amberger, Biological Wastes 32 (1990a) 165
2 C.P. Singh and A. Amberger, Biol. Agriculture and Horticulture (1990b) accepted
3. E. Hofmann and D. Mager, Z. Pflanzenernährung Düngung u. Bodenkunde 62 (1953) 262
4. V. Springer and J. Klee, Z. Pflanzenernährung Düngung u. Bodenkunde 71 (1955) 193
5. E. Schlichting and H.P. Blume, Bodenkundliches Praktikum, Paul Parey Hamburg, Berlin (1966) 136
6. M.K. John, Soil Science 109 (1970) 214
7. J.F. Dormaar, Canadian J. Soil Science 52 (1972) 107
8. F. Fares, J.C. Fardeau and F. Jacquin, Phosphorus in Agriculture 63 (1974) ISMA
9. R.A. Bowman and C.V. Cole, Soil Science 125 (1978) 95