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A Study on the Effect of Phosphate, Molybdate and Humic acid Application on the Availability of Iron Manganese and Molybdenum in Laterite Soil

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A typical laterite soil of West Bengal was treated with phosphate, molybdate and humic acid singly as well as in combination and incubated at moisture saturation. Both phosphate and humic acid application showed considerable increase in Mo availability. Mo application decreased the DTPA-extractable Fe but increased the available Mn content of the soil. Phosphate application decreased both available Fe and Mn. Humic acid did not change the available Fe content but available Mn content was increased. Combined application of HA–Mo, P–Mo and HA–P as well as P–HA–Mo enhanced availability of Mo and Mn in the soil but available Fe content was found to be depressed. With the increase in incubation period, amount of available Mo and Fe gradually increased but Mn content showed a decreasing trend after initial increase.

MICRONUTRIENTS play a vital role in crop and animal production. With the present day trend of intensive cultivation using high yielding varieties of crops and with application of heavy doses of high analysis fertilisers, micronutrients are becoming limiting factor in crop production.

Availability of molybdenum in soil is very small but its role in plant nutrition is immense. Laterite soils in India are particularly low in total as well as available molybdenum content[1]. These soils are also known[2] to fix molybdate ions and phosphates due to their great affinity for ferric oxide and amorphous material which are abundant in them. High amount of phosphate fertilisation also creates problems in such soils through interactions of micronutrient elements with various components in soil as well as within the plant. Organic matter[3] also greatly influences the availability of micronutrients in soil and their uptake by plants.

In the present investigation, the effect of P, Mo and humic acid application on the changes in acid-NH_4 oxalate extractable Mo and DTPA extractable Fe, Mn in laterite soil on incubation for varying periods of time under moisture saturation have been studied.

Experimental

The soil used in the present investigation was collected from a land (Viswa Bharati Agricultural Farm, Birbhum) which has been brought into cultivation for two years using only moderate dose of N-fertilisers. The heavy, medium-textured and lateritic type soil was air-dried, ground and sieved (0.2 mm). Some physicochemical properties of the soil necessary for an understanding of the results of the present experiment are moisture saturation, 48% ; *p*H 5.8 (1 : 2.5, soil : water) ; available P, 1.05 ppm ; available Mo, trace ; DTPA-extractable Fe and Mn, 317 and 55 ppm, respectively ; free oxide, 2.6% ; organic carbon, 0.7% ; CEC 7.56 me/100 g.

The soil was treated with two levels of Mo (0, 5 ppm) as $Na_2MoO_4.2H_2O$, three levels of P (0, 40, 80 ppm) as KH_2PO_4, and two levels of humic acid (0, 600 ppm) singly as well as in different combinations. The samples were kept at room temperature and under saturated moisture condition by adding adequate amount of glass-distilled water. The three sets of sample were kept for 7, 21 and 42 day for analysis of extractable Mo, Fe and Mn.

Extraction : The soil (10 g) was shaken with acid ammonium oxalate solution (100 ml) for 8-10 h or overnight and then filtered and analysed for Mo. The extractant was produced according to the procedure developed by Grigg[4]. An aliquot of the filtrate (40-60 ml) was taken in a porcelain evaporating dish and the solution was evaporated to dryness on a steam-bath. The residue was ignited for 3-4 h at 450° to destroy the oxalate and then cooled. It was subsequently dissolved in 6.5 *M* HCl (10 ml).

For extraction of Fe and Mn, soil sample (10 g) was shaken with the DTPA-extractant solution[5] (20 ml) for 2 h and filtered. The filtrate was digested with concentrated HNO_3 (3 ml) and concentrated H_2SO_4 (5 ml). The resulting material was taken in redistilled water and analysed for Fe and Mn.

Estimation of Mo, Fe and Mn : Molybdenum was estimated colorimetrically by thiocyanate

TABLE 1—EFFECT OF P, Mo AND HUMIC ACID APPLICATION ON DTPA-EXTRACTABLE Fe, Mn AND AVAILABLE Mo CONTENT (ppm) IN SOIL

Treatments	Period of incubation (day)								
	7			21			42		
	Mo	Fe	Mn	Mo	Fe	Mn	Mo	Fe	Mn
$P_0HA_0Mo_0$	Trace	344	52.60	0.040	352	32.66	0.080	400	22.66
$P_0HA_0Mo_1$	0.240	288	68.00	0.290	344	36.00	0.330	360	32 66
$P_0HA_1Mo_0$	0.040	280	77.33	0.080	340	50.00	0.110	360	22.66
$P_0HA_1Mo_1$	0.245	328	73.33	0.300	348	61.33	0.355	364	25.03
$P_1HA_0Mo_0$	0.065	324	43.33	0.080	336	35.66	0.100	352	19.33
$P_1HA_0Mo_1$	0.285	288	62 00	0 315	352	43.33	0.330	364	28.66
$P_1HA_1Mo_0$	0.040	316	64.66	0.110	364	40.63	0.155	368	13 33
$P_1HA_1Mo_1$	0.275	304	86.60	0 315	376	45.75	0.375	380	20.00
$P_2HA_0Mo_0$	0.080	292	40.66	0.110	316	41 00	0.120	348	31 66
$P_2HA_0Mo_1$	0.275	264	50.00	0.355	312	43.33	0.400	352	33.00
$P_2HA_1Mo_0$	0.100	275	63.33	0.110	316	53.33	0.165	328	28.66
$P_2HA_1Mo_1$	0.285	280	63.33	0.330	304	50.00	0.420	348	30.00

TABLE 2—MEAN EFFECTS OF P, Mo AND HUMIC ACID APPLICATION ON THE AVAILABLE Mo, Fe AND Mn CONTENT IN SOIL

Level of application ppm	Mo (ppm) Incubation period (day)				Fe (ppm) Incubation period (day)				Mn (ppm) Incubation period (day)			
	7	21	42	Mean	7	21	42	Mean	7	21	42	Mean
P_0 (0)	0.131	0 178	0.219	0.176	310.0	346.0	371.0	342.3	67.81	44.99	25.75	46.18
P_1 (40)	0.166	0.205	0.204	0.207	308.0	357.0	366.0	343.7	64.15	41.34	20.34	41.94
P_2 (80)	0.185	0.226	0.276	0.229	277.8	312.0	344 0	311.3	54.33	46.91	30.83	44.02
HA_0 (0)	0.158	0.198	0.227	0.194	300.0	335.4	362.7	332.7	52.76	38.66	27.99	39 80
HA_1 (600)	0.164	0.208	0.263	0.215	297.2	341.3	358.0	332.2	71.48	47.80	23.28	47.51
Mo_0 (0)	0.054	0.088	0.122	0.088	305.2	337.3	359.3	333.9	56.98	42.21	23.05	40.74
Mo_0 (5)	0.265	0.318	0.365	0.316	292.0	339.3	361.3	330.9	67.21	46.62	28.22	47.35
Mean	0.160	0.183	0.267		298.6	338.3	360.3		62.09	44.08	25.63	

coloured compounds through reduction with chlorostanous acid[6]. Iron was determined by reduction of ferric-iron to the ferrous state with hydroxylamine hydrochloride and subsequent formation of an intense red ferrous chelate with *o*-phenanthroline as described by Jackson[7]. Mn was estimated colorimetrically by the periodate method[7].

A Spectronic-20 spectrophotometer was used for all absorbance measurements. All reagents and chemicals used were of A.R. quality.

Results and Discussion

The analytical data for DTPA extractable Fe, Mn and acid ammonium oxalate extractable Mo are given in Table 1. Table 2 contains the mean effect of the treatments on nutrient availability.

Available Mo : Application of Mo increased the extractable Mo content in soil, the magnitude of increase being 258.6% over the corresponding value in the control. About 4% of added Mo appeared to remain in the available pool. The results show that the application of P resulted in increase of extractable Mo, both in Mo treated and untreated soil. At higher level of P, the availability is also higher. Humic acid application has a definite effect on molybdenum availability as observed in the present investigation and the magnitude of increase being 10.8% over the control. It has been reported by Szilagyii[8] that humic acid can render molybdenum unavailable to plants. He also reported that humic acid also reduces Fe^{III} to Fe^{II} form. Present investigation, however, indicates that there is an increase in Mo availability. As the soil contains more iron in Fe^{III} form, the beneficial effect of humic acid seems to lie on the partial reduction of Fe^{III} to Fe^{II} and consequent release of some adsorbed or chemically fixed molybdate on the free oxides of iron in soil.

It is a general observation that in all cases there is an increase of Mo availability with the increase of incubation period. As the soil was kept in saturated moisture condition, an anaerobic environment was set up, causing partial reduction of ferric iron, which is largely responsible for adsorbtion of molybdenum.

The combined application of HA–Mo–P, P–Mo, and HA–P on the content of available Mo content in the soil has been found to be beneficial. The interaction effect of P–HA–Mo on the available Mo content in soil show a positive effect.

DTPA-extractable Fe : The results show that application of P, result in decrease in the extractable Fe content. Higher dose of P resulted in greater decrease. The magnitude of decrease is found to be 9.8% over the control. Humic acid application decreased extractable Fe content in the initial period of incubation but there was almost no

change in the mean effect by humic acid application. The application of Mo decreased the extractable Fe content slightly.

It is a general observation in all the cases that there is a gradual increase in extractable Fe content with the increase in the period of incubation.

There is an increase of extractable Fe content due to combined effect of Mo – P and Mo – HA, but the interactions of P – HA – Mo and HA – P have a depressive effect on extractable Fe content in soil. Presence of phosphate appears to keep iron fixed with the humic colloids making it unavailable, especially during short period of incubation of the soils.

DTPA-extractable Mn : The DTPA-extractable Mn content was found to decrease due to application of phosphorus, and the magnitude of decrease being 9.8 and 4.7% for P_1 and P_2 level, respectively. Humic acid application shows a beneficial effect on the extractable Mn content in soil, the magnitude of increase being 16.2% over the control. Mo application has a beneficial effect on the extractable Mn content in the soil, which continued more or less uniformly throughout the period of incubation, the magnitude of increase being 13.7% over the control.

Unlike extractable Fe content in all the cases, there was a gradual decrease in Mn content with the increase in the incubation period.

The combined effect of P – Mo application caused a depressive effect over that of control in the initial period of incubation, but beneficial effect was found in the later stages. The depressive effect of P – HA application on the extractable Mn content was found only in latter stages of incubation. The interaction of P – HA – Mo has been found to be beneficial in all the stages of incubation.

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