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PYRITE OXIDATION IN RELATION TO SOIL ESP IN SALT AFFECTED SOIL

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ABSTRACT

Pyrite oxidation at different soil ESP (8.5, 30.1, 48.0, 63.0 and 79.0) under laboratory conditions and its efficiency on change in soil sodicity indices as well as crop yield with pyrite @ 0, 25, 50, 75 and 100% of gypsum requirement on equivalent S basis in a pot experiment under paddy - wheat crop sequence were studied. The magnitude of pyrite oxidation reduced from 59.5% at 8.5 ESP to 16.9% at ESP of 79.0. Presence of $CaCO_3$ to the extent of 4% did not stimulate the rate of pyrite oxidation. Even such a low pyrite oxidation was sufficient to produce significant response of its application to crop yield as well as reduction in pH, ECe, ESP and SAR.

Success of pyrite as an amendment in salt affected soil depends upon the magnitude of pyrite oxidation which plays decisive role in crop yield and changes in soil properties like pH, ECe, ESP, SAR and RSC. Varying spans of time for pyrite oxidation have been recommended (Singh *et al.* 1981). Very little work has been done so far in view of pyrite oxidation as affected by varying soil ESP which governs the dose of amendment to be applied. The present investigation envisages to find out the effect of soil ESP on the rate of pyrite oxidation in naturally collected salt affected soils and to evaluate the response of pyrite application to crop yield as well as changes in sodicity indices viz., pH, ECe, ESP, SAR and RSC.

MATERIALS AND METHODS

Six hundred surface (0-15 cm) soil samples were collected from contiguous belt of salt affected soil of Varanasi district of Uttar Pradesh. The soil samples were analysed for pH and ESP and out of 600 soil samples, five soils were finally selected as to represent the wide range of pH and ESP under natural condition. The soils have been taxonomically classified as coarse loamy, illitic, hyperthermic family of Typic Natraqualfs. The physicochemical properties of soils have been presented in Table 1. Fifty g soil of each sample was taken in 500 ml capacity beakers. All the soils were treated with pyrite containing 16% S at the rate of 4800 ppm S, uniformly spread on surface and kept at field capacity moisture level for 7 days under room temperature of 27°C - 30°C. Moisture level was maintained as per daily evaporation rate. Biological incubator through fresh soil water extract was also added to provide favourable microbial environment for pyrite oxidation. Soil samples were extracted with water in ratio of 1:40 after shaking them for an hour at 24 hourly interval. Such a high ratio of soil - water suspension was used in order to bring the freshly precipitated $CaSO_4$ also into solution.

A pot experiment was also conducted from bulk of heterogeneously processed salt affected soil having loam texture, pH 10.3, ECe 18.8 dSm^{-1}, ESP 82.8, SAR 148.2 and RSC 148.0 $m.e.L^{-1}$ respectively. Five treatments consisting of pyrite @ O (P_0), 25 (P_{25}), 50 (P_{50})75(P_{75}) and 100 (P_{100}) of gypsum requirement on equivalent S basis were tested in randomised block design with three replications. Initially pyrite was uniformly spread on surface and kept at field capacity moisture level

Table 1. Physico-chemical properties of soils

pH	ECe (d Sm^{-1})	$CaCO_3$ (%)	ESP	SAR	CEC (cmol (p^+) kg^{-1})	Clay content (%)	Texture
7.3	1.52	0.5	8.5	3.6	11.8	22.1	Loam
8.5	3.82	1.0	30.1	10.2	16.0	22.5	Loam
9.2	3.86	2.0	48.0	14.0	18.2	24.6	Loam
10.0	4.12	4.0	63.0	22.8	19.8	23.6	Loam
10.6	12.51	4.0	79.0	56.7	28.5	28.2	Loam

Table 2. **Effect of different levels of soil pH on the pyrite oxidation in saline-sodic soil.**

Initial SO_4-S content (ppm)	Amount of SO_4-S (ppm) at different intervals of time with pyrite application								Average
	Zero hour	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	
200	889 (14.3)	1955 (36.6)	3511 (69.0)	3511 (69.0)	3555 (70.00)	3600 (70.8)	3688 (72.7)	3732 (73.6)	3055 (59.5)
844	2133 (26.8)	1422 (32.9)	2466 (33.0)	2600 (36.6)	2777 (40.3)	2955 (44.0)	3024 (50.0)	3577 (56.9)	2744 (40.1)
600	1600 (20.8)	1778 (24.5)	1822 (25.5)	2044 (30.1)	2044 (30.1)	2044 (30.1)	2089 (31.0)	2133 (31.9)	1944 (28.0)
444	455 (10.6)	1089 (13.4)	1089 (13.4)	1111 (13.9)	1155 (14.8)	1355 (19.0)	1466 (21.3)	1466 (21.3)	1240 (19.8)
1422	1644 (4.6)	2178 (15.7)	2245 (17.2)	2311 (18.5)	2355 (19.4)	2377 (19.0)	2400 (20.3)	2400 (20.3)	2236 (16.9)
Average	1344 (15.4)	1884 (24.6)	2226 (31.6)	2315 (33.6)	2377 (34.9)	2516 (38.7)	2662 (40.6)	2662 (40.6)	

CD at 0.05 pH vs Days (1.96), pH vs pyrite oxidation (2.80) ( ) represents the % of added pyrite-S oxidised

for 2 weeks followed by waterlogging of another 2 weeks. Five weeks old paddy seedlings (Var. Saket-4) were transplanted in thoroughly leached pots and soon after harvesting of paddy crop, wheat crop (Var. HUM-205) was sown. Recommended doses of N,P,K and Zn were applied @ 60, 30, 30 and 12.5 mg kg^{-1} respectively. Yield (straw and grain) was recorded at the harvesting of crops and expressed on dry weight basis. Soil samples were taken to observe the changes in soil properties. Soil pH, ECe, ESP, SAR and RSC were determined as per methods described by Richards (1954). Water soluble SO_4- S was determined turbidimetrically according to procedure described by Jackson (1967) and $CaCO_3$ by the procedure of Hutchinson and Mclennan (1941).

RESULTS AND DISCUSSION

Pyrite oxidation in relation to ESP : Perusal of data presented in Table 2 reveals that amount of SO_4-S content increased from 889 to 3732 ppm, 2133 to 3577 ppm, 1600 to 2133 ppm, 455 to 1466 ppm and from 1644 to 2400 ppm at ESP of 8.5, 30.1, 48.0, 63, 0 and 79.0 respectively as a result of 7 days oxidation, showing differential rate of pyrite oxidation with increasing span of incubation. The acidity produced as a result of oxidation of added pyrite-S further encourages the microorganisms involved in oxidation and eventually helps to promote the process of oxidation. Increased SO_4-S content from 889 ppm at ESP 8.5 to 1644 ppm at ESP 79.0 amounting to 14.3 and 4.6% respectively at zero hour indicates that added pyrite contains some already oxidised S. But varying amount of SO_4 - S is extracted at different pH. The amount of SO_4 - S is extracted at zero hour (difference between SO_4-S content at zero hour and initial content), reduced from 1289 to 222 ppm in the soil ESP range of 30.1 to 79.0 having alkali pH range of 8.5 to 10.6. This is attributed to chemical precipitation of sulphate by calcium carbonate and common ion effect as well in sodic soils associated with soluble salts rich in carbonates.

On an average, soil pH after seven days of incubation was negatively correlated with percentage of pyrite-S oxidised (r = - 0.98**) and oxidised pyrite-S decreased at the rate of 23.04% per unit increase in soil pH (Y = 226.06 - 23.04 X where Y and X stand for amount of oxidised pyrite-S and soil pH respectively). After seven days of incubation, on an average of 59.5, 40.1, 28.0, 19.8 and 16.9% of added pyrite-S was oxidised at soil ESP of 8.5, 30.1, 98.0, 63.0 and 79.0 respectively. However, if amount of oxidised pyrite-S already present at zero hour is considered, the magnitude of pyrite oxidation further becomes extremely low to the extent of 45.2, 13.3, 7.2, 9.2 and 12.3 per cent at soil ESP 8.5, 30.1, 48.0, 63.0 and 79.0 respectively. According to Attoe and Olsen (1966), the maximum amount of sulpher oxidised ranged from 60% for a week of incubation to 80% for 4 weeks between 15 to 48% soil

Table 3. Effect of different levels of pyrite on crop yield and change in different sodicity indices after reclamation.

Treatment	After paddy crop						After wheat crop					
	Yield (g/pot)		pH	ECe (d Sm^{-1})	ESP	SAR	Yield (g/pot)		pH	ECe (d Sm^{-1})	ESP	SAR
	Straw	Grain					Straw	Grain				
P_0	13.00	3.66	10.1	10.2	76.7	77.7	5.33	1.33	10.0	9.9	69.8	63.4
P_{25}	17.66	9.33	9.6	6.9	59.5	36.2	7.66	3.33	9.4	5.9	32.2	32.2
P_{50}	20.66	10.00	9.6	6.2	40.5	33.5	12.33	6.00	9.0	5.4	24.8	26.8
P_{75}	23.66	12.83	9.3	6.1	33.5	24.4	13.00	8.33	9.2	4.9	19.8	23.6
P_{100}	26.33	15.33	9.2	5.3	32.3	20.5	16.33	8.33	9.0	4.1	19.7	23.6
CD (P=0.05)	5.12	3.00	0.20	1.10	7.20	8.12	4.52	3.28	0.20	0.82	6.81	6.86

moisture content. Singh *et al.* (1981) observed 10-12 days for maximum pyrite oxidation. Such a low rate of pyrite oxidation especially in ESP range of 30.1 to 79.0 is mainly attributed to extremely low activity of sulphur oxidising bacteria (*Thiobacillus thioxidans*) responsible for oxidation of pyrite-S which is the major limitation in such problematic soils. Verma and Abrol (1979) observed no further significant oxidation of pyrite-S, once incorporated in highly sodic soil and whatever little change was noted, it was due to product of oxidation already present before its use.

Response of pyrite application : There was no significant effect amongst different pyrite levels on yield of paddy and wheat crop as well as change in soil properties after reclamation (Table 3). However, the effect of P_{75} and P_{100} was better than P_{25} and P_{50} respectively, showing some improvement in efficiency of pyrite as the level of pyrite application is increased. After two crops, soil pHs, ECe, ESP and SAR reduced from 10.1, 10.2, 76.7 and 77.7 to 9.0, 4.1, 19.7 and 23.6 respectively with P_{100}. Sharma *et al.* (1971) observed improvement in physical conditions of saline-alkali soil with pyrite application @ 20 to 80% of gypsum requirment in the pots cultivated with paddy and wheat crops.

The above observations warrant that comparatively higher dose of pyrite needs to be applied to obtain desirable effect on crop yield and reduction in various sodicity indices of sodic soil associated with excessive soluble salts.

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