Note on Some Acid Sulfate Soils in Fiji

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Studies on the soil properties are essential to ensure the agro-developmental projects in Fiji.
There have been observed some extremely poor rice plant growth on some paddy fields. In this study , special attention was paid to the soils of these fields and tried to make clear the cause of the poor growth. They showed the strongly acidic reaction due to free sulfate ion and thus considered to be so-called "acid sulfate soil".

Materials and Methods

Sixteen samples wer collected from 8 localities in Viti Levu and Vanua Levu Islands. Their sampling sites were shown in Figure 1 (p 168) of another report in this MEMOIRS and their brief description were shown in Table 1.

The soil pH in H_2O and 1 M KCI was measured with the soil:solution ratio of 2.5:1.

The pH after oxidation with H_2O_2 was also tested. The oxidation was carried out as follows:One gram of soil was taken and 10 ml of 30% H_2O_2 adjusted at pH 6 with NaOH was added. Soon the vigorous reaction occured and so the reaction was done firstly in flowing water, then at room temperature and lastly in boiling water. After cooling to room temperature, the pH was measured with the soil (original weight): solution ratio of 1:10.

The amounts of soluble SO_4 ion before and after oxidation process were determined turbidometrically at 690 nm using $BaCi_2$-Gelatin solution. The water soluble SO_4 was obtained after shaking the soil-water suspension for 1 hour at room temperature and H_2O_2 oxidative SO_4 was collected from above-mentioned procedure.

Results and Discussion

As shown in Table 2, some soils show relative low pH values (5 >), especially

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Table 1. Description of soil samples

Site No	Locality	Depth (cm)	Soil Color	Kind of Field and Crop	Remarks
1	Raralevu, Nausori (Viti Levu)	0-10	5Y 3/2 (Olive black)	Irrigated paddy field. Rice	After harvest
3	Navua (Viti Levu)	0-10	7.5YR 2/2 (Blownish black)	Irrigated paddy field	Queen's road side
14-1	Dreketi, Macuata (Vanua Levu)	0-10	10YR 1.7/1 (Black)	Rain-fed paddy field. Rice	Traditional field, ill-drained
-2	〃	10-20	2.5Y 2/1 (Black)	〃	
-3	〃	20-30	〃	〃	
-4	〃	30-40	〃	〃	
15-1	〃	0-10	5YR 3/3 (Dark reddish brown)	Irrigated paddy field. Rice	Recently developed field, just after direct sowing.
-2	〃	10-20	7.5YR 3/4 (Dark brown)	〃	
16-1	〃	0-10	10YR 3/4 (Dark brown)	〃	Adjacent field to No. 15, thin seedling
-2	〃	10-20	7.5Y 4/4 (Brown)	〃	
17-1	〃	0-10	10YR 3/4 (Dark brown)	〃	Under plowing
-2	〃	10-20	〃	〃	
18-1	〃	0-10	5Y 3/2 (Olive black)	〃	Under trials of lime and fertilizers application, growth was from boot to milk-ripe stage
-2	〃	〃	5Y 4/4 (Dark olive)	〃	
-3	〃	〃	5Y 4/3 (Dark olive)	〃	
19-1	〃	0-10	2.5YR 4/4 (Dull reddish brown)	Developing irrigated field	Quite barren soil near the coast line, the site of burning mangroves
-2	〃	〃	10YR 3/4 (Dark brown)	〃	
-3	〃	〃	10YR 2/3 (Blownish black)	〃	
-4	〃	〃	—	〃	
-5	〃	〃	—	〃	
-6	〃	〃	—	〃	

those of Site No.19 as pH 3. All of these acidic soils are situated near the coastal side of north-western part of Vauna Levu Island.

Such strong acidity as No.19 soils, which appears very rare in common soils, is thoughtable to be due to the occurrence of some mineral acids.

The No.19 site is quite barren near the coastal line and derived from burning mangroves. This fact indicates that its soil belongs to so-called"acid sulfate soil" ("Thiogleysols" in FAO/Uneseco and "Sulfaquepts" in Soil Taxonomy/USDA", respectively) and its strong acidity is due to sulfuric acid. This was confirmed by their high content of water soluble SO_4 (0.11-0.59%, m = 0.37%).

Acid sulfate soil develops by oxidation process, i.e. reclamation of water area land, of sulfide such as FeS (amorphous), FeS_2 (pyrite) and/or Fe_3S_4 (greigite) to sulfate. Thus even the soils of which pH are relatively high at present may change to be strongly acidic by further oxidation.

The results of artifical oxidation of sample soils with H_2O_2 indicate clearly that, in addition to No.19 soils, Nos.14 and 18 (subsoil) soils are also classified into acid sulfate soil ("Sulfaquents" in Soil Taxonomy). These soils contain 0.6-4.8% (m = 1.75%) of oxidated SO_4 in contrast to less than 0.2% in other soils.

X-ray analysis of No.19 bulk soils revealed no crystalline sulfide diffraction peaks,

Table 2. The pHs and SO_4^{--} contents of sample soils

Site No.	pH (H_2O) (A)	pH (KCl) (B)	pH (H_2O_2)	pH (A-B)	SO_4^{--} (H_2O) %	SO_4^{--} (H_2O_2) %	SO_4^{--} Total %
1-1	5.15	4.17	4.85	0.30	0.01	0.12	0.13(0.04)
-2	5.13	4.58	6.52	-1.39	0.01	0.07	0.08(0.03)
-3	5.25	4.32	5.03	0.22	0.01	0.14	0.15(0.05)
3-1	5.04	4.61	4.38	0.66	0.00	0.18	0.18(0.03)
14-1	4.80	4.02	3.41	1.39	0.04	1.00	1.04(0.34)
-2	5.22	4.81	2.97	2.25	0.04	1.18	1.22(0.40)
-3	5.08	4.37	3.74	1.34	0.05	1.11	1.16(0.38)
-4	5.13		3.49	1.64	0.16	1.55	1.71(0.56)
15-1	5.19	4.25	5.30	-0.11	0.01	0.12	0.13(0.04)
-2	5.30	4.26	5.48	-0.18	0.01	0.10	0.11(0.04)
16-1	5.37	4.46	5.75	-0.38	0.01	0.06	0.07(0.02)
-2	5.37	4.43	5.03	0.34	0.01	0.08	0.09(0.03)
17-1	5.99	5.07	5.41	0.58	0.01	0.08	0.09(0.03)
-2	5.36	4.81	5.00	0.36	0.00	0.16	0.16(0.05)
18-1	4.94	4.10	3.13	1.81	0.03	0.71	0.74(0.24)
-2	6.81	6.15	4.25	2.56	0.07	0.73	0.80(0.26)
-3	5.85	5.15	3.37	2.48	0.06	0.59	0.65(0.21)
19-1	2.85	2.68	1.61	1.24	0.59	4.63	5.22(1.72)
-2	2.93	2.74	1.85	1.08	0.11	2.31	2.42(0.80)
-3	2.96	2.76	1.83	1.13	0.29	3.44	3.73(1.23)
-4	2.80	2.65	—	—	0.32	—	—
-5	2.60	2.52	—	—	0.37	—	—
-6	3.51	3.31	—	—	0.56	—	—

% on oven-dry basis, ( ): as S.

but yellowish small concretion contained in the soils showed the diffrcation peaks of sulfate "jarosite" at 3.08, 2.29 and 5.95 Å etc.. Thus the oxidation process was suggested in the way from FeS (amorphous) to jarosite accompanying by the formation of excess sufuric acid in these sites.

No.18 site situates adjacent to No.19 site. While No.19 site was reclaimed very recently, No.18 fields are now under trials of liming and fertilyzers application and, owing to the effects of the mangements, the acidic nature of theur soils seemed to be improving.

In the case of No.14 site, the ill-drained, rain-fed paddy field conditions may remain their soils in potential acid sulfate soil.

A rice plant is resistant to both acidic and alkaline conditions to some extent though it shows maximum growth near slightly acidic reaction. But when pH value lower than 4, especially less than 3, its growth is considered to be almost impossible.

Table 3. Particle Size Distribution of the Soils

Site No	Sand	Silt	Clay	Texture
14-1	44.1	40.5	15.4	CL
-2	37.9	37.5	24.6	LiC
-3	38.6	32.2	29.2	LiC
-4	40.9	32.5	26.6	LiC
18-1	42.7	24.3	33.0	LiC
-2	14.3	34.5	51.2	HC
-3	18.2	29.7	52.1	HC
19-1	40.9	21.6	37.5	LiC
-2	61.9	20.0	18.3	CL
-3	51.9	23.3	24.8	LiC

% on the oven-dry organic-free fine soil

In the case of acid sulfate soil, therefore, the reclaim of soil acidity by liming is needed essentially.

The neutralization of these soil pHs may be effectively practiced after leaching out of the SO_4 ion and other soluble salts in the soils with much amounts of water after the fully oxidation of potentially oxidative sulfide compounds.

These soils may be also very poor in drainage because they are heavy in texture (mainly LiC-HC) as shown in Table 3. The acceleration of drainage together with chemical improvement would be desirable.

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