EFFECTS OF FIELD DRAINAGE ON SOME CHEMICAL PROPERTIES OF ACID SULFATE SOILS UNDER COCONUT SMALL HOLDINGS IN WEST JOHORE AGRICULTURE DEVELOPMENT SCHEME IN MALAYSIA

Mohd. ZAHARI ABU BAKAR,
Ting Chaong CHAANG and
B.GOPINATHAN*

Summary

The effect of varying water tables on the oxidation rate of pyrite in pyrite-containing alluvial soils is being monitored. Preliminary results indicate that pyrite oxidation proceeds at a rapid rate at the onset of drainage and begins to slow down after a period of time. The pH decreases accordingly in the initial stages and begins to decrease with time, when the pyrite oxidation rate slows down. The pH in the freely drained plots is considerably lower than in both the controlled water table plots or the control plots. This trend is especially clear in the plot away from the sea. Coconut yields in the freely drained plot away from the sea are significantly lower.

Introduction

There are about 200,000 hectares of acid sulfate soil in Malaysia, most of it in Peninsular Malaysia. There are also large areas of potentially acid sulfate soils. These pyrite-containing soils occur in low lying areas which are also densely populated. To render these areas more suitable for settlement and farming, drainage and other flood mitigation measures have been provided from time to time.

The West Johore coastal pain in Peninsular Malaysia is one such area with acid sulfate and potentially acid sulfate soils. Much of the hinterland is subjected to periodic flooding and poor drainage conditions despite the provision of drainage canals and coastal bunds. An integrated Agricultural Development scheme designed to increase the livelihood of the people in the area is presently being implemented. A major component of this program is a more intensive drainage network.

By lowering the water table below the zone of pyrite accumulation, drainage causes the pyrite to oxidize and produce sulfuric acid. This kind of acidification as a result of drainage has been reported in the West Johore coastal plain (Joseph and Nuruddin, 1975). Intensive drainage has also been reported to seriously affect oil palm yields in similar pyrite-containing alluvial soils in Peninsular Malaysia (Poon and Bloomfield, 1977).

It is clear therefore that efficient drainage of poorly drained potentially acid sulfate soils must also bė concerned with the chemical changes that take place in the soil as a result of the oxidation of pyrite. If the rate of oxidation of the pyrite in the field is known, then it is possible to estimate how long it takes for the pyrite to be oxidized and leached out of the soil. Hart *et al.* (1965) reported on an oxidation and leaching experiment under field conditions but no data on the rate of oxidation and loss of pyrite by leaching were presented.

This paper discusses some of the preliminary findings on the rate of oxidation in a field experiment in the West Johore Agriculture Development Scheme where different intensities of drainage are being related to physico-chemical changes in the soil and to coconut yields.

* Research Officers, Soil Science Branch.
Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor, Malaysia.

Methodology

The experimental site covers an area of 165 ha with each of the treatment plots covering an area between 20 to 34 ha.

Fig. 1 indicates the location of the experimental site and Fig. 2 indicates the layout of the experiment and the sampling points. The experiment is carried out in duplicates. The drainage network in the treatment plot is provided with farm drains (0.6 m – 0.9 m) deep at 201 m interval, and the water table level in the farm drains was maintained at two different levels:

(i) Free drainage, without water table control device.

(ii) The water table is being maintained above the pyritic layer (about 45 cm from the soil surface)

In addition, there is a control plot where there were no farm drains provided.

Soil samples were taken from sampling points as indicated in Fig. 2. The sampling density was 2 sampling points for every 1.2 ha or every sample point covered an area of 0.6 ha.

Soils used for analysis were dried using infrared lamp as described by Zahari and Ting, 1981.

The fresh pH was obtained using glass calomel reference electrode. The pyrite-S content of the soil was determined before and after oxidation with H_2O_2. Sulfate-S was determined by digesting the soil with 2N HCl and determined as H_2S after reduction with HI (Archer, 1956).

The pH of the water was obtained using glass calomel electrode and the water soluble sulfate in the ground water was determined as H_2S after reduction with HI.

Soil and water sampling was done at every 4-month interval, and water table readings were recorded at weekly intervals.

Results and discussion

Fig. 3 shows the changes in pH of the soils after the field drainage was introduced. The freely drained plot away from the sea showed the lowest pH. The plot with the water table control showed intermediate pH levels, and the highest pH was recorded in the control plot.

It is interesting to note that even the topsoils (0 – 30 cm) which are virtually non pyritic had pH values less than 4. This is probably due to the capillary rise of the acidic groundwater from the pyritic horizons.

The pyrite content in the soils from the experimental area is sporadically distributed with the amount varying from 0 – 2.4% pyrite-S. Pyrite content increases significantly below the 12" depth. Due to this variability unusually large numbers of samples were collected and analysed. Fig. 4 shows the changes in the pyrite content with time, and the rate of loss of pyrite is a measure of the rate of the oxidation.

The rate of oxidation of the pyrite is inversely proportional to the soil pH. When the rate of oxidation increases, the pH of the soil begins to decrease, but once the rate of oxidation decreases, the pH of the soil begins to increase. It is important to note that in the initial stages just after the introduction of field drainage, the rate of oxidation was highest and at this stage the sulfate moves down into the groundwater, taking with it much of the exchangeable bases. In the freely drained plot at the 12–18" depth (Fig. 4c), it can be seen that the pyrite content drops from 0.43% at the beginning of the experiment to about 0.3% in 8 months. The oxidation rate is reduced considerably in the ensuing period in which pyrite loss is about 0.05% in the next 8 months. This trend is reflected in the sulfate content in the groundwater. Fig. 6(b) shows the sulfate content reducing from 190 ppm to 90 ppm for the first 8 months, and decreasing from 90 to 60 ppm in the following 8 months.

Effects on coconut yields

Table 1 shows the yield of coconuts from the experimental plot. Coconut yield in the freely drained plots away from the sea was the lowest being about half that recorded for the control treatment. The difference in the yield among the plots nearer the sea is not significant probably due to the higher water table (see Figs. 5a and 5b).

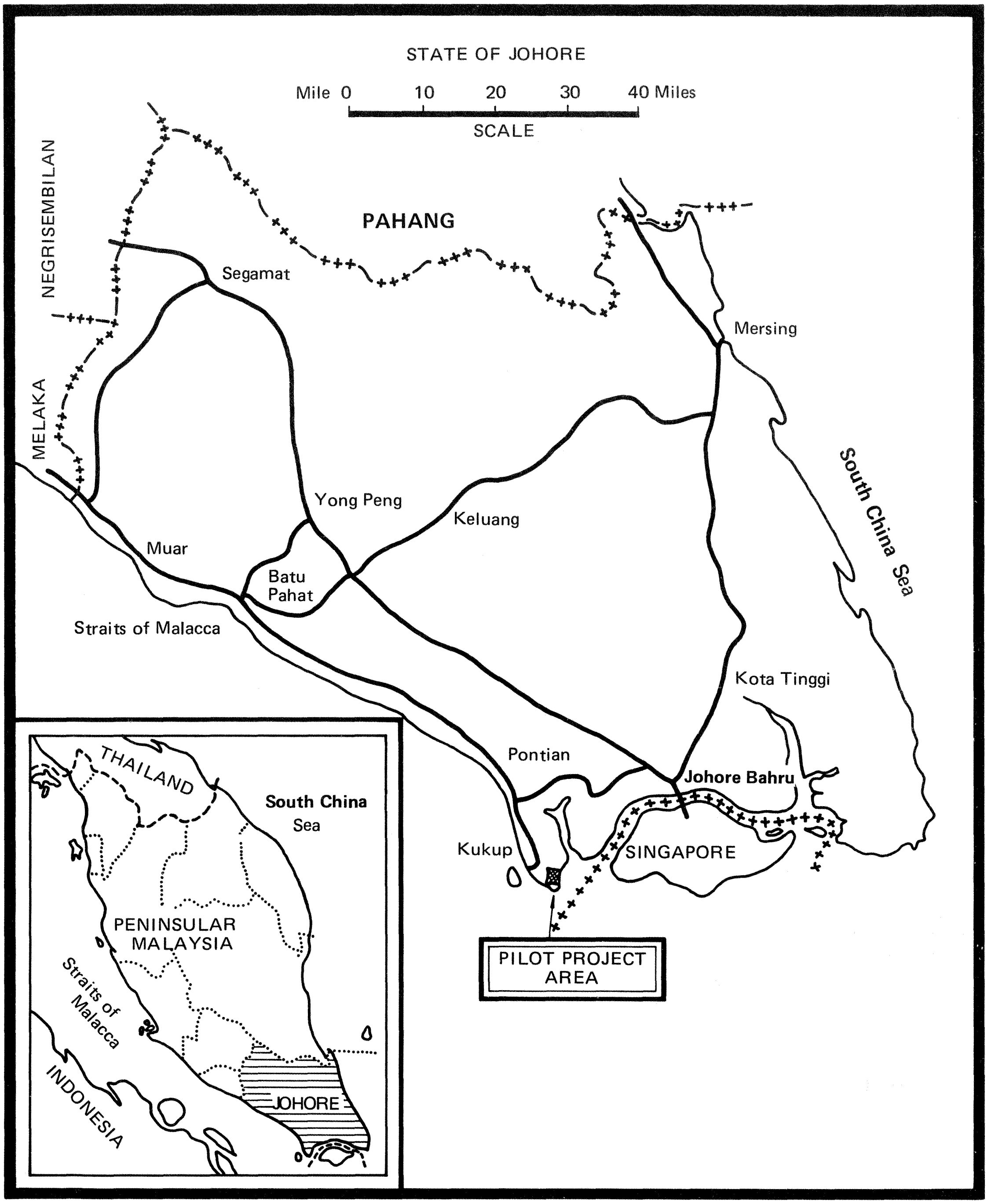


Fig. 1 Location of the experimental site.

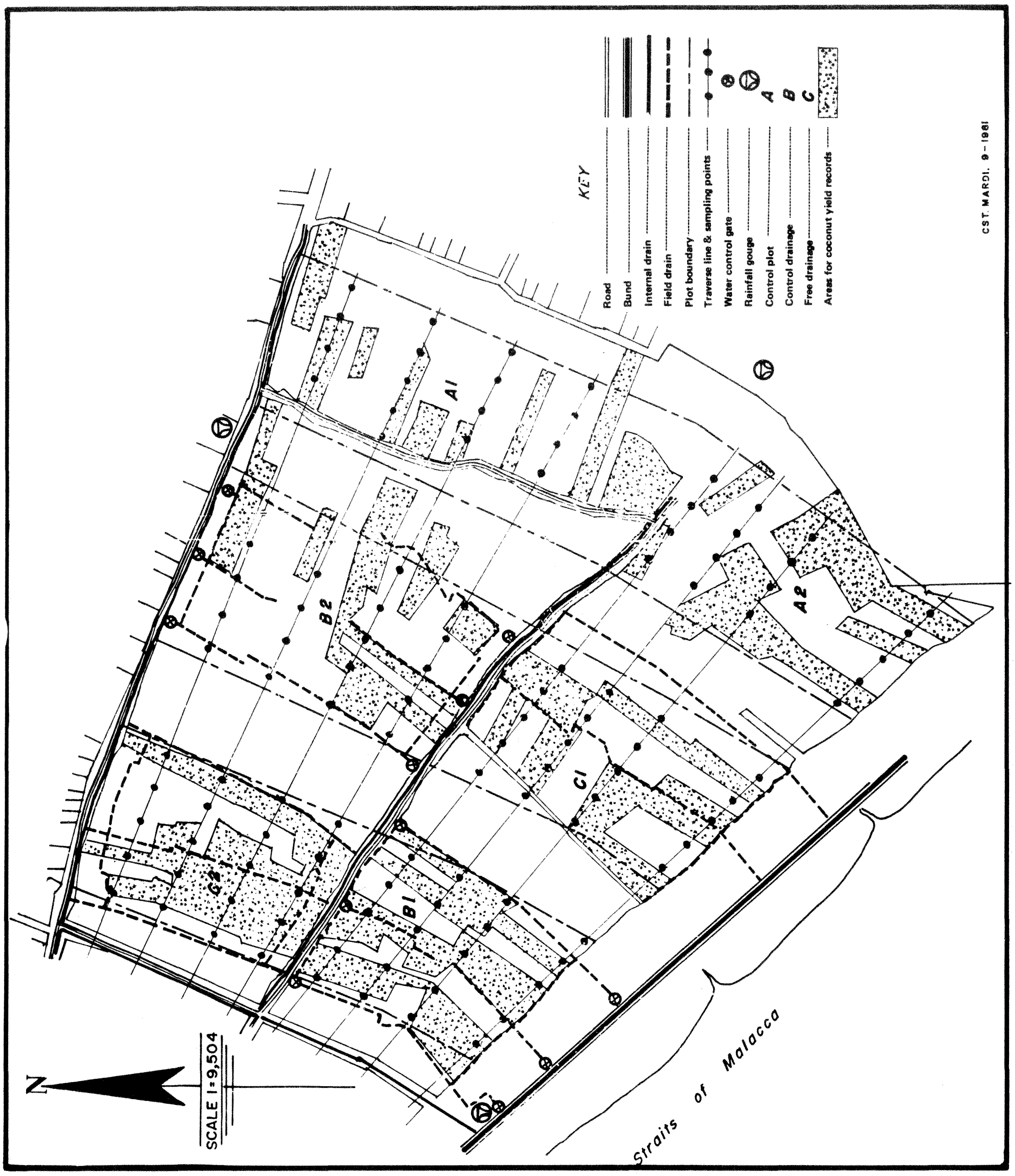


Fig. 2 Map layout of the experiments and sampling points in Acid Sulfate Pilot Project Area Serkat, Pontian, Johore, Malaysia.

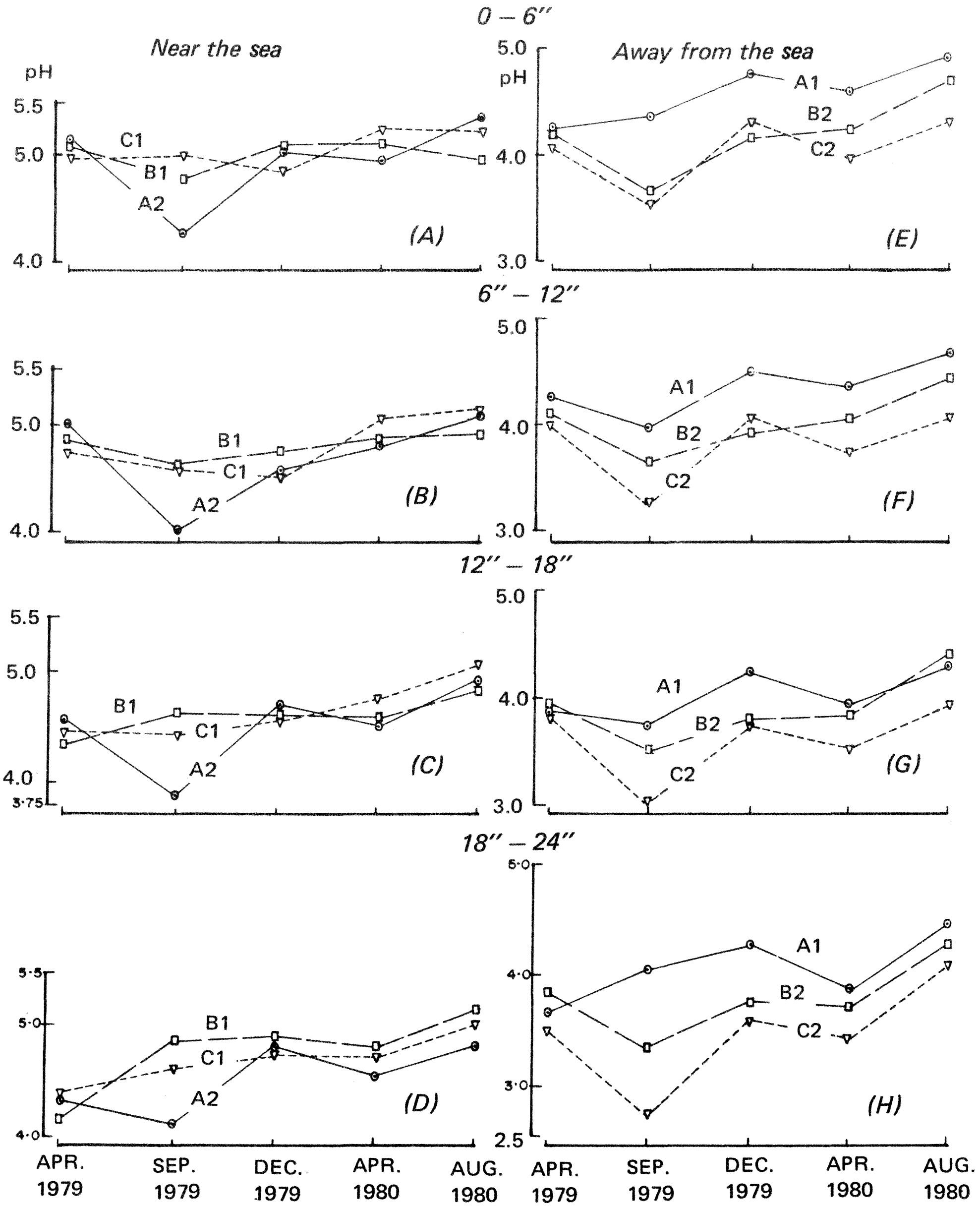


Fig. 3 Fresh pH at various depth fractions in the pilot project area in West Johore.

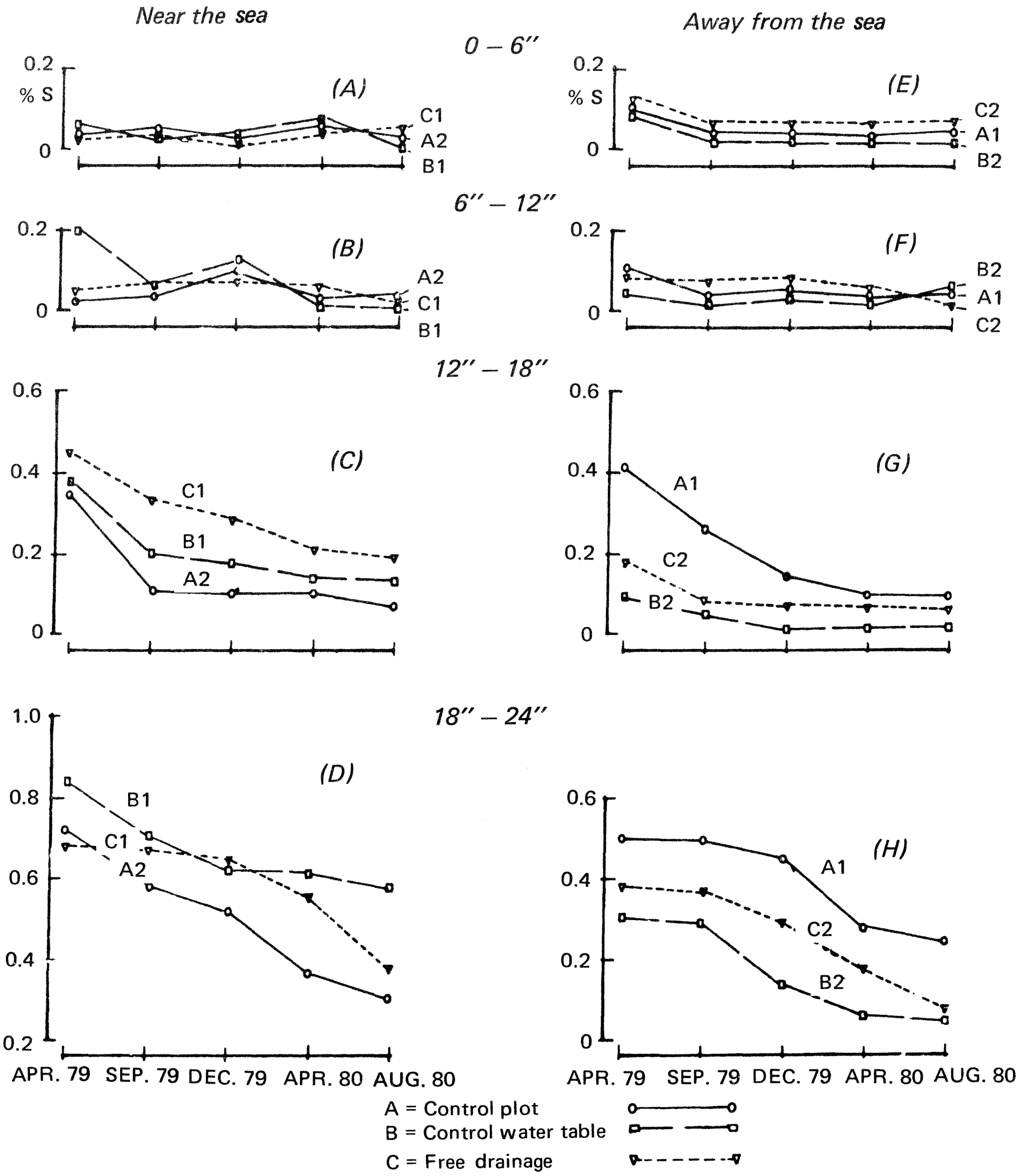
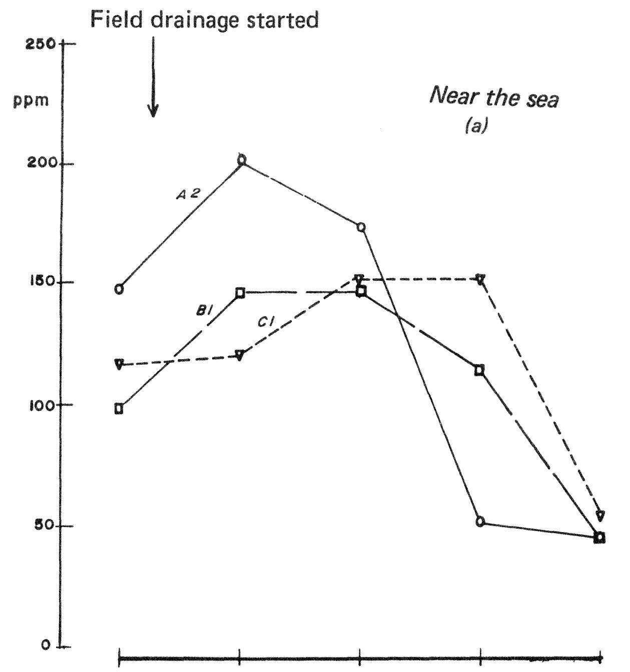


Fig. 4 Pyrite content of the soils at various depth fractions in the pilot project area in West Johore.



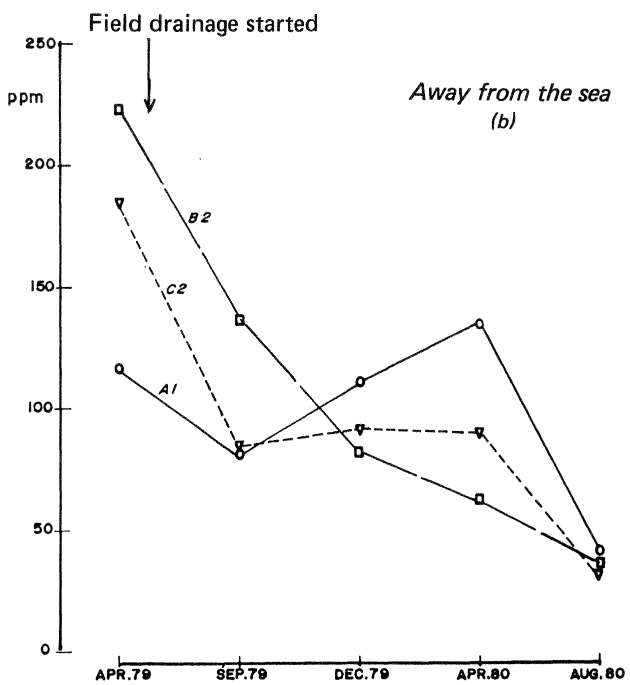


Fig. 6 Water soluble sulfate – groundwater.

Table 1(a) Yield of coconuts (no of nuts/ac/year) from plots away from the sea

	April 1978 – May 1979	June 1979 – June 1980	July 1980 – June 1981
Control plot	2,026	1,902	2,031
Control water table	2,350	2,332	2,858
Freely drained	2,343	1,521	1,671

Table 1(b) Yield of coconuts (no of nuts/ac/year) from plots near the sea

	April 1978 – May 1979	June 1979 – June 1980	July 1980 – June 1981
Control plot	2,554	2,154	2,725
Control water table	2,067	2,439	2,927
Freely drained	2,373	2,174	2,999

Note: Field drainage was introduced in June 1979.

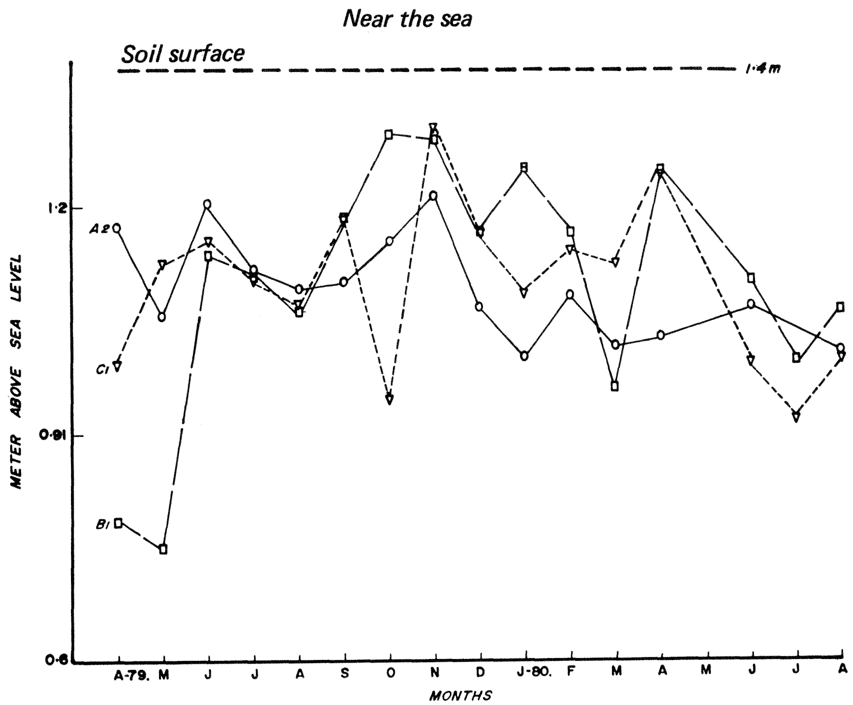


Fig. 5(a) Groundwater table fluctuation in the experimental areas near the sea.

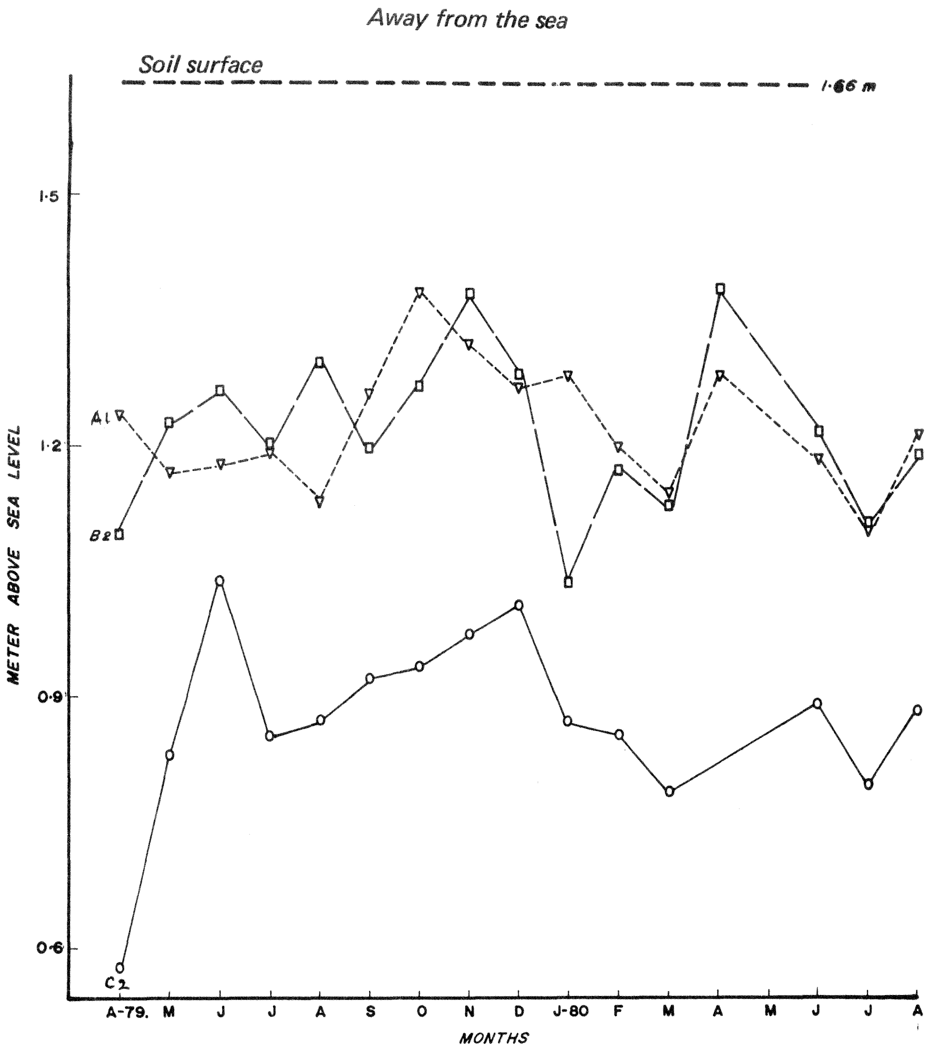


Fig. 5(b) Groundwater table fluctuation in the experimental areas away from the sea.

Conclusion

The initial results indicate that with the water table being maintained above the pyritic horizon, the pH of the soil is kept high (> 4) while freely drained area showed consistently low pH value (< 3.5). Coconut yield in the freely drained plots shows the lowest value, the yield being about half that recorded for the control plot.

Acknowledgement

We would like to thank all our laboratory and field staffs for their cooperation and assistance.

References

1) ARCHER, E.E. (1956): The determination of small amounts of sulphate by reduction to hydrogen sulphide and titration with mercuric or cadmium salts with dithizone as indicator. *Analyst* **81**, 181-182.
2) HART, M.G.R., CARPENTER, A.J. and JEFFERY, J.W.O. (1965): Problems in reclaiming saline mangrove soils in Sierra Leone. *African Soils* **10**, 71-75.
3) JOSEPH, K.T. and NURUDDIN, M. (1975): A field study showing classical changes in acidity over large areas in the Parit Jawa area of Johore during the last decade. 3rd. Asian Soil Conference, Kuala Lumpur (Malaysia) 1975.
4) POON, Y.C. and BLOOMFIELD, C. (1977): The amelioration of acid sulphate soil with respect to oil palm. *Trop. Agric. (Trinidad)* **54(4)**, 289-305.
5) ZAHARI, A.B. and TING, C.C.: Investigation on possible methods of drying pyritic soils. Paper presented at Seminar on Management of Tropical Soils. 30-31 March 1981, Kuala Lumpur, Malaysia.

Discussion

Kyuma, K. (Japan): 1) What is the range of tidal fluctuation in the experimental field? 2) What was the cost for the establishment of the controlled drainage facilities?

Answer: 1) The area was provided with a so-called "borrow pit" parallel to the coast to serve as a buffer and minimize the tidal influence. 2) The cost of the whole West Johore Development Project amounted to three hundred and eighty million M$ with an additional one million dollars for the gates.

Hesse, P.R. (FAO) : 1) How was the pyrites measured? 2) How was organic sulfur differentiated from pyrites sulfur after oxidation with hydrogen peroxide?

Answer: 1) Pyrites was determined as the difference between total sulfur content after hydrogen peroxide oxidation and 2N hydrochloric acid extractable sulfate. 2) We assumed that since most of the sulfur comes from the pyrites and not from the organic matter whose content is low, the error due to organic sulfur would be negligible.