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ACID SULPHATE SOILS

modeling of physical and chemical processes

Report of an introductionary mission to the counterpart institutes CSR-Bogor and BARIF-Banjarbaru and the tidal swamp area of Pulau Petak, South Kalimantan, Indonesia

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Nota's (Notes) of the Institute are a means of internal communication and not a publication. As such their contents vary strongly, from a simple presentation of data to a discussion of preliminary research results with tentative conclusions. Some notes are confidential and not available to third parties if indicated as such

C O N T E N T S

1. OBJECTIVES

The modeling component of the joint Dutch-Indonesian research project on acid sulfate soils is started at 1 October 1987.
To initiate the collaborative research a mission of the Dutch modeling team has been undertaken to the counterpart institutes CSR-Bogor, and BARIF-Banjarbaru, South Kalimantan, in the period 25 October - 8 November.
The objectives of this mission in the very first stage of the project were:

CSR-Bogor

1. Acquaintance of participants in the modeling component
2. Elucidation and discussion of the research programme on basis of a first outline of a simple physical-chemical model on pyrite oxidation and model computations on speed of pyrite oxidation in dependance of soil structure, ripening state, pyrite content of the soil, dissolved oxygen and ferrous iron concentrations to illustrate the usefulness of a model approach (see ICW-Nota 1821).
3. Project organization, coordination, computer, experimental and housing facilities.
4. Duty-stationing of the CSR - jr. soil scientist at ICW, Wageningen, at the earliest convenience.

BARIF-Banjarbaru

1. Idem points 1-3, mentioned above
2. Laboratory/field equipment and experiment fields at the BARIF institute and the experimental station Unit Tatas (Pulau Petak)
3. Thorough introduction of the ICW-modeling team into all aspects of occurence, reclamation, occupation and utilization of (potential) acid sulfate soils through field trips: physiography, spatial variability, reclamation, soil and water management, cropping systems and other aspects/problems related to the tidal swamp environment

The ICW-modeling team mission was formed by:

- dr. A.L.M. van Wijk, research leader ICW;
- ir. J.J.B. Bronswijk, scientist soil physics;
- drs. C.J. Ritsema, scientist soil chemistry.

From the arrival in Jakarta on 26 October ing. Hamming, local and scientific support officer, Euroconsult, joined the ICW-team during the whole stay in Indonesia.

Cooperating Indonesian research members met during the mission:

- Dr. Sudjadi, Director Centre for Soil Research (CSR), Bogor;
- Dr. Putu Gedjer Widjaja Ahdi, Head Soil Fertility Unit, CSR, Bogor;
- Ir. Kusomo Nugroho, Junior Soil Scientist, CSR, Bogor;
- Dr. Hans Anwarhan, Director Banjarbaru Research Institute for Food Crops (BARIF);
- Drs. Isdianto, Field Assistant Modeling component, BARIF;
- Mr. Harmiati, Laboratory Assistant Modeling component, BARIF;
- Ir. Hairunsyah, Research Leader for Water Management component, BARIF;
- Ir. Masgianti, field assistant for Water Management component, BARIF;
- Mr. Fahrid, Logistics/Communications, BARIF;
- Mr. Sarjiwo, Chief of Unit Tatas experimental station, BARIF;
- Mr. Sarkawi, Assistant of Mr. Sarjiwo, BARIF;
- Ir. Mauliana Damanik, Head of Agronomy Department, BARIF.

EUROCONSULT members met in Indonesia:

- Ir. Hulsbos, Head Civil Engineering Unit, Arnhem;
- Ing. Wolf, Head Branche EUROCONSULT Indonesia.

During the visit to South-Kalimantan the ICW-modeling-team was completed by the CSR-modeling-counterparts: Dr. Putu Gedjer Widjaja Ahdi, research leader, and Ir. Nugroho.

2. PROGRAMME

25,26 october:	Flight Amsterdam-Jakarta Van Wijk, Bronswijk, Ritsema
27	: Bogor: Centre for Soil Research (CSR). Discussion and presentation of ideas on modeling processes in acid sulfate soils. Participants: Dr. Sudjadi, Dr. Gedjer Widjaja Ahdi, Ir. Kusumo Nugroho, Ing. Hamming, Dr. Van Wijk, Ir. Bronswijk, Drs. Ritsema. Nugroho will arrive in the Netherlands half of january '88 in order to participate for two years in the research of the modeling component.
28	: Bogor: Visit and introduction of laboratory facilities at CSR. Inspection of guesthouses. Discussion with Dr. Gedjer on presented flow chart of model.
29	: Flight Jakarta-Banjarmasin Dr. Gedjer, Ir. Nugroho, Ing. Hamming, Van Wijk, Bronswijk, Ritsema. Banjarbaru: Visit of Banjarbaru Research Institute for Food Crops (BARIF). Elaboration of the programme and presentation of the BARIF participants in the modeling component: Drs. Isdianto (field assistant) and Mr. Harmiati (laboratory assistant). Further meeting with Ir. Hairunsyah (Research Leader for Water Management), Ir. Masgianti (Field Assistant for Water Management) and Mr. Farid (Logistics, Communications).
30	: Banjarbaru: Meeting with BARIF staffmembers. Introduction into BARIF research on tidal swamps by Dr. Hans Anwarhan (Director). Elucidation and discussion on modeling physical and chemical processes of acid sulfate soils. Preparation of field trips.
31	: Field trip Unit Tatas. Participants: Dr. Anwarhan, Dr. Gedjer, Mr. Nugroho, Drs. Isdianto, Ir. Masgianti, Mr. Harmiati, Mr. Farid, Hamming, Van Wijk, Bronswijk and Ritsema. Inspection research facilities and first introduction into soil and water management conditions in Unit Tatas. Aquaintance with Mr. Sarjiwo (Chief of Unit Tatas) and his assitant Mr. Sarkawi

1 november	:	Field trip Barambai. Introduction into crop, soil and water management. Evaluation and adjustment programme.
2	:	Field trip Tamban area. Visit to former Gajah Madah University (Jogjakarta) field research centre, observations within a rice field near km.sign 15 along Anjir (canal) Tamban and detailed survey of a potential acid sulfate soil near the crossing of the Barito river and Anjir Tamban.
3	:	Banjarbaru. Discussion with several staffmembers of the agronomy department of BARIF on cropping systems, especially those of rice (local variety versus high yielding varieties), maize and cassave.
4	:	Field trip Unit Tatas. Detailed survey at Unit Tatas and hinterland on the occurence of potential acid sulfate soils and observations on soil and water conditions.
5	:	Flight Banjarmasin-Jakarta.
6	:	Jakarta. Discussion with Ing. Wolf (Head Branche Euroconsult Jakarta) on acid sulfate soils in Sumatra and Kalimantan. Field trip surroundings Jakarta.
7	:	Preparations mission report.
8-9	:	Flight Jakarta-Amsterdam.

3. CSR-BOGOR

The most important activities and appointments made during the visits at CSR-Bogor can be summarized as follows:

1. Aquaintance counterparts modeling component Dr. Gedjer and Ir. Nugroho. Nugroho will arrive in the Netherlands half of january 1988.
   The junior soil scientist who will cooperate with the associate expert both in the ICW and the STIBOKA component in Indonesia is not yet nominated.
2. Elucidation and discussion on modeling physical and chemical processes in (potential) acid sulfate soils (see Nota 1821) and possible consequences for field and laboratory experiments.
3. Testing of an IBM compatible GARUDA PC with help of a test-floppy (Hantush/spm11) developed by Dr. Boonstra. Conclusion: Fortran compiler present, works well.
4. Inspection guesthouses. Conclusion: proper and quiet. Rooms are without air-conditioning and seperate bathrooms. Eating facilities present.
5. Visit of physical and chemical laboratories at CSR. Impression: rather well equiped.

4. BARIF-BANJARBARU

Activities and observations carried out at BARIF-Banjarbaru:

1. Introduction of cooperating staffmembers of BARIF by Dr. Anwarhan. Summarizing of BARIF participation in tidal swamp research, especially in the region Pulau Petak, South-Kalimantan.
2. Meeting in which ICW modeling team was introduced to all BARIF staffmembers. Explanation of modeling ideas and research program by ICW staffmembers.
3. General facilities at BARIF:
   - relatively new office, lots of rooms but no office furniture available for cooperating Dutch members
   - no telephone, telex, copysystem or computers
   - no airconditioning.
4. Existing laboratory equipment:
   - 'Spectronic 20' (Bausch & Lomb) for determination of P, Fe^{2+} and total iron. In use.
   - pH-meter (1). In use.
   - Balance (1). In use.
   - EC-meter (1). In use.
   - Spectrophotometer (Tecator, type 5032 controller, type 5020 FIASTAR analyzer) for determination of total N, total sulphite, free sulphite, $H_2PO_4^-$, total P, $(SO_3)^{2-}$, Ca^{2+}, $(NH_4)^+$, $(NO_2)^-$, Cl^-, $(SO_4)^{2-}$, Al^{3+}, silica, total alkalinity, total $CaCO_3$, Fe^{2+}. Spectrophotometer not used, because of a missing part. Hopefully missing part will be installed within four months. Chemicals necessary for above mentioned determinations not present.
   - Flamephotometer (Petracourt PFP1) for determination of Na+, K^+, Li^+. In use, however getting out of date.
   - Ovens (3) for determination of moisture and organic material content. In use.

Ordered laboratory equipment by USAID still not present. Delivery-contracts with Indonesian suppliers signed 1 march 1987. Terms of delivery indistinct. Hamming will contact US-embassy, AARD and several suppliers for information. If ordered equipment is not available april/may 1988 problems will arise.

5. FIELD TRIPS

5.1. General

We have made four field trips into the Pulau Petak area: Two to Unit Tatas, one to Tamban and one to Barambai. The places visited and the inspected soil profiles are marked in figure 1. pH was measured with a portable pH-meter. Pyrite was demonstrated by peroxyde treatment.
In the Pulau Petak area, many small villages are situated along rivers and canals. Some 15-20 years ago, many canals have been constructed, the forest has been cleared and transmigrants (mainly from Java) have settled in the area. Fig. 1 shows the Pulau Petak area, together with the visited sites and soil profiles. Pulau Petak is situated between the rivers Barito and Kapuas. In the centre of Pulau Petak large peat domes occur, which are not used for agriculture. On the river levees, relatively young sediments occur.
Upon the construction of the canals, the greater part of the area between the levees and the peatdomes was drained. Actual acid sulfate soils have developed extensively in this area. At the banks of the Barito (profile 4) we have found poorly drained reduced soils with pyrite in the upper 20 cm. Possibly, these potential acid sulfate soils may occur also on the edges of the central peat dome (profile 6). More close to the sea, some inland areas have remained poorly drained troughout the years. Possibly some potential acid sulphate soils, which have not yet been acidified, can be found here. The low pH values have their effects on crop growth in the area, which is rather poor. The main crops are: Rice, Cassave, Coconut, Maize, Ananas, Oil Palm. Rice varieties include local varieties (a.o. Siam) with growing periods of about 9 months and new varieties (a.o. Kapuas) with a growing period of about 4 months. The influence of the tide is noticable up to Unit Tatas and further. At Unit Tatas the water is mostly fresh, except for rare periods in May/July (dryest period) when it is sometimes brackish).

5.2. Barambai

Profile 1.

Site: Cassave field within the settlement, transmigration project, established some 15 years ago. Well drained actual acid sulphate soil.

Yields approx 6-7 tons/ha, (normal cassave yield: 20 tons/ha).

Profile was taken in between two raised beds.

Groundwaterlevel: 80 cm below soil surface.

pH of water in tertiary channel coming from forest: 3.2

depth	pH	FeS_2	comments
0- 12 cm	3.5	-	no jarosite, well structured, dark grey
12- 24	4.0	-	no jarosite
24- 35	4.0	-	no jarosite
35- 50	4.5	-	no jarosite
50- 65	4.5	±	no jarosite
65- 80	3.5	+	no jarosite
80- 90	3.5	++	jarosite
90-100	4.0	++	no jarosite
100-110	4.5	++	no jarosite

5.3. Tamban

Profile 2

Site: Experimental farm Gajah Madah University: Tamban Luar Kolam Kanan.

Experiments for P4S tidal swamps project. Finished some years ago.

Water management system and meteorological station still present.

Direct tidal swamp, daily flooding at high tide. Rice field.

Groundwater level 30 cm.

pH of water in tertiary canal, at 5 meter distance from profile: 5.8

depth	pH	FeS_2	comments
0- 20 cm	4.8	-	iron oxide mottling, dark brown, well structured
20- 30	4.6	-	iron oxide mottling, dark brown, well structured
30- 50	4.8	-	grey, peaty, half ripe
50- 70		-	grey, peaty, unripe
70- 85		-	grey, peaty, unripe
85-100	5.1	-	grey, peaty, unripe

Profile 3

Site: approximately 500 m from Tamban channel. In the centre of the "potential acid sulphate area" according to Driessen (1973). Settlement established some 15 years ago. Profile taken in rice field. Yield approx. 1.8 ton/ha.
Groundwater level: 60 cm.
Results of pH meter are dubious.

depth	pH	FeS_2	comments
0- 20 cm	4.8	-	no jarosite
20- 40	5.0	-	no jarosite
40- 60	5.0	±	jarosite
60- 70	4.8	±	jarosite
70- 80		+	no jarosite
80-100		++	no jarosite

Profile 4

Site: Situated at the crossing of Barito river and Tamban channel.
100 m distance from Barito river. Ponded rice field.
Groundwater level 5 cm.
Sulphidic clay.

depth	pH	FeS_2	comments
0-10 cm	6.8	++	red brown mottling
10-20	6.9	++	reduced, grey
20-80	6.8	++	reduced, grey, 5 minutes after H2O2 treatment: yellow mottling and pH 4.5

5.4. Unit Tatas

Canals in the Unit Tatas area were dug some 15 years ago, because the area was planned for transmigration purposes. This project was not realised and the experimental farm was founded at this place around 1985. Total area of the farm is 25 ha. Experiments are in the field of soil fertility. The farm has several stone buildings, suitable for offices, lodging and simple laboratory. There is no telephone, communication with BARIF Banjarbaru is via short wave radio (Equipment should be partially renewed). River and rain are fresh water sources. In dry periods (may-july) the river water may be brackish and in absence of precipitation, no fresh water may be available within this period. In the wet period (november-february) the fields are ponded. In theory, water supply and discharge can be controlled by wooden sliding dams. In the canal walls, the required structures for these dams are present. The dam itself however, was never delivered. Therefore, at this moment no water management is carried out. The pH of river Kapuas water was 6, the pH of water near the landing stage of Unit Tatas (primary canal) was 4-5, the pH in a secondary canal, close to profile 7 was 4.

During our visit, the whole Unit Tatas area was rather dry, with deep groundwater levels. Some soil profiles from Unit Tatas are described below. Their location is marked in fig. 2.

Profile 5.

Site: Peanut field, groundwater level 25 cm. This soil has been limed for some years. Profile was taken in between of two raised beds.

depth	pH	FeS_2	comments
0- 20 cm	4.0	-	well structured, dark brown, no jarosite
20- 40	4.2	-	brown red mottles, no jarosite
40- 60		-	half ripe, grey, no jarosite
60- 80	4.4	+	half ripe, grey, no jarosite
80-100	4.4	++	half ripe, grey, no jarosite

Profile 6.

Site: 200 m behind the experimental farm (relative to the landing stage)
Secondary forest at the transition of the clay to the peat area. poorly drained (no canals or ditches) Groundwater level: 7 cm. pH water in borehole: 3.8

depth	pH	FeS_2	comments
+20- 0 cm			undecomposed organic matter, litter
0- 15	4.2	-	black, peaty, crumby structure, wet
15- 35	3.5	-	black, peaty, crumby structure, wet
35- 55	3.8	++	dark grey
55- 75	3.8	+++	grey, half ripe clay, partly
75- 90	4.5	+++	grey, half ripe clay, decomposed
90-110	5.0	+++	grey, half ripe clay, roots

Profile 7.

Site: One of the lowest lying parts of Unit Tatas. In the middle of a rice field. pH was not measured here. Groundwater level: 45 cm. Neither jarosite nor pyrite was found down to the sampling depth of 80 cm. A sample was taken here for mineralogical analysis.

5.5. Crops on Pulau Petak

Crops play an important role in the physical and chemical processes in acid sufate soils. For instance, the extraction of water from the soil by roots promotes oxidation and acidification. On the contrary, a water layer on the field, as in paddy rice, restricts oxidation. Therefore, when modelling the different processes in acid sulfate soils, information on type of crops and corresponding water management and farm operations are essential.

The information in this chapter was obtained during the field trips and during our discussions with BARIF staff. The main crops, grown on Pulau Petak, include: rice,maize,groundnut and cassave. The main tree crop is coconut, but knowledge on treecrops is not available at BARIF Banjarbaru, so information on coconut will not be presented here. At the start of the transmigration projects on Pulau Petak, the settlement area were drained by digging canals. After some time, houses were placed here. These are the best drained places and therefore, only dryland crops like cassave and maize can be grown here. As a result, within the settlement, many ripe acid sulfate soils with low pH have developed, that yield very poor cassave crops. At greater distance from the kampong, drainage is less. Rice growing is possible here. Raw acid sulfate soils may occur here, although we could not locate them.

5.5.1 Rice

Both local varieties and new varieties are grown in South Kalimantan. The main local varieties are: Siam, Pandek, Lemo, Bajar. The main new varieties are Kapuas, IR42, IR36, Mahakan, Barito. In the following, the farm operations required by a local variety and a new one will be compared.

SIAM

Siam is one of the most grown local varieties. No water management is needed for growing siam. The crop is transplanted many times, each time to a rice field that meets the (hydrological) requirements of the crop at a certain stage (fig 3). Yields are maximally 2 ton/ha. Adapted to the local circumstances, resistant to diseases and pests. Main pest: rats. 20-25%, sometimes 100% yield reduction due to rats.
Prices: The farmer gets about 600 rupiah/kilo
Price of seed: 7500 rupiah/ha.

Time of year (approx.)	length of period (days)	name of period	description
oktober	30	Taradak	Planting of seeds in small nursery, 5-10 seeds per hole, holes are 10-15 cm spaced, wet soil, no ponding, max plantheight: 20 cm.
november	30	Ampak	Out of one hole from Taradak, 3-4 bunches of plants are transplanted into a ponded field. In advance, last years crop residual is mixed through the soil, minimum tillage, no puddling. Max plantheight: 30-40 cm.
december	75	Lacak	1 Ampak bunch of plants is divided in four bunches, which are transplanted into the lowest lying field, no tillage, Max plantheight: 75 cm.
march/april	30	Tanam	At the end of Lacak, plants are cut to a height just above the prevailing water level on the field. The plants are then transplanted from the small plant bed over the whole field.
may	150	Growing	
oktober		Harvesting	

KAPUAS

Kapuas is a new variety, with higher yields but also higher costs. The taste of the local varieties is superior to Kapuas, resulting in lower prices on the market for Kapuas. Max. yield: 4 ton/ha. Requirements: Water management, Fertilizer, Liming, pest and disease control. Two crops per year possible but not realized because of high costs. Mixing with local long growing variety is common. Net return of Kapuas rice is about equal to that of local varieties.

Start of period (approx.)	length of period (days)	name of period	description
november	25	nursery	Tillage by man power (hak), seeding, wet field, not ponded, max. plantheigth: 30 cm.
december	75-100	growing	From each bunch of plants in the nursery, 3 bunches are made and transplanted into a ponded rice field, 10 cm waterlayer. Water-management required to maintain constant water levels. after 60 days: flowering. Thereafter the waterlayer is removed from the field, the soil remains wet.
march		harvesting	

5.5.2. Dryland crops

Because of reasons mentioned before, cassave is very popular within the settlements. It requires no high input costs, and therefore it is expected that the cassave area will increase in the following years. Cassave is rather acidity resistant. However, because of the high water tables that sometimes occur and the required rooting zone of about one meter, yields are very low, about 6-7 ton/ha and many times less than that. With respect to rooting depth, groundnut may be more suitable because it only roots to a depth of about 25 cm.

6. CONCLUSIONS

- Buildings at BARIF Banjarbaru and Unit Tatas are suitable for proposed research activities. Interiors (Desks, chairs, airconditioning) and equipment (Laboratory) must be completed.

- Laboratory equipment from USAID donation has not yet arrived at BARIF Banjarbaru and is not expected to arrive within weeks or months (?).

- Unripe Sulphidic Clays (Potential acid sulphate soils) which have high pH and pyrite contents in the topsoil are not available at Unit Tatas. These soils are positioned along the rivers Barito and Kapuas and possibly close to the sea in the areas without man made channels.

- Raw acid sufate soils with pH<4 and pyrite in topsoil, can be found in the poorly drained surroundings of the peat domes in central Pulau Petak. This soil type is also present in the secondary forest outside Unit Tatas. In these soils, not only pyrite oxidation is the source of acidity, but may be the peat as well.

- At Unit Tatas, due to prolonged drainage, ripe acid sulfate soils (sometimes with raw subsoil) have developed with pyrite deeper than 70-80 cm and pH values of about 4 and lower in the upper 50 cm. The question how to reclaim potential acid sulfate soils, with pyrite in the upper part of the profile can not be studied using soils of Unit Tatas.

- The type of crops and corresponding water management have large influence on oxidation and reduction processes in acid sulfate soils. For modelling purposes rooting depth, water use and period of ponding are of main importance. For the moment, attention is focused on: Local variety rice, new variety rice, cassave, purungrass and coconut.

- Lysimeters in actual acid sulfate soils in order to study deacidification can be installed at Unit Tatas. Lysimeters in unripe sulfidic clays must be studied on farm-fields outside Unit Tatas. Information of STIBOKA survey is essential in planning the position of these lysimeters. ILRI is asked to adapt and monitor the water management on these fields. Subsequently ICW can install lysimeters to study the physical and chemical processes.

- Column-experiments on both sulfidic clays and actual acid sulfate soils can be carried out at BARIF-Banjarbaru.

- Alex Hamming should be informed as quick as possible which instruments and chemicals etc. are needed for the project. Hamming shall try to buy them in Indonesia. If they are not available they should be obtained in the Netherlands.

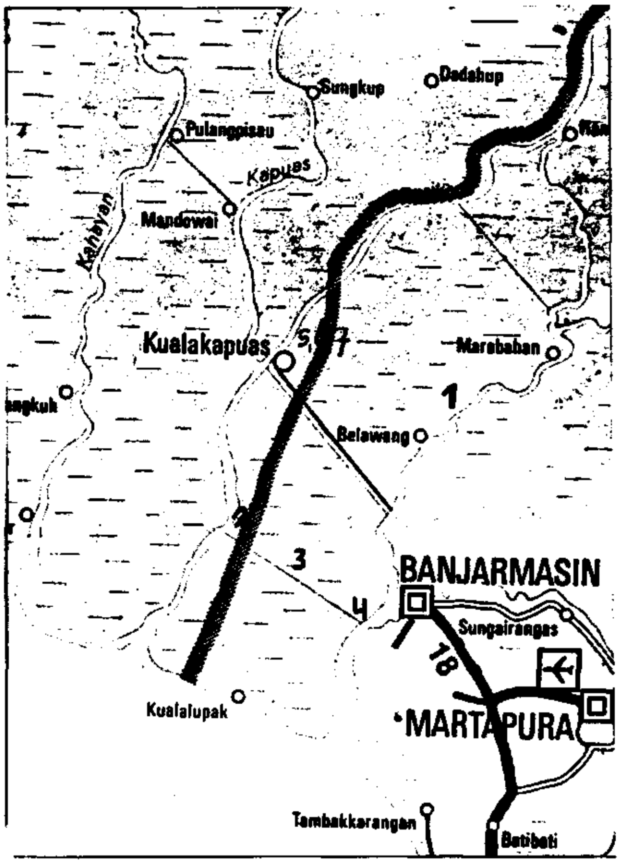

Fig. 1. Location of soil profiles, inspected during field trips

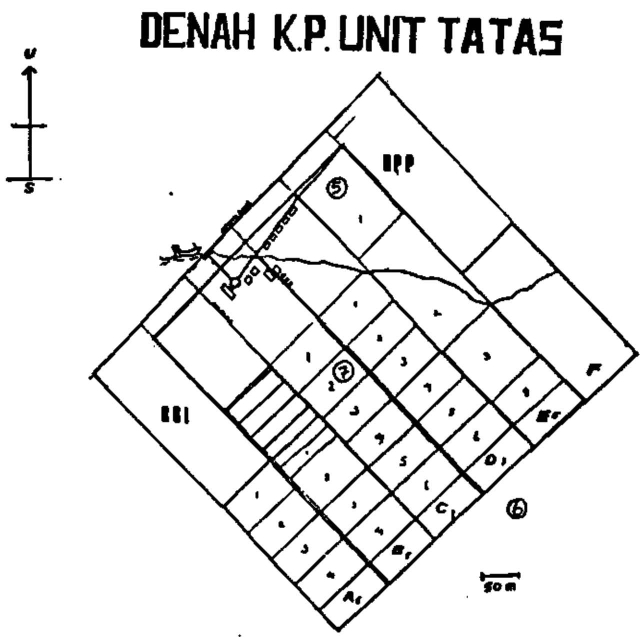

Fig. 2. Location of inspected soil profiles as Unit Tatas experimental farm

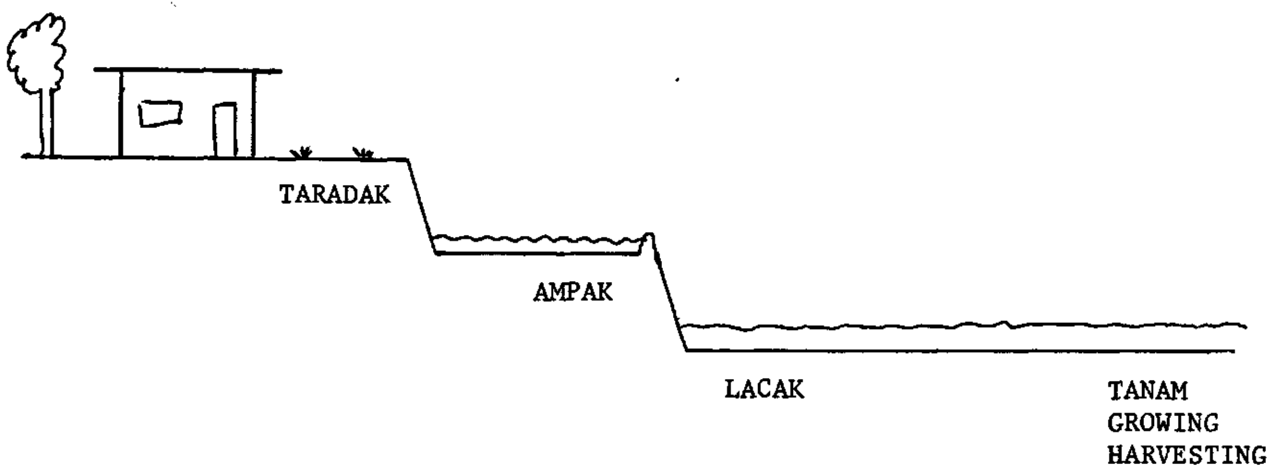

Fig. 3. Four stages of traditional rice growing system at Pulau Petak