RENOVATION OF ACID SULFATE SOIL FOR INTEGRATED FARMING AT DELTA BERBAK, JAMBI PROVINCE

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ABSTRACT

Delta Berbak is one of transmigration areas developed in peatland located in Jambi Province, Indonesia. In the early stage of reclamation, rice production reached 5 tons/ha, but gradually decreased thereafter to a production of less than 1 ton/ha. Nowadays, some farmers are still continuing rice cultivation with low production, while some others abandoned their lands. For improvement of rice production, we used a technological package of acid sulfate soil management that consists of managing canal water, increasing pH of soil and water by liming, fertilization of macro-nutrients containing N, P, K, and Mg and micro-nutrients such as Fe, Cu, Zn through foliar application. With this technological package we got unhulled rice yield of more than 4 tons/ha. For improving people welfare significantly, development of single crop such as rice is not adequate. Alternatively, integrated farming that cultivates multiple diverse crops such as rice, horticulture, plantation as well as animal husbandry and fishery simultaneously is more secure for increasing farmer income.

Keywords: *acid sulfate soil, integrated farming, technological package*

INTRODUCTION

Peatlands in Indonesia are spreading at Eastern seashore of Sumatra Island, Western and Southern of Kalimantan, and Papua with the total area of over 20 million hectares or about 10% of its total land areas. Since 1980's the soils reclaimed for transmigration areas by government and for plantation areas by private companies. Delta Berbak is one of the reclaimed areas for transmigration from Java Island. In the early stage of reclamation of those lands, rice production reached 5 tons/ha, but gradually decreased thereafter to a production of less then 1 ton/ha. Nowadays some farmers are still continuing rice cultivation with low production, while some others abandoned their lands. According to a land use survey conducted by Wijaya, *et al.*(2006, unpublished) about 38% of the Berbak Delta area are covered by shrub and only 27.5% are used as rice field with the production of mostly less than 1 ton/ha. Efforts to renovate the Berbak Delta areas by government have been carried out through many projects, such as canal maintenance through deepening of primary and secondary canals; provision of fertilizers, pesticides, soil tillage equipments, and credit; etc. However, soon after the project finished, the farmers could not continue their activities in rice cultivation and the production declined and ultimately most of fields were become shrub again. Most of scientists say that unsuccessful of acid sulfate soil renovation due to several causes such as extreme acidity of soil and water; soil dried extremely in dry season, and prolonged flooding in rainy seasons. Our observation in the field concludes that it is necessary to demonstrate the possibility of renovating the agricultural lands for integrated farming by increasing rice production as well as horticultural crops, plantation, animal husbandry and fishery simultaneously.

We started renovation studies of the degraded agricultural lands to increase the rice production in 2003. We began with collecting necessary field information and conducted laboratory and field experiments on the abandoned lands. Based on this information, in 2004/2005 we cultivated rice in two farmer's lands of total four hectares in Rantau Makmur village. We used a technological package for acid sulfate soil management that consists of managing canal water, increasing soil and water pH by liming, fertilizer management of macro-nutrients using N, P, K, and Mg fertilizers and micro-nutrients such as Fe, Cu, Zn through foliar application. With this technological package we got unhulled rice yield of more than 4 tons/ha in average with the maximum yield of 6 tons/ha. When the rice was being harvested, the Governor of Jambi Province came to our experiment site and witnessed such promising result. He was surprised and much impressed to see that with a certain technological package the lands that are abandoned for decades can be renovated for rice cultivation with convincing yield. He decided to gradually extent the renovation effort to other thousands hectares of the degraded lands of acid sulfate soils in Jambi Province. To realize the Governor decision, in 2005/2006 we worked together with the Jambi Provincial Government to renovate at first 100 hectares of degraded lands. The results of this pilot project will be used for evaluation and improvement of the next year implementation of rice cultivation in larger areas.

This paper discusses mainly our experiences in the implementation of the 100 hectares Pilot Project of rice cultivation collaborated with provincial government. The discussion will focus on the success as well as the obstacles of the renovation of acid sulfate soil in Delta Berbak. In the end of our discussion, we will give suggestion for increasing farmer income by implementation of integrated farming consist of any agricultural practices suitable for the land.

Location, Landuse, Soil Properties of the Study Area

Location of study Area. The pilot project was carried out on 100 hectares areas of farmer lands around Primary Canal No. 1 (PC-1) and Secondary Canal No. 5 (SC-5) in Rantau Makmur village, Berbak Sub-District, East Tanjung Jabung District, Jambi Province, in Sumatra Island from August 2005 to March 2006. In this project, 60 families whose own the 100 hectares lands are grouped into two farmer-groups. One family cultivated 1.0, 1.5, or 2.0 hectares depended on their total land possessions and the availability of workers. About 10% farmers came from other places for cultivating the fields abandoned by the owners. The project location is presented in **Figure 1**. The observation of the study area was conducted not only focused in 100 ha of pilot project but also the land and farmers around the pilot project.

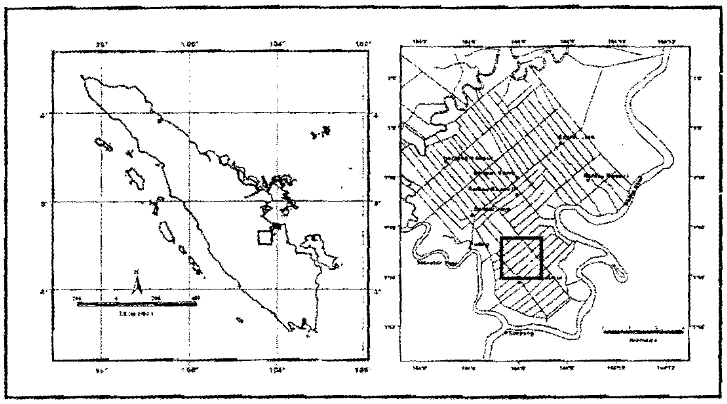

Figure 1. Location of the study area

Landuse of Study Area. According to Wijaya (unpublished), the landuse of our study area was dominated by shrub occupying 38.6% of the area. Shrub mostly occupies the abandoned fields, and usually covered by tall fern, *Melastoma sp*, *Scripus sp*, *Imperata cylindrica*, and other grass species. In the surrounding of their house, farmers planted various crops such as coffee, cacao, coconut palm, betel nut palm, banana, papaya, jackfruit, mango and also food crops such as sweet potato and cassava.

Some farmers still cultivate local rice variety annually with minimize rice practices. They start planting in October and harvesting in March without soil plowing. Preparation of land for rice field is only by application of herbicide. Farmers do not applied fertilizers and nor weeding control. They obtain unhulled rice of not more than 1 ton/ha and sometimes do not harvest at all. With this condition, the farmer's life quality is mostly very bad. A lot of farmer are still life with their original houses given by government more than 20 years ago when they came to this area. Some other farmers choose to abandon their land to go to other places looking for the better life in the nearest city or become illegal logger in the nearest forest.

Soil properties. In the early stage of land reclamation, the studied area was covered by peat swamp forest, and soil in the surface are covered by thin peat layer (< 50 cm depth). Below the peat layer, there was mangrove mud that contained much of pyrite. Because of land reclamation and land utilization, the peat layer has disappeared. In the topsoil was found peat layer mixed with clay (peaty clay) with the thickness of peaty clay varied from 0 to 20 cm.

The characteristic of the acid sulfate soils is very fragile; soil and water characteristic change rapidly in different time and condition. Soil pH changes from one site to other sites as well as from rainy season to dry season and rises to fall of tide. The changing of soil pH affect most of other soil chemical properties such as solubility of Al, Fe and other nutrients in the soils(Table 1). Therefore time schedule for implementation of agricultural activities should be followed accurately starting in land clearing, plowing and harrowing, transplanting, and harvesting. Delaying the schedule of rice cultivation activities causing the serious effect in failure of harvesting or at least reduce the rice production.

Analysis of soil in different depth taken from Pak Badri field (Table 1) shows that the soil pH increases gradually with soil depth. In 155 cm depth the pH increased sharply from 4.41 to 4.94 following by the sharp changed of Al and Fe content where as Al content was decrease and Fe content increase. Analysis of Al and Fe in pH 4.2 resulting the value of about threefold for Al and doubled for Fe compared to the pH 4.8. It means that decreasing soil pH only 0.6 digits in acid sulfate soil will affect the sharp increase of hazardous Al. That is the reason why maintaining the high pH soil by water management and liming is one of the most important keys for rice cultivation in acid sulfate soil.

Table 1. Al and Fe contents of the soil in different pH of extracted solutions

Soil Depth (cm)	pH H_2O	Al content (meq/100g)			Fe content (ppm)			
		Unbuff. sol. (KCl)	pH 4.2	pH 4.8	Unbuff. sol. (KCl)	pH 4.2	H 4.8	pH 7
0-5	4.19	15.6	20.4	6.41	386.1	227.0	172.3	58.9
5-9	4.90	16.8	27.4	7.29	231.7	133.4	94.8	28.5
9-15	4.13	13.4	28.2	7.65	256.7	155.9	144.6	37.6
15-20	4.21	12.7	29.6	8.01	198.3	151.2	146.5	36.4
20-25	4.22	16.9	30.1	9.61	264.9	189.9	198.8	57.7
25-30	4.30	17.3	29.3	9.56	200.7	165.1	136.9	34.9
30-35	4.29	14.7	26.3	10.02	136.1	183.4	130.4	21.0
35-40	4.23	16.2	29.0	7.18	169.6	184.2	213.6	32.4
40-45	4.32	16.1	34.5	9.30	190.6	345.8	197.5	40.1
45-50	4.32	14.8	33.7	9.40	273.5	500.2	132.4	74.0
50-55	4.41	13.8	28.8	9.30	256.9	469.1	286.1	69.6
55-60	4.94	10.8	32.0	10.08	230.2	512.1	352.0	71.0
60-65	4.73	9.3	31.8	9.15	348.3	1346.3	704.7	167.3
65-70	5.08	7.3	37.2	9.46	262.1	1337.4	710.1	141.6

Pilot project of Renovation of Acid Sulfate Soil for Rice Cultivation

Based on our previous experiment, soil and water properties of the location as well as the economic and social of the farmers, we collaborated with provincial government to renovate acid sulfate soil for cultivation of rice. There are two principles in our implementation of this pilot project. Firstly, provincial government provides production input such as lime, fertilizers, pesticides/insecticide as well as agricultural tools such as hand tractor and water pump. Because farmers are very poor, government should support a little money for land clearing works and oil for operating hand tractor and water pumps. Government should improve the primary and secondary canals as well as water gates and field roads. Secondly, farmers practice themselves all agricultural activities relating to rice cultivation together in farmer-group organization. Farmers were also provided local rice seed of Semut variety because according to the results of the previous experiments, the yield of that variety reached 4-6 ton/ha and relatively safe from flooding during peak rainy season in December and January. The project location usually flooded with the high of about 50 -100 cm. The Semut variety has plant height of about 140 cm, in general much taller than national prime rice varieties.

The field works was begun by land clearing from the shrubs then continuing by land preparation. During low tide, the water gates were opened in order to wash away the hazardous acid water. Afterwards, the soil was plowed and harrowed then micro-ditches were made. The aim of micro-ditch construction is to enhance the flushing effect by increasing the water mobility in the field. Calcite or dolomite was applied 2 tons/ha before rice transplanting. In the same time, government should improve the primary and secondary canals.

The preparation of seedling was done in September in order the transplanting can be conducted in October. According to the previous experiment, the dosage of fertilizers is as follows: urea = 100 kg/ha, SP36 = 100 kg/ha, KCl = 100 kg/ha, and $MgSO_4$ = 50 kg/ha. The micronutrient fertilizer at the rate of 3 liter/ha were applied through foliar application. Weeds were controlled manually. Pest and diseases are controlled by spraying of fungicides and insecticides if pest or diseases were above the economical threshold.

Figure 2. Rice growth in pilot project was not uniform due to different transplanting time and farmer managenet.

The growth of rice plant was not uniform in the whole field; it was caused by different transplanting time, different rice varieties, and different maintenance among farmers (Figure 2). Some farmers began transplanting rice in October 2005, the others in late November 2005. There were three varieties that were planted by farmers; namely IR-42, Batanghari, and Semut. A relatively good plant growth for short varieties such as IR-42 and Batanghari was just lucky. Usually, December-January is rainy seasons and maximum flooding is occurred with the deep of 50-100 cm. Fortunately, in that season the flooding was not significantly high, specifically less than 50 cm so it did not affect the plant growth. If the flooding reaches 100 cm such as usually, the IR-42 and Batanghari varieties that have plant height less than 100 cm will be under water and will be spoiled. In that condition, the rice production will be totally loss.

The early stage of rice growth showed a good performance except in location near the canal construction. The rice plant grew not good with yellow colour and weed grew in almost the whole fields. In Pak Bejan rice field where IR-42 variety was planted, rats heavily attacked rice plant. The rice plant in that field was planted earliest among the surroundings areas so that these plants served as the best source of feed for rats. All rats gather at that place to attack the rice plant causing the rice plants were totally destroyed. The other rice fields showed different damage percentage, they appeared to be caused by bird, wild boars, and rats.

The real planting area of the project was 91.1 hectares a bit smaller than the proposed area of 100 hectares (Table 2) because the rice field of some areas were used for yard where farmer house was built. The area of each farmer yard is 0.25 hectares but not all houses are built such type of arrangement. The other houses are built in cluster type where houses and rice fields are separated. The most dominant variety planted by farmers was IR-42 (75.3 ha) followed by

Batanghari (10.5 ha), and Semut (5.8 ha). This composition depends on the amount of IR-42 and Batanghari varieties seeds provided by the government and Semut variety provided by farmers themselves to suffice the amount of seeds needed.

Table 2. Rice dry grain production and harvesting components from 100 ha of rice pilot project.

Rice variety	Planting area (ha)	Average rice Production (ton/ha)
IR-42	75.3	3.5
Batanghari	10.5	3.1
Semut	5.8	2.7

The average of rice production of IR-42 was the highest (3.5 ton/ha) while Semut was the lowest (2.7 ton/ha). A relatively good production of IR-42 and Batanghari varieties were obtain because during rice cultivation the rainy season was late. Usually first rain fall in September but in 2005, the rain was still lowe until October-November. In December and January, the big flooding did not occurred such as in usual rainy season. Thus, the rain type in 2005/06 fortunately was suitable for IR-42 and Batanghari varieties, so that the result cannot be used as referent for the next planting in the same season. If farmers are doing doubled planting, IR-42 and Batanghari can be recommended because in that rice seasons fall in May August the flooding will not occurred.

The production of Semut was only 2.7 ton/ha lower than our experiment in 2004/05 that reached 4-5 ton/ha. The low production was caused by many reasons. Most of Semut variety was planted in SC-5 where the acidity is stronger than other secondary canal such as in SC-6 and SC-7. The high yield in SC-6 and SC-7 is due to that these canals is nearer to Batanghari River so that relatively have been more affected by high pH of water from the river. In general, the production of the rice in SC-5 was lower than SC-6, and SC-7. Moreover, most of IR-42 and Batanghari planted in SC-5 were worst than Semut. The other factor that caused low rice production was due to late rice transplanting and lack of land preparation due to bad government bureaucracy. Therefore, the high production in this planting season was just lucky season where in 2005 there was no high flooding. That is one of the reasons we recommended Semut variety besides its capability to withstand extremely acid soil and water. In the early April 2006, the provincial government and we discussed with the farmers in the field in relation to preparation of the 2006/07 rice cultivation. In that moment, all the farmers confirmed to cultivate Semut variety. The government has agreed with their preference and promise to provide the Semut seeds in 2006/07 rice cultivation.

Although farmers actually worried that they will not harvest their IR-42 and Batanghari varieties, fortunately they obtained relatively good results. That was the first time during decades that they obtained relatively good harvesting results. This has caused some farmers who has leaved their lands many years ago for working other jobs wanted to come back to cultivate their abandoned lands. All the farmers whose had joined this pilot project wanted to continue their rice cultivation in the next year. Provincial and district governments were satisfied with the pilot project results, although some improvements still should be done. In the next year rice cultivation, the government agrees to provide seeds of Semut, fertilizers and pesticides assistance to the same farmers. The Government will extent the rice field areas to other villages in the next year rice planting season with the similar scheme of this pilot project.

Integrated Farming as Solution for Increasing Farmer Income

To sustain continuous activities and incomes, farmers are encouraged for practicing integrated farming. In these activities, farmers combine rice cultivation with other agricultural activities to generate incomes such as cultivation of commercial horticultural crops after rice planting, cultivation of adapted plantation for acid sulfate soils such as rubber, and rearing of livestock and fish. The combination of activities depends on the land condition and experiences of the farmers. In location where relative good quality water is available along the year, cultivation of rice and rearing fish are recommended. In relatively high level land we recommended planting rubber. Principally, kinds of farmer activities are selected based on land suitability and farmer capability.

Some farmers have initiated to cultivate chili as commercial vegetable crop in part of their land after rice plantation. Chili is selected by farmers because it has relatively easy to cultivate and the price is relatively high. Farmers usually obtain more money from cultivation of chili than that from rice production. The obstacles of chili cultivation are the limitation of capital and workers. Relatively high capitals for chili cultivation are needed for chili seeds, organic and chemical fertilizers, and pesticides. Endowment of capital and doing cultivation in farmer group system are possible to improve and enlarge chili cultivation area. Combination of chili cultivation and rearing livestock is very good. The organic fertilizer made from livestock manure is very important as source of fertilizer for growing chili.

The livestock of cows produce cow dung that can be used as source of biogas production. We have installed biogas digester using simple biodigester made from plastic with 1 m in diameter and 12 m long (Figure 3). By addition of cow dung released from 3 tail cows everyday, the biogas production enough for daily cooking of one family.

Introducing of rearing fish is selected in farmer lands where water is available along the year and the acidity is relatively weak. Improvement of water quality is done by increasing pH and reducing toxic materials in the water so that the healthy of fish improved as well as the weight gain grows faster. In the same time the improvement of fish feeding will be introduced. The location of pond will be selected based on the experience and discussion with farmers.

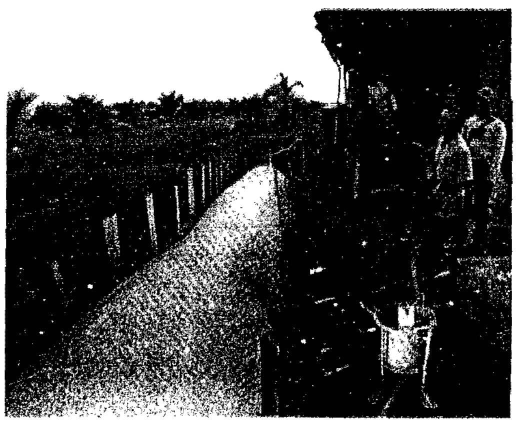

Figure 3. Simple biodigester made from plastic

The other chance for obtaining money is by planting of home garden by valuable plant. Gaharu (*Aquilaria sp*) is one of choices for long term income. *Aquilaria sp* is one of high economical plants naturally adapted at acid sulfate soil. Therefore, we select *Aquilaria sp* to cultivate at farmer home gardens.

The practices of integrated farming give the opportunity of farmers to obtain several income resources in different times. Integrated farming reduces the risk of agricultural activities. If one of agricultural activity fail, the farmers have opportunity to obtain incomes from other activities. Certainly, integrated farming practices need a great efforts and perseverance of the farmers.

CONCLUSIONS

Rice cultivation in acid sulfate soils at Delta Berbak, Jambi province technically could be done although the real production was still low. Increasing the rice production can be achieved by a technological package of acid sulfate soil management that consists of managing canal water, increasing pH of soil and water by liming, fertilization of macro-nutrients containing N, P, K, and Mg and micro-nutrients such as Fe, Cu, Zn through foliar application.

To reduce the failure of harvesting, some important activities should be simultaneously done such as maintaining time schedule of rice cultivation, selection of suitable rice variety in acid sulfate soils, and control of pest and desease.

1. For improving people welfare at acid sulfate areas, development of single crop such as rice cultivation is not adequate. Integrated farming that cultivates multiple diverse crops such as horticulture, plantation as well as animal husbandry and fishery simultaneously is more secure for increasing farmer income. Selection of combination of agricultural activities depends on the characteristics of land and interest of farmers.
2. Gaharu is one of home garden plants having potential income generating in the long run when farmers success in maintanace during gow and innoculation of gaharu plants by fungi. Agricultural activities for utilizing of degraded acid sulfate soil should be adapted to soil, plant, and climate. In the early of rainy season where water much available and the pH of soil still low, farmers can cultivate rice.

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