OPTIMIZING USE OF NATURAL RESOURCES AND INCREASING RICE PRODUCTIVITY

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Abstract

Three studies were carried out during the wet season 2000/2001 to investigate the benefits of reduced tillage in different rice cropping systems in Indonesia. The first study conducted in the tail part of a tertiary irrigation scheme in Subang district demonstrated how minimum tillage and direct seeding practice can accelerate the planting of rice. Using these techniques, the planting time was three to four weeks earlier than the transplanting technique which requires full tillage. Under minimum tillage, the land cultivated for rice was about three times much greater than that of full tillage. The second study was carried out in rainfed rice in Lombok Tengah district where the cost for land cultivation and weed control was quite high, due to the heavy Vertisols. In this area a method of soil cultivation to minimize the rice production cost was assessed. The zero tillage practice facilitated rice cultivation and minimized the cost of production. A third study was conducted in tidal swamp rice in Southern Kalimantan in the Barito Kuala district. Clearing weeds prior to planting using paraquat herbicide followed by shallow rotavation, allowed farmers to accelerate the planting of rice and reduce production costs.

Additional Keywords: reduced tillage, water efficiency, crop intensity, paraquat

Introduction

Most of rice production in West Java is located in northern part of the province. The area receives water from Jatiluhur reservoir which can irrigate about 250 000 ha. The irrigation scheme is divided into 4 groups of water allocation. Group 1 receives water during the first and second week of October. The following groups start receiving water at two-week intervals later. Within each group of irrigation water distribution there are three arbitrarily sub-groups, namely head, middle, and tail, depending on the distance relative to the secondary irrigation canal. Water usually arrives at the tail part 2-3 weeks later than as scheduled. The full tillage technique practiced by farmers in the tail part always results in late planting times and inadequate water supply during the reproductive phase of rice in the dry season.

The Gogorancah rice cultivation system (dry seeded in non-puddled field) was introduced to Lombok Island in 1980. This approach has considerably increased rice production of the island. A major abiotic constrain to gogorancah rice intensification is the dry soil preparation. Pulverizing heavy textured Vertisol from big clods to small fraction requires approximately 100 mandays per hectare. Control of weeds in direct seeded rice is costly and often inadequate due to the lack of manpower.

The rice productivity in tidal swamp ecosystem is low, often less than 1.5 tons ha^{-1}. This fragile area is harsh, because of high acidity, iron toxicity, or mineral deficiencies. This condition makes growing rice difficult. Acid sulphate soil is dominant in tidal swamp areas in South Kalimantan. Water management to maintain pyrites layer under reduced condition using a micro irrigation techniques is a prerequisite. Full tillage is not recommended because it can disturb the pyrite and lower the soil pH.

Materials and Methods

Irrigated lowland area

An experiment comparing minimum tillage and direct seeding practices was conducted in Pondok Bali village, Subang district during the wet season of 2000/2001. The objective of the study was to identify land preparation and planting techniques to accelerate rice planting. The treatments consisted of two tillage systems (full and minimum tillage) which served as main plot, while a combination of planting technique (transplanting and direct seeding) and rice varieties (IR64 and Way Apo Buru) served as sub-plots. Each block was replicated 4 times with a plot size of 12 m x 10 m. Under full tillage, land was plowed two times followed by a rotavation. Under minimum tillage,

weeds were sprayed with 3 l. ha^{-1} paraquat herbicide at 10 days before planting. A day after the land was sprayed, the plots were flooded for about 7 days. Weed debris and rice stubbles were removed before planting. Weeds were controlled manually at 21 and 42 days after transplanting. Twelve farmers participated in the study to assess the economic benefit of minimum tillage practice.

Rainfed lowland area
A study to assess the benefits of the use of the paraquat herbicide for land preparation was conducted in Kawo village during the wet season of 2000/2001. The experiment consisted of a combination between tillage (zero and full tillage), rice variety (Widas and Dodokan), and rice seed rate (30 and 60 kg/ha). The treatments were arranged in a randomized complete block design with four replications. The plot size was 10 m x 8 m. Under a full tillage, soil preparation was managed by using a hoe. The Vertisol type of soil in this area is difficult to cultivate when in a dry state. Under zero tillage, weeds were sprayed with paraquat herbicide applied at 3 l ha^{-1} at 3 days before sowing, when the weeds coverage in the plot reached 80%. Fertilizer application was based on local recommendations. Plots in full tillage treatments were weeded manually twice, during the 3rd and 5th week after sowing. An economic analysis of gogorancah rice was carried out in Kawo and Ketare villages during the following wet season. Seven farmers in Ketare and seven farmers in Kawo village participated to this study. Thirteen farmers near the experimental sites who were practicing a full tillage and mechanical weeding were selected randomly.

Tidal swamp area
The effect of paraquat on rice yield in tidal swamp area was studied in Karang Bunga village, Barito Kuala district during the wet season 2000/2001 and the dry season 2001. The treatments were arranged in a strip plot design with 4 replications. Two land preparations techniques (traditional practice and zero tillage) served as main plots, while the others treatments were two rice varieties (IR66 and Margasari) and two rates of fertilizer (farmers' practice and recommended rate). The rate of fertilizer used by farmers was 67.5 kg N, 36 kg P_2O_5, and 25 kg K_2O per hectare. The recommended rate of fertilizer was 90 kg N, 54 kg P_2O_5, and 25 K_2O. The plot size was 10 m x 8 m. Paraquat herbicide at a rate of 3 l ha^{-1} was applied 3 weeks before planting. One week after, the plot was again treated with the same herbicide at a rate of 1 l ha^{-1} to control the remaining weeds. One week prior to planting, dead weeds were rotavated. The traditional preparation of land using *tajak* (a traditional long sickle) was also initiated 3 weeks before planting. One week prior to planting time, dead weeds were removed from the field. An economic analysis of benefits of paraquat application in the tidal swamp ecosystem was carried-out in Karang Buah village. The study included 20 farmers practicing zero tillage and 20 farmers practicing traditional land preparation.

Results and Discussion
Irrigated lowland in Subang district, West Java
The yield of Way Apo Buru rice variety grown in an irrigated area was not affected by the tillage system. A lower yield of IR64 was observed when rice was grown using a direct seeding technique (Figure 1). It appears that Way Apo Buru rice variety is more suitable than IR64 to the direct seeding technique. This study suggests that rice production under minimum tillage is equal to full tillage. The amount of water saved by practicing minimum tillage under dry conditions is about 34% (Utomo, 1994). Partowijoto (1999) found that soil puddling consumed more water than other phases of rice cultivation. Better water management during the wet season can determine the success of the following dry season rice crop.

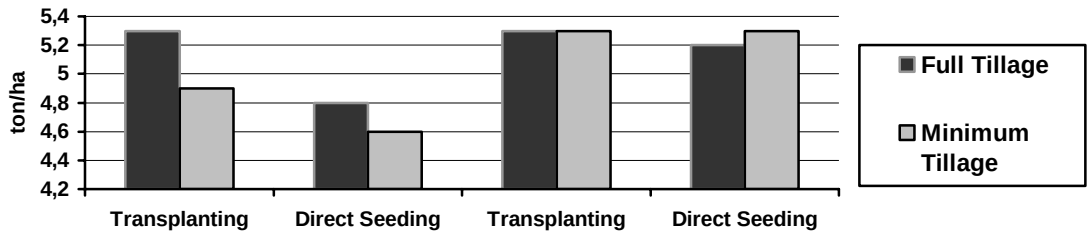

Figure 1. Grain yield of IR64 and Way Apo Buru rice varieties under different methods of land preparation

Paraquat herbicide applied to minimum tillage plots in Pondok Bali village provided weed control equal to that of mechanical weeding. The dominant weed species at the beginning of the wet season of 2000/2001 were

Fimbristilis littoralis, Cyperus diformis, and Monochoria vaginalis. Paraquat herbicide controlled effectively control broadleaves and annual grasses, such as *Leptochloa chinensis* and *Echinocloa crusgalli.* It had an efficacy of 80% against sedges, such as *F.littoralis* and *C. diformis.* However, it had only 20% efficacy against perennial weeds, such as *Paspalum distichum.*

One of the significant different between minimum and full tillage as observed in Bongas village was the time required to cultivate land. Under a minimum tillage a tractor was able to cultivate 3.8 ha, compared to 1.0 ha in full tillage. Under farmer conditions the length of time required may be longer. Saptana *et al.* (2000) found that farmers had to wait for up to 7 days to get a rented tractor.

These field experiment and participatory trials suggest that the adoption of minimum tillage technique by using paraquat herbicide to control weeds for land preparation would allow farmers to grow rice much faster in the tail part of irrigation schemes. In other countries, such as Malaysia, Thailand, and Philippines, herbicides have been used widely to control weeds pre-planting in rice fields (Pingali *et al*., 1997). In the Philippines, a combination of a direct seeding rice and application of herbicide could minimize the use of labour up to 77% when compared to transplanted rice using mechanical weeding.

Rainfed lowland in Central Lombok district, West Nusa Tenggara
The eight dominant weed species in the rainfed lowland area at Kawo village were *E. colona, E. crusgali, C. diformis, C. iria, F. littoralis, Commelina nudiflora, Marselia crenata,* and *Ipomoea aquatica*. Herbicide paraquat and mechanical weeding were comparably effective in controlling weeds as indicated by weed coverage and dry weight. Yield of Widas and Dodokan rice varieties was the same under zero or full tillage (Table 1). Practicing zero tillage without an application of pre-planting herbicide requires more labour. Meindertsema (1997) indicated of about 150 – 200 mandays were required to control weeds, making farmers reluctant to practice zero tillage. This experiment demonstrated that applying herbicide before sowing rice seeds could minimize hand weeding during the critical period of rice development, 3-4 weeks after emergence.

Table 1. Weed coverage, dry weed, and grain yield under gogorancah system, Lombok Tengah, 2000/2001

Description	Zero tillage (ZT)	Full tillage (FT)	Difference (ZT – FT)
Weed coverage (%)	38.7	31.9	4.8 ns
Weed dry weight (g/m^2)	36.8	33.9	4.9 ns
An average grain yield of Widas and Dodokan (t/ha)	3.83	3.65	0.18 ns

The highest yield was obtained from a zero tillage plot planted with Widas variety at the rate of 60 kg seed ha^{-1}, while the lowest yield obtained from that of Dodokan variety at a rate of 30 kg seed. ha^{-1}. No yield difference was observed when rice was planted using 30 or 60 kg seed ha^{-1}. Dodokan is a rainfed rice variety having low number of tillers, while Widas is a high productive rice variety for lowland, either irrigated or rainfed.

Farmers in Central Lombok district are quite familiar with the gogorancah technique. After two or three events of rainfall, women begin seeding rice before the soil becomes saturated. Under direct seeding system, weeds grow much faster than rice requiring more time for hand weeding. The need of labour per hectare and season ranged from 80 -120 mandays (Suyamto *et al*. 1991). An economic analysis of gogorancah rice production revealed that the labour cost was very high. Using a zero tillage technique, farmers could minimize the rice production cost, resulting in higher gross margins per hectare.

Tidal swamp in Barito Kuala district, South Kalimantan
Sulphuric acid soils are characterized by a pyrite (Fe_2S) layer that is located at a depth of either less than 50 cm or more. The pyrite layer is not detrimental to crops as long as it remains under anaerobic conditions. Prolonged drought or improper land preparation induces oxidation, which in turn increases soil acidity. Therefore, land preparation techniques should not disturb this micro-geographic layer. That is the primary reason that full tillage with hand tractors cannot be used in this ecosystem.

The four important weed species at Karang Bunga were *Brachiaria paspaloides, Panicum repens, Paspalum commersonii* and *Leersia hexandra. Eleocharis acutangula* was also considered as a dominant weed species. Weed growth was altered after rice had been planted. There were 15 species of weed recorded in the wet season of 2000/2001 and 10 species identified in the dry season of 2001. Some weed species, such as *Cyperus haipan,*

Ludwigia octavalvis, and *Fimbristilis graffiti* were not present in the field prior to herbicide application. There had been a shift in weed composition due to the change in land preparation technique.

The lower weed coverage at 60 days after transplanting (DAT) indicated that paraquat herbicide provided more effective weed control than mechanical weeding. Although grain yield was not affected by land preparation and weed control measures, the application of herbicide reduced production cost and increased return (Table 2).

Table 2. Economic benefit of different land preparation methods for rice under tidal swamp ecosystem, Barito Kuala, 2001/2002

Description	Zero tillage	Full tillage
Labour used for land preparation (mandays/ha)	3.24	34.00
Grain yield of rice variety, an average of IR66, Margasari and Martapura (t/ha)	3.65	2.45
Retun to cost (R/C)	2.17	1.60
Return to labour (Rp/mandays)	63 714.00	29 849.00

Conclusions

In rice cultivation in the different rice growing regions of Indonesia water is becoming limited and more expensive. Water inadequacy is obvious in the tail part of tertiary irrigation schemes. This condition is critical because rice yields can be greatly reduced during the dry season with improper water management. *El Nino* years are particularly critical. Similarly, the reliance of agriculture to rainfall in rainfed areas forces farmers to set up the right planting time of rice. Low pH of water due to improper management of tidal swamp soils limits the use of this ecosystem for growing food crops. Depending on the type of agroecological zone, the application of minimum tillage or zero tillage techniques in combination with other crop management practices, such as pre-planting application of the non-selective herbicide paraquat can optimize the use of irrigation water, reduce cost of production, increase crop intensity, minimize crop failures due to drought, minimize yield losses due to pests and diseases, and reduce workload for soil preparation.

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