Soil and crop management to increase income of rice farmers in Aceh, Indonesia

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Abstract
Agriculture in Aceh is relatively underdeveloped compared to other parts of Indonesia. The average rice yield of 4.2 t/ha is below the Indonesian national average of 4.7 t/ha. A project funded by the Australian Centre for International Agricultural Research (ACIAR) is assisting the demonstration of the Integrated Crop Management (ICM) for lowland rice and dry-season crops in eight sites in Aceh. The skip-row planting design, transplant of younger seedlings and fertiliser management were adopted across all sites. This paper presents the interim crop yields between 2009 and 2011. The average rice yield with the ICM across the eight sites was 6.1±0.2 t/ha (2 - 8.9 t/ha). For wet season rice alone, the yield average was 6.3±1.7 t/ha (3.9-8.9 t/ha), with profit margin averaged at 55% (44-64%) or 7.6 to 15.8 million rupiah (IDR)/ha. Dry season rice was less profitable with some sites earning as little as IDR 2.4 million rupiah/ha. Reducing fertiliser rates by 25% did not adversely affect yield and can add to farm profitability. Yield from dry season crops such as peanut increased from 0.7 t/ha to 1.8 t/ha when fertilised, limed and managed and generated extra income of IDR. 8.8 million/ha. Mungbean and soybean yields did not change with management as crop failure was common due to flooding or drought. Farmers in villages around these sites have started to adopt some components of ICM particularly the skip-row 2:1 planting. However they are still reluctant to reduce fertiliser rates, implying the need for extension programs to support a cultural shift in fertiliser use.

Key Words
lowland rice, rice-based farming system, ICM, skip row planting

Introduction

The agriculture sector in Aceh is relatively underdeveloped compared to Java. Prolonged social conflict during the 1970s to mid 2000 prevented the flow of information in and out of Aceh. An Integrated Crop Management (ICM) package for lowland rice that was developed in 2002 (Deptan 2007), only began in Aceh in 2006/2007. The average rice yield in Aceh is 4.1 t/ha compared to the 4.7 t/ha national average and 5.3 t/ha West Java average. The rice yield potential for Indonesia is 6.5 t/ha (Makarim 2000). The yield average for other crops for Indonesia, are: 1.3 t/ha for soybean; 1 t/ha for mungbean; 1.2 t/ha for peanut; and 4 t/ha for maize (McLeod and Rahmianna 2009). The average peanut yield in Aceh is below 1 t/ha.

Post-tsunami relief programs opened up an opportunity for increased interaction with farmers in Aceh. An ACIAR funded project was established shortly after the tsunami to assist with restoration of cropping in the tsunami affected areas. This was followed with a project focused on improving livelihoods of smallholder farmers in the lowland areas of Aceh. Objectives of this project are: (1) assessment of lowland farming systems to identify constraints and opportunities to increase incomes (survey of rice-based low land agriculture); (2) evaluation of technologies and farming system changes to increase production (demonstrations and trials); (3) evaluation of strategies to increase the resilience of farming systems (replicated trials); (4) capacity building for farmers and district extension services (training); and (5) facilitation of communication between stakeholders (extension and farmers' exchange). This paper presents current progress with objective (2) and demonstrates what is achievable if the ICM for lowland rice is used.

The typical farming calendar in Aceh's lowland consists of rice during the wet season (October-March) and legumes or maize during the dry season (April - August) (Fig.1). In irrigated systems rice is grown also during the dry season.

Unlike any of previous rice intensification programs in Indonesia, the ICM for lowland rice allows farmers to mix and match tools/components to suit their specific production issues. ICM components include: (1) new varieties, (2) certified seed, (3) transplant of younger seedlings, (4) skip-row planting configuration using 1-2 seedlings/hole, (5) site specific nutrient management (using leaf color chart and soil test kit), (6) organic matter application, (7) intermittent irrigation, (8) integrated weed management, (9) integrated pest and disease management, and (10) harvest and post-harvest management. Of these, only components 1-5 are compulsory (Deptan 2007).

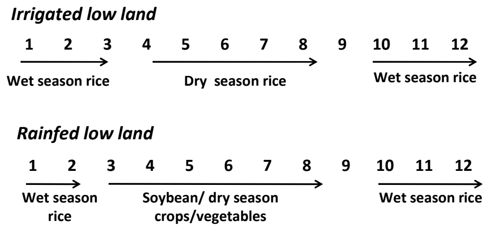

Figure 1. Typical farming calendar in Aceh and Indonesia over 12 months of the year (1-12)

Methods

Eight permanent sites across four districts include Aceh Besar (AB), Pidie (P), Pidie Jaya (PJ), and Bireuen (B) districts (Fig. 2) were selected to evaluate potential impacts of changes to the farming practices on farm profitability. These sites are also used to evaluate technologies to increase production. These were Naga Umbang (NU), Empetrieng (E), Sukun Peudaya (SP), Keutapang Bambung (KB, Irrigated), Drien Bungong (DB), Manyang Lancok (ML, irrigated), Blang Tingkeum (BT), and Mon Mane (MM).

Figure 1. Study area in Aceh (Pidie district was sub-divided into Pidie and Pidie Jaya districts in 2007)

Site selection was based on outputs from Objective 1 (farming system survey), which incorporated criteria such as accessibility and availability of irrigation water, field extension network, representative of the district, the capacity of the group to participate in the study for at least four years. Two of the sites have permanent irrigation system with average rice yield of 5-7 t/ha, while the remaining sites are rainfed with average rice yields of 3.5 - 5 t/ha. In all sites, rice is grown during the wet season whilst legumes (peanut, mungbean, and soybean) or water melon are grown during the dry season. The study covered a total land area of 17.9 ha (2.0 - 2.9 ha per site) and involving 103 farmers (9-16 farmers per site).

The activity across demonstration sites were fitted in with farmer's planting calendar and the decision of planting was made in accordance with local farmer group decision. ICM for lowland rice was used in all sites according to needs (i.e. treatments were site specific as decided by the local farmer group). The universal components of ICM used across the eight sites were new variety, transplant of 15 days old seedlings, fertiliser management, and the skip row planting 2:1 or 3:1 (20 cm spacing between rows and 10 cm spacing within row). The estimated fertiliser requirement was evaluated using 75% and 100% of the soil test kit rate (Setyorini *et al*., 2007).

Rice varieties used include Ciherang (C) Inpari 6 (I_6), Inpari10 (I_{10}), Inpari 13 (I_{13}), Mira (Mi), Mekonga (Mk), Sintanur (Sr), Situbangendit (Sb) and Lusi (a sticky-rice variety). The Ciherang variety released in 2000 (Daradjat *et al*., 2008) was the most popular variety. It has a potential yield of 8.5 t/ha (Deptan 2007) and short growing period of 125 days (Suprihatno *et al*., 2007). All other varieties are newly released. The dry season crops were grown opportunistically in each site using the Kipas Merah (KM) variety for soybean, Bisi variety for corn and the local variety for peanut were used. A simple economic analysis was conducted to determine the cost-benefit ratio for each crop on each site.

Results

Crop yield

The average rice yield across the eight sites is 6.1±0.2 t/ha with values ranging from 2 to 8.9 t/ha (including yields from dry season rice which is tended to be in the lower range). The average yield for wet season rice was. 6.3±1.7 t/ha ranged from 3.9-8.9 t/ha. Detailed yield data for rice and dry season crops over time in response to management are presented in Table 1. Crop failure was common particularly on rainfed systems due to excessive drought or unexpected flooding and pest invasion, particularly rats (Manyang Lancot site).

Table 1. Yield average and range (t/ha) between Nov 2009 and August 2011. Letter inside brackets following M or R values indicate the highest yielding variety. HYA= Historic Yield Average for rice; M=mean; R= range; [a-e]100% fertiliser rates estimated using paddy soil test kit and used to determine the 75% fertiliser rate.

District	**Site**	**HYA (t/ha)**	**Means and standard error , and yield ranges (t/ha)**			
			Nov 09-Apr 10	**May-Oct 10**	**Oct 10 - Apr 11**	**May-Aug 11**
Aceh Besar	NU	3.5-4	M: 5.24 ± 0.17 R: 4.83–5.7(C)	6.0 (L-sticky rice) Peanut: 1.8(local)	5.4 (C, I_{6} and I_{10})	drought
	E	5	M: 6.35±0.46 R: 3.92–8.88 (I_{10}) 75% F-M: 6.48±0.83 100%F-M:6.23±0.53[a]	Soybean-failed	M: 8.14±0.27 R: 7.22-8.88 (I_{13}) 75%F-M: 8.69±0.13 100% F-M:7.59 ±0.19[b]	drought
Pidie	SP	4.8	M: 6.70±0.27 R: 3.45-9.25 (C) 75%F: 8.45±0.17(C) 100%F: 8.5±0.10.3(C)[c]	Rice crop: Failed Soybean: 1. 39 Mungbean: 1.37	M: 6.62±0.27 (I_{13}) M: 7.13 ±0.1(Mk) R: 5.80-7.50(Mk)*	NA
	KB-Irr	5	M: 5.91±0.31 R: 2.10-7.90 (C) 75%F-M: 7.35±0.16 (C) 100%F-M: 7.3±0.35(C)[c]	M: 6.85±0.15 R: 5.40- 7.80(C) 75%F: 7.4±0.1(Mk) 100%F: 7.3±0.1(Mk)[b]	M: 8.39± 0.04 R: 7.90 -8.80(C) 75% F: 8.6±0.1(I_{13}) 100%F: 8.6±0.04(I_{13})[c]	NA
Pidie Jaya	DB	4.5	M: 6.45±0.10 R: 5.06-7.55 (Mi) 75%F-M: 7.2±0.23(Mi)[d] 100%F-M: 7.0+0.19(Mi)	M: 7.03±0.38 R: 4.36-9.28(Sr) 75%F: 8.01±0.71(Sr)[d] 100%F:8.38±0.27(Sr)	M: 6.32±0.07 R: 5.6-7.1 (Mk)**	Soybean 1.69
	ML-Irr	6-7	NA	NA	100% F: 6.8 (M)	5.1(Mk)*** 4.2(C)***
Bire-uen	BT	4.1	M: 5.59±0.15 R: 5.2 – 5.9(I_{10})	Soybean M: 1.67±0.28 R: 1.39 -1.95(KM) Corn:4.0-4.2(Bisi)	M: 5.72±0.37 R: 4.53 - 6.79 (Mk) 75%F-M: 5.26±0.54 100%F-M: 6.18±0.44[e]	2.95±0.34 2,01±4.09 (I_{10})
	MM	3.6	M: 5.212±0.15 R: 4.82 – 5.6(C)	NA	M: 7.17±0.077 R: 6.92-7.5 (I_{6}) 75%F-M: 7.06±0.07 100%F-M:7.28±0.11[e]	NA

[a]100%F = 200 kg/ha NPK + 200 kg/ha urea; [b]100%F = 200 kg/ha NPK + 200 kg/ha urea + 2t/ha cow manure; [c]100%F = 200 kg/ha NPK + 200 kg/ha urea ; [d]100%F = 240 kg/ha NPK + 86 kg/ha urea + 40 kg/ha KCL; [e] 300 kg/ha urea, 100 kg/ha SP36, 100kg/ha KCl + 2 t/ha manure applied to all plots; * 2 variety tested;**Only Mk variety tested with 5 combination of urea, SP36, KCl (fertiliser details are not shown),;***rat invasion

Despite the patchiness of yield data (Table 1), there is a potential to increase yield of various rice varieties in Aceh beyond the national average, and up to 35% - 87% above Aceh's historic yield. Rice varieties performed differently at different sites, suggesting different genetic responses to environment, but in general, Inpari 6 and 13, Ciherang, Mira, Sintanur and Mekonga were the better performers (Table 1).

A limited experiment with reduced fertiliser inputs in each district suggested that reducing fertiliser rates by 25% did not appear to carry a significant yield penalty (Table 1). This indicates the current practice of fertiliser use may be excessive, with normal farmers practice in Empetrieng site applying 350 kg Urea (45%N) and 200 kg $NPK_{(15:15:15)}$, totaling 191 kg N/ha per crop. In some sites such as E and DB, the 75% fertiliser application rate resulted in modest yield gains, but in others such as BT and MM it resulted in yield decline (Table 1). There were cases where yield at 75% fertiliser rate is greater than yield at 100% rate because the site was managed by the 'good' farmers, and visa versa. This indicated that site management is equally important as fertiliser management to yield. Urea fertiliser is heavily subsidised in Indonesia and farmers have a tendency to over-fertilise. Fertiliser and soil management tools such as leaf colour chart and soil test kits are widely available and simple to use. However, most farmers are illiterate and highly dependent on advice from their local agriculture field extension officer who is under-funded. Field discussion with farmers revealed that despite demonstrations of similar yields with 100% and 75% fertiliser rates, they are still cautious about reducing fertiliser application rates because they believe that the 100% rate will guarantee their crop yield. The fact that most farmers still have a tendency to over-fertilise and most are not familiar with the soil test kit and leaf colour chart, highlights a need for better agriculture extension programs. Reduction in fertiliser rates will not only reduce farmers' input costs but also reduce costs to the environment.

During the dry season of 2010, the local peanut variety yielded 1.8 t/ha in NU site when fertilized, limed and managed for pests and weeds. This is a significant increase from the local historic yield average (HYA) of 0.7 t/ha. Yields of mungbean and soybean improved very little across sites, and crop failure was common. Soybean yield (1.37 and 1.95 t/ha) is within the HYA of 1.2-2 t/ha. Mungbean yield of 1.2 t/ha is below the HYA of 2 t/ha. The range of corn yields from 4 to 4.2 t/ha is in line with Indonesian yield average of 4 t/ha. Dry season crop or other types of opportunistic crops (watermelon, cucumber, vegetables) grown in between rice seasons is a source extra cash for many Indonesian small farmers. Additional benefits for growing these crops include pest and disease management and nitrogen fixation if legume crops are used. However, growing dry season crops carries a high risk of failure due to insufficient water to support crops until maturity or unpredictable seasons as have occurred during the life of this study.

Economic analysis

The average input costs for wet season rice across the eight sites was 9.1 million IDR (8.8 – 9.3 million IDR). The price of dry rice grain sold by farmers was 3,000 - 3,500 IDR/kg during the study period. Profit margins on wet season rice averaged at 55%, with profit ranged between 7.6 to 15.8 million IDR/ha. In contrast, dry season rice could earn as low as 2.4 million IDR/ha due to low yield (i.e. in BT site). Peanut showed potential to increase farm income. The extra input costs incurred from fertiliser, lime, crop management and harvesting of the 1.8 t/ha was about IDR 1,981,000. The extra income resulting from this was IDR. 8.8 million rupiah (based on IDR 8000 rupiah/kg dry pod). The 25% reduction in fertiliser inputs in rice could increased profit margins by 1.063 – 1.5 million IDR/ha (6.7% - 11.4%). Of this, 0.4 million IDR gained from savings on fertiliser costs with the remainder attributed to the increased yields. Although reduced fertiliser rates resulted in lower yields at some sites, the overall reduction in fertiliser inputs could increase profits by 5.5% (0.7 million IDR/ha).

Conclusion

The use of ICM for lowland rice in four Districts studied in Aceh could increase average rice yield to 6.1-6.3 t/ha (maximum 8.9 t/ha), and could generate additional income of about 7 - 15 million IDR/ha. Improved management of peanut crops could generate additional income of 8.8 million IDR; improved management of mungbean and soybean crops did not improve income. Farmers in villages around the experimental sites have been observing the changes and are starting to use some components of ICM. They particularly like the skip row planting layout because it allows easier pest and weed management. Although reduced fertiliser caused no yield penalty and increased farm income, farmers are reluctant to adopt, indicating the need for a specific extension program on fertiliser use efficiency.

Acknowledgement

This study is funded by ACIAR and the Department of Primary Industries NSW, Australia.

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