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Original Research Paper

Economic analysis of rice legume rotation systems in Morogoro,Tanzania

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The cost of investing in agricultural technologies and their opportunity costs are key drivers of technology adoption by farmers. Integration of many technologies in the production of a given crop is commonly practiced by many farmers, yet most studies investigate profitability of single rather than combinations of technologies. The objective of this paper was to investigate economic benefits of including legume in rice based cropping system in a major rice producing region of Morogoro in Tanzania. Data was collected by interviewing farmers on planting methods, analyzed using descriptive statistics, gross margin and partial budgeting. Results show that rice is an important crop in smallholder farming systems, benefit cost ratio was higher (2.913) when rice was rotated with legumes and was low (1.381) without rotating with legumes. This study shows that current practices of producing rice is unprofitable with average yields of 180kg/ha in the nearly season compared to the last five season of 405kg/ha. Partial budgeting and cost benefit analysis revealed that introduction of legumes is beneficial and sustainable leading to increased yield and income by more than 100%. Thus the inclusion of legumes into rice cropping system offer an ideal option for maximizing returns in smallholder rice based system.

Key words: Rice, legume, gross margin, benefit cost ratio, partial budgeting

INTRODUCTION

Continuous monocropping practiced by majority of lowland rice producers threatens the sustainability and productivity of rice cropping system because it enhances nutrient mining and encourages the build up of pests and diseases. The inclusion of legumes into as rotation crops proves affordable alternatives to improve soil fertility and sustain rice farming system(Bekunda, et al., 2010). However, there is limited information to convince farmers on the economic benefits of introducing legume into rice system. Many studies that underpin policy formulation are based on single technologies as applied on individual crops, rather than an integration of technologies and crops as is commonly practiced by smallholder rice farmers. Of particular importance is crop, a key strategy used by farmers to manage fertility, pests and diseases as well as maintain productivity (Thiessen *et al*., 2001). The crop rotation cycle may vary from at 2 years depending on the crop growing habits and duration of growing seasons (Thiessen *et al*., 2001).

In order to maximize returns to investments, multiple cropping systems are widely advocated for (Macharia *et al.,* 2011; WARDA 2004). However, many farmers who practice multiple cropping have been doing so without adequate knowledge on what crops to include in their multiple cropping systems. For instance, in Morogoro, Tanzania, small-scale low land rice farmers plant tomatoes and water melon soon after harvesting rice to harness residual moisture. These crops not only require more water but also tend to extensively mine nutrients form the soil (Kibanda 2008). Few farmers who opt to plant legumes after rice have based their decision on trial and error basis and are thus unable to benefit fully from such decisions. Information on the economic benefits of spatial planting of legume with lowland rice will assist farmers in making decision to adopt the technology. This study was conducted to establish economic benefit and cost outlay of rice-legumes spatial

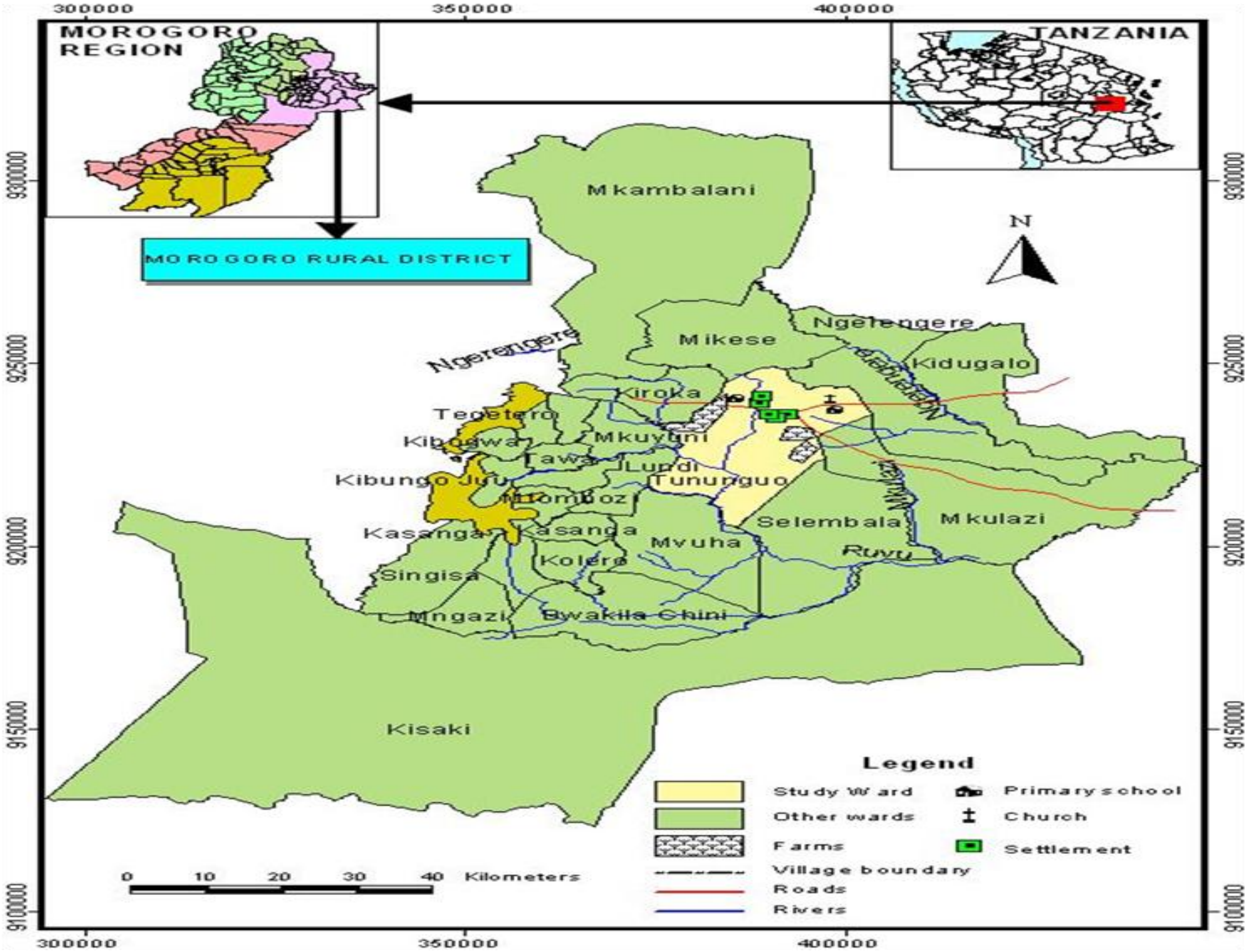

Figure 1: A map showing a research area

planting methods. Specifically the study characterized different rice and legume spatial planting methods, established costs and benefits of different spatial planting methods and identified the best spatial planting methods for rice legume cropping.

METHODOLOGY

The Study Area

This study was conducted in Tununguo village in Morogoro rural district (Figure 1). The area was selected because is representative of lowland rice growing areas in Morogoro and a large proportion (98%) of the population are involved in agriculture growing rice, maize, legumes, cassava and fruits. The area receives a weak bimodal rainfall pattern the short rains begin in late November or early December and the long rains start in early March. Short and long rainfalls are separated by a 2-3 weeks dry spell in February and the average amount of rainfall is about 1000 mm per year. These conditions favour the spatial cropping of lowland rice with legumes.

Sampling procedures and data collection

Data for this study was collected from 50 representative households randomly selected from the list of households at the village offices. Additionally, key informants were purposively selected include district agricultural officers, subject matter specialist, district agricultural extension officer, village agricultural extension officer and village leaders.

Primary data were obtained through direct interviews by using both structured and unstructured questionnaires. The type of data collected included the household characteristics, decision making processes in the household, access to extension services, land uses and constraints in lowland rice farming. Secondary data was obtained from review of related research reports and journals.

Data analysis

Data were subjected to gross margin, partial budget and benefit cost ratio analysis. Two spatial planting methods were analysed for economic benefits to farmers planting the improved rice variety called SARO with and without legumes (Cow pea-*vuli variety*)

Partial budgeting

Partial budget analysis was used to identify benefits to farmers who were willing to shift their farming practices from consecutive rice monocrop to rice-legume spatial planting and get a more systematic picture of the comparative advantage of the technological options (Bekchanov *et al.,* 2010). In this analysis the aspects considered were reduced cost and income, as well as additional cost. Reduced operational costs were due to reduced frequency of weeding and amount of fertilizer applied, this is because the cow pea has an ability to cover the soil and suppress weeds as well as fix nitrogen reducing demand for fertilizers. Added revenue included the revenue gained from yield increase from rice and added expenses were increased cost for labour. We tabulated and compared gains (benefits) and losses (costs) per acre due to the changes from rice monocropping to rice- legume spatial cropping. The expected changes in this case were rice yields as a result of technological options.

Gross margin analysis

Gross marginal was used to establish the magnitude of the benefits to farmers for changing from rice monocropping to legume spatial planting cropping system. The average gross margin for five years was computed as summarized in equation (i).

$$GM = TR - TVC \quad \text{(i)}$$

Where:

GM = Average gross margin in TShs/acre

TR=Average total revenue (gross return) in TShs/acre= yield/acre*price/kg

TVC = Total variable cost (TShs/acre) = cost/acre

TR is the total revenue obtained from the sale of rice and legumes crops while the TVC is the cost of labour and land preparation and the value of fixed cost is zero that's why is not included in the cost calculation.In this analysis, revenue was from the sale of rice and legumes and variable costs included labour and land preparation.

Benefit cost ratio analysis (BCR)

In order to reach a conclusion as to the desirability of either, rice monocrop or as included in a rotation with legume. Cost benefit analysis was done using benefit cost ratio as a decision criterion. In this analysis all costs and benefits of changing from rice monocrop to rice – legume spatial planting were identified, quantified and converted to monetary values using conventional and implicit market values (Asfaw et al., 2012). Streams of benefits and costs for five years were discounted using a discount factor at an interest rate of 10%. A discount rate of 10% was used based on the interest rates paid by farmers in loans for agriculture (Koijen *et al.,* 2010). Discounted benefit cost ratio was computed using equation (ii)

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}} \quad \text{(ii)}$$

Where by;

B_t = Discounted stream of benefits

C_t = Discounted stream of costs

n = number of years (5)

i = discount rate

t = time

Technological options with a BCR equal or greater than 1 was general accepted as economical viable. The greater the value above 1 was most desired.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Table 1 shows that, most (86 %) of respondents are married, few are single (10%), widowed (2%) and divorced (2%). This finding has an implication that many married couples concentrate more on production and thus may influence the efficiency of production thus married people have better chances of venturing in farming activities than unmarried people.

The age of respondents ranged considerably from 18 years to a maximum of 64 years, with mean age of 42 years. About 38% of the respondents are within the range of 18-34 years of age, 54% are within the age range of 35–64 years of age while 8% of them are above 64 years of age. This mean age indicates that most of the respondents belong to the productive age group and have a lot of experience in farming and financially stronger with capital to invest in new technology. Majority (86%) of the respondents had attained upper primary education level (5-8 years), few (8%) had attained lower primary education level (1-4 years), (4%) attained secondary education and (2 %) of the respondents attended college. This shows that the population is relative literate. This has implication on the types of extension methods that can be used to promote technological options of rice with legumes, farmers can better understand and adopt the rice legumes spatial planting method (Thakuria et al., 2009). Results also indicate that relatively large proportion (44%) of households has family size of 1-3

Table 1: Socio-economic characteristics of respondents

Socio-economic characteristics	Frequency	Total percent
Marital status		
Single	5	10
Married	43	86
Divorced	1	2
Widow	1	2
Age of respondent (years)	**Frequency**	**Total percent**
18-34	19	38
35-64	27	54
Above 64	4	8
Level of Education	**Frequency**	**Total percent**
Primary (<4yrs)	4	8
Primary (<5-7yrs)	43	86
Secondary (9-14yrs)	2	4
College (>14yrs)	1	2
Economic activities	**Frequency**	**Total percent**
Farming	49	98
Livestock activities	23	46
Small business	13	26
Other activities	2	4
Household size (people)	**Frequency**	**Total percent**
1-3	22	44
4-6	21	42
>7	7	14

persons and about 42% have household size of 4-6 persons.

Economic activity

Majority (98%) are involved in farming activities and half (46%) are keeping livestock. This implies that farmers in this area are likely to adopt the rice –legumes rotation planting method if it is beneficial to both crops and livestock. Figure 2 indicates the yield levels used in the economic analysis of the two spatial planting methods. Yield in rice legume rotation increased from 180kg/ha during the last five years to a maximum of 405kg/ha in the fifth year. These were based on the actual yield levels in farmer's fields and experiment fields. The situation was opposite to the rice-rice monocrop where the yields were decline from 5bags/acre in the fifth year.

Costs and benefits for the spatial planting options

The labour used for farm works in Tununguo was mainly family labour. However, a cultivation practice that requires hired labour was considered in this research. Therefore, all calculations were carried out with inclusion of family labour in the production costs associated to the options adopted by farmers. The scenarios with the exclusion of family labour cost seem more meaningful for poor farmers. The opportunity cost of labour used in the case of family labour was 1 US $per workday, which is the common price of hired labour in the District. Results show that the average variable cost used in rice production without rotating with legumes was US $ 25.21 per acre, and US $ 28.03 rice production when rotating with legumes (Table 2). Higher portion of variable cost was due to the increasing cost of leveling, weeding and for using human labor and grow other crop such as watermelon and tomato which also tends to increase variable cost in the process of refining itself each year.

Gross margins analysis

Figure 3 shows the gross margins for the two spatial planting methods. Results indicated that rice- legume spatial planting has higher gross margin values than those for the rice-rice monocropping.Higher gross margins were achieved through increased rice yields due the benefits of legume conserving moisture, reducing labour for weeding and eventually increased crop yields. Thus there is no need to value the land if farmers want to change existing land use to a new technology because it would be canceled out when comparing cultivation practices and it was neglected from the calculations. This implies that the fixed cost was zero and the net return was equal to gross margin. The gross

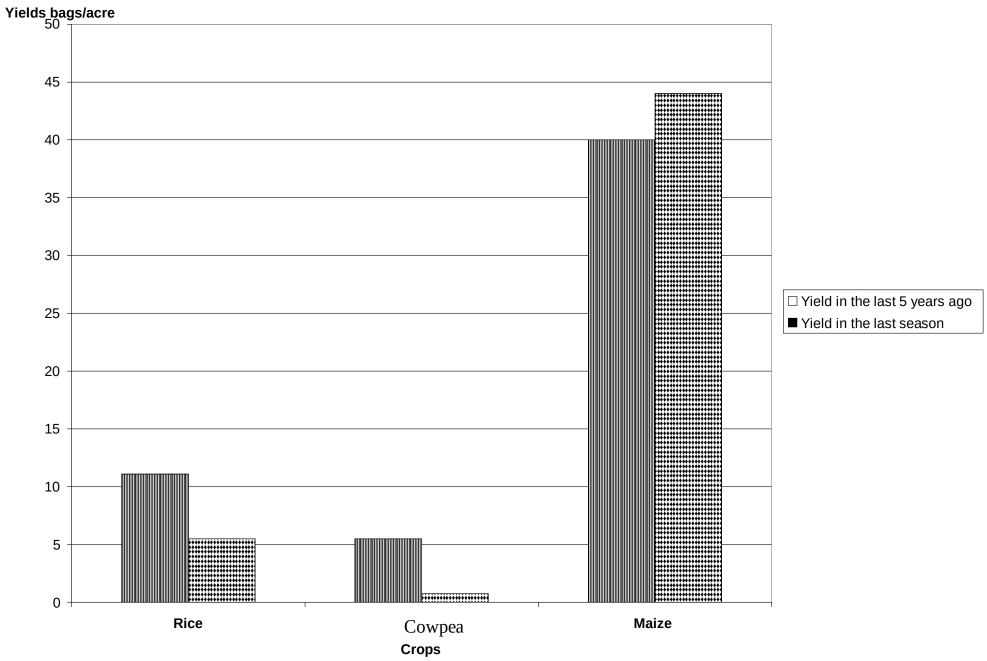

Figure 2: Figure 1.Comparison of rice yield for the past five years

Table 2: Average gross margin for rice legumes crops production

Planting Options	Rice with legume(US$)	Rice without legume(US$)
Revenue	81.67	34.82
Variable costs	28.03	25.04
Gross Margin	53.64	9.60

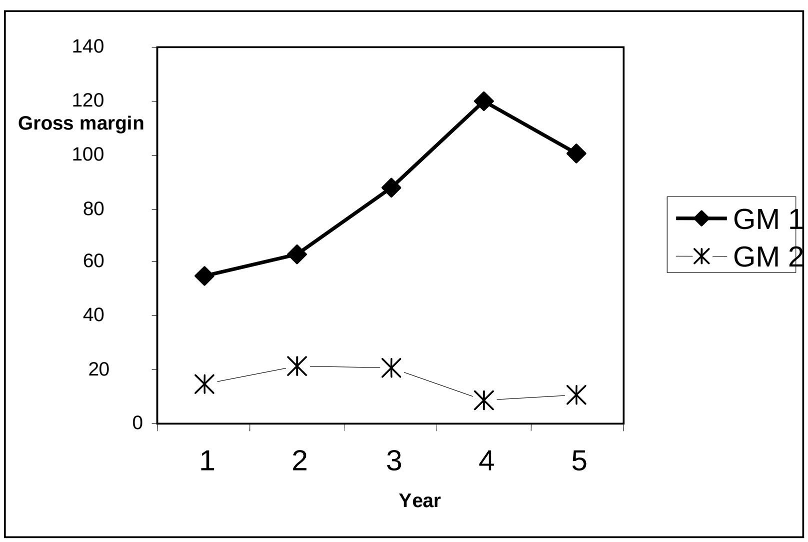

Figure 3. Gross marginal analysis for the two planting options
(GM 1= Gross Margin of rice rotating with legumes and GM= Gross Margin of rice rotating without legume

margin was higher in rice when rotated with legumes (US $ 53.64 per acre) than when rotating without legumes crops (US $ 9.60 per acre) in Table 3. Farmers annualy benefit as gross margin increases. With increase of gross margin, farmers may be willing to adopt the spatial planting method enhancing poverty alleviation. The low value of gross margin for rice production under non rotation rice production was attributed due to high costs associated with weeding and

Table 3: Benefit cost ratio analysis for the two planting options

	Rice with legumes		Rice without legumes	
Year	**Discounted Cost (US $)**	**Revenue(US $)**	**Discounted Cost (US $)**	**Revenue(US $)**
1	22.39	56.97	22.08	31.54
2	29.71	69.40	20.15	33.56
3	30.09	85.36	21.19	34.32
4	19.49	94.95	30.82	36.15
5	38.48	101.70	31.82	38.54
Total	140.18	408.39	126.08	174.13
Average	28.03	81.67	25.04	34.82
Net benefit	-	408.39	-	174.13
Net cost	140.18	-	126.08	-
BCR	2.913		1.381	

Table 4: Partial budgeting analysis

ITEM	**US $**	**US $**
Added revenue		
Income gained from rice rotating with legumes crops	408.39	
Reduced expenses		
Expenses for the rice rotating without legumes crops	126.08	
Total credit(added revenue + reduced expenses)		534.47
Reduced revenue		
Income from rice rotating without legumes crops	174.13	
Added expenses	140.18	
Expense from rice rotating with legumes crops		
Total debits(added expenses + reduced revenue)		314.32
Total credit-Total debits(net farm income gain)		220.15

land preparation which reduced returns. The low returns is due inability of the soil to support development of rice and competitions to the nutrients in the fields. This implies that the planting option is ineffective.

Benefit cost ratio analysis

To determine the best planting options for rice legumes rotation for soil fertility improvement and increasing yield, a cost-benefit analysis was carried out based on the current prices of input and output and other variable cost such as labour.

The benefit cost ratio was higher (2.913) in rice rotating with legumes and was low (1.381) when no rotations were practiced in Table 3. With increasing benefit of growing legumes, farmers may be willing to adopt a new technology of growing legumes in their field.

So farmers could double their yields simply by growing legumes a year as soil fertility and weed was the main problems that cause low yields.

And this will in turn increase profits, for the family and enhance more production.

Currently the non legumes intercropped are mainly horticultural crops such watermelon and tomato according to this analysis are not profitable.

Partial budgeting

The results on partial budgeting analysis of rice legume rotation are shown in Table 4. The results indicated a benefit of farmers changing from rice without legume rotation to rice legume rotation. A positive difference indicates that the net benefits (net farm income gain) in rice rotating with legumes crops exceed the net benefits of rice rotating without legumes crops such as watermelon and tomato which is a common practice by farmers in the village. The partial budget showed that spatial planting method of rice rotation with legumes was financially feasible and beneficial than cultivation of sole rice yearly.

CONCLUSION AND RECOMMENDATIONS

From these it can be concluded that, rotating rice with legumes is financially beneficial and environmental feasible and the higher benefits obtained in rotating rice and legume. We recommend that the use and impact of the research may be used in lowland rice growing areas and other area with similar conditions. By virtue of their living in rural areas, smallholder farmers slightly access information about future technologies that may influence their production and investment choices. The government appears to have few qualms about evicting farmers from their only means of livelihood and food production, especially in times of climate change, will be diverted to production of other crops and are likely to cause increased conflicts over access to land. With Tanzania routinely dependent on imported food aid as drought occurs with increasing frequency, the policy of producing more rice for export instead of food for Tanzanians, will deepen poverty and food insecurity in Tanzania in the years to come. Farmer empowerment also requires effective knowledge information and communication systems. The poor farmers cannot afford to take chances. They need reliable and trusted sources of information on new options as these become available. The programme should facilitate two-way communications of research information and products to and from farmers. There is need to improve the communication pathways of research information and products to and feedback from farmers and build capacity of researchers and other stakeholders on information, communication and promotional skills. Farmers need reliable sources of information on new options as they become available as the poor farmers cannot afford to take chances. The government should facilitate two-way communications of research information and products to and from farmers. There is need to increase the communication pathways of research information and products and feedback from farmers and build capacity of researchers and other stakeholders on information, communication and promotional skills.

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