Economic Viability of Mucuna Intercropped with Maize Cropping System in Muheza District

William George
wgeorgelumwaga@gmail.com
University of Dodoma, Dodoma, Tanzania

ABSTRACT
Mucuna (Mucuna puriens) intercropping with maize is one of the alternatives to revive the declining maize production caused by low soil fertility and pest infestation. However, there is paucity of knowledge on the economic viability of the technology being studied. This research assessed the maize yields, variable costs and economic viability of adopting mucuna-maize intercropping in Muheza district, Tanzania. A total of 400 farmers were selected randomly (200 farmers who adopted mucuna intercropped with maize and 200 farmers growing maize after maize (continuous cropping). The Partial Budgeting approach was used to determine the net change in income when farmers decide to switch from continuous cropping. The results indicated that switching from continuous maize cropping to Mucuna intercropped with maize resulted in a positive net change in income of TZS 235,304.60/ha. The study concluded that mucuna intercropped with maize is economically viable. The use of mucuna intercropped with maize is hereby recommended to farmers.

Keywords: *Adoption, income, mucuna, partial budgeting, soil fertility*

INTRODUCTION

In many districts of Tanzania, soil productivity is considered to be below its potential due to degradation (Graene, 2018). Twenty five percent of 494 million hectares of land are highly degraded (loss in the productive capacity) and 39% is moderately degraded. Nitrogen is among the major nutrients, which is degraded and limits the production of maize (URT, 2016). Many parts of Tanzania including Muheza district, have a negative nitrogen balance valued at about $27kg^{-1}hayr^{-1}$ (URT, 2016). According to Kaizi *et al*. (2017) some of the causes of negative nitrogen balance are growing or planting the same crop in two or more consecutive cropping seasons (continuous cropping). There is inadequate replenishment of the degraded nutrients when maize is grown after maize each season. The continuous cropping and inadequate replenishment of nutrients often lead to the reduction of soil organic matter, the deterioration of soil structural properties, changes in physiochemical parameters, enzymes, micro-organisms community and thus, low soil fertility (Bekunda *et al.,* 2014).

The most sustainable approach to improve fertility of the soil at farm level is the integrated nutrient management (Graene and Casee, 1998). This is a combination of inorganic inputs and soil organic inputs, which serve as compliments in fertility management. According to Graene (2018), maize producers consider chemical fertilizers as substitutes than as compliments because lack of capital limits farmers' utilization of chemical fertilizers in their farms. Place and Dewees (1999) pointed out that chemical fertilizers are not substitutes due to the fact that they increase water holding capacity and help farmers to produce the income same as organic inputs. The balance of nitrogen source in the soil can be improved by combining both Biological Nitrogen Fixation (BNF) and utilization of chemical fertilizers (Kaizi *et al*., 2017). However, Kimetu *et al*. (2004) noted that the combination of BNF and chemical fertilizers has been shown to reduce the quantity of Nitrogen as opposed to the situation when each is used in isolation.

Thus, incorporation of soil nitrogen enriching herbaceous legumes in isolation into the cropping system should be among the strategies to manage noxious weeds (striga) and sustainable nitrogen replenishment under small scale farming (Ali and Narciso, 1996; Charan, 2000; Rao and Mathuva, 2000; Cherr, 2004; Marshall, 2016). Leguminous plants such as *Canavalia, Mucuna and Crotalaria* with high biomass production can improve the productivity and sustainability of smallholder farming.

Any intervention that attempts to introduce a new set of technologies is often confronted with questions such as: how profitable is the technology? What are the impacts on income? What is its return on investment? Answers to these questions are needed by farmers (technology users) who desire information on field levels. The limited studies on economic viability of mucuna intercropped with maize motivated this study. Therefore, the study was undertaken to determine the economic potential of switching from continuous cropping system (maize after maize) to mucuna intercropped with maize. The findings are expected to help as a basis of advising maize producers a better alternative to improve soil fertility and managing striga weeds in maize farming systems at farm level.

METHODOLOGY

Study area

The study was conducted in Muheza district in Tanga region (Eastern Zone of Tanzania) in 2019/2020 cropping season. The district was selected because projects were implemented in the area. Mucuna intercropped with maize as a new technology was promoted to reduce the impact of pests in particular the parasitic weed Striga (at the same time improving soil fertility). The leguminous species of interest in this study is *Mucuna puriens*. In Muheza district, 85% of the farmers adopted and are using the mucuna technology to manage weeds and improve soil productivity.

Design of the research

Data for this study were collected by using a cross-sectional research design. Data were collected at single point in time from a sample selected to represent some large population (Creswell, 1994). The design provided a snapshot of ideas, opinions and information (Bryman, 2004). This design is most preferred because of its broad scope and can incorporate many variables of interest to the study. The design is suitable for purpose of description as well as for determination of relationship among variables at the time of the study (Williman, 2006; Babbie, 2010). The design is considered favourable as it allows a researcher to efficiently utilize the economic resources in terms of time and funds, for collecting data.

Sampling procedures

According to the 2012 Tanzania National Census, the population of Muheza District was 204,461. The sampling frame to conduct this study shall constitute maize farmer in the district. Based on the URT (2016) report of the National Sample Census of Agriculture 2012/2013 there is a total of 90,789 maize growing households in Muheza district. In selecting farmers to be interviewed, a multistage random sampling was used to select 400 respondents comprising of 200 adopters of mucuna i.e. farmers who intercrop mucuna with maize and 200 non- adopters i.e. farmers who grow maize after maize in each season from the three villages.

Data collection and instruments

A survey method was used in this study. A structured questionnaire as a tool was administered to 400 household heads between September 2020 and November 2020. Information obtained in the surveys included yields, costs of operations and prices. Participating farmers were asked to record information throughout the cropping season (2019/2020). Desk review was used to collect secondary data such as maize yields, prices of maize, costs of using mucuna in maize farming systems from the data base of Prime Minister's Office and Local Government Office, annual reports of the district, published articles from journals. The secondary data was used to triangulate the primary data collected in the field.

Data analysis

Computation of Income: The gross income was computed as the product of quantity for maize yields and producer prices as presented in Equation 1.

$$I = QP \quad [1]$$

Where: I = Gross Income,
Q = Output Quantity
P =Producer price.

Variable costs for inputs per treatment (i.e. mucuna intercropped with maize and continuous cropping system) were computed as product of the quantity of inputs used and the price of the variable inputs as presented in Equation 2.

$$VC = XP \quad [2]$$

Whereby: VC = Variable Cost,
X = Quantity of input
P = Input prices.

Computation of Net Income: The net income was calculated as the gross income less the total costs that vary as presented in Equation 3.

$$NI = GI - VC \quad [3]$$

Whereby: NI = Net income,

GI = Gross income,
VC = Variable Cost.

Using partial budget, the advantages (incremental income) were compared to the disadvantages (incremental costs). Decision on the viability of adopting the new production system was made based on the resulting net change. If the net change is positive, mucuna intercropped with maize has economic advantages. That is, if (c) + (d) > (a) + (b) the change is profitable, given that it is a feasible change (Table 1).

Table 1: Partial budget: comparison of mucuna intercropped with maize versus continuous cropping system

		Particulars	Total (TZS/ha)
Costs	a)	**Additional costs:** costs from mucuna intercropped with maize (alternative situation) that is not required when using maize after maize practices (current situation).	a
	b)	**Reduced income:** the income from maize after maize practices that will not be received when using mucuna intercropped with maize.	b
		Total costs	$a+b$
Benefits	c)	**Additional income:** is the income from mucuna intercropped with maize that is not obtained from current situation (maize after maize).	c
	d)	**Reduced costs:** costs from maize after maize practices that will be avoided when mucuna is intercropped with maize.	d
		Total Income	$c+d$
Net change in Income $= [c+d-(a+b)]$			

RESULTS AND DISCUSSION

Crop budgets

The effects of mucuna intercropped with maize on the variable costs and income of maize at farm level was compared with the continuous maize cropping (maize after maize). The information provided was used to construct the budget for maize production *with* and *without* framework of technology assessments

The resulting effect of adoption of mucuna intercropped with maize increased variable cost by 23.90% brought about by the cost of sowing mucuna and potential increase in labour to harvest increased maize yields

(Table 2). The adoption of mucuna intercropped with maize increased marketable yields of maize by 77.17%. This additional marketable yield is an additional return to the farmers brought about by reduction of striga weeds and improved soil fertility. Thus, farmers who adopted mucuna intercroped with maize increased the net income by 95.93%. This result agrees with the study of Crowder and Reganold (2015) who reported that legume intercrops inclusion in cropping systems suppress weeds. Vissoh *et al*. (1998) observed that *Mucuna pruriens* suppressed weeds through shading whereas Smith et al. (2016) reported good spreading of mucuna suppressed weeds.

Table 2: Crop budget per ha of mucuna intercropped with maize and continuous cropping systems (maize after maize) based on 2019/2020 data

Particulars	Options adopted by farmers		Changes (+ve or –ve) from adopting mucuna	
	Mucuna intercropped with maize (N = 200)	Continuous cropping systems (maize after maize) (N = 200)	Quantity change	% change
Variable Costs per acre				
Maize seeds	1,680.00	1,680.00	0.00	0.00
mucuna seeds	0.00	0.00	0.00	0.00
Land preparation	20,550.00	20,550.00	00.00	0.00
Sowing of maize seeds	17,100.00	17,100.00	0.00	0.00
Sowing of mucuna seeds	6,000.00	0.00	6,000.00	100.00
Weeding	21,067.50	21,067.50	0.00	0.00
Harvesting	20,000.00	5,350.00	14,650.00	73.25
Total Variable costs	86,397.50	65,747.50	**-20,650.00**	23.90
Income				
Maize yields (kg) per acre	1,116.80	255.00	861.80	77.20
Prices of maize grain per kg	297.00	297.00	0.00	0.00
Gross Income	**331,689.60**	**75,735.00**	**255,954.60**	**77.17**
Net Income	**245,292.10**	**9,987.50**	**235,304.60**	**95.93**

Sources: Survey 2020

Partial Budgeting

Partial budget of switching to maize intercropped with mucuna from the current situation. The relative attractiveness of mucuna intercropped with maize over the performance of the current practices (maize after maize) was assessed using a partial budget from the information derived from the interview with farmers during surveys as presented in Table 3.

Table 3: Partial budget of maize intercropped with mucuna

	Particulars	Based on 2019/2020 crop budget (TZS/ha)
Incremental Costs	a) Additional costs	
	• Sowing of Mucuna	6,000.00
	• Harvesting	14,650.00
	b) Reduced income:	-
Total Incremental Costs (TIC)		**20,650.00**
Incremental income	c) Additional income:	
	• Increased income	255,954.60
	d) Reduced costs:	-
Total Incremental Income (TII)		**255,954.60**
Net change in Income (TII – TIC)		**235,304.60**

Sources: Survey 2020

The partial budget analysis showed that a positive net change in income of TZS 235,304.60 per hectare is earned by farmers by switching to maze intercropped with Mucuna. The results indicated that at the farm level, mucuna intercropped with maize appears favourable in terms of reducing costs and increasing net income to farmers, hence farmers should accept the new option if mucuna seeds become available in the market each season. The findings of this result conform to that of Evans (2015).

CONCLUSION AND RECOMMENDATIONS

The objective of partial budget was to examine the economic viability of soil fertility management practices used by farmers that are economically superior and socially acceptable to smallholder farmers in Muheza district. The proposed technological change in this study was from continuous maize cropping (maize after maize) to mucuna intercropped with maize. A partial budget result indicated positive net change in income when switching from maize to maize cropping to mucuna intercropped with maize. Smallholder maize farmers in the study area are advised to intensify their efforts in the use of mucuna intercropped with maize to improve the income of their families.

REFERENCES

Ali, M., and Narciso, J.H. (1996). Farmers' perceptions and economic evaluation of green manure use in rice-based farming systems. *Tropical Agriculture* 73:148–154.

Babbie, E. R. (2010). *The Practice of Social Research*. 12th Edition Wards worth Publishing Company. Belton, California. 106pp.

Bekunda, M.A., Batiani, A., Ssali H. (2014). *Soil fertility management in Africa*: A review of selected research trials Pg 63-79, In R.J. Buresh *et al*., (eds). Replenishing soil fertility in Africa. SSA special publication 51 SSA, Madison WI.

Bryman, A. (2004). *Social Research Methods* (2nd edn.). Oxford: Oxford University Press. 592 pp.

Charan, A.S. (2000). Direct primary benefit and cost of Soil Management options Projects. Empirical study of the West Banas project in Rajastathan India. *In: Indian journal of agricultural economics*, Vol. 28, (4). 173-256pp.

Cherr, C.M. (2004). Improved use of green manure as a nitrogen source for sweet corn. M.S. thesis. Univ. of Florida, Gainesville. Available at http://etd.fcla.edu/ UFE0006501/cherr_c.pdf (accessed 31 June 2019).

Creswell, J. W. (1994). *Research Design: Qualitative and quantitative Approaches*. Sage Publishers, London. 228pp.

Crowder DW, Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. Proc Natl AcadSci U S A 112:7611–7616. https://doi.org/10.1073/pnas.1423674112

Evans, E. (2015). *Marginal Analysis: An Economic procedure for Selecting Alternative Technologies Practices*. Department of Food and Resource Economics (Inst. Food Agr. Sci. Publ., Univ. of Florida, Gainesville, FL) 29 pp.

Graene, D., and Casey, F. (2018). *Soil fertility management in sub-Saharan Africa*. World Bank technical paper number 408. Washington D.C. The World Bank. IBRD.

Kaizi C.K., Ssali H., Nansamba A., Vlek Paul L.G. (2017). The potential cost and benefit of velvet bean (*Mucuna pruriens*) an inorganic N fertilizer in improving maize production under soils of different fertility. IFPRI/ ZEF/NARO working paper.

Kimetu, J.M., Mugendi, D.N., Palm, C.A., Mutuo, P.K., Gaihengo, C.N., Bationo, A., Nandwa, D.N. and Kugu, J.B. (2004). Nitrogen fertilizer equivalencies of organic of differing quality and optimum combinations with inorganic nitrogen source in Central Kenya. *Nutrient cycling in Agro ecosystems 68*: *127-135pp.*

Marshall, A.J. (2016). Sunhemp (*Crotalaria juncea*L.) as an organic amendment in crop production. M.S. thesis.Univ. of Florida, Gainesville.

Place, F. and Dewees P. (1999) Policies and incentives for the adoption of improved fallows. *Agroforestry Systems* 47:323-343.

Rao, M.R., and Mathuva, M.N. (2000). Legumes for improving maize yields and income in semi-arid Kenya. *Agricultural Ecosystem Environment* 78:123–137.

Smith P, House JI, Bustamante M, Sobocká J, Harper R, Pan G, West PC, Clark JM, Adhya T, Rumpel C, Paustian K, Kuikman P, Cotrufo MF, Elliott JA, McDowell R, Griffiths RI, Asakawa S, Bondeau A, Jain AK, Meersmans J, Pugh TAM (2016) Global change pressures on soils from land use and management. Glob Change Biol 22(3):1008–1028. https://doi.org/10.1111/gcb.13068

Vissoh, P., V.M. Manyong, J.R. Carsky, P. Osei-Bonsu and M. Galiba. (1998). *Experience with Mucuna in West Africa. In: Cover Crops in West Africa Contributing to Sustainable Agriculture, Buckles*, D., A. Eteka, O. Osiname, M. Galiba and G. Galiano (Eds.), IDRC, IITA and Sasakawa Global 2000, Ottawa, Canada, pp: 1-32.

United Republic of Tanzania (2016). Maize Sector Development Strategy: 2016-2020.

Williman, N. (2006). *Social Research Methods*. London. Sage Publications. 224pp.