Assessing Profitability Of Selected Agro-Ecological Intensification Techniques In Sorghum And Cassava Based Cropping Systems In Yatta Sub County, Kenya.

Wango V.N., Mburu J., Onwong'a R., Nyikal R.

ABSTRACT: As the world population increases there is pressure on agriculture to supply more food, fiber and fuel. This has led to the continual expansion of agricultural land in to arid and semi-arid lands (ASALs) resulting in land degradation. In particular, in sub-Sahara Africa, low soil fertility is one of the most constraining factors to agriculture productivity. Initiatives to address soil fertility through use of inorganic fertilizers have yielded below average results in increasing productivity. Agro-ecological intensification (AEI) technique uses alternative knowledge and local materials to improve soils and increase productivity. This study assesses the economic returns of using AEI techniques compared to simplified conventional agricultural systems. Data was collected from on farm experiment that involved mono cropping, crop rotation and intercropping and application of organic inputs. Survey was used to collect data on farmers' costs of production, yields and commodity prices from a sample of 140 households in Yatta, Kenya. Both plot and survey data showed that significantly greater revenues were attained with the application of the AEI practices. Using legumes in intercrop system with application of farmyard manure had the highest profit while crop rotation without application of organic input had the least. At least 28 percent of farmers that adopt all components of the AEI technique attained significantly higher profits than farmers without any organic inputs. The study concludes AEI is a profitable soil fertility management technique. Thus policy should recognize and promote its uptake.

Key words: Agro-ecological Intensification, Profitability, Soil Management, Cassava, Sorghum, Yatta, Kenya.

INTRODUCTION

The world population is rapidly increasing and there is pressure on agriculture to supply more food, fiber and fuel. But land supply is constant; and agricultural production is threatened by among others; soil degradation; land fragmentation and climate change. In areas such as sub-Sahara Africa, soil degradation is one of the most limiting factors to agriculture production (Nkonya et al., 2011). Poor management practices further aggravate the low nutrient status and degeneration of these soils. In recognition of the important role of soils, the 68th UN general assembly declared the year 2015 the International Year of Soils (IYS). Among the objectives of the year was: to achieve full recognition of the prominent contribution of soils to food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development and to promote policies and actions for the sustainable management and protection of soil resources. The use of external inputs such as fertilizer to sustain crop production on a long term basis may not be sustainable due to decline in soil organic matter content, soil acidification and soil physical degradation (Onwu et al., 2008).

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Despite efforts taken to subsidize agricultural inputs, fertilizer use remains a high risk for smallholders. This is because, in cases of low rains, which are the norm in ASALs, the crops scorch, making fertilizer a very costly risk for the poor farmer (Mbuvi, 2000). Failure to invest in overall soil health can cause decline in the soil capacity to support crop production. Promotion of fertilizer without complimentary investment in improving the biophysical quality yield little response from farmers. (Marenya and Barrettt, 2009). To address this problem, a project aimed at improving agricultural productivity and food security in semi arid lands through capacity building in agroecological intensification of land use was conducted in Yatta. Soil scientist conducted on farm field experiments in the area over two years -October 2010 to Aug 2012- to evaluate the effect of cropping systems and organic inputs on soil nutrients, soil moisture status and yield of neglected crops. Farmers were invited to field days to learn the practices and practice the technique in their farms. Six agroecological practices were presented to the farmers. Cover cropping, farm yard manure, compost manure, crop rotation, utilization of crop residue and crop diversity. The current study was carried out to assess the economic returns from using agroecological intensification technique compared to conventional agricultural systems.

MATERIALS AND METHODS

THEORETICAL FRAMEWORK

The idea of profit is embedded in the theory of the firm, where the firm produces output at the level where marginal revenue equals marginal cost. Profitability is most commonly used in analysis of financial investment but with modification it can be applied in diverse situations including in purely biophysical and field trial research (Ajayi et al., 2006). Profitability is significant in making management decisions and assessing farms' goals (Mishra et al., 2009)

Farmers make economic and short term profitability considerations of soil fertility management techniques when making decisions, and profitability increases the probability of adoption of techniques (Oluyede et al., 2007). Profitability may therefore influence adoption or abandonment of a technology by farmers (Karanja-Lumumba, 2010). This gives good reason for the interest in profitability of technologies in soil fertility management.

EMPIRICAL FRAMEWORK

The study utilizes gross margin analysis to assess the profitability of agroecological intensification technique as applied in Yatta, Kenya. Gross margin gives the difference between the gross revenue realized from an activity and the total variable cost of that activity. To compute the gross margin, all inputs and outputs associated with each farming system were identified. Gross margin for each experimental treatment and for combination of farmers' management practices was calculated. An analysis of variance (ANOVA) test was used to compare the mean gross margins attained. The least significant difference (LSD) post-hoc test used to detect the difference in average gross margin for the different treatments, sites and management practices. Descriptive statistics were used to characterize the farming system and illustrate uptake of AEI technique.

SURVEY AND DATA

This study was part of several other studies under the project 'Towards increased agricultural productivity and food security in east Africa through capacity building in agroecological intensification' funded by The McKnight Foundation. The study utilizes two approaches for data. Data from researcher controlled field experiments and survey data. The field experiments were conducted on two site, Ikombe and Katangi sub-locations of Yatta Sub-County. In the experiments, three cropping systems; monocrop, intercrop and crop rotation treated with either farmyard, compost manure or no input (control) were investigated. Sorghum and Cassava were used as main crops incorporated with either dolichos or pigeon peas. A randomised complete block design with split plot arrangement was used. The resulting design was fifteen plots for each test crop with different treatment or no treatment. Sorghum and dolichos were harvested three months after planting while cassava and pigeon pea were harvested eleven months after planting. All crops had above ground biomass incorporated after harvest in the same plot they were harvested from. Profitability was used to assess the financial viability of these agroecological intensification practices. A survey was also conducted using a sample of farming 140 households in Yatta, Machakos County, Kenya. Yatta is a semi arid region classified in the agroecological zone IV and V (Jaetzold and Schmidt, 2006). Mean annual rainfall is 500-750 mm and temperature 29^{o}C. The area is of moderate agricultural potential (Munyao et al., 2013). The farmers in the area are small-scale mixed farmers, keeping indigenous cattle and small stock as well as growing drought tolerant crops (Macharia, 2010). Three sub locations Ikombe, Katangi and Yatta in Yatta were purposively selected. The number of households interviewed in each ward was determined using proportion to population size. A list of farmers in each ward was generated with agricultural officers. A simple random sample method was then used to select the households to be interviewed. Structured questionnaires were used to gather the data on costs of production, yields and commodity prices.

RESULTS AND DISCUSSION

DESCRIPTIVE STATISTIC OF FARMERS' UPTAKE OF AEI TECHNIQUE

Results show that at least 95% of farmers used farm yard manure, 77% practiced crop diversity in their farm, 76% used compost manure and 72% ploughed in harvested crop residue. Cover cropping was practiced by 57% of the sampled farmers while crop rotation (54%), was least practiced. Table 1 presents results on the uptake of the six agroecological intensification technique.

Table 1: *Percentage adoption of various AEI components*

Components Adopted	% of farmers adopting
Farm Yard Manure	95
Crop Diversity	77
Compost Manure	76
Crop Residue Utilization	72
Cover Cropping	57
Crop Rotation	54

Farm yard manure (FYM), compost manure and crop residue ploughed in to the soil were used as organic inputs. Crop diversity cover cropping and crop rotation were used to enhance sustainability of the agro ecosystem. Animal manure is widely used due to its availability. Most farmers practiced mixed farming and recycled nutrient through manure collected from the animals. It was therefore readily and cheaply available resource. However the quality and quantity vary depending on availability and livestock management system (Mbuvi, 2000). Crop diversity contributes to food security through spreading risk of crop failure. In addition it increases farm productivity. The main crops grown were maize, sorghum, cassava, and legumes. Compost manure utilized harvested crops and household waste. Crop residue had various uses including feed to animals hence utilization depends on most competing factor. Cover cropping reduces water and nutrient losses caused by evaporation and leaching. Crop rotation refers to defined sequence of crops grown in a given cultivated land over a period of time. Crop rotation was least practiced. This could be caused by land scarcity necessary for crop rotation systems. The results indicate that farmers are able to adopt more than one approach of agroecological technique. Table 2 shows the percentage level of adoption for the combined six AEI technique practices. It shows the number of components adopted by individual farmers. At least 2 farmers representing 1.4 percent adopted one of the components while 10.0 percent adopted at least three components and 27.9 fully adopted all the six AEI techniques being investigated. Mean level of adoption was 4.34, std. dev (1.595).

Table 2: *Proportion of farmers adopting AEI technique*

No. Of. Components	% of farmers adopting
0	4.3
1	1.4
2	8.6
3	10.0
4	20.7
5	27.1
6	27.9

The results collaborate with the findings of Roger (1962) that farmers adopt technologies at different rates and times. Adoption is a process, we expect that, more farmers will adopt all components and be able to benefit.

Profitability Analysis from Experimental data

Sorghum based system;

In Ikombe, highest (Ksh 61,708) gross margin was attained in sorghum - dolichos intercrop and the least (Ksh -9,333), was in sorghum dolichos rotation with no organic input (Control). The results show that addition of organic input yield positive returns on the investment except sorghum dolichos rotation that had negative returns. In Katangi the highest gross margin per hectare (Ksh 108,933) was in sorghum dolichos intercrop using farm yard manure while the least (Ksh – 8,283) was in sorghum dolichos rotation with no organic input (Control). The results for test of mean differences in Table 3 show there was significant (p<o.o5) difference for interactions between sites, farming systems and organic inputs. There were also significant (p<o.o5) differences between mono crop, intercropping and crop rotation systems and between farm yard manure and compost at (p<o.o5). However no significant difference in gross margin was observed between Ikombe and Katangi sites. Hence we reject the hypothesis that there is no significant difference in profit in adoption of agroecological intensification technique and conclude that AEI techniques result greater revenues.

Table 3: *Mean Gross Margin results for sorghum based cropping system in Ikombe and Katangi*

Farming system	COMPOST	Ikombe CONTROL	FYM	Means	COMPOST	Katangi CONTROL	FYM	Means
Sorghum	11,725	9,975	13,892	11,864	10,892	7,767	15,475	11,378
Sorghum+Dolichos (Inter)	47,075	41,208	61,708	49,997	97,092	84,825	108,933	96,950
Sorghum+ Pigeon Pea (Inter)	42,420	39,530	49,060	43,670	56,213	48,760	74,613	59,862
Sorghum-Dolichos (Rot)	-8,933	-9,333	-7,433	-8,567	-1,283	-8,283	-5,333	-3,367
Sorghum-Pigeon Pea (Rot)	14,908	13,408	14,968	14,428	11,038	9,593	14,125	11,586
Means	**21,439**	**19,270**	**26,127**	**22,279**	**34,790**	**28,532**	**42,523**	**35,282**
%C.v	17.1							
L.s.d Site	37663.3 **Ns**							
L.s.d Farming System	25020.2*							
L.s.d Input	2570.1*							
L.s.d Site x Farming System x Input	37354.9*							

*Least Significant Difference (LSD) * 5% level of error Intercrop (Inter), Rotation (Rot)*

Cassava based system;

Mean gross margins for sorghum in Ikombe and Katangi under different crop systems and organic inputs in sorghum based system are shown below. In Ikombe the highest (Ksh 89,008) gross margin per hectare was using cassava dolichos intercrop with farm yard manure while the least (Ksh 7,825) was in cassava pigeon pea rotation with compost organic input. In Katangi, the highest gross margin per hectare (Ksh 434,135) was in cassava pigeon pea intercrop with farm yard manure and the lowest (Ksh 10,895) was in cassava pigeon pea rotation with on organic input (Control). Table 4 show results for test for mean differences in gross margin under cassava based system in Ikombe and Katangi. The results show significant (p<o.o5) difference in gross margins between different sites, farming system (p<o.o5), organic inputs (p<o.o5) and in interaction between site, farming system and inputs at (p<o.o5).

Table 4: *Mean Gross Margin results for cassava based cropping system in Ikombe and Katangi*

Farming system	COMPOST	Ikombe CONTROL	FYM	Means	COMPOST	Katangi CONTROL	FYM	Means
Cassava	45,936	68,209	87,095	67,080	135,291	120,030	192,880	140,400
Cassava + Dolichos (Inter)	58,520	24,591	89,008	57,373	59,615	12,870	124,550	65,678
Cassava + Pigeon Pea (Inter)	67,080	51,660	71,813	63518	345,271	344,981	434,135	374,795
Cassava – Dolichos (Rot)	65,250	44,750	54,450	54,817	56,100	27,200	71,700	51,666
Cassava – Pigeon Pea (Rot)	7,825	8,745	12,345	9,638	14,705	10,895	18,795	14,798,
Means	**35,906**	**39,591**	**62,942**	**56,742**	**122,197**	**103,195**	**168,412**	**129,467**
%C.v	32.2							
L.s.d Site	190043.1*							
L.s.d Farming System	110904*							
L.s.d Input	41585.4*							
L.s.d Site x Farm System x Input	196883.2*							

Least Significant Difference (LSD) * 5% level of error Intercrop (Inter), Rotation (Rot) We reject the null hypothesis that there is no significant difference in profit between agroecological techniques. We conclude that there is difference in gross margin. The results confirm findings of Place et. al 2003, that showed that application of crop management vary across agroecological conditions. Different site, systems and organic inputs combinations yield unique results.

Profitability Analysis from Survey data

Table 5 shows results for average gross margin in sorghum at for farmers' different levels of AEI technique from the survey data analyzed. There was a significant (p<o.o1) difference between groups of farmers at various levels of AEI technique in sorghum. Farmers that applied at least five or six practices accrued significantly (p<0.01) higher Ksh 2653 ha-1 and Ksh 2996ha-1 profits respectively. Labour was the highest variable cost.

Table 5: *Farmers' Mean Gross Margin for Sorghum under AEI technique in Yatta*

Level of AEI	0	1	2	3	4	5	6
Revenue							
Yield kg ha-1	**20.0**	**70.86**	**69.81**	**91.09**	**102.04**	**155.77**	**180.72**
Total revenue (Ksh ha^{-1})	**445**	**1559**	**1536**	**2004**	**2245**	**3427**	**3976**
Variable Costs							
Seeds	40.50	58.30	91.10	141.70	83.00	89.50	100.00
Fertilizers	0.00	0.00	0.00	103.20	57.90	0.00	0.00
Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	200.00	260.70	485.80	688.30	299.60	330.00
Labour	323.90	603.20	300.00	313.00	446.60	384.00	550.00
Total Variable cost (Ksh ha^{-1})	364.40	861.50	651.80	1043.70	1275.70	773.10	980.00
Gross margin (Ksh ha^{-1})	**80.63^{a}**	**697.46^{b}**	**884.15^{c}**	**960.28^{c}**	**969.29^{d}**	**2653.93^{e}**	**2996.00^{e}**
Net Return Investment	0.221	0.810	1.356	0.920	0.760	3.433	3.057

Significant of mean difference ^{a,b,c,d,e} =1%

In Cassava, profits were significantly (p<o.o1) different between farmers at different levels of AEI technique. Farmer that practiced at least one technique attained Ksh 448 ha^{-1} compared to Ksh 152 ha^{-1} for farmers that applied none. Manure and labour accounted for the main variable costs. Table 6 shows average gross margins for cassava of farmers' at different levels of AEI technique.

Table 6: *Farmers' mean Gross Margin for Cassava under AEI technique in Yatta*

Level of AEI	0	1	2	3	4	5	6
Revenue							
Yield kg ha^{-1}	**9.00**	**21.86**	**33.19**	**46.96**	**51.52**	**54.50**	**89.06**
Total revenue (Ksh ha^{-1})	**242.91**	**546.56**	**829.96**	**1174.09**	**1295.55**	**1362.14**	**2226.72**
Variable Costs							
Seeds	0.00	16.60	0.00	121.46	100.40	150.00	101.21
Fertilizers	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manure	0.00	0.00	80.97	161.94	147.37	146.96	779.35
Labour	91.09	80.97	125.91	193.52	242.91	170.85	377.33
Total Variable cost (Ksh ha^{-1})	91.09	97.57	206.88	476.92	490.69	467.81	1257.89
Gross margin (Ksh ha^{-1})	**151.82^{a}**	**448.99^{b}**	**623.08^{c}**	**697.17^{c}**	**804.86^{d}**	**894.33^{e}**	**968.83^{f}**
Net Return Investment	1.6667033	4.6017218	3.0117943	1.4618175	1.6402617	1.9117377	1.7702025

Significant of mean difference ^{a,b,c,d,e,f} =1%

From the result we reject the hypothesis of no significant difference between adopter and non-adopters. We conclude that there is difference in incomes between farmers' applying AEI technique. The results also show there is difference in incomes for farmers' at different levels of adoption of AEI technique. The higher gross margins realized may be explained by the better moisture and nutrient management when AEI technique is applied (Namoi, 2014). Furthermore the combination of legumes in rotation allows for nutrient cycling. The differences between farmers' at different levels of adoption indicate greater benefit accrued with application of more AEI technique. The study concludes that gross margins in both field experiment and farmers lands were significantly higher with than without application of AEI technique. Different site, systems and organic inputs combinations yield unique results. Inclusion of legumes in cropping systems showed even higher results. The results confirm findings, that showed that application of crop management vary across agroecological conditions. The study also concludes that farmers can gain more from adopting several components of agro-ecological intensification technique. According to the findings AEI is a profitable technique of soil. However researchers attained higher profits compared to farmers. Farmers are at different levels of adoption. This suggests that farmers are able to adopt several components of AEI. Hence could lead to better management practices that can yield higher incomes if adopted. Since AEI builds on already established farming practices, the findings suggest that linkages between research and farmers should be built to transmit knowledge. Policy should also recognize and promote uptake of agroecological intensification technique.

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