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Full Length Research Paper

Economic analysis of soil fertility restoration options in potato – bean of gardening intercropping in South – rift, Kenya

Ngeno Vincent*, Langat B. K., Rop Wendi, Chepngeno W. and Kipsat M. J.

Department of Agricultural Economics and Resource Management, Moi University, Kenya.

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Soil fertility management options to restore soil fertility depletion have been developed and these consist of inorganic and organic fertilizer applications. However, the adoption rates by smallholder farmers for these soil fertility management options are negligible. The overall aim of this study was to evaluate side-by-side economic aspects of different soil fertility improvement options, which have been tested in the region. Field experiments were carried out to evaluate soil fertility management options on potato-bean production in five districts in South-rift, Kenya (Narok, Bomet, Bureti, Kericho and Konoin). It appeared that application of organic residues is a more feasible and sustainable alternative to the recommended fertilizers. However, for long term yield improvement, fertilization with these recommended fertilizers would only be profitable if applied seasonally.

Key words: Fertility depletion, restoration option, economics.

INTRODUCTION

Soil fertility depletion, in many areas of sub-Saharan Africa, is reported to be the fundamental root cause of declining *per capita* food production (Sanchez and Jama, 2002). In East Africa rates of nutrient depletion are huge and highest especially in areas with favourable climate for crop production and high population density (Stoorvogel et al., 2003). Yields of crops are decreasing on continuously cropped land without nutrient inputs, and fallowing is no longer practical due to the high population pressure (Cleaver and Schreiber, 2007). The use of fertilizers for soil fertility restoration/replenishment is often constrained due to lack of capital by farmers especially after the removal of government subsidies in Kenya and other African countries (Franzel, 2009; Jaetzold and Schmidt, 2003). The net result is low crop productivity of land that is being further degraded by erosion and the nutrient removals from crop harvests.

To replenish these soils, various soil fertility restoration options have been tested by the National and International organizations (Landon, 2004). However, the options tend to be site and institution specific in effectiveness and applicability. Furthermore, soil fertility restoration options or recommendations are normally formulated to cover broad areas with diverse soils in their particular fields (Tisdale et al., 2005). These soil fertility restoration options, and often some of the “best-bets” which have been tested in various parts of Rift Valley Kenya are:- Organic inputs, Farmyard manure, FURP (fertilizer use recommendation project), PRE-PAC (phosphate rock evaluation project package), MBILI (managing beneficial interactions in legume intercrops). Efforts to compare soil fertility management options side-by-side are rather minimal in Kenya with research institutions preferring to test one technology at a time.

Therefore, this study focuses on the side-by-side evaluation of the economic returns of the tested options, so that the recommended soil fertility management options fit the ecological and socio-economic circumstances of the farmers. The ultimate goal is therefore to contribute towards attainment of food security and reduction of poverty through adoption of productive soil fertility management options by smallholder

*Corresponding author. E-mail: vcngeno@gmail.com.

farmers in South-Rift, Kenya.

MATERIALS AND METHODS

Data sources

The study used on-farm experimental data and qualitative information gathered by interviewing participating farm household in different districts namely Narok, Bomet, Bureti, Konoin and Kericho districts in South-Rift Kenya. Production data and prices were collected for three consecutive growing seasons, beginning in the long rains of 2009; since some sites were established in the long rains of 2009 while others were in the short rains of 2009.

Experimental design

The field experiment comprised of six treatments during the initial installation (long rains 2001) and additional two treatments in the short rains 2001. The variation in the treatments was due to recommendations obtained from collaborating institutions in the region. The experiment was laid out in a randomized complete block design and replicated two to four times depending on land availability. The plot size was 5 x 5 m based on recommendations by Okalebo and Woomer (2006). This plot size was considered to represent the widespread low soil fertility patches common at on-farm level and was considered adequate to show treatment differences in the field particularly to smallholder farmers, the expected beneficiaries of the soil fertility management options. Information on the existence and applicability of this treatment was obtained from research publications and brochures in libraries from research institutions namely, Kenya Agricultural Research (KARI), International Centre for Research in Agroforestry (ICRAF), Sustainable Agricultural Centre for Research Extension and Development in Africa (SACRED-AFRICA), Kenya Forestry Research Institute (KEFRI, and Moi University, the treatments hereafter were referred to as soil fertility management options. Several economic indicators were developed and used to compare the benefits of producing potatoes/beans under the different soil fertility management options. The indicators were:

Enterprise budgets

Enterprise budgets were developed and used to compare costs and benefits accruing from food production under the different soil fertility management options. Rather than take an average of the costs and benefits for the cropping seasons, costs and benefits were compared across the seasons. This approach was preferred because it allowed a comparison of residual effects of the different options over time and assessment of incremental net benefits of using these options over typical farmer practices:

$$GR^i = Y^i * P_y^i \quad \text{………………………………(1)}$$

Where:

GR^i = the gross value of output in season *i*, for a given management option in Kshs ha^{-1}.
Y^i = the total output produced under a given management option in season *i*, in Kshs ha^{-1}.
P_y^i = the average price obtained for the output (maize or beans) for season *i*, in Kshs ha^{-1}.

It is an average of the price obtained immediately after harvest and that obtained 2 months after the harvest:

$$NB^i = GR^i - GC^i \quad \text{……………………………(2)}$$

Where:

GR^i = gross value of output in season *i*, produced under a given management option,
GC^i = gross costs incurred in season *i*, with that option in Kshs ha^{-1} and,
NB^i = the net benefit obtained in season *i* in Kshs ha^{-1}.

Incremental net benefit

$$INB_j^i = NB_j^i - NB_0^i \quad \text{……………………………………… (3)}$$

Where:

INB_j^i = the incremental net benefit of option *j* over the farmer's practice in: season (i), in Kshs ha^{-1}.
NB_j^i = the net benefit of option *j*, in season *i*, in Kshs ha^{-1}.
NB_0^i = the net benefit from the farmer's practice (either absolute control option or farm yard manure) in season *i*, in Kshs ha^{-1}.

Return to land

Return to land was devised from the net present value (NPV) of each treatment summed over the cropping seasons (2 to 3 seasons). In general, the return to land is more appropriate as an an economic indicator in situations where land is relatively scarcer than labour or where there are fewer opportunities for the farmer to hire out labour or to engage in off-farm employment. Under such circumstances, land is viewed as the most limiting resource and hence farmers should strive to optimize return to land. For farm households who have ample opportunities for off-farm employment and/or have relatively high land-labour ratios, returns to labour would be the relevant indicator because of the relatively high population pressure, availability of hired farm labour and limited off-farm employment opportunities in the study areas

$$NPV_j = \sum\left(NB^i * {}^{1}/_{(1+r)^t}\right) \quad \text{……………...……. (4)}$$

Where:

NPV_j = The net present value from applying management option *j*,
$r =$ The discount rate estimated at 10%, and,
t = The time in seasons.

The marginal rate of return of investing in the technology

The marginal rate of return (MRR) is used to show how net benefits accruing from an investment increase as the amount invested increases. The MRR was calculated by dividing the marginal net present value by the marginal cost, as a farmer shifts from an option with low net benefit to one with the highest net present value. The first step in calculating the MRR was to identify the option with the highest NPV (that is, return to land). The MRR was then

Table 1. Marginal rate of return (MRR) for adopting different soil fertility management options in Narok.

Technology	MRR (%)
Control to FYM	509
PRE-PAC to FYM	20
MBILI to FYM	208
MBILI to PRE-PAC	491
Compost to FYM	760
MBILI to FURP	109

calculated by dividing the marginal return (difference between the option with the highest return to land and any other option, such as farmers' practice, that is absolute control or farm yard manure) by the marginal costs (difference between the gross costs of the option giving the highest return to land and the one being compared with) times 100%.

RESULTS AND DISCUSSION

Return to land

The returns to land from food production under the different soil fertility management options were estimated by the NPV of the net benefits over the two seasons. The results show negative returns to land for all the five soil fertility management options in Bureti and Sotik sites. The negative returns to land are explained by the relatively low yield levels especially in the second season. In Bomet site, because of relatively high production costs, only use of FYM produced a positive return to land. Both PREP-PAC and FURP registered negative returns to land. This finding implies that rather than shift to new soil fertility management options such as use of organic inputs, FURP or PREP-PAC, farmers may be better off applying FYM to their potato and bean crops. In Kericho, all the technology options recorded negative returns to land, perhaps because of the low yield response observed and the relatively high production costs, especially with PREP-PAC, MBILI and FURP. Even organic inputs and farmyard manure, which recorded some positive net benefits in the second season, on the aggregate had negative returns to land.

Although results of the economic analysis appear daunting, an examination of the yield data suggests that MBILI and farmyard manure might be more promising as soil fertility augmenting and soil fertility management options in Kericho, if something could be done to reduce the production costs, particularly labor costs. The highest return to land in Narok of Kshs. 61,4087- was obtained from use of FYM, a typical farmer practice in the area. The second highest return to land was obtained from MBILI. In Konoin, fortified compost gave the highest return to land (Kshs. 15,4807- per ha per year), followed by MBILI with Kshs. 1,4197. All the other soil fertility management options had negative returns to land. This finding implies that farmers in Konoin can improve their net incomes and overall return to land by shifting from current practices such as zero input or little farmers' FYM to use of fortified compost or MBILI as soil fertility replenishment strategies.

Marginal rate of return

In general, the marginal rate of return (MRR) is another indicator of what the farmers can expect to gain, or on average, in return for their investment when they decide to change from one practice (or a set of practices) to another. Returns to land suggest that in Narok, the typical farmer practice of applying some FYM is by far the most profitable soil fertility option to use in production. However, three other technology options gave higher returns to land than the absolute control. These technology options were, MBILI (Kshs. 59,0667-), FURP (Kshs.51,5907-) and PREP-PAC(Kshs.46,3137-). Table 1 shows the results of marginal analysis, depicting what farmers can expect to gain at the margin, in return to their investment when they decide to change from one of these technology options to another. As the table shows, the highest rate of return to investment is obtained from a shift from absolute control and fortified compost to farm yard manure. A shift from MBILI to FYM or to PRE-PAC or FURP also can result in rates of return to investment of over 100%. The empirical evidence has shown that rates of return above 100% are above the minimum acceptable to farmers. This suggests that all things being constant, it is safe to recommend to farmers in Narok, farm yard manure, and FURP as soil fertility augmenting soil fertility management options with which to produce food crops such as potatoes and beans.

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Table 2. Incremental net benefits (INB) from farmers practice (Kshs) in Konoin district.

Incremental net benefits	1st season INB	1st season discounted INB	2nd season INB	2nd season discounted INB	Total discounted INB
From absolute control to compost	24800.43	22543.59	15359.50	12686.95	35,230.54
From absolute control to PRE-PAC	8153.58	7411.60	16655.55	13757.48	21,169.09
From FYM to compost	18790.50	17080.57	5812.10	5812.10	21,881.36
From FYM to PRE-PAC	2143.66	1948.58	7108.15	5871.33	7,819.91

Table 3. Incremental net benefits (Kshs) for various soil fertility management options in Narok.

Technology	1st season INB	1st season Discounted INB	2nd season INB	2nd season Discounted INB	Total Discounted INB
FYM	1115.15	1013.67	22369.42	18477.14	19490.81
FURP	-755.15	-686.43	12541.57	10359.34	9672.91
PREP-PAC	-13040.80	-11854.10	19672.92	16249.83	4395.74
MBILI	-14516.90	-13195.90	36736.72	30344.53	17148.67

investment of over 100%. The empirical evidence has shown that rates of return above 100% are above the minimum acceptable to farmers. This suggests that all things being constant, it is safe to recommend to farmers in Narok, farm yard manure, PRE-PAC and FURP as soil fertility augmenting soil fertility management options, with which to produce food crops such as potatoes and beans.

The evaluation of the five technology options tested in Konoin so far suggest that it would be profitable for farmers to adopt use of fortified compost or PRE-PAC as soil fertility management strategies. The results of the marginal analysis adopting show that adopting fortified compost implies a 1639% rate of return to farmers who currently use minimum FYM in potato and bean production. For farmers who currently apply nothing to augment soil fertility in potato and bean production, adoption of fortified compost. The technology that offered the highest aggregate output and return to land, implies the highest rate of return for farmers currently applying minimum FYM rate or not applying any inputs. Since experience and empirical evidence have shown that the minimum rate of return acceptable to farmers falls between 50 to 100%, it is safe to recommend fortified compost to farmers in Konoin District.

Incremental net benefit (INB)

Since all the technology options had negative net benefits in Sotik, Bomet, Bureti and Kericho, it was not sensible to determine the incremental net benefit of shifting from farmers' practices to other soil fertility management options. Table 2 shows the potential incremental net benefits that farmers in Konoin District can gain by changing from their current soil fertility management practices to use of either fortified compost or using PRE-PAC. The highest incremental income is obtained by a shift from farmer practice of not applying anything, to use of fortified compost. The results show, for example, that a shift from no inputs to use of fortified compost can increase the net benefits (net income) by about Kshs. 25,000/- in the first season and by Kshs. 15,000/- in the second season.

The incremental net benefits of switching from farmer practice to new technology options in Narok could not be extensively analyzed since the farmer practices seemed to perform better than the alternative new options. Nevertheless, a move from no inputs to use of farmer's farm yard manure promises an incremental net benefit of nearly Kshs. 20,000/- in the two seasons, most of which is achieved in the second season (Table 3).

CONCLUSION AND RECOMMENDATION

On average, the performance of the soil fertility management options in terms of yield response particularly the residual effect in subsequent seasons and the net benefits was inferior than anticipated in most sites. The sites in Bureti, Bomet and Sotik showed the poorest performance with soil fertility management options showing negative net benefits and return to land. Nevertheless, at some locations, the data was indicative of the possible technology options that could be recommended to farmers. In Narok, the farmer practice of use of FYM gave the highest net benefits and return to land from food production, followed by PRE-PAC and FURP. Results of marginal analysis further supported promotion of these technology options to farmers in the area because they showed rates of return to investment of over 100%.

Thus, based on the available data, it is safe to urge farmers in Narok to continue use of FYM and to promote recommended use of PRE-PAC and FURP. In Konoin, the analysis revealed that fortified compost had the highest potential of improving net benefits and returns to land from food production, and therefore should be promoted to farmers in Konoin was PRE-PAC, although the return to land was a modest Kshs. 1,418/- compared to over Kshs. 15,000/- from fortified compost. In general, this study had a limitation of five soil fertility amelioration soil fertility management options at five districts and two cropping seasons. There is need to extend the scope of the study to include a wide range of nutrient depleted soils in Kenya. Nonetheless, guidelines on the usefulness of soil fertility management options have been obtained.

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