Economic evaluation of local inputs in Meru South District, Kenya

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Abstract

Declining land productivity is a major problem facing smallholder farmers in Kenya today. This decline is as a result of reduced soil fertility caused by continuous cultivation without adequate addition of manures and fertilizers. Low soil fertility is one of the greatest challenges facing farmers in the central highlands of Kenya. A farmers' participatory trial was established in Meru South District, Kenya in 2000 to investigate feasible soil nutrient replenishment technologies for poor resource smallholder farmers. Results across seven seasons indicate that sole tithonia gave the highest grain yield followed closely by tithonia with half recommended rate of inorganic fertilizer with 6.4 and 6.3 Mg ha^{-1}respectively. The control treatment gave the lowest yield of 2.2 Mg ha^{-1} across the seasons. The integration of organic and inorganic nutrient sources of N gave higher maize grain yield as compared to the sole organic materials in all seven seasons. Economic analyses indicate that on average tithonia with half the recommended rate of inorganic fertilizer recorded the highest net benefit (US$ 787.2) whereas the control treatment gave the lowest benefit (US$ 271.7). On the other hand the recommended rate of inorganic fertilizer gave the highest (US$ 12.5) return to labour while sole tithonia gave the lowest (US$ 4.0). On average in the farmers' fields, manure alone gave the highest return to labour of US$ 3.6, while the control treatment gave the lowest return to labour US$ –0.2.

Key words: cost benefit ratio, economic analysis, integrated soil fertility management

Introduction

Decline in soil fertility is a major problem contributing to the low maize grain (staple food) yield in Kenyan smallholder farms. This is especially a problem in the densely populated highlands of central Kenya with over 700 persons km^{-2}(Government of Kenya,2001). The soils in this area are Humic Nitisols with moderate to high inherent fertility (Jaetzold and Schmidt, 1983). However, the soil fertility has declined over time with an annual net nitrogen depletion exceeding 30 kg N (Smaling, 1993) as a result of continuous cropping with insufficient nutrient replenishment. The use of inorganic fertilizers is generally less than 20 kg N ha^{-1} (Adiel, 2004), which does not meet the optimal crop nutritional requirement. Crop yield decline has thus, continued to be a major problem facing smallholder farmers in the area. Maize grain yields of small-scale farmers in the densely populated areas is low, usually less than 1.5 Mg ha^{-1}(Wokabi, 1994) whereas the potential yield is 7–12 Mg ha^{-1}.

Surveys carried out in the area indicate that farmers are aware of the declining soil fertility (as expressed by declining crop yields), but in most cases they do not have readily available resources to replenish the soil fertility (Adiel, 2004). A multidisciplinary farmers participatory trial was therefore established in the main maize growing areas of Meru South District, Kenya in 2000 with the main objective of bringing closer feasible soil nutrient replenishment technologies to the smallholder resource poor farmers.

A. Bationo (eds.), Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities, 443–448.

Materials and methods

Study site

The study was conducted in Meru South District, Kenya, which is located in upper midlands 2 and 3 (UM2 and UM3) at an altitude of approximately 1500 m above sea level. Annual mean temperatures are 20°C and rainfall varies from 1200 to 1500 mm per annum (Jaetzold and Schmidt, 1983). The rainfall is bimodal; the long rains (LR) lasting from March through June and short rains (SR) from October through December. The soils are Humic Nitisols (Jaetzold and Schmidt, 1983), which are deep, well weathered with a moderate to high inherent soil fertility.

Experimental design and management

The off-station experiment was established in the 2000 long rainy season on a farm with poor soils and laid out as a randomized complete block design (RCBD). Plot sizes measuring 6 m x 4.5 m replicated thrice. The test crop, maize, (*Zea mays* L, var. H513 – maize variety commonly grown by farmers in the area) was planted at a spacing of 0.75 m and 0.5 m inter- and intra-row, respectively. Nine soil fertility amendment inputs were applied every season to give an equivalent of 60 kg N ha^{-1}[which is the recommended rate of N to meet maize nutrient requirement for an optimum crop production in the area (FURP, 1987)]. The tenth treatment was the control with no inputs. The organic materials (biomass transfer) were harvested, chopped and incorporated into the soil to a depth of 15 cm during land preparation in all seasons. Compound fertilizer (23:23:0) was the source of inorganic N and was applied at sowing. Weeding was done twice in each season. At maturity, maize was harvested and the fresh weight of both grain and stover taken. The maize grain was then air-dried and the weight taken. Maize grain yields were expressed on a 12.5% water content.

Farmers' field days were held at the grain filling stage during each season where the farmers toured the experimental plots. Technologies used were described and farmers evaluated the various technologies and exchanged views. They were then requested to select the technologies they wanted to take to their farms. Eventually, from the 2001/2002 SR, farmers started trying out some of the promising technologies in their own farms. The trials established in the farmers' fields were farmer-designed and farmer-managed. The farmers applied the organic inputs as explained during the field days though some of them adapted the technologies to fit their socio-economic status.

Economic analysis

The economic analysis in this study was done without considering soil nutrients dynamics and the resultant maize yields due to long-term application of inorganic and organic inputs. The local market prices of the various inputs were used in the analysis. However, since the organic amendments had no market prices in the area they were costed in terms of the labour involved in harvesting and incorporation (Table 1).

For the demonstration site, it was assumed that the organic resources were collected within the homestead, thus only the labour for collection, transport and application were taken into account and it was estimated to be 2.9 US$ 100 kg^{-1} on dry matter basis (Nziguheba et al., 2002). The labour was valued at the local wage of 0.13 US$ per hour. The application of the fertilizer was estimated to take an extra 7% of the total labour cost required for maize planting (Jama et al., 1997). Harvested yields in each treatment were reduced by 10% to adjust to realistic values if the experiment was to be managed by the farmer (CIMMYT, 1988).

For the farmers' economic data, time taken to undertake the various activities was indicated (by 6 farmers) and the hours taken costed in terms of US$ per hour. The benefits refer to the gains obtained by selling the harvested maize grain and stover in the area. Monetary values were converted to US Dollars (US$) at the exchange rate of 76 Ksh = 1 US$ (February, 2004).

Table 1. Parameters used to calculate the economic returns for the different nutrient replenishment technologies

Parameter	Actual values
Price of NPK (23:23:0)	1.38 US$ kg^{-1}N
Labour cost	0.13 US$ hr^{-1}
Labour cost for planting maize	10.5 US$ ha^{-1}
Labour for applying fertilizer	0.74 US$ ha^{-1}
Labour for application of organic inputs	2.9 US$ 100 kg^{-1}DM
Price of maize	0.146 US$ kg^{-1}
Price of stover	0.012 US$ kg^{-1}

DM = dry matter basis. Exchange rate 76 Ksh = 1 US$ (Feb, 2004).

Data analysis

Data were analysed using Genstat to compare treatment effects on maize yields. Means were separated using Least Significant Difference at 5% level (P = 0.05).

Results and discussions

Maize grain yield

Average maize grain yields for different treatments across the seven seasons are presented in Table 2. The results across the seven seasons indicate that, sole tithonia gave the highest grain yield followed closely by tithonia with half recommended rate of inorganic fertilizer with 6.4 and 6.3 Mg ha^{-1}respectively. Control treatment gave the lowest yield of 2.2 Mg ha^{-1} across the seasons. The maize grain yields were significantly different ($P < 0.05$) between treatments in the seven seasons.

The integration of organic and inorganic nutrient sources of N gave higher maize grain yields compared to the sole application of organic materials during the seven seasons of the study. These results concur with results by Gachengo (1996), Mugendi et al. (1999), and Mutuo et al. (2000) on the combination of organic and inorganic nutrient inputs. Such combination can be considered as a better option for increasing fertilizer use efficiency and providing a more balanced supply of nutrients (Vanlauwe et al., 2002). Kapkiyai et al. (1998) reported that combination of organic and inorganic nutrient sources resulted into synergy and improved synchronization of nutrient release and uptake by plants leading to higher yields.

Lower maize grain yield in 2000 and 2001 long rains seasons could be associated with the low and unevenly distributed rainfall. Precipitation in the 2000 long rains season averaged 126 mm and most of it was recorded within the first three weeks of the season. In 2001, 431 mm was recorded during the long rains with 86% of the rains falling in the first two weeks of the season. The low and the poorly distributed rainfall could have reduced the availability of nutrients to the maize plants. Soil moisture content influences N mineralization and availability and subsequent maize growth and N uptake (Soon et al., 2001).

Economic analysis

The results of the economic analysis indicate that, on average across the seven seasons, tithonia with half recommended rate of inorganic fertilizer treatment recorded the highest net benefit with US$ 787.2 while the control treatment recorded the lowest with US$ 271.7 (Table 3). Leucaena recorded the highest BCR (7.0) while manure with half recommended rate of inorganic fertilizer and tithonia with half recommended rate

Table 2. Maize yields (Mg ha^{-1}) under different technologies from 2000 to 2003 in Chuka, Meru South District, Kenya

Treatment	Seasons							
	Grain weight (Mg ha^{-1})							
	2000 LR	2000/2001 SR	2001 LR	2001/2002 SR	2002 LR	2002/2003 SR	2003 LR	Mean
1	1.2	6.7	3.7	4.6	4.2	6.1	5.0	**5.3**
2	1.2	6.5	4.9	2.9	5.9	5.0	6.5	**5.5**
3	1.2	6.6	4.3	6.5	5.4	7.0	7.4	**6.4**
4	0.7	6.0	2.8	4.5	4.5	7.6	6.5	**5.4**
5	1.0	6.1	4.0	5.8	4.7	6.3	6.4	**5.7**
6	1.3	6.8	5.4	5.6	5.4	6.2	7.2	**6.3**
7	1.1	5.8	4.3	5.1	4.3	7.2	6.2	**5.7**
8	1.3	6.1	3.7	4.4	5.0	7.2	6.2	**5.7**
9	1.4	6.3	5.0	3.2	4.3	5.8	5.5	**5.3**
10	0.6	2.6	1.2	1.5	1.8	2.6	2.8	**2.2**
LSD	**0.2**	**0.2**	**0.4**	**0.4**	**0.3**	**0.4**	**0.5**	**0.3**

Treatment (1 = manure; 2 = manure + ½ fert; 3 = tithonia; 4 = calliandra; 5 = leucaena; 6 = tithonia + ½ fert; 7 = calliandra + ½ fert; 8 = leucaena + ½ fert; 9 = rec fert; 10 = control).

Table 3. Net benefit, Benefit-Cost Ratio (BCR) and return to labour (US$) from 2000 to 2003 in Chuka, Meru South District, Kenya

Treatment	Net benefit	BCR	Return to labour
Cattle manure	645.0	5.0	5.0
Cattle manure + 30 kg N ha^{-1}	616.3	3.5	6.8
Tithonia	784.2	4.0	4.0
Calliandra	652.5	5.8	5.9
Leucaena	779.7	7.0	7.0
Tithonia + 30 kg N ha^{-1}	787.2	3.5	6.3
Calliandra + 30 kg N ha^{-1}	747.3	4.4	9.0
Leucaena + 30 kg N ha^{-1}	572.4	4.3	6.9
60 kg N ha^{-1}	666.3	3.6	12.5
Control	271.7	5.2	5.2
LSD	**80.2**	**2.0**	**2.4**

Table 4. Return to labour for 6 farmers (3 men & 3 women) at Chuka during the 2003 long rains season

Farmer	Technologies							
	1	2	3	4	5	6	7	8
Njeri Gitari (F, 45 yrs)	–	7.2	1.9	5.3	2.3	1.9	–	0.3
Kaari Mbuba (F, 45 yrs)	–	0.7	2.7	1.3	1.2	0.7	3.7	−1.1
Mercy Micheni (F, 45 yrs)	5.0	3.6	–	2.8	–	–	7.1	–
Martin Ikingi (M, 35 yrs)	4.5	4.0	–	2.7	–	–	2.7	–
Kanga Muga (M, 74 yrs)	–	2.1	1.6	3.5	0.5	3.8	−0.2	0.4
Bedford Ntobori (M, 65 yrs)	1.2	0.9	–	0.9	–	–	−0.05	−0.25

Technologies (1 = manure; 2 = manure + ½ fert; 3 = tithonia; 4 = tithonia + ½ fert; 5 = calliandra + ½ fert; 6 = leucaena + ½ fert; 7 = rec fert; 8 = control).

of inorganic fertilizer recorded the lowest (3.5). On the other hand recommended rate of inorganic fertilizer gave the highest (US$ 12.5) return to labour while sole tithonia gave the lowest (US$ 4.0).

On average across the seven seasons the treatments with sole application of organics recorded a higher BCR compared to the treatments with integrations of organic and inorganic nutrients. On the other hand, treatments with sole organics recorded lower return to labour compared to the treatments with integration of organic and inorganic nutrients. The higher return to labour in the integrations could be due to the low labour required compared to the sole applications. Despite the fact that tithonia had the lowest return to labour in the demonstration site (Table 3), most farmers in the study area were willing and eager to try it in their farms. This could be most probably due to the low opportunity cost of their time as also observed by Mutuo et al. (2000) with some farmers in their study in Western Kenya.

The results of farmers' economic analysis show that the return to labour for each technology varied largely between farmers during the 2003 long rains season (Table 4). Return to labour of inorganic fertilizer ranged between 0.4 and 8.2. This variation could be as a result of different working speeds of the farmers and also due to the inherent soil fertility in their farms. In general, women recorded a higher return to labour compared to the men this is because the men rated their labour higher than the women. However, the age of farmers did not seem to influence the return to labour.

On average, manure with half recommended rate of inorganic fertilizer gave the highest net benefit while control gave the lowest with US$ 938.8 and 63.3 respectively (Table 5). On the other hand sole manure gave the highest BCR and return to labour with 2.9 and 3.6 respectively, while control gave the lowest BCR and return to labour with 0.6 and –0.2 respectively.

Though studies by Jama et al. (1997) and Mutuo et al. (2000) indicated that organics have high labour costs, the results in the farmers' fields indicate that all of

Table 5. Net benefit, Benefit-cost ratio (BCR) and return to labour (US$) for six farmers during the 2003 long rains season in Chuka, Meru South District, Kenya

Treat	Net Benefit	BCR	Return to labour
1	542	2.9	3.6
2	938.8	2.5	3.1
3	304.3	1.8	2.1
4	795	2.2	2.8
5	337.4	1.2	1.3
6	462	1.8	2.1
7	360	1.3	2.7
8	63.3	0.6	–0.2
LSD	**677**	**2.0**	**2.5**

Treat = Treatment (1 = manure; 2 = manure + ½ fert; 3 = tithonia; 4 = tithonia + ½ fert; 5 = calliandra + ½ fert; 6 = leucaena + ½ fert; 7 = rec fert; 8 = control).

them (except calliandra with half recommended rate of inorganic fertilizer) recorded a return to labour greater than 2.0, the minimum acceptable for most smallholder farming activities.

Some of the organic materials like calliandra and leucaena could be more economically attractive when used as a protein supplement for dairy cattle (ICRAF, 1993; Reynolds and Jabbar, 1994; Jama et al., 1997) and the manure returned back to the farm.

Conclusions

After four years of continuous cultivation and application of organic and inorganic inputs, the maize yields have continued to improve. Sole tithonia and tithonia with half recommended rate of inorganic fertilizer technologies gave reasonable yields over the seven seasons and most farmers are trying them in their farms. During the seven seasons, tithonia with half recommended rate of inorganic fertilizer recorded the highest net benefit while control recorded the lowest. On the other hand recommended rate of inorganic fertilizer gave the highest return to labour while sole tithonia gave the lowest. Since the organic materials may not be available in large amounts that are required for sole application, farmers are encouraged to adopt the integration of the organic and the inorganic as they have higher maize grain yields, net benefits and returns to labour.

Acknowledgements

The authors wish to thank the Rockefeller Foundation and TSBF-AfNet for providing financial support for the field experimentation. They also appreciate the contribution and collaborative efforts by the Kenya Agricultural Research Institute (KARI), Kenya Forestry Research Institute (KEFRI) and Kenyatta University (Department of Environmental Sciences) in administering field activities. Lastly, the cooperation and contributions by researchers and Kirege community members (farmers and administration) are acknowledged.

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