Making farmer recommendations from experimental data: A case study of Gucha area of Kisii County

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Abstract
Studies have shown low soil nutrient levels in the Lake Victoria Basin, attributing this to inappropriate soil and water resource management methods used. Organic and inorganic fertilizers are recommended but farmers need to get economically viable fertilizer options for increased benefits. A study was carried out in Gucha District, one of the severely degraded areas in the Lake Victoria Basin, to determine fertilizer options that are economically viable to small scale farmers. On-farm trials were conducted with different levels of organic and inorganic fertilizers. The use of organic fertilizers gave high yields. However by use of the marginal rate of return analysis, the results showed that the use of DAP, CAN and Mavuno gave economically viable results. The results also showed limited options for farmers in their prevailing circumstances.

Key words: soil fertility, fertilizer options, marginal rate of return.

Introduction
Inappropriate soil and water resource management (SWM) practices in the Lake Victoria basin have led to soil degradation as well as low crop and livestock productivity (Swallow et al., 2001). This phenomenon has also been reported by Makokha and Kamoni (2011) who showed that between 1998 and 2008 maize yields reduced from 25 to 4-5 90 kg bags/acre. Most farmers in Kisii get less than 2.0t of maize grain ha\(^{-1}\) compared with on-station researcher yield of 9.0t ha\(^{-1}\) (Okoko et al., 2000; Nzabi et al., 2000). Farmers attributed the low yields to declining soil fertility caused by continuous cropping, crop residue burning, soil erosion and inadequate use of organic and inorganic fertilizers. Population pressure has resulted in sub-division of the parcels to very small sizes (mean land acreage was 2.5) with the consequence that past practices, which used to improve soil fertility are no longer practiced.

About 87% of households depended on on-farm employment. The study by Makokha and Kamoni (2011) shows that about 74% of the households had a monthly income of up to KES 10,000. With an average household size of 5 persons, each household member had KES 2,000 per month. This was lower than the International Poverty Line of USD 1.25/person/day (World Bank, 2008). Soil fertility analysis of 30 samples from the study site showed that 90% of the samples had low N, 13.3% had low P, 3.3% had low K, 36.7% had low Ca, 3.3% had low copper, 3.3% had low iron and 10% had low Zinc.

Tongi and Mochoge (2000) have shown that seasonal soil losses for a bare soil with a 9% slope were 54 to 76t ha\(^{-1}\), 1.6 to 2.54 t ha\(^{-1}\) for maize and 0.64 to 0.91 t ha\(^{-1}\) for intercropped maize. The same results show that in addition to other SWM interventions, efforts need to be made to increase fertility of depleted soils in the study area. Therefore the aim of this study was to determine the appropriate soil fertility options for improved smallholder farm productivity.

After diagnosis of the soil fertility problems, a survey was done to understand the conditions of farmers and the soil fertility status. One of the recommendations made after the survey was to set up on-farm experiments to determine the most appropriate soil fertility options. However, agronomic recommendations need to be economically viable in order for farmers to adopt, because costs and benefits have to be considered before adopting a new practice. Although research has been carried out in the Kisii region on various combinations of fertilizer and manure treatments in maize (Nzabi et al., 2000; Obaga et al., 2000; Onyango et al., 2000), a few economic analyses studies have been carried out to give insights on the economic viability of the various tested treatments. An experiment may show
insignificance among the treatments but an economic analysis may reveal hidden differences on net benefits, which may cause changes in the final recommendations.

Materials and methods

The study sites were in Ogembo and Sameta Divisions, Gucha District. The actual sites were located at Kiragia and Eburi in Ogembo Division and Etora and Itumbi in Sameta Division. Two thirds of the study area is classified as uplands with slopes of 5 to 16% and they are referred to as undulating to rolling, while one third of the area is rolling to hilly (slopes 8-16%) or mountainous (slopes > 30%) (Wielemaker and Boxem, 1982). The area has a mean annual rainfall of 1700-1800mm. The soils are mainly Nitosols, which are well drained, and very deep (>120cm). Gucha River with its tributaries cuts through the middle of the area and drains into Lake Victoria. Due to population pressure and scarcity of land, all the land was under cultivation with very tiny portions under pasture.

Six treatments and a control were tested in a Completely Randomised Block Design (CRBD) in four on-farm experiments in Ogembo and Sameta Divisions. The treatments were:

- 60 kg P₂O₅ ha⁻¹ (P supplied by DAP at planting, topdressed with CAN at 60 kg N ha⁻¹ at knee high)
- 30 kg P₂O₅ ha⁻¹ + 5t FYM ha⁻¹ (DAP and FYM at planting, topdressed with CAN at 30 kg N ha⁻¹ at knee high)
- 60 kg P₂O₅ ha⁻¹ (P supplied by Mavuno at planting, topdressed with CAN 60 kg N ha⁻¹ at knee high)
- 30 kg P₂O₅ ha⁻¹ + 30 kg Nha⁻¹ + 5t FYM ha⁻¹ (Mavuno and FYM at planting, topdressed with CAN at 30 kg N ha⁻¹ at knee high)
- 5t ha⁻¹ FYM at planting, topdressed with CAN at 30 kg N ha⁻¹ at knee high
- 10 t ha⁻¹ FYM at planting
- Control (no inputs).

The plots were in an area of 4.5 x 6 m (27 m²). The chemical composition for Mavuno was 10% N, 26% P₂O₅, 10% K₂O, 4% S% Ca, 4% Mg plus trace elements.

Data was collected for three seasons; short rains 2010, short rains 2011 and long rains 2011. Yields from the short rains of 2011 were very low because the maize was attacked by a virus, therefore not included in the analysis. Each plot was in triplicate except the one at the Itumbe site, which was in duplicate.

The following data was collected for economic analysis:

**Average Variable Costs** for each of the seven treatments across the sites.

Variable costs are all inputs affected by moving from one treatment to another. In the experiment the variable costs involved were DAP, Mavuno, CAN, manure, planting, 1st and 2nd weeding, topdressing and maize harvesting. However, the variable costs that changed from one treatment to the other were DAP, Mavuno, CAN, manure and topdressing.

**Average Yield (in kg/ha) for each of the seven treatments across the sites**

Price of dry maize at the study site during harvesting. The price of maize at the time of harvest was KES 3000 per 90 kg bag, translating to KES 33 per kg.

The demonstration sites were managed by farmers from planting to harvesting, so the yields recorded are assumed to be the yields a farmer would get on their farm for the particular treatment. From the data the net benefits and the Mean Rate of Return (MRR) were derived. The net benefits are obtained by subtracting the total costs that vary from the gross value of maize yield while the MRR is the change in net benefits divided by the change in costs. It indicates what farmers expect to gain, on average, in return for their investment when they change from one practice (or technology) to another.

To calculate recommendations that would be economically viable to the farmers, the calculated variable costs are arranged from the lowest to the highest, and tabled with their corresponding net benefits.
From the Table the net benefit that is lower than the previous one is eliminated from the analysis. This is because no farmer can adopt recommendations that have higher costs and lower benefits. The MRR from one treatment to another is calculated until it goes below the minimum MRR. The minimum MRR for most agronomic treatments is taken as 50% (CIMMYT, 1988).

Results
In all the seasons the treatments yields were significantly different from the controls (F (6, 47) = 6.189, p, 0.001 SR2010); (F (6, 33) = 5.609, p, 0.001 LR2011). However, without the controls the other treatments yielded equally on seasonal basis.

**Short rains 2010**
Table 1 shows mean maize yield, variable costs, benefits and MRR for data obtained during the short rains 2010.

<table>
<thead>
<tr>
<th>Variable (ha⁻¹)</th>
<th>T7</th>
<th>T1</th>
<th>T3</th>
<th>T5</th>
<th>T2</th>
<th>T4</th>
<th>T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean yield</td>
<td>85,305</td>
<td>141,240</td>
<td>159,588</td>
<td>146,751</td>
<td>160,578</td>
<td>140,547</td>
<td>160,908</td>
</tr>
<tr>
<td>Total benefit (KES)</td>
<td>0</td>
<td>33,985</td>
<td>38,499</td>
<td>44,319</td>
<td>51,090</td>
<td>53,347</td>
<td>58,333</td>
</tr>
<tr>
<td>Variable cost (KES)</td>
<td>85,305</td>
<td>107,255</td>
<td>121,089</td>
<td>102,432</td>
<td>109,488</td>
<td>87,200</td>
<td>102,575</td>
</tr>
<tr>
<td>Net benefits (KES)</td>
<td>0</td>
<td>33,985</td>
<td>38,499</td>
<td>44,319</td>
<td>51,090</td>
<td>53,347</td>
<td>58,333</td>
</tr>
<tr>
<td>MRR=Marginal Rate of Return; N/A= Not applicable; T7-Control, T1-60 kg P₂O₅ ha⁻¹ (P supplied by DAP at planting, top dressed with 60 kg N ha⁻¹ CAN at knee high; T3-60 kg P₂O₅ ha⁻¹ (P supplied by Mavuno at planting, top dressed with 60 kg N ha⁻¹ CAN at knee high; T5-5 t FYM at planting, top dressed with 30 kg N ha⁻¹ CAN at knee high; T2-30 kg P₂O₅ ha⁻¹ + 5t FYM ha⁻¹ (DAP and FYM at planting, top dressed with 30 kg N ha⁻¹ CAN at knee high; T4-30 kg P₂O₅ ha⁻¹ + 30kg N ha⁻¹ + 5t FYM ha⁻¹ (Mavuno and FYM at planting, top dressed with CAN at knee high; T6-10 t FYM at planting</td>
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<td></td>
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</tbody>
</table>

From Table 1 the highest yield was 10t ha⁻¹ FYM at planting, and as expected, the lowest was the control. The highest net output was in T3, where Mavuno was used. To calculate the MRR the net benefit that is lower than the previous one is removed. In this case treatments T5, T2, T4 and T6 have lower benefits and higher costs than T3. From the MRR, T3 is the best recommended for farmers. An MRR of 306% means that for every KES1 invested, a farmer gets KES1 back and KES3.06 more. T1 is still good because it is higher than the conventional MRR of 50%. The choice of whether T3 or T1 will depend on the availability of Mavuno, although T3 still has an advantage over T1 in that it does not acidify the soil after long use.

**Long rains 2011**
Table 2 shows the mean yield, variable costs, benefits and MRR for data obtained during the long rains.

A comparison of mean yields in Tables 1 and 2 shows that the short rains gave higher yields than the long rains, although they were not statistically significantly different. Late weeding contributed to the decreased yields in LR2011 compared with SR 2010.
Table 2: Mean maize yield, variable costs, benefits and MRR for Long Rains in 2011 for Kiragia, Eburi, Etora and Itumbe sites

<table>
<thead>
<tr>
<th>KES/ha</th>
<th>T7</th>
<th>T1</th>
<th>T3</th>
<th>T5</th>
<th>T2</th>
<th>T4</th>
<th>T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (kg/ha)</td>
<td>1,513</td>
<td>4,282</td>
<td>3,883</td>
<td>4,104</td>
<td>4,681</td>
<td>4,344</td>
<td>3,583</td>
</tr>
<tr>
<td>Total benefit (KES/ha)</td>
<td>49,929</td>
<td>141,306</td>
<td>128,139</td>
<td>135,432</td>
<td>154,473</td>
<td>143,352</td>
<td>118,239</td>
</tr>
<tr>
<td>Variable costs (KES/ha)</td>
<td>0</td>
<td>42,836</td>
<td>48,598</td>
<td>51,966</td>
<td>60,608</td>
<td>63,489</td>
<td>68,519</td>
</tr>
<tr>
<td>Net benefit (KES/ha)</td>
<td>49,929</td>
<td>98,470</td>
<td>79,541</td>
<td>83,466</td>
<td>93,865</td>
<td>79,863</td>
<td>49,720</td>
</tr>
<tr>
<td>MRR</td>
<td>113%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

MRR=Marginal Rate of Return; N/A= Not applicable; T7-Control, T1-60 kg P₂O₅ ha⁻¹ (P supplied by DAP at planting, top dressed with 60 kg N ha⁻¹ CAN at knee high; T3-60 kg P₂O₅ ha⁻¹ (P supplied by Mavuno at planting, top dressed with 60 kg N ha⁻¹ CAN at knee high; T5-5 t ha⁻¹ FYM at planting, top dressed with 30 kg N ha⁻¹ CAN at knee high; T2-30 kg P₂O₅ ha⁻¹ + 5 t FYM ha⁻¹ (DAP and FYM at planting, top dressed with 30 kg N ha⁻¹ CAN at knee high; T4-30 kg P₂O₅ ha⁻¹ + 30 kg N ha⁻¹ + 5 t FYM ha⁻¹ (Mavuno and FYM at planting, top dressed with CAN at knee high; T6-10 t ha⁻¹ FYM at planting

Treatment T2, a combination of half rate fertilizer (30 kg N ha⁻¹ N supplied by CAN and 30 kg P₂O₅, P supplied by DAP at planting) and half rate manure (5 t ha⁻¹) gave higher yields in the two seasons compared with the other treatments. Generally, treatments with farm yard manure gave high yields but the costs made the treatment uneconomically viable. From Table 2, movement from the control to T1 gives an MRR of 113%. This treatment involves the use of research recommended full rate fertilizer (60 kg P₂O₅ ha⁻¹, P supplied by DAP at planting and 60kg N ha⁻¹, N supplied by CAN at topdressing).

Discussion

The results indicate that without fertilizers, yields are quite low depicting the known fact that the soils in the study area are highly depleted and interventions are needed to increase fertility. Half rate farm yard manure in combination with half rate fertilizer (DAP) gave highest output in both seasons but did not give the highest net output because manure was not easily available, making it expensive. In addition the quality of manure, especially for cattle is critical for crop yields (Lekasi et al., 2000)

The highest net output was in T3, in SR2010 where the recommended full rate fertilizer (60kg N ha⁻¹ and 60 kg P₂O₅ kg ha⁻¹) with P supplied by Mavuno at planting was used. However this trend was not consistent in the next season (LR2011) raising the question whether Mavuno composition is consistent in every season.

Conclusions

These results indicate that under the prevailing circumstances of unavailability and high cost of manure, farmers’ options are limited. This means that some of the current fertilizer treatments that farmers are using may be giving low returns. Farmers would have more options if several treatments had an MRR of more than 50%.

Recommendations

- Extension officers should promote generation and use of manure by farmers in the region in order to increase its availability and hence reduce its costs
- Treatment T2 (30 kg P₂O₅ ha⁻¹ + 5 t FYM ha⁻¹ (DAP and FYM at planting, top dressed with 30kg N ha⁻¹ CAN at knee high) consistently had more than 50% MRR in both seasons and therefore is the best that can be recommended. The combination of fertilizer and manure also promotes good soil health and is a sustainable land management practice. The combination is also expected to take care of the long term acidifying effects of DAP
More research using Mavuno should be carried out together with its analysis to determine its consistency in benefits and in its composition. A final decision on its suitability is therefore not possible for now

More similar on-farm experiments with other crops should be done. This is because different crops have different fertility requirements

All on-farm experiments should undergo such economic analysis to optimally allocate scarce resources

Acknowledgement

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References


