Diagnostic ‘best-bet’ soil fertility management technologies for potato production in Nyandarua County, central Kenya

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Abstract

Irish potato is the second most important food crop in Kenya after maize. However in recent time soil fertility decline has been attributed to be one main cause of decline in potato yields in prominent growing areas comprising the Greater Nyandarua County, Central Kenya. The objective of the study was to test economic viability of existing technologies for improving and sustaining soil fertility in mixed farming system by use of integrated soil fertility approaches. This study was conducted at the KARI Oljo Orok station and in Bahati at Mzee Gakuru’s farms located within Nyandarua County with potato used as the test crop. The composition of the different treatments that were applied in the trial were: (T1) Mineral fertilizers 17:17:17 at 200 kg ha\(^{-1}\) (T2) Mineral fertilizer CAN, TSP, and MOP (T3) Manure alone 10 t/ha (T4) Manure 5 t/ha combined with mineral fertilizer 17:17:17 at 100 kg ha\(^{-1}\) and (T5) Unfertilised control. No significant differences in ware potato yield were observe at the KARI Oljo Orok station, but at Mzee Gakuru’s farm yield were significant (p < 0.05) with yields ranging between 13.7 and 22.3 t ha\(^{-1}\) equivalents to 50 and 89 bags per acre, for the control and half manure half fertilizer treatments, respectively. An assessment of economic viability of the tested technologies indicated that since treatment five (T5) was the control (none use of fertilizers and/or manure), it is can be concluded that the use of manure and fertilizer gives better economic benefits than the none use of fertilizers and/or manure. The highest Marginal Rate of Return (M.R.R = 354%) was obtained from the application of mineral fertilizer 17:17:17 at 200kg/ha, followed by T4 and T2 and lastly T3. It is worth noting that the application of manure alone (T3) compared to the control, gives an M.R.R of 157%. This further implies that manure application gives better returns than the control. It is also worth noting that the change from either use of fertilizers or manure alone (T1, T2 and T3) to the use of a combination of both (T4) has positive economic gains, M.R.R of 164, 318 & 438% respectively.

Key words: Irish potato, soil fertility, fertiliser, manure, technology viability marginal rate of return.

Introduction

Irish potato is the second important source of dietary carbohydrate in Kenya with approximately 25 000 to 30 000 hectares being grown annually, granting employment to more than 2.5 million people across the entire production and marketing chain. (Ministry of Agriculture, 2007; Hortfresh Journal, 2012). Despite increased demand of ware potato, production has been experiencing a declining trend Kenya in the past two decades producing 779,190 tons in 1990 to 670,303 in 2000 and 450,000 in 2010 (GeoHive, 2013). Potatoes are produced in the cool highlands mostly by small scale farmers under rain-fed conditions. The soils in these areas have a history of mainly forest origin rich in organic matter which after many years of continuous cultivation become generally acidic and of low fertility (Kiiya et al., 2006). The national production is far below the potential, largely due to low application of fertilizers and other organic amendments, limited use of certified seeds, and low use of fungicides and other production chemicals (Mureiithi and Irungu, 2004). Visits to potato growing areas of the County indicated severe soil degradation. Informal talks with resident farmers also revealed their understanding of the extent and severity in soil fertility decline (Lekasi et al, 2010). The main objectives of the project were to test viability of existing technologies for enhancing and sustaining soil fertility in mixed farming system by use of integrated soil fertility approaches. Specifically this project’s intend:

- to test and promote existing technologies for improving and sustaining soil fertility in mixed farming system by use of integrated soil fertility approaches for irish potato production in Nyandarua County and
to assess the economics benefit and viability of the tested technologies

**Materials and methods**

The study was conducted on-farm during the long rains of 2009 at the KARI Oljoro Orrok station and in Bahati at Mzee Gakuru’s farm, located within Nyandarua County. Irish potato was used as the test crop. Inorganic fertilisers used were CAN, TSP, MOP and compound 17:17:17. Manure used for the study was obtained from within the respective farms.

The composition of the different treatments that were applied in the demonstrations were as follows:

- **Treatment 1**\( (T_1) \) = Mineral fertilizer 17:17:17 at 200 kg/ha
- **Treatment 2**\( (T_2) \) = Mineral fertilizer CAN, TSP, MOP at 100kg, 100 kg and 50 kg
- **Treatment 3**\( (T_3) \) = Manure alone at 10 t/ha
- **Treatment 4**\( (T_4) \) = Manure 5 t/ha combined with mineral fertilizer 17:17:17 at 100 kg/ha
- **Treatment 5**\( (T_5) \) = Unfertilized control

Study plots were 4 x 6 m per treatment replicated three times. Irish potato variety *Tigoni* was used as the test crop. The choice of the variety was as advised by the frontline extension staff based on local farmers’ preferences from the selected sites. Usual agronomic practices were followed till maturity of the crop (Lung’aho and Kabira, 1999). At maturity, harvesting was done in the inner 4 rows from an area of 3 x 3 m and ware potato yield measurements done.

**Results and discussions**

Some selected soil characteristics are shown in Table 1 for the KARI Oljoro Orrok and Mzee Gakuru’s sites. Soils from the two sites indicate severe soil acidity. It is worth mentioning that a brief soil survey of the neighboring farms also depicted the soil acidity characteristic some as low as pH 4.39. This observation was not surprising because when we held discussions with the farmer it was evident that the source of this acidity was continuous use of ammonium containing DAP fertilizer, which is known to enhance soil acidity. This condition normally interferes with plant nutrient availability, especially phosphorus and micronutrients. These soils require judicious liming for the individual farms.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>KARI Oljoro Orrok site</th>
<th>Mzee Gakuru’s farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH ( (1:2.5 \text{ 0.01M CaCl}_2) )</td>
<td>4.97</td>
<td>4.54</td>
</tr>
<tr>
<td>Total OC (%)</td>
<td>1.95</td>
<td>2.13</td>
</tr>
<tr>
<td>Total nitrogen (%)</td>
<td>0.17</td>
<td>0.24</td>
</tr>
<tr>
<td>Available phosphorus by Bray P(_2)</td>
<td>28.4</td>
<td>16.8</td>
</tr>
</tbody>
</table>

Figures 1 and 2 show potato yields obtained from the KARI Oljo Orrok station and Mzee Gakuru’s farm, respectively. At the KARI Oljoro Orrok station the yields ranged between 7.8 and 10.3 t ha\(^{-1}\) equivalents to 104 and 139 bags per hectare, for the manure only and inorganic fertilizer only treatments, respectively. However the yields were not significantly different. This could have been attributed to the fact that the field used for this trial had been under continuous cultivation with conventional fertilisation and therefore no response to further soil amendments. This observation is important because it emphasizes the need for proper use of external soil amendments based on proper soil testing and use of recommended sources and rates. In essence, this particular soil needed no fertilization in order to produce optimum yields.
At Mzee Gakuru’s farm, the yield ranged between 13.7 and 22.3 t ha⁻¹ equivalents to 50 and 89 bags per acre, for the control and half manure half fertilizer treatments, respectively. The yields were significantly different (p < 0.05). Treatments received external nutrients either as organic or inorganic, always produced higher yields than the check, a trend also followed by the number of marketable tubers. Observation shows the need for soil organic matter improvement as well as nutrient replenishment.

**Assessment of economic viability of the tested technologies**

Table 2 shows the various cost of potato production associated with soil fertility the different soil amendments regimes. These are used in the calculations of benefits of the different treatment for use in deducing economic suitability of technologies applied in the study. Some costs are uniform with all the treatments since they are associated with agronomics operations of production.

<table>
<thead>
<tr>
<th>Variables</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Potato yields (bags/ha)</td>
<td>69</td>
<td>64.2</td>
<td>69.0</td>
<td>76</td>
<td>41.3</td>
</tr>
<tr>
<td>(c) Gross field Benefits GB/ha (KES)</td>
<td>99,360</td>
<td>92,448</td>
<td>99,360</td>
<td>109,440</td>
<td>59,040</td>
</tr>
<tr>
<td>(d) Costs that Vary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of seeds/ha (KES)</td>
<td>3,900</td>
<td>3,900</td>
<td>3,900</td>
<td>3,900</td>
<td>3,900</td>
</tr>
<tr>
<td>Cost of fertilizer or manure/ha (KES)</td>
<td>7,200</td>
<td>7,200</td>
<td>14,000</td>
<td>10,600</td>
<td>0.00</td>
</tr>
<tr>
<td>Cost of labour land prep., planting, fertilizer application</td>
<td>1,400</td>
<td>1,400</td>
<td>1,400</td>
<td>1,400</td>
<td>1,400</td>
</tr>
<tr>
<td>Cost fungicide/ha (KES)</td>
<td>13,890</td>
<td>13,890</td>
<td>13,890</td>
<td>13,890</td>
<td>13,890</td>
</tr>
<tr>
<td>Cost of labour- harvesting/ha (KES)</td>
<td>3,450</td>
<td>3,210</td>
<td>3,450</td>
<td>3,800</td>
<td>2,065</td>
</tr>
<tr>
<td>Cost of bags</td>
<td>690</td>
<td>640</td>
<td>690</td>
<td>760</td>
<td>410</td>
</tr>
<tr>
<td>Cost labour for weeding, etc</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Total costs that Vary (TCV) i+ii+iii+iv+v+vi+vii</td>
<td>30,880</td>
<td>30,640</td>
<td>37,680</td>
<td>34,700</td>
<td>22,015</td>
</tr>
<tr>
<td>Net Benefits (GB-TCV)</td>
<td>68,480</td>
<td>61,808</td>
<td>61,680</td>
<td>74,740</td>
<td>37,025</td>
</tr>
</tbody>
</table>

Price of a 110 kg bag of potatoes was KES 1440 = US$ 20

Table 3 lists the treatments in order of increasing costs that vary. The Table also gives Marginal Net Benefit (M.R.R) of changing from one treatment to the next “better” treatment.
Marginal Rate of Return (M.R.R) is Marginal Net Benefit (change in Net benefits from the control to the next better treatment) divided by the marginal cost (i.e. the change in TCV of the respective treatments) expressed as a percentage.

Change in net benefits/change TCV for T5 to T4 we have:

$(74,740 - 37,025) \times 100 = 297\%$

$(34,700 - 22,015)$

The M.R.R are calculated as you move from one treatment to the next better treatment as shown above.

The M.R.R marked X in Table 2 indicates that the Net benefits are lower than those of the previous treatment. The M.R.R for changes from none use of fertilizers and/or manure (T5) to application of fertilizers and/or manure (treatments, T1, T2, T3 and T4) are summarized in Table 4. The Table also summaries the M.R.R from one treatment to another.

The minimum acceptable M.R.R is 50%. The meaning of M.R.R of 50% is that per every extra shilling spend on the “next” treatment compared to the previous treatment you get the shilling plus an additional fifty cents. If the M.R.R is 100% then it means that for every one shilling spend you are getting an extra shilling and so forth.

Since treatment five (T5) was the control (none use of fertilizers and/or manure), it is can be concluded that the use of manures and fertilizer gives better economic benefits than the none use of fertilizers and/or manure. The highest M.R.R (354%) was obtained from the application of mineral fertilizer 17:17:17 at 200kg/ha, followed by T4 and T2 and lastly T3. It is worthy noting that the application of manure alone (T3) compared to the control, gives an M.R.R of 157%. This further implies that manure application gives better returns than the control. It is also worthy noting that the change from either use of fertilizers or manure alone (T1, T2 & T3) to the use of a combination of both (T4) has positive economic gains, M.R.R of 164, 318 & 438% respectively.

Conclusions
Results from this study indicated that in potato growing areas of Nyandarua County, soils require soil organic matter and fertilizer nutrients replenishment if crop yields are to be maintained sustainably. It is also worth noting that the change from either use of fertilizers or manure alone to a use of a combination of both has better economic returns. Further from the economic analysis it can be recommended that soil fertility improvement through the application of fertilizers and manures is worthy while as it results in increases in the economic benefits. The application manure alone seems to be dominated and leaving the choice between the use of either fertilizer alone (T1) or a combination of fertilizer and manure (T4). The decision to use either the combination or fertilizer alone (T1) will depend on whether there are soil physical benefits associated with application of manures. However from the soil characteristics it is inferred, that soil acidifying fertilizers such as DAP should cease to be used in this region and liming should be encouraged upon proper soil testing is done.

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References


