Overview of soil fertility & available soil testing programs to develop fertilizer recommendations in Kenya

CN Kibunja, EW Gikonyo, SK Kimani, LW Mbuthia, AO Esilaba and D Kamau

KALRO and IPI
OUTLINE

- Introduction
- Major soil fertility constraints
- Crop responses to potassium fertilizer
- National Soil Testing Information
- Importance of Soil Testing in fertilizer recommendations
- Conclusions and recommendations
Introduction

• Productivity of many crop enterprises is below yield potential;
  ➢ Low crop yields, e.g. maize - 1.5-2.5 t/ha and beans - 0.3 – 0.5 t/ha;
  ➢ Declining yield trends with a notable yield gap between research & farmer-managed plots;

• Underlying problems include:
  ➢ Low inherent soil fertility (low SOC, N, P, K, micro-nutrients eg. Cu and Zn);
  ➢ Poor land management - nutrient loss through crop removal, erosion, leaching - depletion rates at 21 N, 8 P and 43 K kg/ha/year (Smaling et al. 1993);
  ➢ Low fertilizer use (12 - 32 kg nutrient/ha/yr) and low financial ability

• Constraints experienced include:
  o Limited information on crop-specific nutrients requirements,
  o Lack of comprehensive information on site-specific characteristics of soils and,
  o High level of variation in soil properties across the country.
Distribution of major soils in Kenya

- Kenya has 25 major soil types
- Top 10 dominant soil types (% coverage):
  1. Regosols (15.04)
  2. Cambisols (11.02)
  3. Luvisols (8.13)
  4. Solonetz (6.36)
  5. Planosols (6.33)
  6. Ferralsols (6.05)
  7. Fluvisols (6.02)
  8. Arenosols (5.49)
  9. Calcisols (5.46)
  10. Lixisols (5.15)
SOIL FERTILITY CONSTRAINTS

FURP project - 231 sites data

- 80% soils exhibited low P
- High P fixation in most soils
- 100% of soils had pH < 7.0
- 63% of soils had pH < 5.5
- 82% of soils had organic carbon ≤ 2.0%
- hence N deficiency (Gikonyo, 2002)
Extents of Acidic Soils and Nitrogen deficient soils

- Occupy about 13% total land
- 88% soils pH ≤ 5.5

➢ More than 80% soils have <0.2% Nitrogen
Soil organic matter

\[ y = -0.024x + 49.179 \]

- Soil organic carbon easily lost under continuous cropping, e.g., a decline of 28 - 54% in 25 yrs;
- However, manure and crop residue addition reduced depletion rate of SOC (Long-term experiment, Kabete)
Potassium in soils of Kenya

Historical perspective

1960-70’s:
• none, low or negative responses to addition of K Fertilizers (MOA, 1969, 1970, 1975)
• No benefit from K fertilization (Hinga and Foum, 1972)
• Kenya fertilizer recommendations to date dominated by N and P

1980-90’s:
• Soil analysis data showing K deficient zones in Kenya
• Research highlighting K declining status and crop responses (Nandwa, 1988; Mochoge, 1991; ICRAF 1995; Kanyanjua, 1999)
Crop responses to K fertilizer application on maize in western Kenya

Clear response to addition of K at 40 kg K2O/ha in Bungoma & Trans Nzoia to maize and 80 kg K2O in Rice in Mwea – not shown (KALRO-IPI, 2018, unpublished);
AVERAGE SOIL TEST RESULTS FOR 4 COUNTIES IN W. KENYA
Source: Soil Suitability Evaluation for Maize Production in Kenya (NAAIAP, 2014 - about 4500 farms)

<table>
<thead>
<tr>
<th>SOIL PARAMETERS</th>
<th>BUNGOMA</th>
<th>% farms below adequacy level</th>
<th>KAKAMEGA</th>
<th>% farms below adequacy level</th>
<th>NANDI</th>
<th>% farms below adequacy level</th>
<th>BOMET</th>
<th>% farms below adequacy level</th>
<th>Critical Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil depth (cm)</td>
<td></td>
<td>0-20 20-50</td>
<td>0-20 20-50</td>
<td>0-20 20-50</td>
<td>0-20 20-50</td>
<td>0-20 20-50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil pH (1:1)</td>
<td>4.87</td>
<td>6.94</td>
<td>27</td>
<td>4.61 6.46</td>
<td>48</td>
<td>4.45 5.75</td>
<td>95</td>
<td>5.38 6.71</td>
<td>≥ 5.5</td>
</tr>
<tr>
<td>Org. Carbon (%)</td>
<td>0.29</td>
<td>1.89</td>
<td>100</td>
<td>0.91 2.03</td>
<td>100</td>
<td>1.29 4.16</td>
<td>75</td>
<td>0.91 3.58</td>
<td>≥ 2.7</td>
</tr>
<tr>
<td>Total Nitrogen (%)</td>
<td>0.05</td>
<td>0.18</td>
<td>100</td>
<td>0.08 0.19</td>
<td>100</td>
<td>0.13 0.41</td>
<td>22</td>
<td>0.10 0.36</td>
<td>≥ 0.2</td>
</tr>
<tr>
<td>Available P (ppm)</td>
<td>10</td>
<td>212</td>
<td>60</td>
<td>7 69</td>
<td>87</td>
<td>14 168</td>
<td>62</td>
<td>6 77</td>
<td>≥ 30.0</td>
</tr>
<tr>
<td>Potassium (me%)</td>
<td>0.08</td>
<td>0.57</td>
<td>57</td>
<td>0.08 0.89</td>
<td>77</td>
<td>0.18 1.15</td>
<td>7</td>
<td>0.24 1.59</td>
<td>≥ 0.24</td>
</tr>
<tr>
<td>Calcium (me%)</td>
<td>1</td>
<td>18.3</td>
<td>23</td>
<td>0.8 6.9</td>
<td>27</td>
<td>1.1 3.9</td>
<td>35</td>
<td>2 8.9</td>
<td>≥ 2.0</td>
</tr>
<tr>
<td>Magnesium (me%)</td>
<td>0.09</td>
<td>3.15</td>
<td>48</td>
<td>0.16 2.69</td>
<td>47</td>
<td>0.01 4.29</td>
<td>35</td>
<td>1 3.73</td>
<td>≥ 1.0</td>
</tr>
<tr>
<td>Manganese (me%)</td>
<td>0.01</td>
<td>0.44</td>
<td>8</td>
<td>0.2 0.82</td>
<td>0</td>
<td>0.07 1.39</td>
<td>5</td>
<td>0.12 1.05</td>
<td>≥ 0.11</td>
</tr>
<tr>
<td>Copper (ppm)</td>
<td>0.11</td>
<td>3.12</td>
<td>32</td>
<td>1.92 17</td>
<td>0</td>
<td>0.6 4.07</td>
<td>23</td>
<td>0.19 11.9</td>
<td>≥ 1.0</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>16.5</td>
<td>225</td>
<td>0</td>
<td>10.5 89</td>
<td>0</td>
<td>22.9 151</td>
<td>0</td>
<td>27.9 200</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>0.53</td>
<td>4.52</td>
<td>100</td>
<td>0.31 28.3</td>
<td>82</td>
<td>0.37 8.79</td>
<td>93</td>
<td>1.96 38.8</td>
<td>≥ 5.0</td>
</tr>
</tbody>
</table>

Major deficiencies in the 4 Counties were N, SOC, P and Zn, followed by K and Mg; Micronutrients, Cu and Fe adequate except in Bomet and Kakamega, respectively.
Importance of Soil Testing in Fertilizer Recommendations

- Soil testing and plant analysis are tools used for determination of crop nutrient needs.
- Soil testing evaluates the fertility of the soil to determine the basic amounts of fertilizer or lime to be applied.
- Plant analysis is used to monitor whether the fertilization or liming program, according to the soil test, is providing the necessary nutrients for at the necessary levels for top yields.
- Important in diagnosis of nutrient deficiency towards crop-specific fertilizer recommendations.
Soil testing methods

- Soil testing methods require to be calibrated with field trials to give the Soil Nutrient Critical Levels (SNCLs)
- **Dilemma**: different soil labs use different testing methods which give different nutrient levels for the same soil (Figures: P & K analysis)
- Hence fertilizer recommendations vary from one laboratory to the other
- Soil/plant test results repeatability is an issue
- Need for harmonization or correlation with well-calibrated methodologies
### FERTILIZER SUBSTITUTE AND SOIL TEST IMPLICATIONS

<table>
<thead>
<tr>
<th>ISFM practice</th>
<th>Urea</th>
<th>DAP/TSP</th>
<th>KCl</th>
<th>NPK 17-17-17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Previous crop was a green manure crop, e.g. Lantana camara for maize or Azolla for lowland rice</strong></td>
<td>100%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td><strong>Fresh vegetative material (e.g. prunings of tithonia, grevillea, banana leaves, coffee husks) per 1 ton of fresh material</strong></td>
<td>4 kg</td>
<td>2 kg</td>
<td>2 kg</td>
<td>8 kg</td>
</tr>
<tr>
<td><strong>Farmyard manure per 1 t of dry material</strong></td>
<td>5 kg</td>
<td>3 kg</td>
<td>2 kg</td>
<td>10 kg</td>
</tr>
<tr>
<td><strong>Residual value of FYM applied for the previous crop, per 1 t</strong></td>
<td>2 kg</td>
<td>1 kg</td>
<td>1 kg</td>
<td>3 kg</td>
</tr>
<tr>
<td><strong>Dairy or poultry manure, per 1 t dry material</strong></td>
<td>9 kg</td>
<td>4 kg</td>
<td>5 kg</td>
<td>16 kg</td>
</tr>
<tr>
<td><strong>Residual value of dairy and poultry manure applied for the previous crop, per 1 t</strong></td>
<td>2 kg</td>
<td>2 kg</td>
<td>1 kg</td>
<td>3 kg</td>
</tr>
<tr>
<td><strong>Compost, per 1 t</strong></td>
<td>8 kg</td>
<td>3 kg</td>
<td>3 kg</td>
<td>15 kg</td>
</tr>
<tr>
<td><strong>Residual value of compost applied for the previous crop, per 1 t</strong></td>
<td>3 kg</td>
<td>2 kg</td>
<td>1 kg</td>
<td>5 kg</td>
</tr>
<tr>
<td><strong>Rotation</strong></td>
<td>0% reduction but more yield expected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cereal-bean intercropping</strong></td>
<td>Increase DAP/TSP by 7 kg/ac, but no change in N &amp; K compared with sole cereal fertilizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cereal-other legume (effective in N fixation) intercropping</strong></td>
<td>Increase DAP/TSP by 11 kg/ac, reduce urea by 9 kg/ac, &amp; no change in K compared with sole cereal fertilizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>If Mehlich III P &gt;15 ppm; Mehlich 1 – 30ppm</strong></td>
<td>Apply no P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Available P (Olsen) &gt; 10 ppm</strong></td>
<td>Apply no P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>If soil test K &lt;100 ppm</strong></td>
<td>Band apply 20 kg/acre KCl</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions and Way forward

- More soil testing to cover more farms and regions to create a robust Kenya Soil Information database;
- Available information still indicate that N, P, SOC are the major limiting nutrients;
- Recent soil testing and field trials have identified deficiencies for K, Mg and micro-nutrients Zn, Cu and Fe;
- Information gaps - secondary nutrients, S and micro-nutrients, Bo and Mo;
- Crop responses – critical for site and crop specific fertilizer recommendations
- Harmonize soil test reporting system across public-private labs;
- Liming - manage soil acidity in areas with soil pH less than 5.2;
- Raise soil organic matter and conserve environment through integrated soil fertility management strategies;
- Incorporate locally available materials into fertilizer recommendations – increase farmer profitability