Maize-Nitrogen Response in Malawi’s Smallholder Production Systems

Sieg Snapp, T.S. Jayne, Wezi Mhango, Jacob Ricker-Gilbert

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A few observations

Research evidence across numerous countries shows that:

1. maize response to inorganic fertilizer consistently lower on farmer fields vs. on-farm trial plots

2. highly variable crop response rates – even among farmers in same areas in same seasons (represents varying management skills)
Variation in farmers’ efficiency of fertilizer use on maize, Agroecological Zone IIa, Zambia

Note: Zone IIa is a relatively high-potential zone suitable for intensive maize production
Microeconomic studies reporting nitrogen use efficiency on farmer-managed maize fields in Malawi.

<table>
<thead>
<tr>
<th>Study</th>
<th>Year(s) of survey</th>
<th>Data sets (yield measurement)</th>
<th>Geographic coverage</th>
<th>Estimated N-use efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorward and Chirwa, 2013</td>
<td>2009, 2010</td>
<td>Nationally representative IHS-II and IHS-III, and AISS-I and -II surveys (farmer recall, with exception of 2009 which also contained yield sub-plot measurement)</td>
<td>Nationally representative for IHS-II and IHS-III; nationwide for AISS-I and AISS-II</td>
<td>Negative to 9.0 b</td>
</tr>
<tr>
<td>Ricker-Gilbert and Jayne, 2011, 2012</td>
<td></td>
<td>Same as with Dorward and Chirwa</td>
<td></td>
<td>6.6 to 11.5</td>
</tr>
<tr>
<td>Snapp et al. 2013</td>
<td></td>
<td>Same as with Dorward and Chirwa</td>
<td></td>
<td>5.33 for monocropped maize; 8.84 for intercropped maize</td>
</tr>
</tbody>
</table>
Factors affecting N use efficiency

1. Number and intensity of weeding
2. Crop rotation and intensity of intercrop
3. Timeliness and management of fertilizer
4. Crop population density
5. Sufficient active soil organic carbon (N interacts with C)
6. Weather (& soil water holding capacity)
7. Soil P and S

• Input subsidies need to be part of a more holistic approach so that N can get sufficiently high crop response.
## Evidence from HH surveys in Malawi

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>% of plots left entirely fallow</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>1.1</td>
</tr>
<tr>
<td>Average area left uncultivated in ha (unconditional) By Region:</td>
<td>0.192</td>
<td>0.154</td>
<td>0.237</td>
<td>---</td>
</tr>
<tr>
<td>North</td>
<td>0.411</td>
<td>0.181</td>
<td>0.520</td>
<td>---</td>
</tr>
<tr>
<td>Center</td>
<td>0.195</td>
<td>0.217</td>
<td>0.296</td>
<td>---</td>
</tr>
<tr>
<td>South</td>
<td>0.056</td>
<td>0.099</td>
<td>0.062</td>
<td>---</td>
</tr>
<tr>
<td>% of maize plots intercropped w/legume</td>
<td>50.1</td>
<td>46.1</td>
<td>45.4</td>
<td>37.9</td>
</tr>
<tr>
<td>% of maize plots using organic manure</td>
<td>15.2</td>
<td>---</td>
<td>---</td>
<td>12.7</td>
</tr>
</tbody>
</table>
Regression analysis based on cross-country farmers household survey

- IHS, AISS – three surveys in 2004-2009
- Questions on farming practices, fertilizer use, harvest
- Maize+Legume Intercrop significantly increases fertilizer efficiency

<table>
<thead>
<tr>
<th>Technology</th>
<th>Average fert. use (F), when F&gt;0</th>
<th>Average yield(Y), when F=0</th>
<th>Average Y, when F&gt;0</th>
<th>N Fert Effic*</th>
</tr>
</thead>
<tbody>
<tr>
<td>M (maize)</td>
<td>144</td>
<td>627</td>
<td>921</td>
<td>6.2</td>
</tr>
<tr>
<td>ML (maize+legume)</td>
<td>122</td>
<td>664</td>
<td>978</td>
<td>7.8</td>
</tr>
</tbody>
</table>

*Assumption: Fertilizer = 33% Nitrogen

(S. Snapp and M. Ivanyna, AAAS Feb. 2013)
## Evidence from HH Surveys in Malawi

<table>
<thead>
<tr>
<th>% of maize plots receiving zero or one weeding&lt;sup&gt;1&lt;/sup&gt;</th>
<th>IHS2 Panel Survey Wave 1 2002/03&amp;2003/04</th>
<th>AISS1 Panel Survey Wave 2 2006/07</th>
<th>AISS2 Panel Survey Wave 3 2008/09</th>
<th>IHS3 2008/09 &amp; 2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of maize plots receiving 2 weedings&lt;sup&gt;1&lt;/sup&gt;</td>
<td>---</td>
<td>25.5</td>
<td>27.2</td>
<td>---</td>
</tr>
<tr>
<td>% of maize plots receiving 3 or more weedings&lt;sup&gt;1&lt;/sup&gt;</td>
<td>---</td>
<td>65.3</td>
<td>69.7</td>
<td>---</td>
</tr>
</tbody>
</table>
## Evidence from HH surveys in Malawi

<table>
<thead>
<tr>
<th>% of maize plots where area harvested was less than area planted</th>
<th>AISS1 Panel Survey Wave 2 2006/07</th>
<th>AISS2 Panel Survey Wave 3 2008/09</th>
<th>IHS3 2008/09 &amp; 2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of HH experiencing lower yields due to poor soil fertility in past 2-3 years</td>
<td>32.2</td>
<td>39.6</td>
<td>---</td>
</tr>
<tr>
<td>% of HH experiencing lower yields due to bad weather or rainfall in past 2-3 years</td>
<td>27.3</td>
<td>29.9</td>
<td>---</td>
</tr>
<tr>
<td>% of HH experiencing lower yields due to crop disease or pests in past 2-3 years</td>
<td>13.7</td>
<td>17.3</td>
<td>---</td>
</tr>
</tbody>
</table>

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Evidence from HH surveys in Malawi
Weeks After Planting of First Fertilizer Application in Malawi.

**2006/07**

- % of Households:
  - < 1: 4.3
  - 1: 17.2
  - 2: 25.1
  - 3: 23.4
  - 4: 19.2
  - 5: 4.6
  - > 5: 6.2

**2008/09**

- % of Households:
  - < 1: 6.7
  - 1: 20.7
  - 2: 29.9
  - 3: 28.5
  - 4: 8.1
  - 5: 6.0
Broad issues to consider:

1. Does devoting substantial share of ag budget to subsidizing N and P constitute a sustainable approach to agricultural productivity growth?

2. How to move from a situation where increasing use of N and P is the cornerstone of agricultural development to a holistic program?

3. Would it be valuable to provide equal emphasis to raising the efficiency with which farmers use N and P?
• A focus on soil fertility has sometimes been viewed as “alternative” or “low-input” agriculture.
• Research evidence from the agronomy/soil science literature increasingly indicates that holistic soil fertility management (SFM) will be required to enable a more intensity use of inorganic fertiliser to be both profitable and sustainable.

**Complimentary relationship** inorganic fertilizer and SFM not a substitute relationship.
The Importance of SOM


![Graph showing the marginal value product of applied nitrogen against plot carbon content. The x-axis represents plot carbon content (%) ranging from 2 to 6, and the y-axis represents the marginal value product of nitrogen ranging from 0 to 1000. There is a shaded area under the curve indicating the range of values. The line intersects with the horizontal line representing the price of nitrogen (Kshs 200/kg) at a certain point.]
Fertilizer use is going up with subsidies, how to improve the returns?

- Low crop response rates to N
- Land pressures / incentives to intensify
- Deficiencies in SOC and micronutrients / acidification
- Reduced fallows / increased fertilizer use
- Population growth
Elements of a holistic strategy:

1. Improved seeds that have the characteristics desired by farmers (requires more support to national ag research systems)
2. Extension programs (to help the bottom half of farmers achieve the same NUE and yields as the mean – 8 to 11% rise in national maize output)
   - Improve weed management
   - Improve fertilizer management
   - Programs to help farmers restore soil quality
3. Reducing costs in input supply chains
Elements of a holistic strategy:

4. Should the FISP be more flexible to include choice among inputs?
   - More legume seeds
   - Herbicides

5. Link FISP receipt to EDUCATION and adopting and maintaining improved management practices
   - Monitoring system to make sure targeting guidelines are followed.
Thank you for your time!

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