Possibility of an African Green Revolution

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In Pursuit of an African Green Revolution

Views from Rice and Maize Farmers’ Fields
Contents of My Presentation

• For lowland rice, to examine

1. To what extent a Green Revolution has taken place in irrigated areas.

2. To what extent technology and management training programs are effective in disseminating Green Revolution technology.

• For maize, to explore

4. Promising changes towards a maize Green Revolution,

5. Strategy to realize a maize Green Revolution.

We focus on rice and maize, which are promising strategic crops in SSA.
What is the Green Revolution in Asia?

• Development and diffusion of a series of semi-dwarf, fertilizer-responsive, high-yielding modern varieties (MVs) in irrigated and favorable rainfed areas.

• Early MVs are susceptible to pests and diseases, whereas improved MVs are more resistant to pest and diseases as well as drought and submergence.

• Asian Green Revolution is alternatively called “seed-fertilizer revolution,” which is very misleading.

• Rice production tripled, yield per hectare more than doubled, and double cropping increased appreciably as MVs are photo-period insensitive and short-growth duration, from the end of the 1960s in Asia.
Comparison of IR8, the original shorter modern rice variety, with Peta, a traditional tall variety and one IR8’s parent (1st two photos); lodging (bottom photo)
Yield Curves of Traditional Varieties (TVs) and Modern Varieties (MVs) with and without Improved Management Practices

- Yield/Ha
- Fertilizer/Ha

- Improved MVs with Improved Management Practices
- TVs
- MVs
- Lodging
Why is rice so important in SSA?

• Consumption has been rising faster than production. As a result, import of rice from Asia increased accounting for more than 1/3 of consumption. SSA is self-sufficient in foods except for rice and wheat.

• Rice is the most promising crop in raising productivity on small farms in SSA because of the high transferability of Asian rice technologies.

• I believe that rice production environments are more favorable in SSA than in Asia.
Changes in aggregated harvested area in SSA by crop (million hectares)
Findings from Harvest Areas

• Maize is most important closely followed by millet and sorghum. While maize harvested area has been increasing, millet and sorghum areas began declining.

• Wheat area has been small and relatively stable, as there is not much room for area expansion for this crop. Moreover, unlike other grains, wheat is generally grown on large-scale farms in SSA.

• Rice harvested area is smaller but has been increasing. Considering that rice yield is far higher than millet and sorghum and substantially higher than maize, its importance should not be underestimated. Furthermore, rice consumption has been increasing rapidly and become a major staple crop.
### Total consumption, production, and net import of major cereal crops in SSA (million tons) in 1980 and 2010

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<tbody>
<tr>
<td>Maize</td>
<td>15.74</td>
<td>14.17</td>
<td>1.87</td>
<td>47.93</td>
<td>47.38</td>
<td>1.10</td>
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<tr>
<td>Rice</td>
<td>6.59</td>
<td>4.33</td>
<td>2.21</td>
<td>22.49</td>
<td>15.39</td>
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<td>Millet</td>
<td>7.61</td>
<td>7.28</td>
<td>0.06</td>
<td>13.65</td>
<td>15.97</td>
<td>0.13</td>
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<tr>
<td>Sorghum</td>
<td>11.07</td>
<td>11.62</td>
<td>-0.19</td>
<td>23.60</td>
<td>23.84</td>
<td>0.95</td>
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Changes in average maize yields in SSA, top 10 and bottom 10 countries, and India
Finding from Maize Yield

• Average maize yield has been gradually increasing.
• Yield of top 10 countries has been growing but barely reached 2 tons/ha, which is substantially lower than in India. It does not appear that maize Green Revolution took place widely even in advanced regions in SSA.
• It seems that average maize yield cannot increase by transferring technology from India to SSA nor from advanced areas to less advanced areas within SSA.
• It must be pointed out that location specificity of improved maize seeds is much higher than lowland rice and wheat and that hybrid seeds, as well as OPV seeds, must be purchased every season.
Changes in average paddy yields in SSA, top 10 and bottom 10 countries, and India
Findings from rice yield

• Average yield has been increasing, particularly in recent years.

• Yield of top 10 countries has been growing and achieved 3 tons/ha, which is moderately lower than in India, indicating that rice Green Revolution has taken place in the advanced regions, where average irrigation ratio is about 50%.

• It seems that the average rice yield can increase further by transferring technology from India, or more generally from Asia, to SSA and from advanced areas to less advanced areas within SSA.
Changes in average sorghum yields in SSA, top 10 and bottom 10 countries, and India
Changes in average millet yields in SSA, top 10 and bottom 10 countries, and India
Findings from sorghum and millet yields

• Neither in India nor SSA there is any indication of Green Revolution.
• It would be difficult to realize Green Revolution in these crops in SSA, at least in the short run.
Changes in Average Wheat Yield in SSA, Top 10 and Bottom 10 Countries, and India

Source: FAOSTAT (2015)
Findings from Wheat Yield

• Average wheat yield more than doubled over the last several decades and the yield of top 10 countries is not much less than that in India. Thus, it is clear that wheat Green Revolution has been taking place in SSA.

• Wheat, however, can be grown in limited highland areas in SSA.
Possibility of Rice Green Revolution in SSA

Hypothesis 1: Owing to high transferability of Asian rice technology, rice Green Revolution has already taken place in many irrigated areas as well as some rainfed areas where rice production management training has been offered.

Hypothesis 2: Not only improved seeds and fertilizer but also improved management practices (e.g., bunding, leveling, straight-row planting, proper timing of transplanting, …) are critically important for productivity growth.
“Asian” Rice Green Revolution in the Senegal River Valley
The importance of bund
No bund → lack of water → a lot of weeds
The importance of leveling and straight-row planting to avoid uneven growth and to facilitate weeding.
Lack of leveling → Uneven growth → Periodic harvesting by knife → Significant crop loss + Low-quality rice
Yield increases with increased adoption of improved technology and management practices (MVs, fertilizer, bunding, leveling, straight-row planting, etc.) even in rainfed areas, supporting Hypothesis 2.

<table>
<thead>
<tr>
<th>All improved practices</th>
<th>Uganda&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ghana&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
<td>Training villages</td>
<td>3.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Non-training villages</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Almost all improved practices</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>One improved practice only</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>No improved practices</td>
<td>0.8</td>
<td>1.0</td>
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<sup>a</sup> Uganda<br>
<sup>b</sup> Ghana
Possibility of Maize Green Revolution in SSA

• Adoption rate of improved varieties varies from country to country but it is high in certain countries such as Kenya.

• Yield effect of improved maize varieties seems reasonably high, even though average yield at the country or regional level is low.

• Many economists conjecture that since soil management is critically important, an integrated maize-based farming system, consisting of the adoption of hybrid maize and chemical fertilizer and the application of soil management practices, including application of manure, compost, and crop residue, would be important.
Dairy Cows in Kenya
As population pressure on land grows rapidly in Kenya, farmers started to intensify land use. The emergence of the integrated maize farming system.
Advantages of new maize-based farming system in Kenya

1. Like Asian Green Revolution, high-yielding hybrid seeds and chemical fertilizer are adopted.
2. Like Agricultural Revolution in UK, cows are stall-fed by feed crops, such as turnip and nitrogen-fixing leguminous crops.
3. Like White Revolution in India, cross-bred cows between local and European cows are adopted.
Data

- Two rounds of panel household surveys were implemented in Kenya jointly by GRIPS and Egerton University - Tegemeo Institute in 2004 and 2012.

- Limit samples to HH who grow maize on at least 20% of their farm land.

- Panel sample size: 622 households.
Comparison of maize yield, crop income and technology adoption between Kenya and Uganda

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<tr>
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<th>Kenya</th>
<th>Uganda</th>
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<tr>
<td></td>
<td>2004</td>
<td>2012</td>
</tr>
<tr>
<td>Maize yield (ton/ha)</td>
<td>1.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Crop income (1,000 KSh/ha)</td>
<td>32.1</td>
<td>38.9</td>
</tr>
<tr>
<td>Chemical fertilizer use (kg/ha)</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>Manure use (kg/ha)</td>
<td>970</td>
<td>1,385</td>
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<tr>
<td>Share of intercropped fields (%)</td>
<td>78</td>
<td>72</td>
</tr>
<tr>
<td>Quantity of legume seeds (kg/ha)</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Adoption of hybrid maize (%)</td>
<td>49</td>
<td>72</td>
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</table>
Findings from maize yield comparison between Kenya and Uganda

• Yield is substantially higher in Kenya (1.9 t/ha) than Uganda (1.2 t/ha).
• Note that since legumes occupy non-negligible areas, “true” maize yield is higher than maize yield on intercropped field.
• Manure application increased significantly.
• Real crop income in Kenya substantially improved over time.
• It is amazing that farmers voluntarily adopt this complex farming system.
• We believe that this farming system is highly promising, but to our knowledge there has been no support for it from public-sector research and extension systems.
Concluding remarks

1. The main conclusion of our study is that not only “improved technology” but also “improved management practices” are keys to Green Revolution in SSA.

2. The second conclusion is that improved technology and management practices for rice production can be introduced and disseminated to SSA by the management training programs. Thus, rice Green Revolution is possible if sufficient resources are allocated to capacity building for effective extension systems.

3. The third conclusion is that maize Green Revolution is possible in SSA but new profitable farming systems must be established.

* Note that I am not arguing that investments in infrastructure (e.g., irrigation), provision of credit, and improving input-supply systems and product-processing sectors are not important. I am arguing that strengthening extension system is an entry point to rice Green Revolution, whereas investment in research on improved maize-based farming system is the key to the maize Green Revolution in SSA.
Thank you very much for your attention