Green Manure Intercropping Systems to Boost Maize Yields

A Case Study in Kamuli District, Uganda

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PROJECT OUTLINE

• Summary
• Background and Justification
• Objectives
• Methods
• Findings
• Conclusions
• Recommendations
• Acknowledgements
BACKGROUND: Low maize yields on farm

• Uganda experiencing rapid population growth and demand for agricultural products
• Agriculture industry forced to develop ways to increasing production.
• Expansion and commercial intensification not economically viable or environmentally sustainable for small landholders
Environmental demands on agricultural productivity

- Conversion of unsuitable land to agriculture
- Small scale operations convert to continuous mono cropping
- Increased use of synthetic fertilizer with contamination from runoff

Economic demands on agricultural productivity

- Heavy reliance on commercial and synthetic fertilizers (nitrogen)
- Improved seed
- Increasing scale of operation
- Agricultural mechanization
Sustainable food production system for small scale farmers

Local production systems that increase the food resource base
Compatible with existing food crops and cultural practices
Enhance soil fertility and productivity
Require minimal financial investments
Provide holistic benefits (pests control, profitable, labor etc)
Farmer participatory

**Reduce dependence on nitrogen fertilizer**

Maize/legume intercropping systems
BACKGROUND: importance of maize

• In Uganda, maize is a staple food and a cash crop

• Typically grown intercropped with other stable foods (legumes) by small landholders

• Yields on small landholder farms have been declining due to loss of soil fertility and less predictable weather

• Research results on impact of legumes on maize yield are highly variable
Lablab (*Dolichos lablab*) as a green manure
Lablab vs current cultural practice

Lablab
- Improves soil fertility
- Alternative food source and improves food security
- Fodder for animal feed
- Reduces labor for weed control
- Less tillage-bridge to CA
- Less popular as a food crop favoring adoption as a green manure

Weed mixtures
- Are indigenous to all cropping systems
- Regular weeding is key component of farmer training programs
- Dominate labor investment in mono-cropping systems
A Case study in Kamuli District, Uganda

Goal
Use controlled green manure management practices to improve maize yields on non commercially fertilized farms

Specific Objectives
• Use controlled green manure management practices to improve maize yields on non commercially fertilized farms
• Evaluate a range of maize/lablab/weed intercropping systems
• Evaluating impact on soil fertility and maize yields
• Identify the most ‘yield responsive’ lablab green manure intercropping system
Methodology

• Conduct a baseline survey of farmers’ Knowledge, Attitudes, and Practices regarding green manure practices

• Identify farmers to host experimental sites

• Establish and evaluate six green manure treatments (type, stage of incorporation, and intercropping system) over two seasons

• Conduct follow up survey of farmers’ KAPs.
Green Manure Treatments

1: maize/lablab relay

2: maize/lablab synchronous mixed cropping

3: maize/lablab delayed mixed cropping

4: maize/lablab delayed mixed cropping with pod yield

5: maize/lablab delayed mixed cropping with seed yield

6: control plot with weeds as green manure
**Timeline**

<table>
<thead>
<tr>
<th>Month</th>
<th>Soil sampling</th>
<th>Planting lablab</th>
<th>Planting maize</th>
<th>Lablab Incorporation</th>
<th>Harvesting maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2012</td>
<td>Initial soil sampling prior to planting lablab</td>
<td>Lablab for 1st season Maize/lablab GM relay plot planted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>2nd soil sampling Maize/lablab GM relay plot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>3rd soil sampling Maize/lablab GM relay plot</td>
<td>Lablab for Maize/lablab synchronous GM plot planted. Lablab in Maize/lablab mixed delayed plots planted</td>
<td>Maize planted in all 6 plots</td>
<td>Relay plot incorporated.</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>4th soil sampling for relay plot. 2nd soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td></td>
<td>Treatments 2 and 3 incorporated.</td>
</tr>
<tr>
<td>June</td>
<td>3rd soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>4th soil sampling treatments 2-6.</td>
<td>Lablab for 2nd season Maize/lablab GM relay plot planted</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*NB: Project carried out over two planting seasons*
<table>
<thead>
<tr>
<th>Month</th>
<th>Soil sampling</th>
<th>Planting lablab</th>
<th>Planting maize</th>
<th>Lablab Incorporation</th>
<th>Harvesting maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
<td>Treatment 4 incorporated.</td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>5(^{th}) soil sampling for treatments 1-6. used as 1(^{st}) soil sampling season 2</td>
<td></td>
<td></td>
<td>Treatment 5 incorporated.</td>
<td>1(^{st}) season maize harvested</td>
</tr>
<tr>
<td>October</td>
<td>2(^{nd}) soil sampling Maize/lablab GM relay plot. Also used as 3(^{rd}) soil sampling.</td>
<td>Maize/lablab synchronous GM plot planted. Maize/lablab mixed delayed plots planted</td>
<td></td>
<td>Relay plot incorporated.</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>2(^{nd}) Soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>3(^{rd}) Soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td>Treatments 2 and 3 incorporated.</td>
<td></td>
</tr>
<tr>
<td>January 2013</td>
<td>4(^{th}) soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td>Treatment 4 incorporated.</td>
<td></td>
</tr>
<tr>
<td>Feb</td>
<td>5(^{th}) soil sampling treatments 2-6</td>
<td></td>
<td></td>
<td></td>
<td>2(^{nd}) season maize harvested</td>
</tr>
</tbody>
</table>
Soil Sampling and Analysis


- Five soil samples collected corresponding to major management ‘events’ (e.g. planting, incorporation, harvest)

- Impacts of Treatments 1-6 evaluated by green manure type, stage of incorporation, intercropping pattern, farm, and season.
KEY FINDINGS – SOIL FERTILITY
Incorporating lablab raised soil phosphorus and pH levels in the maize/lablab cropping systems.
Data are pooled for all lablab treatments across two seasons.

<table>
<thead>
<tr>
<th>Soil fertility parameters</th>
<th>Prior to planting lablab</th>
<th>One month after planting lablab</th>
<th>On day of lablab incorporation</th>
<th>One month after lablab incorporation</th>
<th>End of season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus range (ppm)</td>
<td>0-25</td>
<td>25-50</td>
<td>25-50</td>
<td>25-50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>pH range</td>
<td>4.0-4.9</td>
<td>4.0-4.9</td>
<td>4.0-5.9</td>
<td>4.0-5.9</td>
<td>4.0-5.9</td>
</tr>
<tr>
<td>Nitrogen (ppm)</td>
<td>15-30</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Potassium (ppm)</td>
<td>&gt;100</td>
<td>&gt;100</td>
<td>&gt;100</td>
<td>&gt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Organic Matter</td>
<td>&gt; 4%</td>
<td>&gt; 4%</td>
<td>&gt; 4%</td>
<td>&gt; 4%</td>
<td>&gt; 4%</td>
</tr>
</tbody>
</table>
KEY FINDINGS – SOIL FERTILITY
Intercropping and incorporating lablab as green manure improved soil N and P levels. Waiting until harvest maturity to incorporate lablab was most beneficial.

Data are pooled for 4 farms, two seasons, and five sampling dates.

<table>
<thead>
<tr>
<th>Soil fertility parameters</th>
<th>Relay GM</th>
<th>Synchronous mixed GM</th>
<th>Mixed delayed GM</th>
<th>Mixed delayed pod yield</th>
<th>Mixed delayed seed yield</th>
<th>Weed mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (ppm)</td>
<td>15-30</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>&gt;30</td>
<td>15-30</td>
</tr>
<tr>
<td>Phosphorus (ppm)</td>
<td>0-25</td>
<td>25-50</td>
<td>25-50</td>
<td>25-50</td>
<td>50+</td>
<td>0-25</td>
</tr>
</tbody>
</table>

Initial N was 15-30 ppm
Initial P was 0-25 ppm
KEY FINDINGS – SOIL FERTILITY
Overall impact of green manure management on soil fertility parameters in maize intercropping systems.
Initial values taken prior to experiment. Final values taken at the end of Season 2.

<table>
<thead>
<tr>
<th>Soil fertility parameters</th>
<th>Initial values</th>
<th>Final values lablab treatments</th>
<th>Final values weed mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (ppm)</td>
<td>15-30</td>
<td>&gt;30</td>
<td>15-30</td>
</tr>
<tr>
<td>Phosphorus (ppm)</td>
<td>0-25</td>
<td>0-50</td>
<td>0-25</td>
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<tr>
<td>Organic Matter</td>
<td>&gt; 4%</td>
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<td>&gt; 4%</td>
</tr>
<tr>
<td>pH</td>
<td>4.0-4.9</td>
<td>4.0-5.9</td>
<td>4.0-4.5</td>
</tr>
</tbody>
</table>
Summary- lablab impact on soil fertility

• Lablab was superior to weed mixtures as a source of nitrogen and phosphorus in the maize intercropping systems.

• Intercropping lablab with maize over longer periods of the maize growing cycle prior to incorporation maintained higher soil nitrogen levels and improved the soil phosphorus levels.

• Soil pH increased from Season 1 to Season 2 suggesting further soil improvement could be possible with continued lablab intercropping. From 4.0-4.9 to 4.0-5.9.
KEY FINDINGS - yield comparisons
Maize Yield Comparisons

Maize yields form lablab and weed mixtures green manure treatments.

Data are means for four farms in kg/plot (225ft$^2$).

<table>
<thead>
<tr>
<th>Green manure treatments</th>
<th>Previous Crop</th>
<th>Season 1</th>
<th>Season 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay GM</td>
<td>5.9</td>
<td>9.0</td>
<td>11.3</td>
</tr>
<tr>
<td>Synchronous mixed GM</td>
<td>5.9</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Mixed delayed GM</td>
<td>5.9</td>
<td>7.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Mixed delayed GM pod yield</td>
<td>5.9</td>
<td>8.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Mixed delayed seed yield</td>
<td>5.9</td>
<td>8.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Weed mixtures</td>
<td>5.9</td>
<td>5.3</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Maize Yield Comparisons

- The best yield (11.3 kg/Plot) was realized from Treatment 1 [maize/lablab relay] in Season 2

- The worst yield (2.8 kg/plot) was from Treatment 2 [maize/lablab synchronous mixed cropping] in Season 2

- Treatments with delayed Lablab planting and incorporation (Treatments 3,4,5) yielded 7.0-9.3 kg/plot.

- Weedy control plots yielded about 5 kg/plot on average
YIELD ADVANTAGE OF LABLAB OVER WEED MIXTURES

Maize/Lablab green manure
• Average maize yields increased on all farms.

Maize/weed mixtures
• Maize yields decreased on all farms

Average maize yields per type of green manure over the seasons

Average maize yield under maize/lablab green manure management practice
Average maize yield under Maize/weed mixtures green manure management practice
Summary- maize yields

• There was an overall improvement in maize yields on all four farms both seasons with lablab incorporated as the green manure.

• The stage of incorporation was not as important as the intercropping system (relay, synchronous, or delayed)

• Planting lablab as a relay crop with maize provided the greatest yield advantage.
Challenges with green manure management
KEY FINDINGS – farmer evaluations

Post study farmer KAPs

• Greater preference for utilizing lablab as a cover crop or as forage for animal feed rather than a green manure

• Expressed interest in intercropping lablab with a more robust and sturdy crops such as bananas

• Lablab in relay with maize would be considered beneficial
CONCLUSIONS/RECOMMENDATIONS

• Lablab as a green manure is superior to weed mixtures or maize monoculture for increased production.

• Evaluating temporal and spatial aspects of lablab intercropping systems is critical for adoption by small landholder farmers, particularly for labor management.

• Advantage of maize/lablab relay as an intercrop system over mixed or row intercropping may take several season to realize. Other advantages such as human or animal food source need to be evaluated for this system to be a realistic option for all small landholder farmers.
Acknowledgements

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• POS Committee
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Family