Validating AKILIMO
2nd season validation exercise results
What are validation exercises?

- **Side-by-side comparisons** of the recommended practice against a control, current practice and/or best alternative

- **Static design** if options to test are <4 (as for intercropping), else **dynamic, agile design** (all other use cases)

- Carried out by the farmer, with support of an extension agent, all data collected by the extension agent and the farmer

- The extension agent is motivated through a **performance-based remuneration system**

- Organized by the **primary partner state/district coordinators**, with training and technical support provided by NARES partner

- **Training-of-trainer** and overall support provided by IITA
Last year, we showed a validation of the V1 tools...

At the start of the validation exercises in 2018, the first version of the tools (delivered in 2017) was available.
We will now show a validation of the V2 tools.

At the start of the validation exercises in 2019, the second version of the tools (delivered in 2018) was available.
This session

1. A plenary presentation of the main results for all use cases

2. Break-outs by use case for more detailed discussion
   - Tailored fertilizer recommendations (Bernadetha and Guillaume)
   - Cassava-maize intercropping (Mark and Christine)
   - Cassava-sweet potato intercropping (Salma and Freddy)
   - Tillage (as part of best planting practices and weed control) (Busari and Stefan)
   - Scheduled planting and harvest (Florence and Meklit)

3. An evaluation of the validation approach
Cumulative distribution curve shows the distribution of the response to the recommended practice.

A fictive example...

- 95% confidence interval
- Distribution of the response to the recommended practice
- 75% observe a significantly positive response
- Median value: 5.5 t/ha
- 10% do not observe a positive yield response
Site-specific fertilizer recommendations

<table>
<thead>
<tr>
<th>Season 1 + Season 2</th>
<th>DST runs</th>
<th>Planted</th>
<th>Harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE Nigeria</td>
<td>189 + 155</td>
<td>182 + 141</td>
<td>174 + 134</td>
</tr>
<tr>
<td>SW Nigeria</td>
<td>114 + 155</td>
<td>103 + 144</td>
<td>87 + 124</td>
</tr>
<tr>
<td>Tanzania Coastal Zone</td>
<td>207 + 216</td>
<td>186 + 215</td>
<td>173 + 192</td>
</tr>
<tr>
<td>Tanzania Lake Zone</td>
<td>127 + 131</td>
<td>113 + 129</td>
<td>86 + 120</td>
</tr>
</tbody>
</table>

Numbers are filtered for exercises that are complete and meaningful.
Site-specific fertilizer recommendations

Agile design
- Control (no fertilizer)
- AKILIMO recommendation (if fertilizer use is predicted to be profitable)
- Blanket recommendation (if fertilizer use is not expected to be profitable)

DST recommendation
- GPS location to derive soil information
- Planting date to obtain attainable yield
- Harvest after 12 months
- Current yield (in 5 discrete classes)
- Investment of max. 200 $/ha
- Fixed choice of fertilizers
- Fixed common price of fertilizers
- Fixed common price of cassava roots
- Standardized crop density and variety
- Standardized application regime

In Nigeria, cassava was planted at 1m x 0.8m (6.4 m x 8m plot size). In Tanzania, cassava was planted at 1m x 1m (7m x 8m plot size).
Site-specific fertilizer recommendations

Agile design
• Control (no fertilizer)
• AKILIMO recommendation (if fertilizer use is predicted to be profitable)
• Blanket recommendation (if fertilizer use is not expected to be profitable)

During season 1, the first version of the modelling framework was tested, with literature-based predictions of nutrient supply and LINTUL-based estimations of water-limited yield.

During season 2 in Nigeria (planted from March 2019 onwards), the V2 of the modelling framework was tested, with improved predictions of nutrient supply using SoilGrids and machine learning.

During season 2 in Tanzania (planted from September 2020 onwards), the V2 of the modelling framework was tested, but with improvements in the prediction of attainable yield with an updated LINTUL model, and improved predictions of nutrient supply.
Yield response to fertilizer

Overall many positive responses in both seasons

But the tool is still unnecessarily conservative in Nigeria (fixed rate is tested when tool predicts no response)
Yield response to fertilizer

More pronounced positive response in Tanzania in season 2 vs season 1.

Few situations where no response is predicted, and often correctly so (fixed rate is tested when tool predicts no response) likely due to the fix in modelled attainable yield.
Distribution of yield response

Improved performance in Nigeria in season 2:
- 80% with positive response
- 0% with negative response
- Median increase from 4.7 to 5.5 t ha⁻¹

But the tool is too conservative in Nigeria (fixed rate gives similar response while DST predicts no response)
Distribution of yield response

Improved performance in Tanzania in season 2:
- 82% with positive response
- 0% with negative response
- Median increase from 1.6 to 4.8 t ha$^{-1}$

False negative issue solved through improved LINTUL model, providing better estimations of attainable yield.

When the tool predicts no response, there is very limited (not profitable) response
Distribution of net revenue increase

Net revenue calculated using price entered into the DST at onset of the validation exercise

<table>
<thead>
<tr>
<th>Nigeria</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Median profit increase: 110 $ ha(^{-1})</td>
<td>- Median profit increase: 200 $ ha(^{-1})</td>
</tr>
<tr>
<td>- 58% with positive net returns</td>
<td>- 61% with positive net returns</td>
</tr>
<tr>
<td>- 22% with net loss in revenue</td>
<td>- 20% with net loss in revenue</td>
</tr>
</tbody>
</table>

Improvements in performance of tool in season 2 in both countries:

- Cumulative probability
- Net revenue from fertilizer [USD/ha]
Cassava-sweet potato intercropping

<table>
<thead>
<tr>
<th></th>
<th>Unguja</th>
<th>Pemba</th>
</tr>
</thead>
<tbody>
<tr>
<td>DST runs</td>
<td>114</td>
<td>77</td>
</tr>
<tr>
<td>Exercises planted</td>
<td>106</td>
<td>77</td>
</tr>
<tr>
<td>Sweet potato harvested</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>Cassava harvested</td>
<td>97</td>
<td>77</td>
</tr>
</tbody>
</table>
Cassava-sweet potato intercropping

Fixed design
- Cassava monocrop
- Sweet potato monocrop
- Cassava – sweet potato intercrop
- Cassava – sweet potato intercrop + NPK

DST recommendation
- Intercropping or monocropping (dependent on price of sweet potato and cassava roots)
- NPK fertilizer application (dependent on farmer-estimated yield class and price of sweet potato and cassava roots)
Intercrop versus monocrop yield

On average 40% reduction in sweet potato yield, relative to monocrop (while DST assumed 20%)
Intercrop versus monocrop yield

On average 20% reduction in cassava root yield, relative to monocrop (while DST assumed 40%)
Intercrop versus monocrop yield

High level of variation in yield reductions (to be further explored, to evaluate if this can be predicted)
Response to fertilizer

On average 33% increase in sweet potato yield due to NPK fertilizer (while DST assumed 20%)
On average 20% increase in cassava root yield due to NPK fertilizer while DST assumed 40% for yield class I-III (<22.5 t/ha); 20% for yield class IV (22.5-30 t/ha) and no response in yield class V (>30 t/ha)
Net revenue from fertilizer

40% of participants do not break even from investment in fertilizer due to extra revenue from increased sweet potato yield.
Net revenue from fertilizer

70% of participants record positive changes in net revenue. Less than 10% do not break even.

Median profit from fertilizer is $1,000 per ha when revenue increase from both sweet potato and cassava is considered.
Cassava-maize intercropping

<table>
<thead>
<tr>
<th></th>
<th>SW-Nigeria</th>
<th>SE-Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>DST runs</td>
<td>71</td>
<td>229</td>
</tr>
<tr>
<td>Maize harvested</td>
<td>68</td>
<td>213</td>
</tr>
<tr>
<td>Cassava harvested</td>
<td>40</td>
<td>216</td>
</tr>
</tbody>
</table>
Cassava maize intercropping

**Layout of the validation exercise**
- High density + fertilizer F1
- Low density (control) LM
- High density D

**Height classes of maize**

**Recommendations given for**
- Maize density: 20 000 or 40 000 plants/ha
- Fertilizer application
- Cassava always at 12 500 plants/ha

**Recommendations based on**
- height class of maize (without fertilizer at tasseling)
  - 3 classes in 2018
  - 5 classes in 2019
- Cost benefit analysis (for fertilizer)

**Default recommendation**
- 2018: high maize density, no fertilizer
- 2019: low maize density, no fertilizer

**Number of analysed trials**
- 2018: 93
- 2019: 121
Yield response in large cobs

Treatment
- high maize density
- high maize density + fertilizer
Almost 70% of farmers turned a profit from fertilizer.

~80% of farmers realize a yield increase from fertilizer.

Almost 70% of farmers turned a profit from fertilizer.
Performance of the DST

2019
• F1 (high density plus fertilizer) recommended correctly in 38 out of 48 cases (79 %)
• F1 had highest revenue in 86 cases but was recommended only 38 times (44 %). 56 % of farmers lost out on the opportunity to further increase their revenue

2018
• F1 recommended correctly in 13 out of 16 cases (81 %)
• F1 had highest revenue in 67 cases but was recommended only 13 times (19 %). 81 % of farmers lost out on the opportunity to further increase their revenue
Best planting practices

<table>
<thead>
<tr>
<th></th>
<th>SW- Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>DST runs</td>
<td>327</td>
</tr>
<tr>
<td>Cassava harvested</td>
<td>171</td>
</tr>
</tbody>
</table>
Best planting practices

Layout of the validation exercise

Recommendations given for
- Ploughing intensity
- Soil shaping

Recommendations based on
- Current yield level (farmer’s estimate)
- Costs of
  - Tillage operations
  - Weed management
- Expected price of cassava produce
- Cost benefit analysis

Number of analysed trials
- 2018: 114
- 2019: 53
Cassava fresh root yield

Change current practice:
DST recommended a change of tillage operations

Keep current practice:
DST recommended the same tillage that the farmer currently applies
Under recommendation, we test a reduction in tillage
Cumulative probabilities of yield and profit

14% of farmers realize a yield increase due to a reduction in tillage.

50% of farmers realize a yield increase due to a change in tillage.

10% of farmers turn a profit due to a reduction in tillage.

60% of farmers turn a profit due to a change in tillage.
Scheduled Planting and Harvest

Additional paired yield observations in farmers’ fields in 2020

<table>
<thead>
<tr>
<th>Zone</th>
<th>DST runs</th>
<th>Planted</th>
<th>Harvested</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-West</td>
<td>232</td>
<td>185</td>
<td>93 + 166</td>
</tr>
<tr>
<td>South-East</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Coastal</td>
<td>266</td>
<td>252</td>
<td>138 + 219</td>
</tr>
<tr>
<td>Lake</td>
<td>162</td>
<td>160</td>
<td>25 + 163</td>
</tr>
</tbody>
</table>
Scheduled Planting and Harvest

Semi-fixed design
- Blue plot: farmer’s choice of harvest date (FHD)
- Red plot: harvested two months prior to FHD

Changes in design compared with preceding season
- Not linked to a DST run (fixed harvest interval)
- Close supervision by researcher team to ensure correct collection of harvest date information, monitoring and yield measurement
- Increased accuracy of yield measurement in Nigeria (6 triangles instead of single plots)
Yield data quality in Nigeria

Substantial improvement in precision of yield measurement (target CV 15%):
- Median CV @ farmer’s harvest: 12% [10-19%]
- Median CV @ early harvest: 17% [12-29%]

Correlation between yields:
about 4.5 t ha\(^{-1}\) less yield at early harvest
(2 months prior to farmer’s harvest)

Triangle method: 6 triangles per harvest
Scheduled Planting and Harvest

Modeled and observed yields are correlated but model overestimates yield, and model underestimates yield changes over time...

Nigeria 2020
Latest LINTUL model fails to predict yield changes within the harvest window. Further investigation and improvement is needed.
Yield data quality in Tanzania

Also in Tanzania, improvements in observed yield data (no CV available), as shown by good relationship between yields at two harvest dates.

Higher yields at earlier harvest date:
Most farmers harvest in the middle or towards the end of the dry season, hence little yield difference as there is often no rain received.
## Summary

<table>
<thead>
<tr>
<th>Use case</th>
<th>median ΔY (t/ha)</th>
<th>%HH ΔY &gt; 0</th>
<th>mean ΔNR ($/ha)</th>
<th>%HH ΔNR &gt; 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR - Nigeria</td>
<td>5.5</td>
<td>8.0</td>
<td>80%</td>
<td>110</td>
</tr>
<tr>
<td>FR - Tanzania</td>
<td>4.8</td>
<td>8.0</td>
<td>82%</td>
<td>200</td>
</tr>
<tr>
<td>IC - Nigeria</td>
<td>maize: 1.3</td>
<td>cassava: 2.8</td>
<td>0.5</td>
<td>81%</td>
</tr>
<tr>
<td>IC - Tanzania</td>
<td>sweet potato: 0.44</td>
<td>cassava: 2.9</td>
<td>0.5</td>
<td>70%</td>
</tr>
<tr>
<td>PP - Nigeria</td>
<td>1.1</td>
<td>4.0</td>
<td>50%</td>
<td>152</td>
</tr>
<tr>
<td>SP - Nigeria</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>??</td>
</tr>
<tr>
<td>SP - Tanzania</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>??</td>
</tr>
</tbody>
</table>

Values in blue are target values set in the ACAI project proposal as a basis for the calculation of total value generated. For each use case, a target of at least 75% was aimed to obtain a positive yield impact.
Main results in plenary session

- **Yield responses** in scatter plots (recommendation vs. control or current practice)
- **Cumulative distribution curves** of yield responses and changes in net revenue

Breakouts for detailed discussion

- **Comparison of revenue** obtained with price data as provided by/to the tool vs. actual prices at harvest
- **Background** on the tool and validation exercises
- **Post-hoc analyses** on performance with current version of the tools