Taking Maize Agronomy to Scale in Africa (TAMASA)

Transformation of agronomic research and delivery services for smallholder farmers in maize-based systems in Eastern and Southern Africa
Contents

• Why TAMASA?
• Objectives & TAMASA works & with whom
• Framework for nutrient management use-case
• Baseline soil & yield survey
• Agronomy panel survey
• Capacity development
Why TAMASA?
Technology adoption – where & what innovations are needed?

Large ‘space’ between data/ knowledge generation & both
demand from service providers (intermediaries) for products & knowledge to help reach & support more end-users

Products/tools are needed that translate data to useful (agronomic) information/knowledge that can be acted upon & used at scale by different users

Source: BMGF Next Generation Farming System Models Convening Aug 2014
What do we have to do to produce technology that is both credible (≈profitable) & scalable (logistics)?

- Understand scale & method of partners
- Co-develop product with (intermediate) users
- Make accessible & share knowledge
- Improve capacity of others to use product
INGO: research to delivery at scale

- **Phase 0 (Strategic Research)**
  - Preliminary desktop & site visit research

- **Phase 1 (Verification)**
  - Research station evaluation

- **Phase 2 (Validation)**
  - On-farm evaluation; 50 to 500 farmers in one County/District/LGA

- **Phase 3 (Validation & scalability)**
  - On-farm validation & demand assessment in one County/District; 1,000 to 20,000 farmers
  - **Criteria:** Profitability, Fit to existing system & practice; Simplicity, Operability (logistics)

- **Phase 4 (Scale-out)**
  - Incorporation into Core package in all Districts; 100,000+ farmers

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<table>
<thead>
<tr>
<th>No.</th>
<th>Farmers</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Counties</td>
<td>80,000-120,000</td>
<td>1680</td>
</tr>
<tr>
<td>County supervisor</td>
<td>20,000-30,000</td>
<td>420</td>
</tr>
<tr>
<td>Supervisor for District</td>
<td>1,000-1500</td>
<td>21</td>
</tr>
<tr>
<td>Field officer (FO)</td>
<td>50-75</td>
<td>1</td>
</tr>
<tr>
<td>Farmer group</td>
<td>10-15</td>
<td></td>
</tr>
</tbody>
</table>
TAMASA objectives

• Use modern large data & analytics to:
  – map maize areas, soil constraints, infrastructure & attainable yields at different scales & in near real-time; open-access databases of soil and agronomic data
  – Shared objective with AfSIS

• Co-generate with partners decision-support tools for:
  – maps, fertilizer/nutrient management & blending, crop management for different stakeholders;

• Increase capacity in national programs & partners, including post-graduate training, to support these approaches
Four WorkStreams

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**Use of tools in new geographies**

- 1.3.1 Capacity of core & new scaling partners to use & scale out use-cases increased
- 1.3.2 Awareness of tools to support out-scaling increased among institutions & industry
- 1.3.3 ME&L strategy that supports project

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**Tool development in core geographies**

- 1.2.1 Nutrient management
- 1.2.2 Variety selection
- 1.2.3 Fertilizer business
- 1.2.4 Monitoring
- Other use-cases/tools to be developed

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**Mainstreaming & institutionalization**

- 2.1.1 Assessment institutional needs for mainstreaming
- 2.1.2 Capacity national institutions to undertake & support predictive agronomy increased by PhD & MSc training
- 2.1.3 Capacity of national scientists to undertake predictive agronomy increased
- 2.1.4 Ex-ante assessment of ROI on investing in predictive agronomy in each country

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**Analytics & support for predictive agronomy by TAMASA & AfSIS**

- 1.1.1 Maize crop area maps
- 1.1.2 Maize yield gap maps
- 1.1.3 Maize soil constraint maps
- 1.1.4 Maize panel/survey agronomic practices
- 1.1.5 Maize agronomy (& soils) database
Core countries are Ethiopia, Nigeria & Tanzania

Cropland area in Africa
Courtesy AfSIS geo-survey predictions

Ethiopian Institute Agricultural Research (EIAR)

Selian and Uyole Agricultural Research Centres

Bayaro University Kano (BUK)
Framework for nutrient management use-case
IPNI Nutrient Expert use-case

The four 'Rights' of nutrient management:
- Source
- Rate
- Time
- Place

The focus is to match nutrient supply with crop requirements and to minimize nutrient losses from fields.

Nutrient Expert for Hybrid Maize

- Name and/or location: Site A
- Current yield: 5.5 t/ha (15.5% MC)
- Yield goal: 7.2 t/ha (15.5% MC)
- Planting density: 69,444 plants/ha
- Distance between rows: 60 cm
- Distance between plants: 24 cm

Recommended alternative practice for hybrid maize

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Days after planting</th>
<th>Soil moisture</th>
<th>Fertilizer sources</th>
<th>Weight of full bag (kg)</th>
<th>Amount (bags)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V10 or later</td>
<td>35</td>
<td>sufficient</td>
<td>Urea, KCl</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>V6</td>
<td>25</td>
<td>sufficient</td>
<td>Urea</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>V3</td>
<td>0</td>
<td>sufficient</td>
<td>10-46-0</td>
<td>50</td>
<td>1.5</td>
</tr>
<tr>
<td>VE</td>
<td>0</td>
<td>sufficient</td>
<td>Crop residue (rice):</td>
<td>medium</td>
<td></td>
</tr>
</tbody>
</table>

Fertilizer rates are adjusted to field size.
Soil mapping - soil fertility framework

Maize area & yield prediction

Digital soil database (ISRIC/AfSIS @250m²)

Define criteria
- pH <5.2
- Texture
- SOC
- CEC

Core agronomy domain

Hypothesis on scaling recommendations

Generate geospatial sampling frame/design

Not + lime + micronutrient experiments on-farm in targeted sites (n=90)

Tool (i.e. Nutrient Expert) calibration for core domain

Rol of different approaches

Generate geospatial sampling frame/design

Not + lime + micronutrient experiments on-farm in targeted sites (n=90)

Tool (i.e. Nutrient Expert) calibration for core domain

Core agronomy domain

Validation on-farm (n=100s); core & new domains to test hypothesis

RCTs on scaling/adopter process

Capacity development for scaling

Partners Logistics Local knowledge

Scaling-out by partners in core & new domains

User consultation/feedback on tool

Agronomy database

Hypothesis on scaling recommendations

Generate geospatial sampling frame/design

Not + lime + micronutrient experiments on-farm in targeted sites (n=90)

Tool (i.e. Nutrient Expert) calibration for core domain

Agronomy database

Where to invest?

Agronomy database

National baseline maize yield & soil constraint mapping

Agronomy database

Agronomy database

Maize area & yield prediction

Agronomy database
Confluence of partners: Iringa, TZ

**Hypothesis testing.** NOT in
- Accessible sites (norm)
- Dominant soil types of target area
- All soil types in target area
- How many NOT? How many years?

**Validation**
- FP vs recommendation + RoI

- AfSIS clustered soil sampling
- One Acre Fund famers M&E & soil survey
- Baseline yield survey

- pH
- SOC
Baseline yield & soil survey
Baseline yield & soil survey

‘actual yield (farmer yield)’ bottleneck

• Aim: To map maize areas, determine spatial soil characteristics & predict maize yields in each country

• Method: Stratified (using a crop mask), random sample of 1000 points (pixels) in each country; sample as many as possible

Measure yield (replicated crop-cut) & soil analysis (using AfSIS protocols);

• Joint activity with AfSIS
1000 points for baseline yield survey in Tanzania
Baseline yield survey cob fresh weights

160 maize fields sampled to date (soil & yield)

Variety
Fertilizer applied
Plant density is a major limitation

Measured yields from 123 fields in Southern Highlands Tanzania in 2015

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>45.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Field area</td>
<td>0.50</td>
<td>0.62</td>
</tr>
<tr>
<td>Sex</td>
<td>M %</td>
<td>F %</td>
</tr>
<tr>
<td></td>
<td>71</td>
<td>29</td>
</tr>
</tbody>
</table>

>95% sole maize
‘Actual yield’ data sources

- Baseline studies; e.g. SIMLESWA in TZ recorded data on 750 households & >2000 maize fields
- Panel data; e.g. LSMS TZ 2012/13 ≈ 5000 entries

Does minimum tillage with planting basins or ripping raise maize yields? Meso-panel data evidence from Zambia

Despite nearly two decades of minimum tillage (MT) promotion in Zambia, there is limited empirical evidence on its effect on maize yields under typical smallholder conditions. We use nationally representative survey data from nearly 48,000 smallholder maize plots for the period 2008–2011 to estimate the maize yield effects of the primary MT strategies promoted in Zambia: planting basins and ripping.

Agriculture, Ecosystems and Environment 212 (2015) 21–29
Agronomic panel survey
Agronomic panel survey

• Aim: To capture & understand **spatial & temporal** variability in farmers’ maize fields in core geographies

• Method: Panel survey (i.e. repeated each year) in core geographies of c. 100 maize fields in a 10 X 10 km cell. Grid or stratified, clustered sampling design.

• Collect data on: socio-economic characteristics; crop agronomy observations/measurements at vegetative, flowering & harvest; soil analysis (using AfSIS SOP); some hand-held sensor (e.g. Greenseeker) data

• Fly UAVs at low and high resolution for additional data

• *Panel data contributes to M&E*
Decomposing yield gaps from surveys to identify entry points

Wheat yield (N= 1485)

Sowing day

Variety

Short (2.8 t/ha)

Long (3.7 t/ha)

K₂O

Weed management

Average to poor (4.3 t/ha)

Good (4.9 t/ha)

Irrigation no.

< 2.5 irrig (4.6 t/ha)

≥ 2.5 irrig (5.1 t/ha)

Extension service providers want to know what interventions to promote that give maximum ‘bang for the buck’

Wheat in India: Courtesy Andy MacDonald
Panel survey: vegetative stage

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>41.0</td>
<td>21</td>
<td>75</td>
<td>12.7</td>
</tr>
<tr>
<td>Measured field area (ha)</td>
<td>0.43</td>
<td>0.10</td>
<td>3.0</td>
<td>0.40</td>
</tr>
<tr>
<td>Inorg. fertiliser (kg)</td>
<td>84.5</td>
<td>0.15</td>
<td>350</td>
<td>65.2</td>
</tr>
<tr>
<td>No. plants (ha*1000)</td>
<td>27.8</td>
<td>12.4</td>
<td>56.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Dist. to input dealer</td>
<td>2.5</td>
<td>0.1</td>
<td>10</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Fertilizer: DAP, urea & NPS. Farmers (& extension) do not know NPS
PANEL data examples

What was the sowing/planting date of the maize?

- 100% planted maize only
- 99% used an ox plough
- 94% used improved seed (Limu, BH540, BH543)

ODK output: forms available at https://ona.io/cimmyt_gcap
PANEL survey: vegetative stage
Panel data examples

What is your level of trust in extension?

- Very high
- High
- Medium
- Low
- Very low

65% farmers had received training in agronomy in last 3 years
ODK for near real-time data collection

### Shared Forms

<table>
<thead>
<tr>
<th>Name</th>
<th>Submissions</th>
<th>Enter Data</th>
<th>View</th>
<th>Download</th>
<th>Last Submission</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAMASA_VegetativeStage_ET <a href="https://ona.io/cimmyt_gcap">Shared by oloofrank</a></td>
<td>100</td>
<td>[Web]</td>
<td><img src="https://ona.io/static%D8%AC%D9%8A%D9%84.png" alt="csv" /> <img src="https://ona.io/static%D8%AC%D9%8A%D9%84.png" alt="xls" /> <img src="https://ona.io/static%D8%AC%D9%8A%D9%84.png" alt="kml" /></td>
<td></td>
<td>Aug. 04, 2015</td>
<td>true</td>
</tr>
</tbody>
</table>

The url "of" this web application [https://ona.io/cimmyt_gcap](https://ona.io/cimmyt_gcap) must be given to ODK Collect before it will get forms from and submit data to ona. In Collect’s Main Menu, press the Menu button. Select Server Preferences, then Server. Enter [https://ona.io/cimmyt_gcap](https://ona.io/cimmyt_gcap) as the server.
Thank you for your interest!

Photo Credits (top left to bottom right): Julia Cumes/CIMMYT, Awais Yaqub/CIMMYT, CIMMYT archives, Marcelo Ortiz/CIMMYT, David Hansen/University of Minnesota, CIMMYT archives, CIMMYT archives (maize), Ranak Martin/CIMMYT, CIMMYT archives.
Capacity development
Capacity development

Ten international PhDs across ET, NG & TZ

- Four at WUR (yield gaps, scaling, HH data)
- Four at Leuven (fertility/nutrition, HH data)
- Two at Reading (data assimilation TAMSAT & SMAP)

Co-development & training in using geospatial tools & APIs
Panel survey: Bako, Ethiopia

- 10 x 10 km grid
- Samples on intersections
- Data collected using ODK
Spatial targeting of new maize varieties

- New drought tolerant varieties (CZH0616) performed better than checks (Melkassa2) in many areas.
- Combining suitable varieties with climate information & good agronomy increased income of farmers by up to 40%.
Map of Soil Organic Carbon (SOC)
Profitability of current & improved SI technology

Technologies include:
tillage; rotation; fallowing; intercropping; fertilizer & amendments; pest & disease control; improved varieties

Black bars – farmer practice
Red bars – improved practice

Harris and Orr, 2013

Median returns
$558
$185

≈70 studies from lowest to highest net return for improved practice

Core partners are:
TAMASA objectives (2/2)

- Organised in four main Workstreams...
1000 points in Ethiopia
Background

• TAMASA is a BMGF supported project
• Started November 2014; duration is 4 years
• Core geography is **maize-based systems**
• Focus is **small-holder farmers, service providers & industry** supporting them
• Partners are: CIMMYT, IITA, IPNI, BuK, DRD & EIAR
• BMGF/donor investments in large maize breeding & seed system projects in the region (e.g. DTMA, WEMA, DTMASS, STMA)

• BMGF investments in AfSIS (African Soil Information System)

• Availability of BIG data, analytics & IT solutions: innovative science using geospatial & modeling techniques

• Opportunity to use tools & applications (APIs) to share data & knowledge

  = Impact on (maize) agronomy at scale
Where is the bottleneck?

Information constraints?

Observed

Optimum

Resource & information constraints?

Where is the bottleneck?

One Acre Fund data
Control & OAF farmers

Amount of seed planted (kg)

Field size (ha)

y = 14.243x
Soil acidity in Western Kenya

Significant areas in Western Kenya where soil acidity is a problem, compounded by use of only DAP – all that is available
Operability of these configurations at scale would require the following:

- Distributing over 18,000 tonnes of lime assuming a 0.2 hectare package and microdosed application.
- Design and production of 150,000 standard sized lime application cups
- Writing of new trainings and the training of over 800 field officers.
- Potential addition of hundreds of distribution trucks.

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>No.</th>
<th>Yield (t/ha)</th>
<th>Profit ($/ha)</th>
<th>Lime required/0.2 ha (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>120</td>
<td>7.4</td>
<td>2,759</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>+2.0 t/ha CaO</td>
<td>120</td>
<td>9.2</td>
<td>3,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reduced quantity &amp; banding of lime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>91</td>
<td>4.0</td>
<td>1,413</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>+1.0 t/ha CaO banded</td>
<td>91</td>
<td>4.7</td>
<td>1,704</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Micro-dosed lime</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>6.6</td>
<td>2,433</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>+0.5 t/ha CaO spot applied</td>
<td>84</td>
<td>7.5</td>
<td>2,806</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Control: cv WE1101; 124 kg/ha DAP; 124 kg/ha CAN; 53,000 plants/ha
Closing yield gaps: scaling-out partners want ‘Bang for the Buck’

Service providers want to improve the effectiveness of the interventions they promote.

Zimbabwe 2013/14, ZimCLIFs. Courtesy I. Nyagumbo
TAMASA Theory of Change (i)

- newly emerging data streams across scales from remote-sensing, crowd-sourcing and other sources, supported by modern analytics and APIs, and linked to a participatory co-development process with users, will result in improvements in agronomy at scale leading to household maize yield and production increases.
TAMASA Theory of Change (il)

- greater investment in post-graduate capacity for national programs in predictive agronomy and geospatial sciences, the use of this knowledge within national programs allied to real evidence at farm and national levels of the benefits of these investments, will lead to greater long-term investment in agronomy and systems to support agronomy by national programs.
Scaling-out IPNI Nutrient Expert