Conclusions and recommendations

The Optimizer is an innovation that considers the money the farmer has available to invest in fertilizer. It helps the resource-constrained farmers to make decisions on the most profitable crop-nutrient combination so as to get maximum return. The FOT is an innovation with the potential to improve both incomes and food security for resource-constrained smallholder farmers. [See monograph 3 for supporting evidence].

Generally there is lack of awareness amongst smallholder farmers of the 4 Rs of fertilizers [right source; right rate; right time and right place] and also of other integrated soil fertility management (ISFM) strategies to increase crop yields. Awareness raising campaigns to support the introduction of FOT should therefore include the roles of fertilizer in the context of ISFM and the potential returns on investment.

The Uganda versions of the FOT consider only maize, sorghum, upland rice, soybean, groundnut and beans. There is demand to update it to include more crops, and also incorporate other ISFM components, such as benefits of a legume in crop rotation and other fertilizer types. This requires response functions obtained from either new trials or existing data. The current FOT is an Excel tool that runs on a computer. There is a therefore the need to circulate the paper-based version of the FOT.

The FOT helps the resource-constrained farmers to make decisions on the most profitable crop-nutrient combination so as to get maximum return.

Acknowledgement

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Links with additional information

1. More profitable fertilizer use for poor farmers http://bit.ly/1LJtU1G
2. Uganda work positioned to make fertilizer use more profitable for poor farmers http://bit.ly/1RCl1c8
3. Fertilizer use among smallholder farmers in Uganda http://bit.ly/1GVaRAr
4. The fertilizer use optimizer solver and macros programming manual http://bit.ly/1LJuegY

Monograph series:

This monograph is part of a series of four published in July 2015 and based on case study research and focus group discussion in Uganda.

Monograph 1: Fertilizer Optimization Tool, an innovation for resource poor farmers in Africa

Monograph 2: Institutionalization of the Fertilizer Optimization Tool, a key ingredient to sustainability lessons from Uganda

Monograph 3: Farmers start appreciate the benefits of using the Fertilizer Optimization Tool in guiding fertilizer application in Uganda

Monograph 4: Fertilizer Optimization Tool: From the community knowledge and extension workers perspective in Uganda [following-up on trained intermediaries]

These monographs can be downloaded from www.africasoilhealth.cabi.org

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Integrating ISFM approaches

Nutrient substitution look-up table (being developed and will be available soon) is used to adjust the output of the FOT to take into account other integrated soil fertility management (ISFM) practices the farmer is using that impact on nutrients supply.

The ISFM practices to be included in the look-up table are the use of various types of organic matter (manure, compost, crop residues), intercropping and rotations with legumes, fallows and the results of selected soil tests.

For each practice, the table suggests how the fertilizer recommendations generated by the FOT should be adjusted; for example, for every one tonne of farmyard manure (dry matter) applied per acre, fertilizer equivalent to 4 kg urea, 2 kg DAP and 2 kg MOP could be spared.

Integrated soil fertility management: Substitution for fertilizer nutrients

ISFM Practice	Urea	DAP or TSP	MOP	NPK 17-17- 17
	Fertiizer reduction			
Previous crop was green manure	100%	70%	70%	70%
Fresh vegetative material applied per tonne of fresh material[1]	4 kg	2 kg	2 kg	8 kg
Farmyard manure per 1 tonne of dry material	5 kg	3 kg	2 kg	10 kg
Residual value of farmyard manure applied for the previous crop, per 1 tonne	2 kg	1 kg	1 kg	3 kg
Dairy or poultry manure, per 1 tonne dry material	9 kg	4 kg	5 kg	16 kg
Residual value of dairy or poultry manure applied for the prvious crop, per 1 tonne	2 kg	2 kg	1 kg	3 kg
Compost per 1 tonne	8 kg	3 kg	3 kg	15 kg
Residual value of compost applied for the previous crop	3 kg	2 kg	1 kg	5 kg
Rotation	No reduction but expect more yield			
Intercropping cereal-bean	Increase DAP/TSP by 7 kg/ acre – but no change in N & K compared with sole cereal crop			
Intercropping cereal-other legume (effective in N fixation)	Increase DAP/TSP by 11 kg/acre, reduce urea by 9 kg/acre, and no change in K compared with sole cereal fertilizer			
If Mehlich III P > 1 parts per million	Apply no P			
If soil test K <100 parts per million	Band apply 20 kg/ acre murate of potash in band or point placement			

[1] If lantana and tithonia are already abundant, they should be considered for use but planting them is discouraged as it is an invasive weed species.

Figure 6: Current recommendations for Uganda

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Fertilizer Optimization Tool an innovation for resource poor farmers in Uganda

Optimization of Fertilizer Recommendations in Uganda. Monograph 1

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Overview of the OFRA intervention

The Optimising Fertilizer Recommendations in Africa (OFRA) project was funded to find strategies to enable resource poor farmers to get the best return form their small investments in fertilizer. The project sought to develop new guidelines for investment, developed through a tailored interaction with farmers, to provide a better basis for decision making than blanket nation-wide fertilizer recommendations. Many of the blanket recommendations are not appropriate for resource-constrained smallholders.

Through the project, a Fertilizer Optimization Tool (FOT) has been rolled out in Uganda. In Uganda there are 7 different tools based on the different agro-ecological zones.

The FOT is an innovation to help farmers optimize returns on their investment in fertilizer by selecting the best crop-nutrient combination.This is highly beneficial to smallholder farmers due to the high cost of borrowing money in sub-Sarahan Africa. In April 2015 the Bank of Uganda increased the central business rate to 12 per cent, so borrowed money has to work hard.

The Ugandan FOTs are available as both an Excel-based computer tool and a paper-based tool for use by intermediaries such as extension staff or agro dealers. The tool helps farmers to maximize net returns to fertilizer use for finance-limited crop management. It considers the area of each crop, fertilizer costs, expected grain value, and the money available for investment. The recommendations are based on extensive research into fertilizer response functions taken from new field trials undertaken by the National Agricultural Research Organization and further data drawn from legacy research.

The FOT is an innovation to help farmers optimize returns on their investment in fertilizer by selecting the best crop-nutrient combination.

Low inorganic fertilizer use by smallholder farmers in developing regions of the world commonly constrains productivity. High fertilizer costs and low commodity prices often reduce profit potential. Competing needs for money often take priority. Many farmers do not have the financial capacity to purchase enough fertilizer to maximize net returns on all their land. Such farmers need high net returns on their investments to justify the application of fertilizers.

Most fertilizer recommendations ignore the finance constraints to fertilizer use. These recommendations commonly strive to maximize mean net returns across all planted acres. These recommendations are infeasible for smallholders with limited financial capacities. Maximizing net returns requires the fertilizer investment to be focused on crop-nutrient combinations with the highest marginal returns, until the budgeted financial resources are exhausted.

Fertilizer optimization diagram

Inputs	→	Processes	→	Outputs
Crop selection: • area planted (ha) • expected grain value ($ ha^{-1}) **Fertilizer selection and prices:** • fertilizer product • nutrient amount • cost $ per 50 kg bag **Budget constraint:** • amount available to invest	→	**User (producer) constraints:** • crop selection and grain value/kg • fertilizer selection and cost **Model constraints:** • amount available to invest • fertilizer minimum and maximum rates per crop • nutrient application requirements for P and K, eg. P applied to cereals only if N is applied **Model optimization** • total net returns to fertilizer use maximized through re-iterative consideration of 15 response functions	→	**Information** • fertilizer application rates optimized (kg ha^{-1}) • effects on expected yield (kg ha^{-1}) and net return increases ($ ha^{-1}) • total expected net returns to investment in fertilizer

Figure 1: Operational flow model of the Fertilizer Optimization Tool (Source FOT Manual, 2014)

The optimization process using the FOT

There is a stepwise process followed to optimize fertilizer allocation and application using the FOT. These processes consider the income a farmer wants to invest in purchasing fertilizer and works on Liebig's law.

The Crop Selection and Prices table shows the range of crops for which reliable data on fertilizer response functions has been amassed. The farmer is asked to assess what the value of the grain will be at harvest time or planned point of sale.

The Fertilizer Selection and Prices table gives options for the most common fertilizers on sale in the region; where necessary additional fertilizer options can be added as new products become available.

The Budget Constraint box asks the farmer how much they want to invest in purchasing fertilizer.

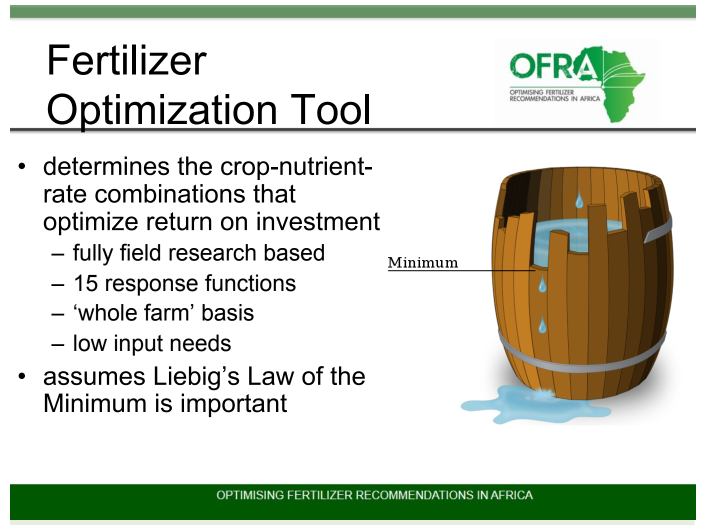

Figure 2: Liebig's law of the minimum suggests that plant growth is controlled, not by the total amount of nutrients or resources available, but by the availability of the scarcest resource. Simplistically, water can be seen as one of those resources and we know that it does not matter how many other resources there are in the soil for our crops, without any water those crops cannot grow.

Once you have entered the area to be planted under each crop, and also the market price for the fertilizer and the amount the farmer want to invest in fertilizer that season, you click the optimize button. Figure 4 shows the output after optimization.

The Fertilizer Application box shows the suggested amount of each fertilizer (kg/ha) to be applied to each crop by the farmer.

The Expected Average Effects per Hectare box shows the estimated mean effect on yield for each crop if the farmer applied fertilizer following the recommendation. The output also shows the net returns per crop, which helps the farmers see which crop gives them the highest return to investment in fertilizer.

Figure 4 shows the total returns to investment from the crops where fertilizer has been applied.

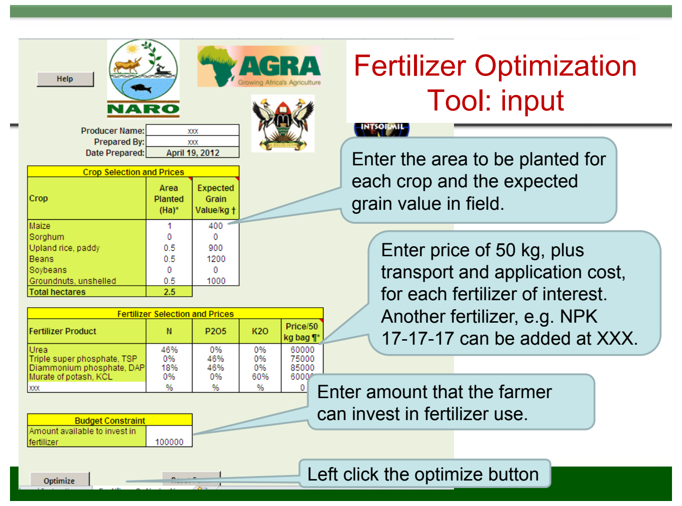

Figure 3: Annotated screen shot of the FOT illustrating how information is input

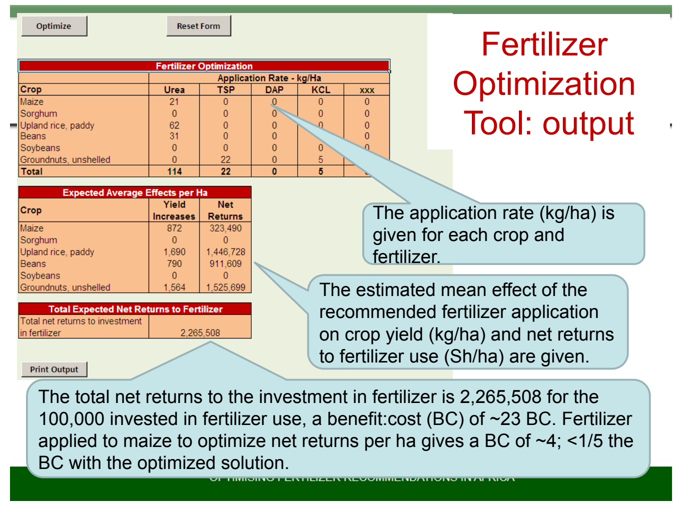

Figure 4: Annotated screen shot of the FOT illustrating the output as generated from the FOT

OFRA Fertilizer Calibration Tool

The FOT fertilizer recommendations demonstrated in this monograph produced outputs based on kilograms per hectare. The next challenge for intermediaries is to convert this into a farmer-friendly format. To help with this challenge, University of Nebraska-Lincoln and African scientists have developed a calibration tool that translates recommendations expressed in kilograms per hectare into more farmer-friendly measuring units.

Step-by-step

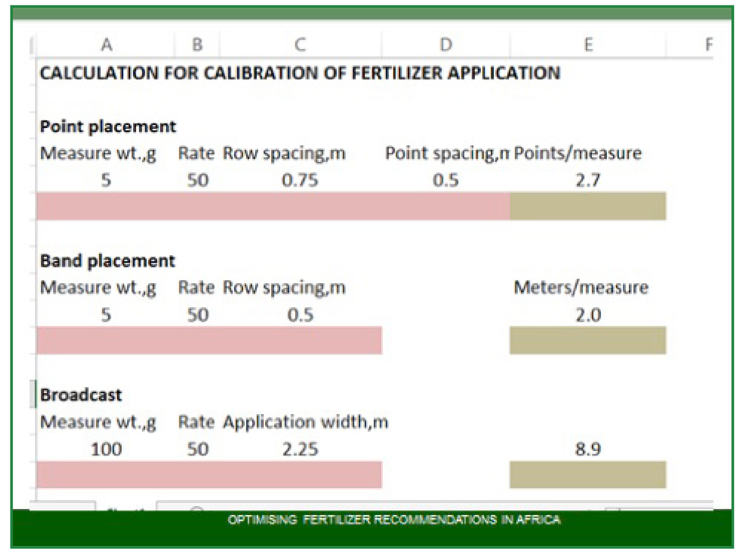

Figure 5: calculator for the calibration of fertilizer

Volume: A locally available farmer-friendly measure is selected for the calibration – e.g. a bottle top or a matchbox, and the dimensions are entered in to the tool.

Fertilizer type: Next a fertilizer type is selected from the drop-down list. This list automatically provides the density of the nutrient or fertilizer blend. New fertilizer blends can be added by the user at any time to keep the tool relevant and up-to-date.

Fertilizer rate: Then a kg/ acre or kg / hectare rate is selected.

Planting density: The distance between rows and planting points are entered.

Method of application: The method application is selected, e.g. broadcast.

The tool can give a farmer-friendly suggestion for fertilizer placement or application, based on the preference made in the first question. So, for example, the calibration will say that one matchbox full of DAP should be spread along 2 metres of the row.

Farmer-friendly approaches for fertilizer guidelines are important for several reasons:

- Farmers and others find it hard to estimate the area of a field or plot
- Once they have estimated an area of a field, they find it hard to estimate how to apply the right weight of fertilizer to that area
- People often assume all fertilizer has the same density; in fact there are big variations between different fertilizers with some being more than twice as dense as others.