A second table indicates the expected yield increases and net return on investment for each crop. A third table shows the total net return on the investment in fertilizer – that is the total value of increased yield of each crop less the amount invested in fertilizer.

Fertilizer Optimization					
	Application Rate - kg/Ac				
Crop	Urea	TSP	DAP	KCL	xxx
Maize	33	0	3	0	0
Banana	17	0	16	0	0
Upland rice	49	0	28	0	0
Beans	11	0	33	0	0
Soybeans	0	33	0	6	0
Groundnuts, unshelled	0	51	0	26	0
Total fertilizer needed	**96**	**118**	**56**	**37**	**0**

Expected Average Effects per Ac		
Crop	Yield Increases	Net Returns
Maize	613	124,899
Banana	890	180,814
Uplandrice	706	649,907
Beans	345	398,381
Soybeans	370	204,323
Groundnuts, unshelled	434	693,299

Total Expected Net Returns to Fertilizer	
Total net returns to investment in fertilizer	2,166,327

Output from the FOT after clicking on the optimize button

Step 2: Next a simple **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.

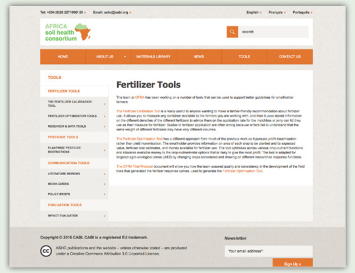
The ISFM practices to be included in the look-up table are the use of various types of organic matter (manure, compost, crop residues), intercropping and rotations with legumes, fallows and the results of selected soil tests.

For each practice, the table will suggest how the fertilizer recommendations generated by the FOT should be adjusted.

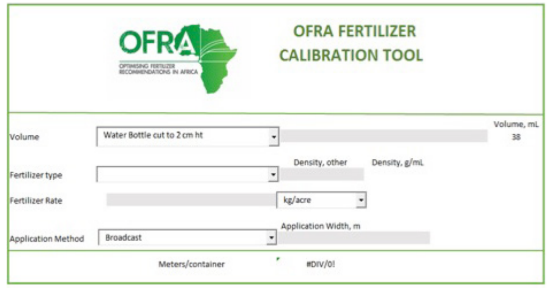
Where to find the OFRA tools

The FOT tools are available at http://africasoilhealth.cabi.org/tools/fertilizer-tools

The reports section of the website http://africasoilhealth.cabi.org/reports/ contains value information, including the OFRA monograph series.



Step 3: Finally a **fertilizer calibration tool** is used to convert the recommendation, expressed as kg of fertilizer per hectare of land, to a more farmer-friendly measure.



A fertilizer calibration tool is used to convert the recommendation, expressed as kg of fertilizer per hectare of land, to a more farmer-friendly measure.

Few if any small-scale farmers will have access to scales to weigh out the fertilizer and not all will know the size of the plots they are using to grow each crop. To overcome this problem, the calibration tool is based on the use of items that are freely available and that can be adapted and used as calibrated measuring scoops. These include cut-down, discarded plastic bottles that previously held water or some other liquid; bottle tops, such as the crimped metal bottle-tops commonly used to cap beer or soda (known as crown corks); or rectangular containers, such as empty match boxes. The calibration tool runs on a laptop.

First the dimensions of the container to be used are entered; the tool uses these to calculate the volume of the cylindrical or rectangular container. Secondly, the type of fertilizer being used is selected from a drop-down menu: not all fertilizers have the same density, so one bottle-cap full of one fertilizer will have a different weight to the same bottle-cap full of another type of fertilizer. Next the number of kg of fertilizer to be applied per hectare is entered, along with the method of application (broadcast, banding or point placement, also known as micro-dosing) and the distance between rows and plants within rows.

Based on the information provided, the calibration tool provides a user-friendly fertilizer recommendation; for example, instead of 40 kg DAP per hectare it might suggest a plastic water bottle lid full of DAP applied as a band 2.1 meters long.

The Fertilizer Optimisation Tool is an output of the Optimising Fertilizer Recommendations in Africa (OFRA) project. OFRA is a partnership between CAB International, the University of Nebraska Lincoln, USA and National Agricultural Research and Extension Systems in 13 countries in sub-Saharan Africa. It is supported by the Alliance for a Green Revolution in Africa (AGRA) Soil Health Program.

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First published October 2015

AGRA Growing Africa's Agriculture

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OFRA OPTIMISING FERTILIZER RECOMMENDATIONS IN AFRICA

A better approach to enable small-scale farmers to derive the most benefit from their modest investments in fertilizer

Optimization of Fertilizer Recommendations in Ethiopia

The problem

Most small-scale farmers in Ethiopia apply little or no mineral fertilizers to their crops. They also usually incorporate less organic matter into the soil than is ideal: manure and compost is often available only in limited amounts on small-scale farms; for crop residues, including straw and stover, there are often competing uses, such as for animal feed or bedding, as thatching materials or as fuel for cooking. In addition, organic matter is bulky and therefore expensive to transport and handle.

These farmers' yields are lower than they could be. This can make them food insecure and prevent them from generating cash incomes from the sale of surplus crops – locking them in to a cycle of poverty.

The result is that these farmers' yields are lower than they could be. This can make them food insecure and prevent them from generating cash incomes from the sale of surplus crops – locking them in to a cycle of poverty. Worse still, continually cropping land without returning the nutrients removed with the crops results in degraded and impoverished soils which are hard, sometimes impossible, to restore to good health.

Even if farmers wish to apply some mineral fertilizer to their crops, it is difficult for them to know the right fertilizer to apply at the right rate of application, at the right time and in the right way. Applying the wrong fertilizer, applying it to the wrong crops, or applying it at the wrong rate could all result in the farmer failing to benefit from the fertilizer they purchased - they could waste their hard-earned money.

Most existing fertilizer recommendations tell farmers how much fertilizer they should apply to a specific crop, usually expressed in kg per hectare. These blanket recommendations often apply to huge areas, even up to whole countries, and encompass several agro-ecological zones.

Such recommendations do not help farmers decide which of their crops would benefit most from the application of fertilizer, nor do they reflect current input and output prices. Also, they are not tailored to address the reality for all small-scale farmers – 'I have only this small amount of money to spend on fertilizer. What is the best way to use that limited sum to provide me with the greatest financial return?'

Finally, they are not user friendly: it is hard for farmers to implement such recommendations on their fields and plots where they are unlikely to know precise acreages or have access to weighing equipment.

Farmers who do use mineral fertilizers often buy compound fertilizers which contain the three main crop nutrients, nitrogen (N), phosphorus (P) and potassium (K) in the same bag (NPK fertilizers). Although it may appear simpler to apply one fertilizer that supplies all three major nutrients together, in most cases it would be more cost-effective and efficient to use several different single nutrient fertilizers, each of which supplies just one of the three nutrients. This allows the correct amount of the three major nutrients to be applied, with each nutrient being applied when it is needed by the crop, minimizing waste and losses of nutrients to the air or being washed away with water. Some examples of single nutrient fertilizers include urea (to supply N), triple superphosphate (TSP – to supply P) and muriate of potash (MOP – to supply K).

The solution

Fertilzer Optimisation is an approach designed to address many of these issues.

Some crops respond better to the nutrients applied than others and different crops need different nutrients – for some nitrogen (N) will be the nutrient that limits the yield, while for others this will be phosphorus (P) or potassium (K). In all cases, the relationship between the price paid for fertilizer and the value of the crops produced is important.

Fertilizer Optimisation entails allocating the available single nutrient fertilizers to the crops a farmer wishes to grow, such that the farmer's return on their investment in fertilizer is maximized.

3 complementary tools, based on the principle of fertiliser optimization, have been developed for use in a range of agro-ecological zones in Ethiopia.

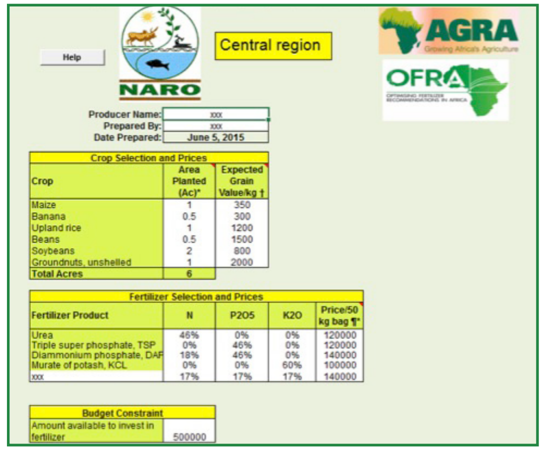
A set of three complementary tools, based on the principle of fertilizer optimization, has been developed for use in a range of agro-ecological zones in Ethiopia. They are based on data generated from several series of crop-nutrient response trials carried out in Ethiopia, both prior to and under the auspices of the Optimising Fertilizer Recommendations for Africa (OFRA) project.

The tools are intended to be used by extension workers who have been specially trained. Working with a farmer, the extension worker uses the set of tools to generate fertilizer recommendations which reflect that farmer's specific circumstances, including hectares of the different crops grown, fertilizer prices, expected crop output prices, how much the farmer can afford to spend on mineral fertilizer that growing season and other relevant farming practices, such as use of manure. The recommendations generated for each farmer will be different, 'tailor-made', but in all cases the solution provided will result in the greatest return on the farmers' investment in fertilizer.

The 3 complementary OFRA tools

Step 1: First the **Fertilizer Optimisation Tool** (FOT) is used. Different FOTs have been developed for different agroecological zones in Ethiopia. FOTs were developed for different crops in the following AEZs:

- Cold to very cold sub afro Alpine, above 2500m
- Hot to warm moist lowlands N9 degrees
- Hot to warm moist lowlands South of 9 degrees
- Hot to warm sub-moist and drier lowlands, less than 1000m
- Hot to warm sub-moist and drier lowlands, 1000-1800m
- Tepid to cold humid mid highlands, 1700-2200m
- Tepid to cold humid mid highlands, 2000-2700m
- Tepid to cold moist mid highlands, 1700-2200m
- Tepid to cold moist mid highlands, 2000-2700m
- Tepid to cold sub-humid mid highlands, 1700-2200m
- Tepid to cold sub-humid mid highlands, 2000-2700m
- Tepid to cold sub-moist mid highlands, 1700-2200m
- Tepid to cold sub-moist mid highlands, 2000-2700m



Input data required from the farmer before optimization

The FOT currently runs on a laptop computer or tablet. The FOT is based on a Microsoft Excel spreadsheet. It uses Solver, a standard tool within the Excel spreadsheet which can be used to identify optimal solutions. An even simpler 'paper-based' version is being developed based on look-up tables that will need no electronic gadgets.

For the version currently available, using a laptop or tablet onto which the FOT has been loaded, the extension worker and farmer together enter the hectares of the various crops being grown, the price of fertilizers available, the expected price for crop outputs and how much money the farmer has to invest in fertilizer. They then press the 'optimize' tab.

The Excel Solver then generates a table showing how much of which type of fertilizer should be applied to which crops. The solution, expressed as kg of fertilizer per hectare, aims to maximize the financial return on the money spent on fertilizer.