More Profitable Fertilizer Use For Poor Farmers

By Crammer Kayuki Kaizzi, Charles S. Wortmann and Jim A. Jansen

Fertilizer use is often of low profitability compared with other uses of money available to finance-constrained farmers. Fertilizer use profitability varies with crop-nutrient choice, application rate, and fertilizer costs relative to commodity values. An optimization tool integrates 15 crop-nutrient response functions for Uganda to allocate available money to crop-nutrient-rate options expected to maximize net returns on the investment. This optimization approach is applicable to finance-constrained smallholder farmers globally once the relevant crop-nutrient response functions are known.

Low fertilizer use by smallholder farmers commonly constrains productivity. Many of these farmers do not have the financial capacity to use enough fertilizer to maximize net returns per hectare. High fertilizer costs and low commodity prices, associated with costly input supply and inefficient marketing, reduce profit potential. Competing needs for money often take priority when profitability of fertilizer use is inadequate. Such farmers need high net returns on their investments in fertilizer use.

Recommendations for non-finance-constrained fertilizer use commonly strive to maximize mean net returns per hectare. These recommendation approaches are inappropriate for financially constrained fertilizer use where purchasing capacity is inadequate to apply enough fertilizer to maximize net returns per hectare. Fertilizer use by finance-constrained smallholders, however, needs to aim at maximizing net returns on small investments in fertilizer use.

This is achieved by allocating fertilizer to an optimized choice of crop-nutrient-rate combinations. The profitability of different crop-nutrient combinations varies with the relative value of crops, the costs of fertilizer nutrients, the magnitude of each crop's response to an applied nutrient, and the shape of the response curve. Nutrient application rate is a consideration when crop response is curvilinear, with greater returns on finance-constrained investment with lower versus higher rates. Underlying this approach to fertilizer rate determination are robust crop-nutrient response functions. A method of optimizing across these response functions is then needed to determine the allocation of fertilizer investment to the crop-nutrient-rate combinations that maximize net returns on investment. The approach is valid for mono-culture cropping systems where several nutrients are considered, but is especially important when cropping systems are comprised of several crops.

An Example from Uganda

Research was conducted in Uganda with funding from the Alliance of a Green Revolution in Africa. Fifteen nutrient response functions were determined from the results of 80 field trials for corn, sorghum, upland rice, drybean, soybean, and peanut; and for N, P and K as appropriate for the crop (Kaizzi et al. 2012a b c). While the study used an incomplete design, N by P interactions were evaluated and the effects were found to be not significant. Some crop-nutrient combinations were more profitable than others (**Figure 1**). Application of at least a low rate of N to upland rice or to dry bean was much more profitable than other fertilizer uses. The response functions were curvilinear and the figure also illustrates the effect of application rate on profitability. It implies a need to determine combinations of crop-nutrient-rate that will give the best net return on the amount of fertilizer that the farmer can afford to use.

Abbreviations and Notes: N = nitrogen; P = phosphorus; K = potassium; ppm = parts per million.

A team of Ugandan soil scientists led by Dr. Kaizzi, center, conducted research to determine 15 crop-nutrient response functions that were then integrated by UNL collaborators into the Uganda Fertilizer Optimization Tool. Angela Nansamba, on the left, was a team member and is a graduate student supported by UNL through INTSORMIL.

Information such as in **Figure 1** can be used to prioritize crop-nutrient-rate options, in consideration of fertilizer use costs and expected grain values. Depending on which crops the farmer wishes to plant, application of a low rate of N to upland rice and bean may be of highest priority if the financial constraint is severe. With a less severe financial constraint, the priority options include additional N applied to rice and bean, some N applied to maize and sorghum, and some P applied soybean and groundnuts. With no financial constraint, fertilizer should be applied for each crop-nutrient combination that maximizes net return per hectare for the given fertilizer cost to commodity value ratios. To fully and more accurately use the information from the 15 crop-nutrient response functions, a more complex process of consideration is needed.

The Uganda Fertilizer Optimization Tool

To enable full optimization across the 15 crop-nutrient response functions, the Excel-Solver based Uganda Fertilizer Optimization Tool was developed (Jansen et al., 2013; http://cropwatch.unl.edu/web/soils/software). The tool considers the land area that the farmer wishes to plant for each crop, expected commodity values at harvest (accounting for both the values for home consumption and market), the costs of fertilizer use, and the finance available to the farmer for fertilizer use (**Figure 2**). The output includes the recommended fertilizer rate for each crop and the expected effects on crop yields and net returns.

Using the tool when the financial constraint is moderate or severe, the estimated net returns to the investment in fertilizer use are typically greater than twice as much as when fertilizer is applied to maximize net returns per hectare. The greater potential for profitability with the tool is expected to enable finance-constrained farmers to gradually break out of poverty and increase fertilizer use to the point of maximizing net returns per hectare.

This fertilizer use optimization approach was introduced to 60 government and non-government extension staff in Uganda with training for the remaining extension staff planned. Participants learned of the approach and underlying principles, use of the tool, and working with farmers in making recommendations.

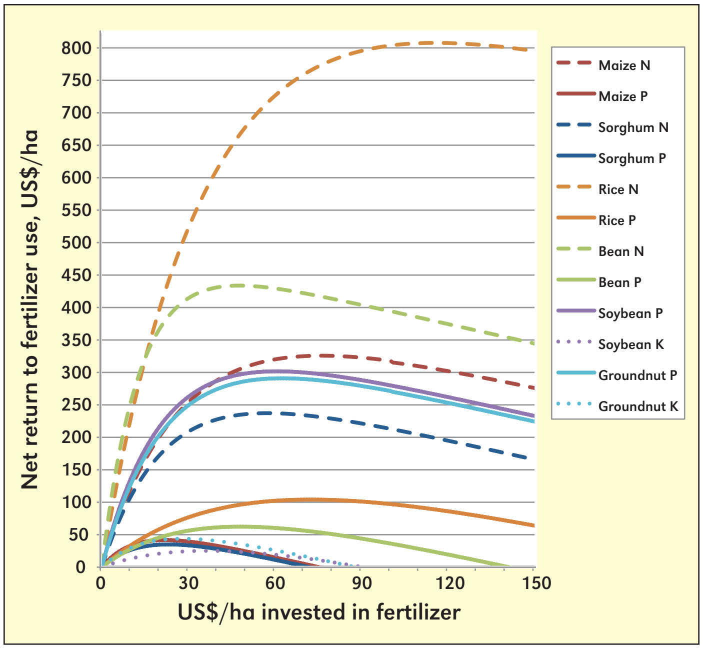
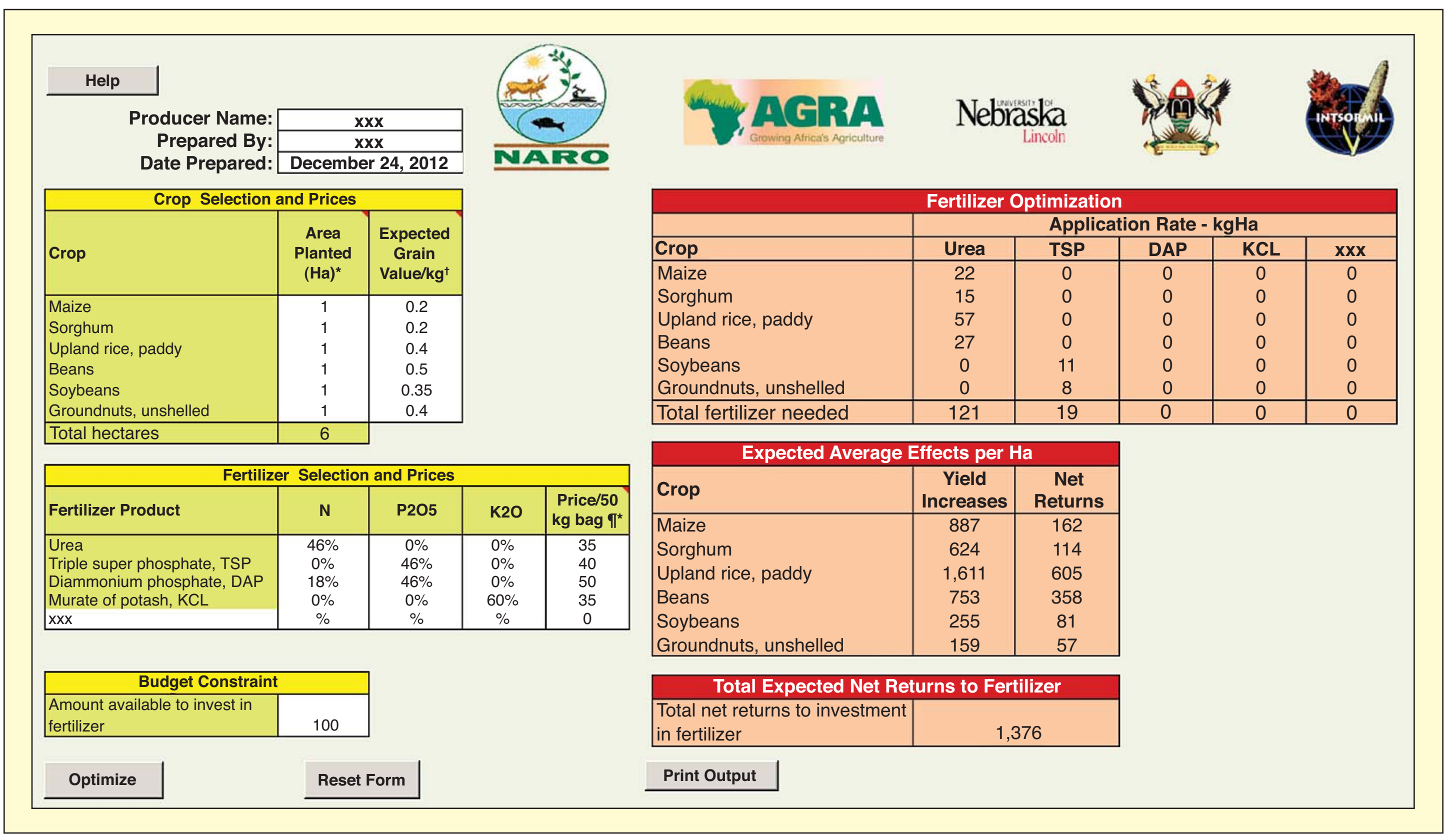


Figure 1. The profitability of fertilizer use varies greatly depending on which nutrient is applied to which crop and at what rate. Nitrogen applied to rice or dry bean were especially profitable options as shown in this figure. Profitability of crop-nutrient-rate combinations varies with per kg crop values and fertilizer costs; crops values used here were US$0.20, 0.20, 0.40, 0.50, 0.35, and 0.40 for maize, sorghum, rice, bean, soybean, and peanut, respectively; and costs of fertilizer use were US$1.50, 2.50 and 1.00, respectively for N, P and K.

Wider Applications

This fertilizer use optimization approach is applicable to more profitable fertilizer use for finance-constrained crop production throughout sub-Saharan Africa and other continents. The tool is also useful to those who have adequate access to credit or other finance for fertilizer use as it enables them to account for the effects of fertilizer use costs and grain values as needed to determine application rates for maximized net returns to fertilizer use per hectare. The crop-nutrient response functions will need to be determined for the appropriate crops in any other agro-ecological zone where this approach is applied. In the 80 Uganda trials, soil test information did not account for variation in response curves. However, Mehlich 3 soil test P was always <12 mg/kg (ppm) and exchangeable K was always >130 mg/kg indicating high and low probabilities



Crop Selection and Prices		
Crop	Area Planted (Ha)*	Expected Grain Value/kg†
Maize	1	0.2
Sorghum	1	0.2
Upland rice, paddy	1	0.4
Beans	1	0.5
Soybeans	1	0.35
Groundnuts, unshelled	1	0.4
Total hectares	6	

Fertilizer Selection and Prices				
Fertilizer Product	N	P2O5	K2O	Price/50 kg bag ¶*
Urea	46%	0%	0%	35
Triple super phosphate, TSP	0%	46%	0%	40
Diammonium phosphate, DAP	18%	46%	0%	50
Murate of potash, KCL	0%	0%	60%	35
xxx	%	%	%	0

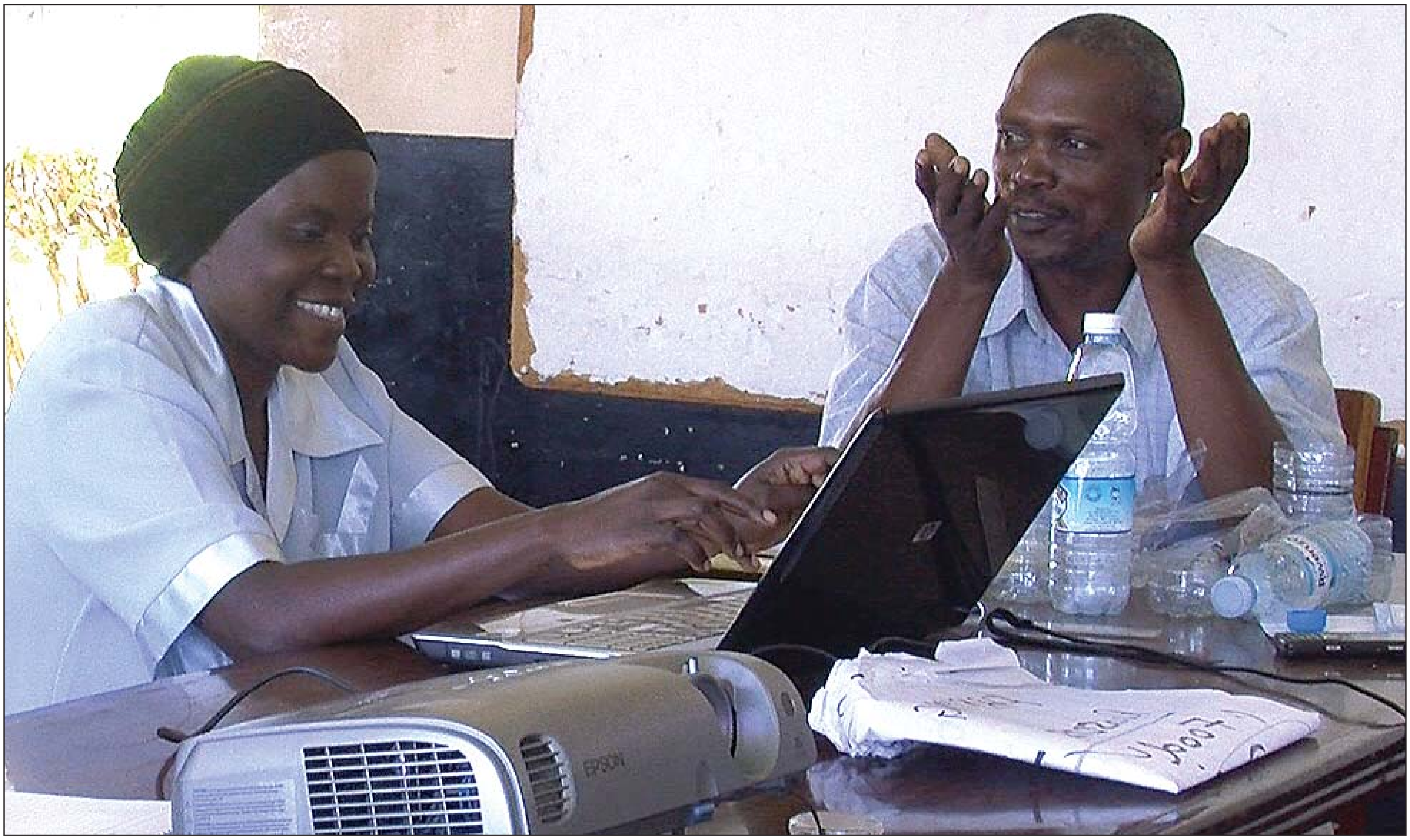
Budget Constraint	
Amount available to invest in fertilizer	100

Fertilizer Optimization					
	Application Rate - kgHa				
Crop	Urea	TSP	DAP	KCL	xxx
Maize	22	0	0	0	0
Sorghum	15	0	0	0	0
Upland rice, paddy	57	0	0	0	0
Beans	27	0	0	0	0
Soybeans	0	11	0	0	0
Groundnuts, unshelled	0	8	0	0	0
Total fertilizer needed	121	19	0	0	0

Expected Average Effects per Ha		
Crop	Yield Increases	Net Returns
Maize	887	162
Sorghum	624	114
Upland rice, paddy	1,611	605
Beans	753	358
Soybeans	255	81
Groundnuts, unshelled	159	57

Total Expected Net Returns to Fertilizer	
Total net returns to investment in fertilizer	1,376

Figure 2. Data input and output views of the Uganda Fertilizer Optimization Tool. Monetary values are in US$ (1US$ = 2,400 shillings).



Two participants involved in a role-playing exercise during training on the use of the Uganda Fertilizer Optimization Tool. The woman is assuming the role of an extension agent interviewing a farmer for input information and advising him of the fertilizer use recommendation.

for P and K response, respectively, for all site-seasons. In other places or for other crops, soil test information may need to be considered, either in the tool or separately. The optimization tool is now computer run but a cell phone application is being developed to improve farmer access to the optimization approach. BC

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