



Agriculture Challenges

Winter 2016

Increase Effective Use of Fertilizer

Increasing fertilizer use has the potential to lift millions of smallholder farmers out of poverty. Done effectively, fertilizer use has potential to increase yields for farmers in sub-Saharan Africa. In three months, pilot an evidence-based model that increases effective fertilizer use and reliably boosts the standard of living for 50 smallholder farmers, growing to 1000 farmers in two years. A successful plan will include continuous monitoring and testing, and a commitment to change if evidence suggests your approach is not working.

The problem: Most of the world's poorest people are smallholder farmers. There are at least 570 million farms worldwide, and at least 475 million of these being family farms less than 2 hectares in size.¹ In sub-Saharan Africa, agriculture accounts for 64% of the labor force. In rural areas, 75% of people living on \$1 a day work in agriculture.²

Unfortunately, crop yields produced by smallholder farmers in sub-Saharan Africa [remain well below their potential](#). For example, cereal crops grown in sub-Saharan Africa average 1.2 tons per hectare, while the developing world average is about 3 tons/ha.³ It is possible to bridge this gap. Farmers in South Asia during the "Green Revolution" implemented modern farm practices, and between 1961-2001 increased crop yield by 145%. Smallholder farmers in sub-Saharan Africa during that same time period increased crop yield by only 30%.⁴ Increasing the productivity of African smallholder farms has potential to lift millions of people out of extreme poverty.⁵

The proven solution: Fertilizer, when used effectively, has increased crop yields throughout most of the world. For example, increased fertilizer use contributed to 50% of the yield growth in Asia during their "Green Revolution" and is responsible for 33% of recent growth in worldwide cereal production.⁶ Currently fertilizer is used at a much lower rate among sub-Saharan African farms. African farmers use

1 Lowder, Sarah K., Jakob Scoet, and Saumya Singh. "What do we really know about the number and distribution of farms and family farms in the world?." Background paper for the State of Food and Agriculture 8 (2014).

2 Jack, B. Kelsey. "Market inefficiencies and the adoption of agricultural technologies in developing countries." (2013). p. 2

3 http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Africa.pdf

4 From figure in World Bank. Independent Evaluation Group, ed. World Bank assistance to agriculture in Sub-Saharan Africa: an IEG review. World Bank Publications, 2007. p. 70

5 World Bank. Independent Evaluation Group, ed. World Bank assistance to agriculture in Sub-Saharan Africa: an IEG review. World Bank Publications, 2007. p. 64

6 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 33

just 9 kg per hectare, compared to 104 kg in South Asia and 86 kg in Latin America.⁷ Increasing effective use of fertilizer in sub-Saharan Africa has potential to radically increase crop yields.

However, how to increase *effective* use of fertilizer in sub-Saharan Africa is still unclear.

Variables we know impact effectiveness

[Many approaches have been tried](#), with mixed results. One reason is that fertilizer's effectiveness highly depends on local variables, like crop type and region. A second reason is that local pricing and market conditions matter, and increased yield does not always result in increased profitability. These are the local conditions we've encountered in our research that can impact effectiveness:

- Local variables can impact effectiveness. Because fertilizer's effect can vary widely, farmers can have low incentives:⁸
 - Crop type matters: some crops have a much lower response to fertilizer.
 - Region and season matter: response to fertilizer varies considerably between locations and seasons. Farmers can face a risk of lost profit in some years and in some regions.
 - Other factors can matter: crop response is often limited by other factors such as lack of water.
- High cost of fertilizer can reduce farmer ROI. High transport costs, small markets lacking economies of scale, lack of a rural dealer network, and a lack of a competitive private sector can all lead to high input prices.^{9, 10}
- Farmers are exposed to high risk.¹¹ Bad weather can completely wipe out crop yields, and as can volatility in crop prices.¹² Because investing in fertilizer inputs might not pay off, farmers can face a disincentive to use it.¹³

Your solution will need to address these constraints within your local operating region.

Unknown variables that impact effectiveness

This challenge includes unanswered questions which could significantly alter the potential of your program. Your successful solution will need to address these unanswered questions:

- What are the factors contributing to low fertilizer use in your operating region, and how strong is each factor? Answering this would enable you to operationally target the most important factors.
- How optimal are existing levels of fertilizer use in your operating region (accounting for the rational risk aversion that farmers have)? If current levels are already optimal, changing fertilizer use rates without changing the costs and benefits could do nothing or even be harmful.

7 World Bank. Independent Evaluation Group, ed. World Bank assistance to agriculture in Sub-Saharan Africa: an IEG review. World Bank Publications, 2007. p. 75 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 18

8 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 61

9 World Bank. Independent Evaluation Group, ed. World Bank assistance to agriculture in Sub-Saharan Africa: an IEG review. World Bank Publications, 2007. p. 75

10 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 73

11 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 68

12 <https://www.povertyactionlab.org/sites/default/files/publications/Swarna.pdf> Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 68

13 Morris, Michael L. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank Publications, 2007. p. 70

- Given high variation in yields and soil nutrient availability, are farmers able to choose profitable amounts of fertilizer? If they cannot, changing the costs and benefits of fertilizer use may do nothing or be harmful.
- How dependent is the profitability of fertilizer on other inputs, such as irrigation on better seed varieties? If dependency is high, a fertilizer-only approach will do little.

Given the large variation in conditions for African farmers, any answers to these questions need to take account of geographic variation.

Key metrics to measure success

There are several categories of metric which you might use to evaluate program success:

- Yield indicators, such as % improvement in yield. This has a couple of weaknesses:
 - A farmer may increase yields whilst decreasing earnings if the cost of fertilizer required for increasing the yield are too high¹⁴
 - Yields are variable year-to-year, which means that unless you compare with a control, a yield increase may not be due to your intervention
- Income indicators, such as % improvement in earnings. This is better than measuring yield because it avoids the weaknesses listed above. However, the improvement in earnings could still be temporary, perhaps because of normal year-to-year variation.
- [Long-run standard of living indicators](#), such as asset accumulation or [Grameen Bank's 10 indicators](#). These show lasting improvement to farmers lives.

Metrics should be weighted so that gains to the poorest score more highly than the same gain to a richer person.

Your Challenge: We will award up to \$20,000 to a Distribution Entrepreneur who will reliably boost the standard of living of 50 smallholder farmers (cultivating land of 2 hectares or less) by increasing effective use of fertilizer. This must occur without causing increased risk of losses to any of the farmers. Winning entrepreneurs will have a vision for growing to support 1,000 farmers over two years.

Because there is no proven method for increasing effective fertilizer use, you must have a localized plan that can manage uncertainty, including:

- An evidence-based model which identifies the strongest factors that cause low earnings for farmers, specific to the region in which you will operate
- An evidenced-based model of how and why your intervention will boost earnings in the long run
- A plan for continuous testing and evaluation of the program
- A commitment to change the plan if the evidence suggests that the approach isn't working

It may be possible to combine this challenge with other D-Prize Agriculture challenges, such as *Teach Microsoding Technique* or *Scale Up Distribution of Quality Seeds*.

A successful team for this challenge will likely require previous experience in research and impact evaluation in international development, especially relating to agriculture, and previous field experience with agriculture in the region where you will operate.

¹⁴ Duflo, Esther, Michael Kremer, and Jonathan Robinson. "How high are rates of return to fertilizer? Evidence from field experiments in Kenya." *The American economic review* 98.2 (2008): 482-488.

Additional useful resources

- Overviews:
 - [World Bank Assistance to Agriculture in Sub-Saharan Africa: An IEG Review](#) by the World Bank
 - [Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines](#) by the World Bank
- In-depth research:
 - [J-PAL's agriculture research](#)
 - [Our folder of agriculture papers](#)
- Maps and data
 - [yieldgap.org](#) - an atlas of yield gaps
 - [Atlas of African Research and Development](#)

Ready To Start?

Download a First Round Application Packet at www.d-prize.org/application.pdf

Questions? Email the D-Prize team at help@d-prize.org