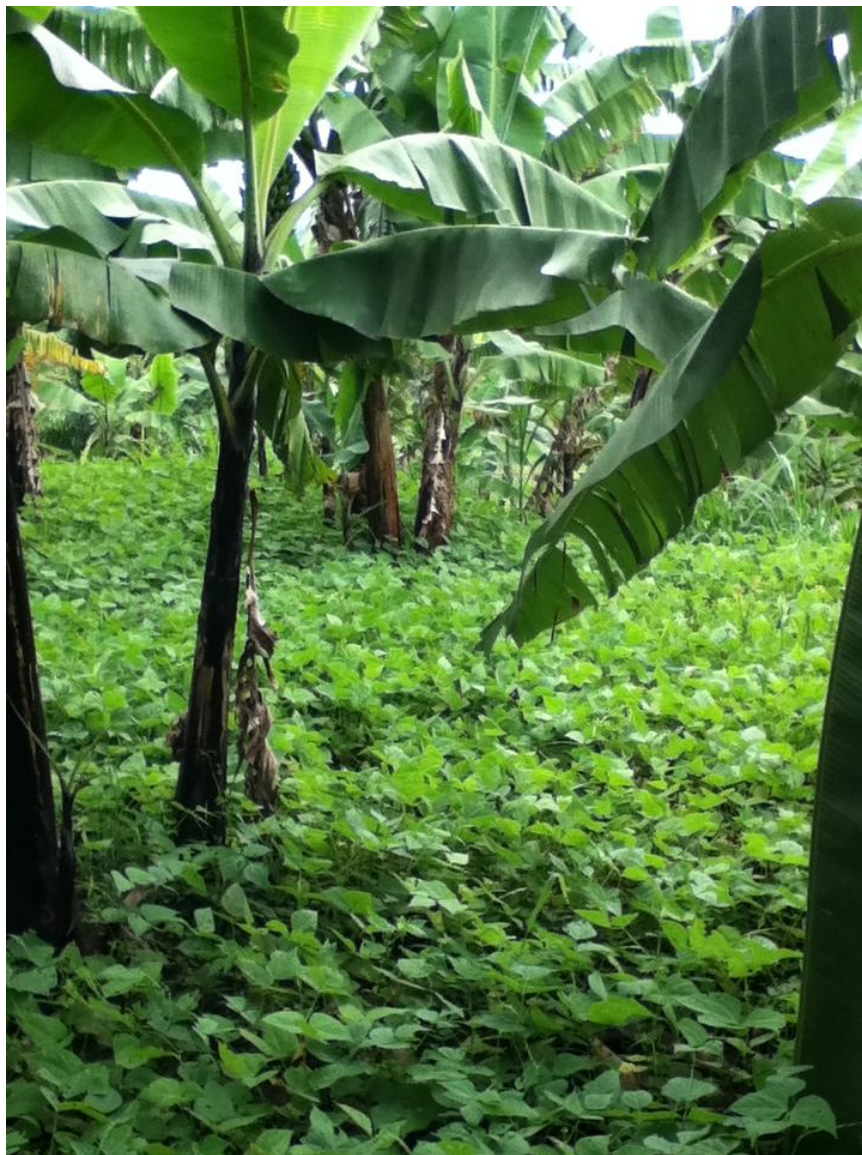


ONE ACRE FUND

Scaling Banana Agronomy for Smallholder Farmers

2015 Full-Scale Report



David Guerena/One Acre Fund.

Background

Banana (*Musa spp.*) is a major staple and food security crop for much of East Africa. Banana is estimated to be produced by over 30 million smallholder farmers in East and Central Africa, with bananas contributing to between 16 and 31 percent of caloric intake¹. The highland nation of Rwanda has some of the greatest concentrations of smallholder banana farmers in Africa. Banana production in Rwanda is estimated at over 3 million metric tonnes per year from around 374,000 hectares. Several types of bananas are cultivated in Rwanda: the “dessert” banana, eaten as a sweet fruit; the cooking banana, consumed as a starchy food; plantains, also cooked; and beer bananas, fermented into an alcoholic beverage. While the east and central African highlands are a global center of banana biodiversity, genetic gains have been recently made to improve the productivity of local banana cultivars. These improved cultivars are particularly important to protect against disease pressures. As bananas are vegetatively propagated, bulky, and perishable, the commercial dissemination of improved cultivars at scale is challenging. This report outlines the advancements in the banana program of One Acre Fund in Rwanda.

I. Results Summary

- **Partnerships:** One Acre Fund partnered with the Rwandan Agricultural Board (RAB) and the International Institute of Tropical Agriculture (IITA) to identify the most promising commercial and pre-commercial improved banana varieties and nutrient management techniques.
- **Variety trials:** One Acre Fund trialed three improved banana varieties (cooking and beer) as well as local varieties to determine the optimum variety selection.
- **Fertilizer trials:** One Acre Fund trialed three different nutrient management strategies for banana to optimize banana yield and farmer profit.
- **Yield impact:** One Acre Fund banana farmers are projected to receive an average of \$31 per year, or 472 percent return on investment.
- **Commercialization and delivery:** In the 2015/2016 season One Acre Fund worked with RAB and local tissue culture labs to offer the improved cooking variety, FHIA 17, at scale; 22,208 plants were sold to 2,676 farmers.

¹Abele et al., 2007.

II. Product Rationale and Approach

- **Purpose:** Bananas are a major part of the agricultural systems for smallholder farmers in Rwanda. Bananas provide stable high-value and high-nutrition produce that is not limited by seasonality.
- **Rationale:** Many high-yield and disease-tolerant improved banana cultivars have been generated. However, these cultivars have not been widely disseminated at scale. In addition, poor nutrient management for banana may be limiting yields.
- **Our approach:** We did extensive consultations with banana breeders and multipliers from RAB and IITA to identify high yield potential banana cultivars and nutrient management techniques. The improved cultivars and nutrient management systems were trialed on the fields of 100s of smallholder farmers to determine the yield potential, profit, and viability of these products at scale.
- **Commercialization:** One Acre Fund worked with our partners to commercially offer the banana product package at scale in the 2015/2016 field season.

III. Partners Consulted

One Acre Fund consulted with several public and private research centers and organizations with decades of banana breeding and agronomy experience (many of them funded by the Bill and Melinda Gates Foundation). The knowledge partners included:

- **RAB** – Basic agronomy, variety recommendations, genetic material supply
- **IITA** – Variety and agronomy recommendations

These organizations were extremely helpful and were excited to see their research being put into farmers' hands.

IV. Research phases (Phases 0-2)

One Acre Fund tested improved banana cultivars and nutrient management strategies in farmers' fields. The results of these trials are summarized below:

A. Phase 0: Research

The first stage of One Acre Fund product development cycle is a research phase that compares potential intervention configurations to our four product selection and evaluation criteria:

Table 1. Product evaluation criteria.

Criteria	Evaluation Question
Impact	<i>Can the product significantly increase client income?</i>
Adoptability	<i>Are a significant number of clients willing to purchase this product?</i>
Simplicity	<i>Is the product simple enough that all clients can achieve a consistent result?</i>
Operability	<i>Can we scale this product with a minimal increase in operational complexity?</i>

Preliminary surveying and exploration of the benefits of common improved common bean varieties was done prior to field research. A brief synopsis of the initial research is summarized below:

Table 2. Primary variety selection criteria for improved banana cultivars and nutrient management strategies.

Selection Criteria	Cooking Bananas	Beer Bananas
Yield	<ul style="list-style-type: none"> • Average yields: 30 t/ha per cropping cycle • Yield potential: 60 t/ha per cropping cycle 	
Reasons for yield gap	<ul style="list-style-type: none"> • Low soil fertility • Pests • Disease • Poor crop management • Water stress 	
Variety	<ul style="list-style-type: none"> • FHIA 17 • Mpologoma • Local 	<ul style="list-style-type: none"> • FHIA 25 • Local

One Acre Fund worked with the Rwanda Agricultural Board (RAB) and IITA to identify the most promising improved varieties of cooking and beer bananas.

Table 3. Improved banana variety trial experimental design.

Trial	Improved varieties	Control A	Control B	Cells	Districts	Participants
Beer Banana Varieties	FHIA 25	Existing local stand	New planting local	Manishya	Gatsibo	20
	FHIA 25	Existing local stand	New planting local	Muganza	Gisagara	20
	FHIA 25	Existing local stand	New planting local	Ruragwe	Karongi	16
Cooking Banana Varieties	Mpologoma	Existing local stand	New planting local	Kanyangese	Gatsibo	20
	Mpologoma	Existing local stand	New planting local	Murehe	Rwamagana	19
	Mpologoma	Existing local stand	New planting local	Rwesero	Nyamasheke	18
	Mpologoma	Existing local stand	New planting local	Gisanze	Karongi	12
	FHIA 17	Existing local stand	New planting local	Kibare	Rwamagana	20

B. Phase 2: On-farm Trial Configurations and Results

Variety

Ageographically diverse variety trial was conducted on the farms of participating farmers. The trial began in 2012. The field trials were established on farms with existing stands of local banana varieties, and farmers were encouraged to maintain these stands using their usual management practices. On another portion of the farm, farmers were requested to plant suckers from their best (farmer self assigned) local varieties. Concurrently, farmers were supplied with improved varieties, all sourced from RAB. All newly established suckers (local and improved) were planted using the One Acre Fund recommended practices: 2.5m spacing, pruned to have no more than 3 active suckers, and regular application of compost and mulch.



Photo 1. Banana tissue culture lab for the FHIA varieties, FAIM Africa. Kaitlyn Smoot/One Acre Fund.

Beer variety trial

The yields for both the improved practice and improved variety were significantly higher than the local practice and variety. On average, improving practice resulted in 24 percent yield increase, while improving both practice and variety resulted in a 141 percent yield improvement. Improving practice alone resulted in a 96 percent increase in farmer revenue while including improvements in both practice and variety resulted in a 486 percent increase in revenue.



*Photo 2. Improved planting spacing of banana suckers, Rwanda, 2012.
Kaitlyn Smoot/One Acre Fund.*

Table 4. Results from the improved beer banana multi-season field trial conducted by One Acre Fund, Rwanda from 2012 to 2015.

Treatment	Average fingers per bunch	Average fruit length (cm)	Average bunch weight (kg)	Bunches harvest per mat (March 2014 – July 2015)	Total yield (kg) [†]	Yield advantage (% relative to control)	Farmer preference (qualitative)	Bunches sold (%)	Expected income (USD/bunch)
Local variety – Mature stand	120	49.3	15.4	3.6	55.5	N/A	Low	38	\$1.3
Local variety – New stand	125	53.1	17.6	3.9	68.6	23.6	Medium	58	\$1.7
FHIA 25	300	78.6	39.2	3.6	141.1	154	High	78	\$3.8

[†]Difference significant, P<0.05

Table 5. FHIA 17 improved cooking banana multi-season field trial conducted by One Acre Fund, Rwanda from 2012 to 2015.

Treatment	Average fingers per bunch	Average fruit length (cm)	Average bunch weight (kg)	Bunches harvest per mat (Sep. 2014 – July 2015)	Total yield (kg) [†]	Yield advantage (% relative to control)	Farmer preference (qualitative)	Bunches sold (%)	Income (USD)
Local variety – Mature stand	117.7	56.2	23.1	1.64	37.9	N/A	Medium	23	\$2.8
Local variety – New stand	112.9	56.5	20.2	2.74	55.6	47	Medium	23	\$2.6
FHIA 17	188.1	80.2	40.8	2.48	101.2	167	High	29	\$5.2

Farmers First

†Difference between FHIA 17 and the local mature stand significant, $P < 0.05$. There are no significant differences between the local new stand and any of the other treatments.

Table 6. *Mpologoma improved cooking banana multi-season field trial conducted by One Acre Fund, Rwanda from 2012 to 2015.*

Treatment	Average fingers per bunch	Average fruit length (cm)	Average bunch weight (kg)	Bunches harvest per mat (Sep. 20142– July 2015)	Total yield (kg) [†]	Yield advantage (% relative to control)	Farmer preference (qualitative)	Bunches sold (%)	Income (USD)
Local variety – Mature stand	123.5	51.9	19	1.81	34.4	N/A	Medium	25	\$2.2
Local variety – New stand	112.7	51.9	17.5	2.74	48	40	Medium	20	\$2.2
Mpologoma	100.4	48.9	16.2	2.02	32.7	-5	High	33	\$2.2

Cooking banana variety trial

In 2012 a cooking banana variety trial was established in conjunction with the beer banana variety trial. Of both of the improved varieties trialed, only FHIA 17 resulted in significantly greater yields over the control. The FHIA 17 variety resulted in a 167 percent yield improvement while yields from the improved practices accounted for between 24 and 47 percent yield increases. Yields from the Mpologomavariety were not significantly different from the control.



Figure 3. FHIA 17 tissue culture plants established with the improved agronomic practices in western Rwanda. Kaitlyn Smoot/One Acre Fund.

Banana fertilizer trial

In 2014 a banana fertilizer trial was established to determine the yield impact of two different fertilizer sources. These fertilizers were NPK 17-17-17 and Yara Winner. These fertilizers were applied two times per year at the rate of 200g per mat (a cluster of shoots from one mother plant) per season to mature stands of local varieties, self-selected by farmers, of mostly mixed Intutsi and Nkazikamyé cooking varieties. At the end of a complete year the bunch weight of each of the fertilizers and a control were compared.

Table 7. Banana fertilizer response trial.

Treatment	Average fingers per bunch	Average fruit length (cm)	Average bunch weight (kg)	Yield advantage (% relative to control)
No fertilizer	108	54.1	17.7	N/A
NPK 17	121	56.7	19.0	7
Yara Winner	120	58.4	19.8 [†]	12

[†]Only Yara Winner was significantly greater than the control, $P < 0.05$.

While bunch weights with Yara Winner were significantly greater than the control, the yield differences were marginal.

V. Operability, Adoption, and Impact

Operability

Distribution of banana suckers or tissue culture seedlings does pose substantial difficulties at scale. The tissue culture labs in Rwanda are efficient and highly professional. However, young banana plants are very bulky and highly perishable. This has added to the transportation and distribution costs.



Figure 4. One Acre Fund farmers in Rwanda receiving young tissue culture banana plants. Kaitlyn Smoot/One Acre Fund.

Adoption

Despite positive yield gains from the improved banana varieties projected farmer adoption in the 2016 field season is relatively low. In 2016, 2,676 farmers purchased a total of 22,208 tissue culture plants. This represents a 3 percent adoption rate across our entire Rwandan program. However, product selection from farmers occurred prior to the completion of the variety trials. It is possible that for 2016, farmers had not yet seen the benefit of the improved varieties. Smallholder farmers are a very risk-averse group; it is possible that once farmers have seen the yield gains from the new varieties in Feb. 2016, there will be increased adoption rates in the 2017 field season.

Impact

For the 2016 field season farmers were able to purchase the FHIA tissue culture banana plants for \$1.05 USD per plant, delivered to within walking distance of their farms. We estimate the banana program will generate a return on



Figure 5. FHIA 17 harvested bunch. Kaitlyn Smoot/One Acre Fund.

Farmers First

investment for each farmer of between 470 and 525 percent over five years. However, this calculation only considers monetary value. Bananas are also high in vitamins and minerals, particularly vitamin A, so increasing banana yields can have positive effects on human nutrition and development.

Table 8. Five-year impact projection model of improved beer and cooking banana varieties.

Variety	Nominal profit (USD/mat after 5 years)	Nominal impact (USD/mat over 5 years)	Discounted impact (USD/mat over 5 years)	Discounted ROI [†] over 5 years	Avg. discounted impact (USD/mat/productive year)
Best Local: Beer	\$15.9	N/A	N/A	N/A	N/A
FHIA 25	\$30.7	\$14.5	5.5	527%	\$1.6
Best Local: Cooking	\$32.0	N/A	N/A	N/A	N/A
FHIA 17	\$45.4	\$13.3	\$5.0	472%	\$1.5
Best Local: Cooking	\$7.5	N/A	N/A	N/A	N/A
Mpologoma	\$4.6	-\$2.9	-\$1.6	-157%	-\$0.49

†Return on investment

Impact for the current fertilizer trial was less than the control. This was largely due to the increased costs of fertilizers were greater than the incremental yield gains. It is possible this was due to the methodology rather than bananas not responding to fertilizer.

Table 9. 1-year impact projection model of fertilization on banana yields.

Variety	Harvest value (USD/bunch)	Bunches/mat/year	Revenue (USD/mat/year)	Input cost (USD/mat/year)	Profit (USD/mat/year)	Impact (USD/mat/year)	ROI (%)
No fertilizer	\$2.3	1.06	\$2.5	0	\$2.5		

Farmers First

NPK 17	\$2.6	1.06	\$2.8	\$0.30	\$2.5	0	- 1.4%
--------	-------	------	-------	--------	-------	---	-----------

VI. Conclusion and next steps

Tissue culture bananas and agronomic trainings are already offered at scale in Rwanda through One Acre Fund. However, banana production in Rwanda clearly has ample opportunity for improvement. Irrespective of variety, improved agronomic practices can result in significant increases in yield and farmer impact. When improved varieties (the FHIA hybrids) are included with better agronomic practice, banana yields can double. However, low farmer adoption continues to be a major barrier to greater programmatic impact. In addition, bananas are perennial crops. They require multiple years to mature and bear fruit. Accurate evaluation of banana impact requires a long-term investment in on-farm research.

A. Yield and profit

This recent research cycle has demonstrated that considerable yield gains are possible for banana. However, the evaluation of fertilization and nutrient management for banana has not yet been conclusive. In the coming seasons, One Acre Fund will continue to investigate nutrient management strategies for bananas in conjunction with improved varieties and agronomic practices. In addition, One Acre Fund has been and will continue to evaluate tools to manage Banana Xanthomonas Wilt disease (BXW), which has entered into Rwanda and is devastating bananas across the country. Promising tools include tolerant or resistant varieties as well as cultural tools to manage infected plants and reduce the spread of the disease.

B. Farmer adoption

In 2016 alone, One Acre Fund will sell and deliver more than 20,000 tissue culture banana plants and banana agronomy training to thousands of smallholder farmers. However, despite these large numbers, only an average of 3 percent of total participating farmers purchased the banana package. Considerable variability exists in the adoption numbers between regions. The adoption of the banana product ranged from 2 percent to 12 percent. Understanding the adoption dynamics of improved varieties will be a critical component of the One Acre Fund research program in 2016 and beyond.

C. Operability at scale

Centralized distribution of young banana plants is challenging at scale. Young banana plants consist of tender vegetative leaves and are very sensitive to heat stress, physical damage, and water stress. Ensuring these negative situations are avoided while shipping 20,000+ plants across rural Rwanda is a logistical challenge. However, as banana plants are perennial and can be propagated through suckers, the delivery of tissue culture planting material may only be necessary for plant establishment. Once the mats are established farmers may continue to benefit from fertilizers and training materials, but may not need additional planting materials.

D. Next steps

In 2016, One Acre Fund Rwanda will:

- Continue to evaluate the yield potential of newer improved varieties.
- Evaluate the efficacy of alternative banana nutrient management strategies.
- Investigate effective strategies to manage and prevent the spread of BXW disease.
- Assess the drivers for adoption of the existing banana program.
- Continue to improve the efficiency of our banana delivery system to reduce costs and improve the quality of the banana plants delivered to farmers.