

ONE ACRE FUND
Improved Bean Seed
2015 Full-Scale Report



David Guereña/One Acre Fund

Background

Common beans (*Phaseolus vulgaris*) are the second most important crop in eastern, central, and southern Africa. These regions are the primary bean-growing regions in Africa, with a combined production total of almost 1 million metric tonnes¹. In rural smallholder communities in these parts of Africa, common beans are the most important source of dietary protein and an important source of vitamins and essential minerals. In addition, as beans are legumes, they play a critically important role in smallholder agroecology and soil fertility due to their ability to fix nitrogen into the soil. The importance of beans for health, farm productivity, and livelihood generation is greatest for the most vulnerable subset of smallholder farmers, particularly women, children, and the most impoverished families. An estimated 90 percent of bean production, storage, and trading is led by women. Despite the enormous importance of beans for African farming communities, bean production receives only a fraction of the formal investments in genetic improvement compared with investments in maize. Aggregate bean yields in Africa are commonly well below 1 tonne per hectare (t/ha) while yields in Asia and Latin America routinely exceed 2 t/ha. Over the past few years, One Acre Fund has been making major investments to bring the best bean varieties and agronomy to hundreds of thousands of smallholder farmers across Eastern and Central Africa.

I. Results Summary

- **Partnerships:** One Acre Fund partnered with the Kenyan Agricultural and Livestock Research Organization (KALRO), the Rwandan Agricultural Board (RAB), and the International Center for Tropical Agriculture (CIAT) to identify the most promising commercial and pre-commercial improved bean varieties.
Variety trials: In Kenya and Rwanda, One Acre Fund trialed eight different bush bean and nine different climbing bean varieties.
- **Yield impact:** Between USD \$135 and \$1,179, depending on the country and variety.
- **Commercialization and delivery:** In 2015 One Acre Fund worked with National Agriculture and Research Organizations (NAROs) and seed multipliers to successfully bring 25 and 66 metric tonnes of improved bean seed to scale in Rwanda and Kenya, respectively.

II. Product Rationale and Approach

- **Purpose:** Beans are an integral part of smallholder agroecology. They provide a nutritious, high-protein source of food, have higher market value than maize, and are capable of biological nitrogen fixation to increase the on-farm nitrogen economy.
- **Rationale:** Bean yields in Africa are chronically and substantially below yield potential. While there are many reasons for low bean yields, improved varieties are widely lacking across the region and may be an important step in increasing bean yields.
- **Our approach:** We did extensive consultations with bean breeders from KALRO, RAB, and CIAT to identify high yield potential commercial and pre-commercial varieties. Once the most

¹ Bationo et al., eds. 2011. Fighting poverty in Sub-Saharan Africa: The multiple roles of legumes in integrated soil fertility management. Springer, NY, NY, USA.

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promising varieties were identified, we conducted trials at a research station and on-farm field to verify the productivity potential across a wide range of conditions, and to collect farmer feedback on taste and preference.

- **Commercialization:** When the most promising varieties were identified, we worked with the NAROs and local seed multipliers to facilitate the commercialization of these varieties.

III. Partners Consulted

One Acre Fund consulted with several public and private research centers and organizations with decades of legume intercropping experience. These knowledge partners included:

- **KALRO** – Basic agronomy, variety recommendations, genetic material supply
- **RAB** – Basic agronomy, variety recommendations, genetic material supply
- **Kenya Seed Company** – Provided fertilizers and legume inoculants
- **CIAT - HarvestPlus** – Assisted with variety recommendations and supplied genetic material

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 bean seeds in the research station and in farmers' fields. The results of these trials are summarized below:

A. Phase 0: Research

The first stage of the One Acre Fund product development cycle is a research phase that compares potential intervention configurations to 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 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 common bean seed.

Selection Criteria	Bush beans	Climbing beans
Yield	- Average yields in Sub-Saharan Africa (SSA) are below 1000 kg/ha - Yield potential exceeds 2000 kg/ha	- Average yields in SSA below 1000 kg/ha - Yield potential exceeds 4000 kg/ha
Nitrogen fixation capacity	- Bush bean: 35 kg N/ha	- Climbing bean: up to 125 kg N/ha
Disease	- Major diseases include root rot (<i>Pythium</i> , <i>Fusarium</i> , <i>Rhizoctonia</i>), Angular Leaf Spot, Halo Blight	
Pests	- Bean fly, pod borers, foliage beetles.	
Seed color preferences	- Solid red or red-brown spotted seed coats.	

One Acre Fund contacted bean breeders in the Kenya Agricultural and Livestock Research Organization (KALRO), the Rwanda Agricultural Board (RAB) and at the International Center for Tropical Agriculture (CIAT) to determine the most promising pre-commercial climbing and bush bean varieties.

B. Phase 1: Research Station Configurations and Results

Research station trials focused on identifying the highest yielding improved bean varieties. A variety of factors were considered.

Seed variety selection

New varieties of improved bean seed were selected on the basis of yield potential, disease resistance, seed coat color, seed availability, and enhanced nutritional qualities. This was accomplished with the expert consultations of breeders from KALRO, RAB, and CIAT. Most of the selected bean varieties came from the genetic archives of one of these institutions. The one exception is Rosecoco in Kenya. Rosecoco is one of the commercially available bean varieties in Kenya. It is highly popular with farmers and has been around East Africa for many years. It is a brown and cream-colored seed with red spots. While many farmers prefer this variety, it has very little tolerance to root and foliar fungal diseases. Once selected, all the varieties went through an initial screening process at the research stations in Kenya and Rwanda. The results of these trials are below.



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Table 3. Variety trial configurations, Kakamega research station (phase 1) in the long-rain season of Kenya, 2015. All control varieties were KK8, 123.5 kg/ha and DAP was applied to all treatment and control plots.

Variety	Yield (kg/ha) [†]	Yield difference relative to the control (%)	P-Value	Profit difference relative to the control (USD/ha)
Control: KK8	280	NA		
CAL 33	150	-48	0.02	-\$40
KK15	250	-12	0.85	\$100
KK22	50	-82	<0.0001	-\$61
CAL 194	120	-44	0.05	-\$53
Red 13	150	-34	0.16	-\$29
Red 16	130	-40	0.08	-\$33

[†]In 2015 there was an outbreak of common bean mosaic virus on the research station. This may be the reason yields were low.

The 2015 research station variety trials in Kenya were largely inconclusive due to an outbreak of common bean mosaic virus (CBMV). CBMV is a viral disease of beans that can be present in western Kenya. The spread of CBMV in our research station trials reduced yields way below expectations. In 2016 this variety trial will be run again, screening for CBMV prior to installation.

The KK series of beans were developed by Dr. Ruben Otsyula at KALRO, Kakamega station in Kenya. The KK series are known to have good root-rot tolerance, however, they had not yet been commercialized. From trials in previous seasons KK8 consistently outperformed Rosecoco under root-rot conditions. While KK15 also performed well in previous seasons, it has a black seed coat. Farmers in western Kenya stated strong dislike for black-seeded bean varieties due to cultural aversion to the color it imparts on cooked food.



KK15 (left) and KK8 (right) seeds. David Guerena/One Acre Fund

C. Phase 2: On-Farm Trial Configurations and Results

Kenya

In 2014, an on-farm bush bean variety field trial was executed to determine the yield potential of the improved root-rot tolerant variety, KK8. This variety was tested relative to Rosecoco, a commercially available bush bean variety. The results of this trial are highlighted below:

Table 4. Phase 2 (on-farm) bush bean variety trial conducted in western Kenya (Bungoma South) in the long-rain season of 2014.

Trial	Configuration	Yield (t/ha)	Profit (USD/ha)	Profit Change vs. Trial Control
Control: Rosecoco seed, 124 kg/ha DAP at planting	211 farmers	0.213	\$662	N/A
KK8 bean seed: KK8 seed, 124 kg/ha DAP at planting	211 farmers	0.217	\$601	-\$61

Rwanda

In Rwanda several new lines of bean seed have been developed through the HarvestPlus program within CIAT. The HarvestPlus varieties were bred to be higher in nutritional iron than traditional varieties. In addition, RAB has developed several promising varieties of bush and climbing beans. In 2014 and 2015, One Acre Fund Rwanda conducted a series of on-farm field trials to evaluate the performance of improved bush and climbing bean varieties, both HarvestPlus and RAB varieties, relative to locally saved farmer seed. The variety trials were stratified along the prevalent agroecological zones in Rwanda.

Table 5. Phase-2 bean variety trial in the Bugarama agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Bush Bean	Local	Bush	600	660	1330	N/A	N/A	8%
Mac 44	HarvestPlus	Climbing	N/A	930	2190	N/A	N/A	37%
RWR 1668	RAB	Bush	1120	680	1540	1160	7.7%	30%
RWR 2245	HarvestPlus	Bush	1600	690	1450	1180	83.3%	41%
SER 16	RAB	Bush	N/A	N/A	N/A	1560	38.5%	N/A
KK8	KALRO	Bush	N/A	N/A	N/A	1520	25.0%	N/A

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Table 6. Phase-2 bean variety trial in the Eastern agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Bush Bean	Local	Bush	2450	1040	1700	NA	NA	5%
Mac 44	HarvestPlus	Climbing	3700	1300	2880	NA	NA	17%
RWR 1668	RAB	Bush	2780	1050	2110	2520	30.0%	19%
RWR 2245	HarvestPlus	Bush	3020	1590	2160	1900	0.0%	42%
SER 16	RAB	Bush	NA	NA	NA	3020	100.0%	NA
KK8	KALRO	Bush	NA	NA	NA	2540	20.0%	NA

Table 7. Phase-2 bean variety trial in the Central Plateau agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Bush Bean	Local	Bush	1680	1080	1360	NA	NA	16%
Local Climbing Bean	Local	Climbing	NA	NA	2060	NA	NA	10%
Mac 44	Harvest Plus	Climbing	NA	1370	2440	NA	NA	49%
RWR 1668	RAB	Bush	1420	1180	1960	1060	0.0%	32%
RWR 2245	HarvestPlus	Bush	1560	1180	1380	1180	33.3%	29%
RWV 1129	HarvestPlus	Climbing	NA	NA	1670	NA	NA	0%
SER 16	RAB	Bush	NA	NA	NA	1170	66.7%	NA
KK8	KALRO	Bush	NA	NA	NA	970	0.0%	NA

Table 8. Phase-2 bean variety trial in the Mayaga-Busera agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Bush Bean	Local	Bush	1240	1330	1280	NA	NA	3%
Local Climbing Bean	Local	Climbing	NA	NA	1940	NA	NA	0%
Mac 44	Harvest Plus	Climbing	1680	1490	2350	NA	NA	23%
RWR 1668	RAB	Bush	NA	1460	1840	1610	30.0%	30%
RWR 2245	HarvestPlus	Bush	1280	1580	1760	1550	0.0%	53%
RWV 1129	HarvestPlus	Climbing	NA	NA	1680	NA	NA	14%
SER 16	RAB	Bush	NA	NA	NA	1670	55.0%	NA
KK8	KALRO	Bush	NA	NA	NA	1580	30.0%	NA

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Table 9. Phase-2 bean variety trial in the Cyangugu agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Climbing Bean	Local	Climbing	1750	1660	1350	1750	60.0%	49%
Mac 44	HarvestPlus	Climbing	NA	NA	1230	NA	NA	25%
RWR 2245	HarvestPlus	Bush	NA	NA	710	NA	NA	13%
RWV 1129	HarvestPlus	Climbing	NA	1360	1200	1240	44.0%	11%
RWV 2269	RAB	Climbing	NA	1640	1370	NA	NA	41%
RWV 3316	HarvestPlus	Bush	1260	NA	710	NA	NA	19%
RWV 2872	HarvestPlus	Bush	NA	NA	1090	NA	NA	29%
CAB 2	HarvestPlus	Climbing	NA	NA	1060	1210	16.0%	13%
RWV 1348	RAB	Climbing	NA	NA	1760	1680	40.0%	100%

Table 10. Phase-2 bean variety trial in the Lake Kivu agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Climbing Bean	Local	Climbing	NA	640	NA	NA	NA	0%
Local (SHY)	Local	Climbing	1850	1920	3500	1240	31.3%	22%
Mac 44	HarvestPlus	Climbing	1340	1900	NA	NA	NA	38%
RWR 1668	RAB	Bush	NA	1150	NA	NA	NA	15%
RWR 2245	HarvestPlus	Bush	NA	1520	1490	NA	NA	14%
RWV 1129	HarvestPlus	Climbing	1800	1770	2520	870	17.6%	39%
RWV 2269	RAB	Climbing	NA	1760	3920	NA	NA	53%
RWV 2887	HarvestPlus	Climbing	NA	NA	2500	NA	NA	0%
RWV 2872	HarvestPlus	Climbing	NA	NA	2900	NA	NA	50%
CAB 2	HarvestPlus	Climbing	NA	NA	2520	700	0.0%	0%
RWV 1348	RAB	Climbing	NA	NA	3280	1070	26.3%	75%

Table 11. Phase-2 bean variety trial in the Congo-Nile agroecological region of Rwanda, 2014 and 2015 field seasons.

Variety	Source	Type	2014A (kg/ha)	2014B (kg/ha)	2015A (kg/ha)	2015B (kg/ha)	2015B preference	Average preference 14A-15A
Local Climbing Bean	Local	Climbing	2380	1480	1540	1280	25.0%	40%
Mac 44	HarvestPlus	Climbing	NA	NA	1120	NA	NA	11%
RWR 2245	HarvestPlus	Bush	NA	NA	920	NA	NA	13%
RWV 1129	HarvestPlus	Climbing	NA	1410	1280	1090	17.6%	36%
RWV 2269	RAB	Climbing	2350	1600	2580	NA	NA	43%
RWV 2887	HarvestPlus	Climbing	1480	1020	630	NA	NA	7%
RWV 3316	HarvestPlus	Bush	2220	750	1300	NA	NA	13%
RWV 2872	HarvestPlus	Climbing	NA	NA	1410	NA	NA	22%
CAB 2	HarvestPlus	Climbing	NA	NA	1000	800	0.0%	14%
RWV 1348	RAB	Climbing	NA	NA	1910	1460	26.3%	59%

Many of the improved varieties, particularly the HarvestPlus varieties, did not have greater yields than the local varieties. Of these varieties, MAC 44 and RWR 2245 had the most consistent yield gains above the local varieties and scored highest in terms of farmer preference. These two varieties were moved to full scale in 2015.

V. Operability, Adoption, and Impact

Kenya

In 2015, the KK8 package was offered at full scale to all 187,000 One Acre Fund farmers in Kenya. The product package consisted of 5kg KK8 seeds and 6.25kg DAP for each quarter acre. Farmers were allowed to purchase up to an acre in quarter-acre increments.

Operability

KK8 seeds had previously passed through the national performance trials in Kenya. However, the seeds were not commercially available through any seed company. This posed considerable challenges to take this product to scale. Foundation seed had to be acquired, a multiplier had to be identified, and the seeds had to be sorted and packaged. One Acre Fund worked with KALRO, who generously provided foundation seed from their stocks. We then identified and contracted with a local seed multiplier to produce and package the seed.

Adoption

In 2015, 15,300 One Acre Fund farmers in Kenya purchase the quarter-acre package for an average adoption rate of 8.2 percent. In total, we purchased 66 metric tonnes of KK8 seed.

We will offer the same product package to One Acre Fund farmers in 2016. We have currently enrolled over 280,000 farmers in Kenya for the 2016 season. Initial figures show that an average of 21,000 farmers have enrolled in the quarter-acre bean package; this represents a 7.5 percent adoption rate.

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In total, we have ordered 94 metric tonnes of KK8 seed for the 2016 season.

Impact

The KK8 bean program in Kenya had fairly high impact in 2015, with a commensurate return on investment for program farmers. However, the overall organization impact for the Kenya common bean program remains relatively small due to the low adoption rate for this program.

Table 12. Programmatic impact of the KK8 common bean program in western Kenya, 2015

Farmer group	Average bean yields (kg/ha)	Impact (USD/farmer)	Impact (USD/ha)	Return on investment (%)
One Acre Fund	445	\$149	\$433	498
Control	412	\$137	\$401	NA

Rwanda

In 2015, RWR 2245 bush beans were sold at full scale to 86,000 farmers. The climbing bean variety MAC 44 was sold in the eastern and southern districts and the climbing bean variety RWV 1129 was sold in Karongi district.

Operability

There are fairly established bean seed multipliers in Rwanda, and many of the main Rwandan varieties are already being multiplied by these seed producers. This has made the seed procurement process relatively easy. However, seed quality protocols from these producers have been relatively low. There are high proportions of “off-type” seeds (small, misshapen, bleached seed coats, cracked seed coats etc.) and foreign matter in the bulked seed. One Acre Fund has had to sort and repackage the seeds manually in-house, which has resulted in increased cost for farmers.

Adoption

In the main season of 2015, 4,813 farmers purchased RWR 2245 seed and 1,445 farmers purchased MAC 44 seed. This represented 5.6 percent and 3.3 percent adoption, respectively. However, adoption of improved bean seed ranged from 1 percent – 10 percent, depending on geographical area. In total, One Acre Fund in Rwanda sold 25 metric tonnes of improved bush bean in 2015.

Impact

Farmer profit numbers for the Rwandan improved bean seed program are relatively high. As farmers typically save bean seeds over multiple seasons, the profit values substantially increase in the second season. However, the overall programmatic impact data is relatively small (compared to the maize and fertilizer program). This is primarily due to the low farmer adoption for improved bean seed.

Table 13. Projected 2015 impact for the One Acre Fund, Rwanda bean program.

Variety	1 st season profit (USD/ha/year)	2 nd season profit (USD/ha/two years)	Number of farmers	Average land size under bean cultivation (ha)	Impact (USD)
RWR 2245	\$194	\$1179	4813	0.07	\$398,042
MAC 44	\$135	\$220	1445	0.17	\$54,043

VI. Conclusion and Next Steps

Common beans are the most important leguminous crop for farmers in East Africa. However, aggregate yields continue to be low across the region due to poor soil fertility and high pest and disease pressure. Unlike maize, there are improved bean varieties on the market, which may be a major contributor to low yields. Providing farmers with access to robust improved bean seed will continue to be a major organizational strategy.

A. Yield and Profit

- Rwanda – In Rwanda, bean yields are relatively high. However, many of the improved varieties have failed to show significant yield advantages over the local varieties. Variety screening will continue to be important to identify promising improved bean varieties that consistently show marked improvements over local types. In addition, as beans are legumes, optimizing biological nitrogen fixation may increase profit margins as nitrogen fertilizer use decreases.
- Kenya – Bean yields in Kenya continue to be a fraction of yield potential. However, despite the relatively low yields, profit margins for beans are high. Pest and disease pressure appear to be major drivers of reduced yields, particularly root rot and foliar fungal diseases. Identifying tolerant improved varieties may be a way to increase both yields and profit margins with common beans.

B. Farmer Adoption

- Despite the high prevalence of beans in both Kenya and Rwanda, adoption rates for improved seed continue to be low. In Rwanda, this may be due to a low product differentiation between the local and improved varieties with regards to yields. While the nutritionally fortified HarvestPlus varieties provide a social benefit, the higher nutritional content is a relatively intangible benefit for farmers. In Kenya, the persistent low bean yields (even with improved varieties) may be a reason for the low adoption.
- By continuing to evaluate the possible drivers for the bean yield gap, we may be able to overcome some of the adoption barriers.

C. Operability at Scale

- There are relatively few remaining barriers to the operability of scaling improved bean seed.
- Rwanda - In Rwanda, poor seed quality seems to be one of the major barriers to scaling improved seed. In addition, most of the current seed multiplication capacity is primarily

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devoted to the HarvestPlus varieties. Multiplication capacity for any non-HarvestPlus varieties is limited.

- Kenya - In Kenya, we have worked with an excellent local seed multiplier who consistently delivers high-quality products and services. The major problem in Kenya is access to disease-free foundation seed. There is a major outbreak of CBMV near the areas where foundation seed is produced. It is imperative that foundation seed be totally disease free.

D. Next steps

- Rwanda – RWR 2245 and MAC 44 will continue to be offered at scale in Rwanda for the 2016 field seasons. Concurrently, we will continue to evaluate promising new improved bush and climbing bean varieties as they emerge.
- Kenya – KK8 will continue to be offered at scale in 2016. As with Rwanda, the Kenya program will continue to evaluate new promising bush-bean varieties as they emerge.