AgResults Evaluation:
Uganda Legume Seed Pilot
Baseline Report

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Acronyms

CAPI	Computer-assisted personal interview
CI	Confidence interval
COMESA	Common Market for Eastern and Southern Africa
DFID	Department for International Development
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic information systems
ha	Hectare
ICC	Intra-cluster correlation
IQA	Initial qualitative assessment
ISTA	International Seed Testing Association
KAP	Knowledge, attitudes, and practice
kg	Kilogram
LSB	Local seed business
LSMS-ISA	Living Standards Measurement Surveys – Integrated Surveys on Agriculture
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
NAADS	National Agricultural Advisory Service
NARO	National Agricultural Research Organisation
NSCS	National Seed Certification Service
NGO	Non-governmental organisation
OWC	Operation Wealth Creation
QDS	Quality-Declared Seed
SCP	Structure, Conduct, Performance
UGX	Uganda shillings

Note to the reader

This baseline report was prepared as part of the external evaluation of the Uganda Legume Seed pilot. However in August 2018, just as the report was being completed, AgResults decided to terminate the Uganda Legume Seed pilot early. Nonetheless, we believe this report could prove useful to others still working to improve Uganda's seed sector. For one, we present a rich portrait of Uganda's legume farming households, their knowledge, attitudes, practices, and constraints. Further, the report presents the results of a seed quality assessment where we not only assessed seed quality among farmers who thought they were growing "improved" or good quality seed, we also carried out statistical analyses to investigate the factors associated with adoption of quality seed and, conversely, the characteristics associated with farmers' thinking they had adopted quality seed when in fact their seed was not of good quality. As other donors and Ugandan entities alike work to improve the local seed sector in the future, we hope that our research can benefit future seed sector reform efforts by providing insight into issues in the sector and determinants of quality seed adoption by farmers.

The Uganda Legume Seed pilot's original business plan, finalized in May 2014, described a pilot to "improve smallholder farmers' access to improved legume seed varieties in Uganda" with the aim of improving their income, nutrition, and soil health. It was hoped that the pilot would incentivize Ugandan seed companies to increase their legume seed production and sales by paying out a prize for year-over-year sales growth above a pre-set threshold.

In May 2015, when the evaluator undertook a scoping trip as the first step in the evaluation, interviews with key informants, including local seed sector experts, seed company executives, and government officials, revealed a pervasive problem: a large proportion of seed, including seed certified by the government as meeting quality standards, was counterfeit or adulterated and did not actually meet the standards. (The dynamics of this problem are discussed further in the report.) The seed quality problem meant that the pilot could have inadvertently rewarded seed companies for increasing their sales of poor quality seed into the market because there was no quality requirement beyond the ineffective government seed certification process.

In response, AgResults considered several options to mitigate the quality issue, eventually deciding to establish a partnership with a new third-party quality verification provider, AgVerify, which was starting operations at the time focusing on maize seed and other agricultural inputs. AgResults would provide AgVerify with funding to expand its quality verification operations to legume seed, and the support would be phased out as seed companies paid increasing proportions of the verification costs.

Despite AgResults' support, AgVerify did not prove to be a solution to the need for seed quality control. By mid-2018, a number of factors began to undermine AgVerify's viability, both as a partner for AgResults and more generally. The challenges included seed companies' concerns about the cost of AgVerify, their difficulty submitting seed that met quality requirements, internal organizational changes within AgVerify, and AgVerify's lack of government accreditation to issue seed certifications—this last issue meant seed companies effectively had to get their seed inspected twice, and it may also have given them pause because they were hesitant to do anything seen as not sanctioned by the government. AgResults terminated its contract with AgVerify in June 2018. Other proposed solutions were deemed infeasible, and the AgResults Steering Committee officially decided to terminate the pilot in August 2018.

Preface

AgResults is a $122 million multi-lateral initiative promoting the development and dissemination of high-impact agricultural innovations for global food security, health, and nutrition through the design and implementation of *pull mechanism* pilots. It is funded by the governments of Australia, Canada, the United Kingdom, and the United States, and by the Bill & Melinda Gates Foundation, and managed through a Financial Intermediary Fund operated by the World Bank. By using pull mechanisms, AgResults goes beyond traditional aid measures to promote the adoption of innovative technologies with high-yield development impact. AgResults provides economic incentives to private sector actors to develop and ensure the uptake of innovative technologies with the potential for high development impact. It helps overcome market failures impeding the establishment of sustainable commercial markets for such technologies, or goods produced by means of them. It thereby achieves substantial and sustained development impacts, including improved food security and food safety, increased smallholder incomes, and better health and nutrition. AgResults calls upon the ingenuity and drive of the private sector to identify and execute the most effective and efficient strategies to achieve development outcomes.

The AgResults initiative team comprises a Steering Committee, a Secretariat, a Trustee, country-specific Pilot Managers, and an External Evaluator. The Steering Committee oversees the implementation of AgResults and is composed of the five donor agencies and the Trustee. The Steering Committee is responsible for strategic oversight of the initiative, including endorsement of key management decisions, approval of concepts and business plans for proposed pilots, and monitoring of pilots and the initiative as a whole. The Secretariat is responsible for implementation of the initiative and reports to the Steering Committee. In order to fulfil its role effectively, the Secretariat maintains a close working relationship with the Trustee and External Evaluator. Core functions include appointing and managing pilot implementation and verification agents, developing and sourcing new pilots, and communicating results. As Trustee for AgResults, the World Bank provides an agreed set of financial intermediary services that include receiving, holding, and investing funds, and transferring them to recipients or other agencies for implementation as directed by the Secretariat on behalf of the Steering Committee.

The Steering Committee appointed Abt Associates Inc. to serve as External Evaluator for the AgResults pilots. Abt's role is to use rigorous scientific tools to determine if the pull mechanisms achieve their objectives—to measure whether they produce private sector behaviours and social outcomes different from, and better than, what would have happened in the absence of the AgResults initiative. In our role as the External Evaluator, Abt defines the overall evaluation framework for the AgResults initiative and an impact analysis strategy for each pilot. Our role will be vital to the AgResults learning agenda of understanding the potential of private sector involvement in the development and spread of agricultural innovation.

This report presents the findings from research that Abt conducted at baseline to evaluate the Uganda legume seed pilot. The Abt Uganda team is headed by Betsy Ness-Edelstein, Pilot Lead, who has worked closely with Dr Tulika Narayan, the AgResults evaluation Research Director, on overall research direction and adherence to the theoretical framework for the evaluation. Dr Denise Mainville is the Qualitative Lead. Miriam Kyotalimye serves as our Uganda-based Agricultural Economist. Dr Stephen Bell provided quality assurance on quantitative aspects of the evaluation. Dr Abigail Conrad provides guidance and feedback on smallholder-focused qualitative aspects of the evaluation. Dr Judy Geyer is the Quantitative Lead. Molly Brune supports the evaluation as a Research Analyst.

Executive summary

This report presents the findings of baseline research the Abt team conducted in late 2016 and 2017 for the evaluation of the AgResults Uganda legume seed pilot. The legume seed pilot aims to benefit smallholder farmers by catalysing a private sector-driven market for quality legume seed in Uganda, primarily through the use of pull mechanisms. The pilot aims to increase Ugandan smallholders' access to quality bean and soybean seed that offer higher yields (and, subsequently, the potential for increased consumption and income) compared to the local seeds that most Ugandan smallholders currently plant. Unlike traditional approaches to development, the pull mechanism aims to benefit smallholder farmers and create a sustainable market by offering incentives for national seed companies to increase their production and sale of quality legume seed. The incentive consists of an annual prize awarded to seed companies for increases in sales of quality legume seed over their previous year's sales. Participating seed companies participate in independent quality verification to ensure that companies are rewarded for selling high-quality seed. Quality verification is handled through AgVerify, an independent seed inspection and quality verification service that companies must subscribe to as a condition of their pilot participation.

The evaluation team will assess the impact of the pilot on private sector involvement in the legume seed market, quality of commercially sold legume seeds, smallholder farmers' uptake of quality legume seed and incomes, the pilot's cost-effectiveness, and the market's sustainability. It will also contribute to lessons learnt about best practices in the design and implementation of pull mechanisms generally.

Evaluation questions and research methods

Exhibit ES-1 presents the evaluation questions and the approaches we use to address them.

Exhibit ES-1. Evaluation questions and approaches

#	Evaluation question	Evaluation approach
1	What has been the impact of the pilot on private sector involvement in the development and uptake of improved legume seed?	Mixed methods using Structure, Conduct, Performance (SCP) conceptual framework; results from Evaluation Questions 2–3.
2	What has been the impact of the pilot on smallholders' uptake of improved legume seed?	Performance evaluation using pre-post quantitative data complemented by qualitative inquiries from key informant interviews and focus group discussions. Seed quality assessment to determine the quality of seeds that smallholders report as being 'quality.'
3	What has been the impact of the pilot on smallholders' incomes?	Performance evaluation using pre-post quantitative data complemented by qualitative inquiries using key informant interviews and focus group discussions.
4	What has been the impact of the pilot on poor consumers' demand for legumes and derivative products?	Not applicable.[1]
5	What evidence exists that the effects of the pilot will be sustainable in the medium to long term?	Combination of SCP and assessment of farmer demand.

#	Evaluation question	Evaluation approach
6	What is the evidence on the scale of any effect on private sector investment and uptake, and on the cost-effectiveness of the pilot as an approach?	SCP, with focus on market structure and per-unit cost-effectiveness of key outcomes.
7	What lessons can be learnt about best practices in the design and implementation of pull mechanisms?	Synthesis of results from Evaluation Questions 1-6; Compilation of results from all AgResults pilot evaluations.

[1] The legume seed pilot is intended to spur the market for legume seed only; the pilot does not aim to directly impact consumer demand for legumes or derivative products. In other words, it aims to shift the supply curve, not the demand curve. Therefore, we do not expect to see changes in demand for legumes due to the pilot in the time period of our analysis and have accordingly excluded this question from our evaluation.

The evaluation approach is designed to test the assumptions underlying the theory of change for the AgResults legume seed pilot using mixed methods, with tailored approaches for each evaluation question. Major themes of inquiry include how impacts may vary by location, gender, socio-economic profile, and relative access to quality legume seed as well as the role of the AgVerify scheme in facilitating the pilot.

To assess the pilot's impact on the development of the market for quality legume seed, including its sustainability, we employ the Structure, Conduct, Performance framework. SCP is a theory-based approach to conducting value chain or commodity systems analysis. The SCP framework links the underlying characteristics of a market to the strategic decisions that market players, including firms, smallholders, and consumers, make about whether and how to engage in the market. The strategic decisions of numerous firms give rise to the market structure, which includes the numbers and characteristics of market participants, the predominant marketing channels, and modes of product transformation and value addition. Together, these factors affect the performance of the market, including such considerations as whether the market for quality legume seed expands and whether it improves poor smallholders' access to and uptake of quality legume seed.

To evaluate the impact of the pilot on smallholders (specifically, on their uptake of and income from using quality legume seed), we employ a pre-post performance evaluation design, which allows us to assess what changes occurred between the beginning and the end of the pilot. We will incorporate both quantitative data from a survey of approximately 1800 smallholders at baseline and endline and qualitative data from in-depth interviews with a subset of survey respondents. We will also compare results from seed quality assessments conducted at baseline and endline using seed sampled from 300 farmers who report using quality legume seed at baseline and endline. This will account for the previously unknown (and hypothesized to be very low) level of actual quality of seed purported to be 'quality' seed in Uganda.

Because of the pilot's nationwide reach, it was not possible to design an impact evaluation with a control or counterfactual group that could attribute changes at the farmer level directly to the pilot. However, our performance evaluation will incorporate contribution analysis at endline. Contribution analysis entails searching for alternative explanations for changes detected between baseline and endline. It will entail the systematic application of logic to rule out external factors that could account for observed changes. This approach will allow us to reach an evidence-based conclusion about whether the pilot contributed to the observed changes, though it does not definitively establish attribution of impacts to the pilot.

The purpose of this report is to present baseline findings pertaining to each evaluation question.

Baseline findings for Evaluation Question 1: What is the impact of the AgResults pilot on private sector involvement in development and uptake of quality legume seed?

The basic conditions underlying the Uganda legume seed market are important to the evolution of the market once AgResults 'pull' incentives are put in place. As of 2016, those conditions included weak institutions—an ineffective certification system, an incomplete legal framework, and a culture of contract non-compliance— that increase transaction costs and risks of engaging in the market. Demand-side constraints included unpredictable and price-sensitive demand among buyers, and limited awareness of the benefits of certified legume seed among most smallholders, accompanied by more robust demand for certified seed among those smallholders that are cognizant of its potential benefits. Supply constraints included inadequate availability of breeder and foundation seed, lack of working capital among seed producers, and a high opportunity cost of money invested in legume seed production. Together, these conditions result at baseline in a risky market environment with limited profitability potential for national-level seed companies.

In response to these basic conditions, national-level seed companies have historically focused primarily on the hybrid maize market. They treat legume seed production and sales as a means of diversifying their portfolios, not as an attractive market in itself. National-level seed companies are conservative in their legume seed production decisions and differentiate their legume seed product offerings on the basis of quality to respond to the demands of different market segments. National-level seed companies and other legume seed value chain players undertake diverse strategies to try to protect themselves from quality shortfalls given the prevalence of low-quality and counterfeit seed—seeds sold as high quality that are not—in the market.

There are approximately 17 seed companies actively supplying government-certified legume seed throughout Uganda. They sell their seed to large institutions, agro-input dealers, farmers' organisations, and individual (usually commercial) farmers, selling from their head offices, distribution outlets, and in some cases through mobile distributors who deliver seed directly to the buyers. There are also more than 140 local seed businesses (LSBs) located throughout Uganda, selling Quality-Declared Seed (QDS, which is also government-inspected but meets a slightly lower set of quality standards) locally to farmers and some institutional buyers.

National-level seed companies source seed from contracted outgrowers working individually or in farmers' organisations or multiply it on their own land. Many also fill out orders for certified legume seed with grain purchased on the open market that is meant for consumption and does not meet quality requirements to be sold as seed. Seed company and industry experts estimate that from year to year, 50-90% of legume seed sold as 'certified' is in fact 'standard seed', the term used for grain that is falsely sold as seed. This estimate is confirmed by our own results, as detailed below. Institutional buyers are estimated to account for approximately 80% of formal legume seed purchases. Commercial distributors (agro-input dealers and seed companies who sell directly to farmers through their own distribution systems) account for the remaining 20% of formal seed purchases. Farmers rely primarily on informal sources such as their own saved seed, neighbours, or the local grain market for the legume seed that they plant, particularly for beans, and certified seed accounts for a small proportion of farmers' seed supply.

Uganda's legume seed market suffers failures at every level as a result of this set of issues, which together create adverse incentives to market actors, including national seed companies, leading them to under-produce quality legume seed relative to market and potential demand. Demand for quality seed at baseline is low, erratic, and undermined by the dominance of institutional purchasers. Supply is undermined by lack of foundation seed, capital constraints, and most importantly institutional failures with respect to quality

certification. The inability to certify the quality of improved legume seed creates a 'market for lemons.' The fact that there is no cost-effective means of differentiating between high- and low-quality seed on the market depresses the price that consumers are willing to pay for legume seed in general. This forces suppliers to move even further into low-quality seed production at a cost below the depressed market price (Akerlof 1970), further reducing the availability of higher quality seed.

Baseline findings for Evaluation Question 2: What has been AgResults' impact on smallholders' uptake of quality legume seed?

The pilot aims to increase smallholder uptake of quality legume seed both by ensuring the quality of seed sold under the pilot through AgVerify and by incentivizing private sector seed companies to increase sales. Companies will do this by raising awareness of their products and expanding marketing to smallholders. At baseline, the evaluation team assessed the pre-pilot adoption of seed that farmers self-reported as being quality seed, as a starting point for looking at these later changes. It also tested the actual quality of seed that farmers reported as being quality seed. The evaluation team will compare both adoption and seed quality levels from baseline to endline to gauge the changes in each that occur during the pilot.

The evaluation uses a knowledge, attitudes, and practice (KAP) framework to understand quality seed adoption. This framework posits that adoption of a new technology or practice, in this case quality legume seed, relies on smallholders' knowledge of quality legume seed and its benefits and their attitudes surrounding quality legume seed—from which their practice of using (or not using) the seed will flow. Based on survey data and in-depth interviews, the team found that smallholder knowledge of quality legume seed was fairly low at baseline—just over 20% of respondents reported being aware of any improved varieties of bean or soy (only improved varieties can be certified and sold as quality seed), and only 7.7% knew the name of any seed company that sells legume seed.

Smallholders who were aware of quality legume seed had generally positive attitudes about it. Smallholders tended to compare improved varieties of legume seed favorably to local varieties in terms of yield, germination, price for which the crops can be sold, resistance to drought/waterlogging, pest resistance, and disease resistance. They tended to favor local seed in terms of taste and the amount of fertilizer and other inputs required to grow the crop (i.e., they prefer the lower level of inputs required by local seed).

Among smallholders with direct experience growing certified seed prior to the pilot, attitudes were more mixed. In in-depth interviews, some smallholders mentioned concerns about counterfeit and expired seed. While some respondents reported positive experiences growing certified seed, at least as many described experiencing or hearing about certified, so-called 'quality' seed that had failed to germinate or yield well. This mixed view of quality seed among those who had tested it reinforces the importance of trustworthy quality verification, since a bad experience with 'quality' seed is likely to discourage farmers from using that seed again in the future.

In terms of practice, or actual uptake of quality legume seed, the evaluation team found that 22% of smallholders planted improved varieties in 2016 (defined as first-, second-, or third-generation seed of an improved variety of certified seed, whether it came from a retailer, government seed distribution, or another source). Household characteristics that increased the likelihood of planting quality seed included smaller household size, male headship, having a literate household head, needing a loan in the past year, and having an income that qualified the household as living below the poverty line. Smallholders in the North were also more likely to have adopted quality legume seed than those in other regions, perhaps reflecting the higher concentration of non-governmental organisation (NGO) and government aid throughout the North following years of war that ended in the mid-2000s. Qualitative findings support this interpretation—some smallholders who have adopted have gone to

retail shops and intentionally purchased seed, but most others say that the main source of their seed is government distribution.

Because of the extensive counterfeiting present in the Ugandan seed market, the evaluation team is also conducting seed quality assessments at baseline and endline to determine the actual quality of seed that is used by smallholders who self-report that they are using quality seed. In this context, quality seed is defined as seed of an improved variety that meets quality standards of the Common Market for Eastern and Southern Africa (COMESA). The evaluation team sampled seed directly from smallholders who reported that they were using 'improved' or 'quality' seed and had it tested for germination rate, moisture, and purity, the parameters that make up the COMESA standard for legume seed. At baseline, only 39% of the seed sampled met COMESA seed quality standards for Certified First Generation Seed, the requirement it must meet to be sold under the pilot. The rest failed to meet COMESA quality standards for one or more parameters.

Baseline findings for Evaluation Question 3: What has been AgResults' impact on smallholder income?

The pilot expects to impact smallholder income through increased legume yields, which should lead to increased quantities of legumes available to be sold and saved for home consumption. At baseline, the evaluation team assessed the role of legume production in smallholders' livelihoods prior to the pilot and the extent of smallholders' legume sales.

As expected, legume sales provided an important source of income for smallholders at baseline, establishing the potential for increases in smallholder income through a shift to higher quality seed engendered by the pilot's incentives. Sixty percent of households reported selling legumes in 2016, and those that sold legumes sold an average 41 percent of their harvest and earned an average of $85 from bean and soy sales combined, compared to an average of $268 earned from sales of agricultural production overall. These sales were fairly profitable: on average, annual legume profit (revenue net of input and labour expenditures for production) in 2016 was $65.

At the same time, legumes (particularly beans) formed a key part of smallholders' diets. Nearly all (99%) of households reported consuming beans during the past year, consuming them, on average, every other day. Furthermore, 43% of households reported purchasing beans for consumption in the past year, suggesting that if smallholders had better yields from their own crops they might be able to reduce or eliminate the amount they spend on bean purchases. The likelihood of households increasing their bean consumption in the future is unclear—households already report consuming beans fairly often (on half of all days), so it remains to be seen whether increased production, should it occur due to the pilot, would propel them to consume beans even more often. Smallholders expressed an interest in producing more legumes (especially beans) for both sale and consumption in the future, expressing competing priorities for saving versus consuming that they must navigate on a continuing basis according to household needs.

Baseline findings for Evaluation Question 5: What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to long term?

Three factors are likely to be important in determining the medium- to long-term sustainability of the pilot's impact on the market for quality legume seed: 1) government accreditation of the AgVerify initiative; 2) development of effective demand for quality legume seed; and 3) seed companies' ability to cost-effectively produce adequate volumes of quality legume seed. It would be premature to predict sustainability based only on baseline results. We will provide a more complete treatment of this evaluation question at endline and 2 years after the pilot as part of an AgResults-wide sustainability analysis.

Baseline findings for Evaluation Question 6: What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach?

This question is best answered after endline data are available to assess the scale of impact and the cost-effectiveness of the pilot.

Baseline findings for Evaluation Question 7: What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?

We expect to draw out lessons learnt throughout the pilot and to synthesize them at endline. At baseline, we highlight some early lessons regarding best practices in the development of viable pull mechanisms.

First, implementation of the Uganda pilot was delayed by a redesign, the need for which was recognized based on information provided by the evaluation team's Initial Qualitative Assessment (IQA). The evaluation team conducted a comprehensive value chain analysis, which resulted in the identification of previously unidentified issues in the pilot's design and operating context. These included the counterfeiting issues pervading Uganda's seed sector, which stemmed largely from the lack of a functioning quality certification system. This discovery led to discussions that resulted in the pilot's partnership with AgVerify to establish a seed certification for legume seeds, which will verify the quality of seeds sold to qualify for pull mechanism prizes. An important lesson learnt is the need to design pull mechanisms based on a careful and comprehensive value chain analysis. Such analysis needs to consider not only the structure of the underlying market (in this case the legume seed value chain) but also the constraints and motivations of actors participating in the value chain and its institutional context.

The IQA also revealed that industry actors had critical feedback on certain facets of the pilot design, including its prize structure. The pilot redesign largely addressed these concerns, apparently increasing seed companies' enthusiasm for participating in the pilot. An important lesson learnt from this, then, is the need for careful vetting of the pilot design with private sector actors along the value chain, particularly those to be targeted as implementers, or 'solvers', as well as other industry experts.

Next steps

The evaluation team will continue to monitor pilot implementation and the evolving implementation context as part of its ongoing qualitative assessment. We will be particularly attuned to adjustments to the pilot design and implementation activities, tracking these and proactively considering how they might affect the pilot's impact. We will also monitor the evolution of other seed sector interventions in Uganda, as well as government involvement in the market for legume seed, such as its continuing distribution of bean seed as part of Operation Wealth Creation, the government's signature agricultural development initiative. Our research will consider potential implications of these activities not only for pilot impact, but also for the challenges or opportunities they offer for evaluating the pilot's impact and expanding the AgResults learning agenda more generally.

Beginning in early 2021 (barring unanticipated changes to pilot design that might necessitate a shift in the evaluation timeline), we will prepare for endline data collection and analysis.

1. Overview of the AgResults legume seed pilot in Uganda

This report presents the results of baseline research Abt Associates conducted from August 2016 through July 2017 as part of our evaluation of the AgResults legume seed pilot in Uganda.

The pilot aims to increase Ugandan smallholders' access to quality legume (bean and soybean) seeds—i.e., improved varieties of legume seed that are certified for quality and are higher yielding than the seeds most Ugandan smallholders currently plant. Currently, most smallholders plant local varieties, many of which are actually improved varieties descended from certified seed that has been replanted for so many seasons that it no longer retains the beneficial characteristics of the improved variety from which it descended.

Several factors have historically inhibited seed companies' investments from expanding their production of quality legume seed. First, demand is highly variable from year to year, and orders are rarely made in advance of production. This keeps seed companies from developing realistic sales forecasts on which to base their production decisions. Instead, they make conservative production decisions to mitigate the risk of producing more seed than they can sell and thus losing money. Second, financing constraints keep seed companies from expanding their production of seed. They have lower interest and ability to invest significantly in the legume seed market given the trade-off between the legume seed market and the larger, more profitable hybrid maize market. These factors combine to suggest unmet demand for quality legume seed.

Additionally, the prevalence of counterfeit and low-quality seed being marketed as certified seed suggests a lack of effective quality assurance mechanisms. The inability to signal the quality of legume seed effectively makes the legume seed market a 'market for lemons.' In other words, there is no cost-effective means of differentiating between high- and low-quality seed on the market, which depresses the price that consumers are willing to pay for legume seed in general. This forces suppliers to move even further into low-quality seed production at a cost below the depressed market price (Akerlof 1970).

To attempt to change this pattern, the AgResults legume seed pilot offers incentive payments to participating seed companies based on their increased year-over-year sales of quality legume seed.

A note on seed characteristics and terminology

A legume is considered to be of an 'improved' variety if it descends from seed that has been developed and released through Uganda's National Agricultural Research Organization (NARO). Seed is 'certified' if it has earned the certification of the National Seed Certification Service (NSCS) of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). MAAIF certification is meant to represent an assurance that seed meets Uganda's standards for seed quality which, following the regional COMESA standard, specifies threshold requirements for seed purity, moisture content, and germination rates. All certified seed produced by seed companies in Uganda is legally required to be both an improved variety and certified by the NSCS. AgResults uses the same quality standard for the pilot. However, since legumes are self-pollinating (not hybrid), their progeny can be replanted for two to three seasons before they lose the characteristics they were bred for. This means that legume seed can still be considered of good quality even if it is the second or third generation of a crop that descended from certified seed, as long as it was sorted and stored properly. For this reason, the evaluation will use the term 'quality seed' to refer not only to certified seed but also to seed that is multiplied from certified seed and replanted for up to three seasons.

Locally, the different terms for seed (e.g., improved, quality, certified) are often used interchangeably, complicating efforts to quantify adoption at baseline. Furthermore, smallholders often acquire seed without knowing its official name or origin, and seed produced by seed companies is often separated from its original packaging and given a local name before smallholders receive it, making it impossible to know for sure if what smallholders think is 'improved', 'certified', or 'quality' seed truly is. In collecting data on seed usage, enumerators were trained to discuss the seed in some detail with respondents to help determine how to categorize it according to the evaluation's definitions. We asked respondents both about whether their seed was an improved variety and whether it was certified, and found that respondents often used 'improved seed' as a broad category that represented everything that was not 'local seed', or seed that had been present in local markets for many years.

This report is organised as follows. The current section presents the Uganda legume seed pilot's objectives, design, and theory of change, followed by an overview of the legume value chain in Uganda. Section 2 presents a summary of the evaluation questions and the designs and methods we use to address each one. Section 3 discusses the data the evaluation team gathered and analyzed at baseline. Section 4 then presents baseline findings pertaining to each evaluation question. Section 5 concludes by discussing the timeline for further analysis and reporting.

1.1 Pilot objectives

The AgResults initiative aims to offer the right incentives to the right market actors to overcome the most crucial bottleneck preventing a well-functioning private sector market for a given technology. Pull mechanisms provide incentives for private sector actors to work creatively to achieve development goals. Unlike traditional approaches to development problems, which tend to rely on grants, loans, and technical assistance to 'push' stakeholders and beneficiaries down pre-determined paths to desired outcomes, pull mechanisms are agnostic with respect to the specific inputs and processes that stakeholders choose to adopt. Rather, they reward achievement of pre-defined results without preference for strategies and technologies involved in achieving those goals.

1.2 Design of the pull mechanism

The AgResults pilot in Uganda offers results-based financial incentives to national seed companies ('solvers' in AgResults parlance) to expand their production and sales of quality legume seed; AgResults pays these incentives only when the results are achieved. These incentives reward efforts and seek to mitigate the risk of aggressively expanding production, motivating participating seed companies to take a long-term view of their investment in the market. The seed companies are responsible for building demand for quality legume seed, which will require sustained investment in their marketing and promotion, among other areas. The pull mechanism design in Uganda includes the following incentives provided to all qualifying seed companies:

- **Annual prizes proportionate to increases in sales of quality legume seed:** Cash payments proportional to increases in sales are intended to increase returns to expanding sales as well as enable reinvestment in the market; for example, supporting expenditures on marketing, packaging, staffing, and certification.[1]

[1] Implementers are eligible to receive a cash prize equal to 20% of the value of increased seed sales during the pilot year, provided that they are able to demonstrate an 8% or greater increase in sales of eligible legume seeds relative to the previous year's sales level for that period. Increases in sales of more than 20% over the previous period's sales are not eligible for the cash

- **At-cost provision of refrigerated storage:** This component is intended to reduce costs and risk of aggressively expanding production by facilitating carry-over of stocks to the following season.[2]
- **Subsidized participation in the AgVerify[3] third-party seed quality verification system:** This aspect of the pilot is intended to offset the cost of participating in the AgVerify initiative, and is intended to be phased out over the life of the pilot.

To counteract the counterfeiting and quality problems that curtail development of the seed market, AgResults has arranged for AgVerify to provide a third-party quality verification system in addition to the certification. In order for legume seed sales to be counted towards the cash incentive, the seed must be certified for quality, either through AgVerify or a random quality check. The initial design required 100% of sales to undergo the quality verification process throughout the pilot, but this requirement was loosened due to AgVerify's potential capacity constraints. Instead, an increasing proportion of seed sold, growing from 60% in the first year to 100% by year 5, must be quality-certified by AgVerify, and random samples of non-AgVerify seed will be subject to laboratory-based quality testing.

1.3 Pilot theory of change

The pilot's theory of change (Exhibit 1-1) posits that, when there is a means to verify seed quality (the AgVerify initiative) coupled with financial incentives that reward increased sales and effectively increase expected revenue and mitigate the risk of investing in the production and marketing of quality legume seed, seed companies will increase their investment in the market. This investment would enable greater production and wider distribution of high-quality seed and the establishment of effective and sustainable distribution channels for legume seed. As awareness and availability of quality-verified improved legume seed increase, seed companies will increasingly meet existing unmet demand for quality legume seed. Furthermore, seed companies' marketing investments and efforts to develop distribution channels, coupled with the effects of witnessing the benefits of quality legume seed among neighbours, should lead smallholders who did not previously participate in the formal legume seed market to develop demand for quality legume seed as well. As increasing numbers of smallholders procure the seed (either through their own purchases from commercial suppliers or from institutional sources of seed such as development projects), plant it, and realise its yield and profitability benefits, a sustainable market for quality legume seed should emerge. Because legumes are self-pollinated, they can be replanted for up to 3 years before they need to be refreshed. Even so, the pilot's design expects that continuous introduction of new varieties will create demand for each new variety and make legume seed a profitable business line for seed companies.

The potential development impacts for smallholders include increased legume yields, higher income from legume sales, higher consumption of legumes, and greater soil health (legumes

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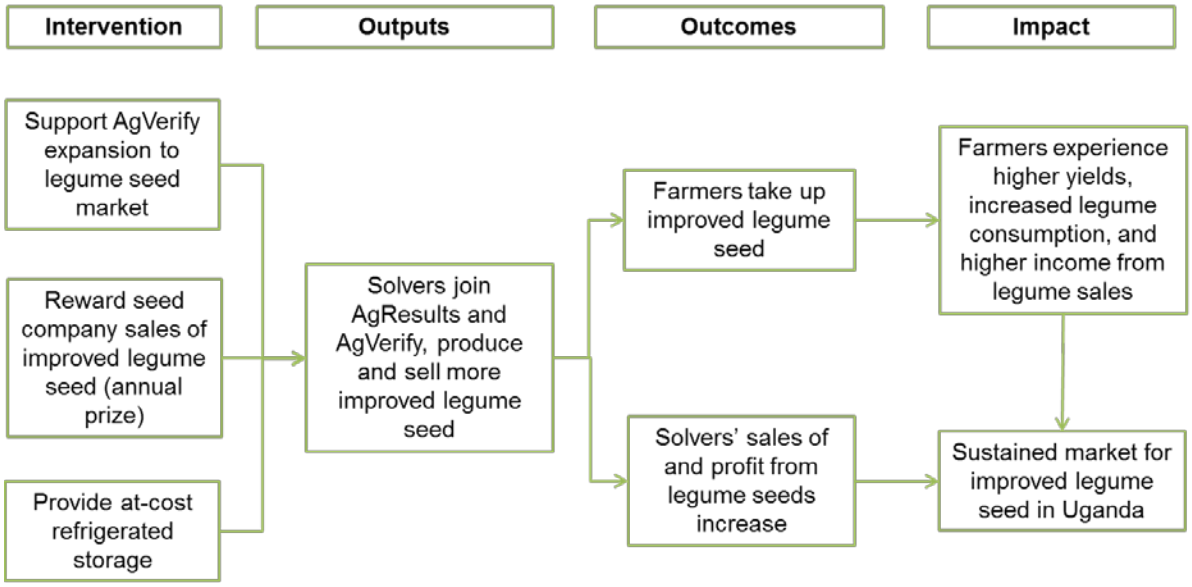
prize. Implementers' sales are verified by a third party as part of the pilot application and verification process.

2 This component may be described as a 'push' element of the design. The original pilot design would have had the Pilot Manager dispose of unsold seed after each season to prevent it from spoiling and being sold despite being spoilt. The provision of cold storage achieves the same goal—preventing spoilt seed from entering the market—without having to destroy seed.

3 AgVerify, which launched in 2016 with verified products first being marketed in the 2017A season, will complement the services of Uganda's NSCS. AgVerify provides independent quality assurance for seed via field inspection, laboratory testing, and training for companies who pay to use its service. AgVerify currently verifies quality of maize and legume seed, and products meeting its COMESA-based quality standards will bear a label attesting to their quality as well as a scratch-off that allows buyers to verify the legitimacy of the label through an SMS (text message) exchange with AgVerify.

are nitrogen-fixing crops, improving soil fertility). Under ideal conditions, yield increases could be as high as 40% (AgResults 2014), though the actual improvements could be lower because many factors affect yield. At a household level, yield increases will likely translate to higher legume-related income and increased availability of legumes for consumption.

Exhibit 1-1. Uganda legume seed pilot theory of change



Note: The AgResults Secretariat's officially stated goals for this pilot extend only to the point of increasing the availability (not adoption by smallholders) of quality legume seed in Uganda. However, in keeping with the overall objectives of the AgResults initiative and the specific evaluation questions we are charged with answering, this evaluation traces out the theory of change beyond seed availability. Our theory of change posits that smallholder adoption and subsequent benefits from quality legume seed are in fact integral components in the success and sustainability of the pilot.

Several key assumptions (and accompanying risks) underlie the pilot's theory of change, some of which the pilot can influence but, in large part, that cannot be controlled by the pilot. The most prominent are highlighted here:

- **Assumption: a sufficient portion of the legume seed sold under the pilot will remain in Uganda (as opposed to being exported) to enable smallholders to represent the main group of end-users.** The Uganda pilot does not explicitly require participating solvers to market or sell their seed to smallholders, nor does it restrict seed exports. There is therefore the potential that some seed will be exported or sold to relief agencies that export it for distribution in neighbouring countries facing humanitarian crises, such as South Sudan or the Democratic Republic of the Congo.
- **Assumption: AgVerify certification will ensure a high-quality product, and consumers will trust that certification.** AgResults funded AgVerify to put a robust plan in place to verify the quality and legitimacy of legume seeds in Uganda. However, the private sector verification approach is untested in Uganda. It may encounter some of the same pitfalls that the NSCS has encountered or encounter new problems unique to private sector verification—in other words, it may still be possible for quality issues to persist. This could happen if AgVerify's initiative becomes overwhelmed by volume, if its funding falls short of what is needed to provide comprehensive seed inspection and testing, or if corruption or tampering occur. Furthermore, AgVerify has the difficult job of earning consumers' trust in a country where counterfeiting is rampant. Farmers must trust that the higher price associated with AgVerify certification is worth paying. The pilot assumes that AgVerify, individual seed companies, or both will find ways to convince smallholders that AgVerify certification is worth paying for.

- **Assumption: there truly exists significant latent demand for quality legume seed among smallholders.** Ugandan smallholders are largely unaccustomed to purchasing legume seed from the formal market. Purchasing seed from private sector companies would be a significant shift in behaviour for most smallholders, who are used to saving their own seed, purchasing it locally from neighbours or the grain market, or receiving free or subsidized seed from NGOs and the government. Furthermore, particularly with regard to common beans, some rural Ugandans cite strong taste preferences for the beans they grow using their own saved seed. This may be less of a challenge for soybeans, which are not commonly grown for consumption but rather are produced commercially in most cases, which creates a stronger profit incentive for smallholders to invest and increase productivity in soybean farming.
- **Assumption: legume seed availability and quality are true binding constraints inhibiting improvements in legume production and sales.** The pilot's overarching objectives of increasing the availability of quality legume seed to smallholders rests on the assumption that limited availability of quality legume seed is a significant enough factor limiting legume production that alleviating that shortage will increase production. This implies that other factors, such as availability and utilization of complementary inputs (such as fertilizers and pesticides) are themselves not binding constraints, or that their roles as constraints will also be alleviated with increased availability of quality seed. For example, producers will be more inclined to purchase and use complementary inputs if their efficacy will be increased through planting seeds of higher yield potential.

Prior to arriving at the above-described pilot design, the pilot went through a redesign of several of its elements between preparation of the initial business plan, finalized in May 2014, and the pilot's launch in February 2017. We discuss some of the key changes in Section 4.6 as part of our continuing synthesis of lessons learnt (Evaluation Question 7).

2. Evaluation purpose, questions, and methods

The evaluation of the AgResults Uganda pilot, like the other AgResults pilot evaluations, ultimately seeks to answer questions designed to test the key components of the pilot's theory of change.

Exhibit 2-1 presents the seven evaluation questions and the methods we employ to answer them. Our evaluation approach for Uganda conforms to our overall theoretical framework for evaluating all the AgResults pilots. Preliminary research that informed the mix of specific evaluation methods we are employing in Uganda began with a careful reading of the pilot business plan and subsequent pilot design updates, extensive desk research, and formative research trips to Uganda in May 2015 and March 2016. We held discussions with DFID and the AgResults Steering Committee in September 2016, and prepared a detailed evaluation design report for DFID in October 2016, incorporating DFID's detailed technical feedback into the final version of the design in February 2017. The seed quality assessment took place from August to December 2016, while other qualitative and quantitative data collection took place between March and June 2017.

Exhibit 2-1. Evaluation questions and approaches

#	Evaluation question	Evaluation method
1	What has been the impact of the pilot on private sector involvement in the development and uptake of improved legume seed?	Mixed methods using Structure, Conduct, Performance (SCP) conceptual framework; results from Evaluation Questions 2–3.
2	What has been the impact of the pilot on smallholders' uptake of improved legume seed?	Performance evaluation using pre-post quantitative data complemented by qualitative inquiries from key informant interviews and focus group discussions. Seed quality assessment to determine the quality of seeds that smallholders report as being 'quality.'
3	What has been the impact of the pilot on smallholders' incomes?	Performance evaluation using pre-post quantitative data complemented by qualitative inquiries using key informant interviews and focus group discussions.
4	What has been the impact of the pilot on poor consumers' demand for legumes and derivative products?	Not applicable. [1]
5	What evidence exists that the effects of the pilot will be sustainable in the medium to long term?	Combination of SCP and assessment of farmer demand.
6	What is the evidence on the scale of any effect on private sector investment and uptake, and on the cost-effectiveness of the pilot as an approach?	SCP, with focus on market structure and per-unit cost-effectiveness of key outcomes.
7	What lessons can be learnt about best practices in the design and implementation of pull mechanisms?	Synthesis of results from Evaluation Questions 1–6; Compilation of results from all AgResults pilot evaluations.

[1] The legume seed pilot is intended to spur the market for legume seed only; the pilot does not aim to directly impact consumer demand for legumes or derivative products. In other words, it aims to shift the supply curve, not the demand curve. Therefore, we do not expect to see changes in demand for legumes due to the pilot in the time period of our analysis and have accordingly excluded this question from our evaluation.

The evaluation approach is designed to test the assumptions underlying the theory of change for the AgResults legume seed pilot using mixed methods, with tailored approaches for each evaluation question. Major themes of inquiry include how increased adoption and income may vary by location, gender, socio-economic profile, and relative access to quality legume seed suppliers, as well as the role of AgVerify in facilitating the pilot.

To assess the pilot's impact on the development of the improved legume seed market, including its sustainability, we employ the Structure, Conduct, Performance framework.[4] SCP is a theory-based approach to value chain or commodity systems analysis. The SCP framework links the underlying characteristics of a market to the strategic decisions that market players, including firms, smallholders, and consumers, make about whether and how to engage in the market, given their perspectives on the underlying market conditions. The strategic decisions of numerous firms give rise to the market structure, which includes the numbers and characteristics of market participants, the predominant marketing channels, and modes of product transformation and value addition. Together, these factors affect the performance of the market, including such considerations as whether the market for improved legume seed expands and whether it benefits nutritionally vulnerable consumers.

To assess changes at the smallholder level (specifically, their uptake of and income from using improved legume seed), we will complete a performance evaluation using both quantitative and qualitative data. We will also perform a seed quality assessment, detailed in the next section, to account for the unknown (and likely very low) level of quality of seed sold as 'improved' in Uganda. In overview, our approaches to the various evaluation questions are as follows:

To answer Evaluation Question 1 on the impact on private sector involvement in the market for high-quality legume seed—we apply the SCP framework to develop and test qualitative hypotheses regarding the effects of the pilot incentive on private firms' perceptions of, participation in, and outcomes in the market for quality legume seed. Data for Evaluation Question 1 draw from key informant interviews with actors from all levels of the value chain and from diverse market actors including seed companies, agro-input dealers, smallholders, and sector experts in government and the development community; small-sample surveys of actors along the legume value chain; and data collected from smallholders to answer Evaluation Questions 2 and 3. As the pilot progresses, it will also draw heavily on pilot monitoring data on legume seed production and sales. Our SCP analysis differentiates results on the basis of the type of legume seed being targeted, private sector actors, and region, and includes analysis of the relative roles of the AgVerify certification scheme and the AgResults initiative in the development of the market for quality legume seed over the pilot period.

To answer Evaluation Questions 2 and 3 on smallholder uptake of quality legume seed and subsequent changes in income—we employ a performance evaluation using a pre-post design to compare outcomes before and after the pilot. We supplement this with qualitative research on smallholders' knowledge, attitudes, and practice (KAP) to understand smallholders' conduct and decision making with regard to legumes. We couple this with a

[4] The SCP paradigm is a product of the Industrial Organisation school of economics (Caves 1987; Scherer & Ross 1990). The use of SCP as an evaluation tool was pioneered by John Holtzman of Abt Associates (Holtzman 2003). The seminal SCP framework delineates how the underlying conditions in a market influence the market's structure, which in turn influences individual firms' conduct in the market (such as decisions to invest in new market segments and technological and organisational decisions). Individual firms' decisions, at an aggregate level, lead to market performance outcomes of interest such as the adequacy of a product's supply in terms of volume and quality, prices, returns to investors, and responsiveness to consumer demand. Building on the basic SCP framework, Sutton (1992) introduced the practice of examining how endogenous and exogenous sunk cost investments influence industry structure. This approach will be applied in the current analysis; it recognizes that firm strategic conduct is a direct response to market conditions and that aggregation of the outcomes of firm strategic behaviour gives rise to market structure.

national seed quality assessment. Results from these investigations will also inform Evaluation Question 1.

Because of the pilot's nationwide reach, it was not possible to design an impact evaluation with a control or counterfactual group that could attribute changes at the farmer level directly to the pilot. Therefore, we have designed a performance evaluation, rather than an impact evaluation, to address these questions. As a result, we will be able to assess changes that occur during the pilot period but will not be able to causally attribute those changes to the pilot. Given this, contribution analysis will be our primary approach to ensuring rigour and to assessing the *likely* contribution of the pilot to observed changes.[5] Contribution analysis is an approach to reaching conclusions about whether a programme or intervention is likely to have contributed to observed results based on a preponderance of evidence that events did or did not play out as intended according to the programme's theory of change. It is a structured way of synthesising information to reach evaluation conclusions. We will use it to structure our consideration of primary and secondary data that we collect throughout the evaluation to determine whether a preponderance of evidence suggests that the pilot has contributed to observed outcomes. Our use of contribution analysis recognises that, because identifying a causal effect is impossible given the context of this pilot, our best option is to identify its likely contributions.

To answer Evaluation Question 5 on the pilot's sustainability—we will draw on results of Evaluation Questions 1 through 3 to examine the sustainability of the pilot's impact. In particular, we will examine whether conditions are right for the market developments the pilot stimulates, if any, to continue after cessation of the direct pilot incentives; that is, whether the preconditions for a sustainable market have been established or not. Qualitative contributions to the evaluation of sustainability will come from the SCP and farm-level analyses, and will focus on whether the basic conditions that provide incentives for continued private sector and smallholder engagement in the market are present. We will also conduct a 'sustainability' survey several seasons after the end of the pilot to assess whether seed companies are selling, and smallholders are continuing to purchase and plant, improved legume seed.

To answer Evaluation Question 6 on the pilot's scale and cost-effectiveness—we will determine the scale of improved legume seed activity in the market. In particular, we will investigate the extent to which the improved legume seed market is truly national and spans a range of buyers or whether companies have instead made 'boutique' investments and limited their efforts to specific market segments. We will assess the cost-effectiveness of the pilot at endline when the total project costs are known, by estimating the cost of the pilot per unit of impact (smallholder uptake and income changes) measured in response to Evaluation Questions 2 and 3.

To answer Evaluation Question 7 on best practices and lessons learnt—we will synthesise results from Evaluation Questions 1 through 6 to determine where the pilot intervention worked well and where it did not. Using a common framework across all AgResults pilots, we will also identify and draw lessons from the design and contextual conditions that influenced the pilot's outcomes and relate what has happened in Uganda to the learning from the other AgResults pilots.

The remainder of this report presents baseline findings pertaining to each evaluation question.

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[5] For more background on the use of contribution analysis as an evaluation tool, see http://betterevaluation.org/en/plan/approach/contribution_analysis.

3. Data sources

In this section we discuss the data sources used in the current baseline report, the methods used to frame and select qualitative and quantitative data collection samples, and the nature of the data we collected from each source along with the data collection process used including quality assurance measures. We also describe how the data we collected from each sampled population contribute to the overall evaluation. We begin with a discussion of our qualitative data, which we collected through a combination of semi-structured individual or group interviews with respondents from across the legume seed value chain. We then turn to the quantitative survey data, drawn from the structured survey of farming households across Uganda. Then, we discuss our seed quality assessment data, which we gathered by sampling seed directly from farmers. Finally, we summarize secondary geographic information system (GIS) data we incorporate throughout the evaluation to add depth and context to our findings.

3.1 Qualitative data

Qualitative data collection to address baseline aspects of Evaluation Questions 1, 2, and 3, as well as Evaluation Question 7 to some extent, took place between April and June 2017, coinciding with the signing of grant agreements with solvers who had applied to participate in the pilot. During this time, we collected in-depth interview data from critical players in the legume seed value chain, including:

- National-level private seed companies (many of which were AgResults implementers)
- Potential legume seed buyers (including smallholder farmers, commercial farmers, farmer groups, NGOs, and agro-industry)
- Legume seed producers (including NARO producers, local seed businesses, and individual and farmer group outgrowers of national-level, private-sector seed companies)
- Agro-input dealers
- Other legume seed sector experts in the government, academic, NGO, and donor communities.

3.1.1 Sampling, sample size, and geographic distribution

For non-smallholder value chain actors, we selected samples designed to represent the diversity of regions within Uganda and the various actors in the legume and legume seed value chains. At the national level, we interviewed representatives of national seed companies, including all but one prospective pilot implementer; as well as representatives of development initiatives and major institutional buyers of seed. Those interviews helped to provide overarching insights into the market and supported triangulation of data and findings from the market actor interviews.

Within each of Uganda's administrative regions, we interviewed regional seed producers (such as LSBs) or distributors (such as seed retailers or wholesalers based in the major cities). We also interviewed seed producing bean and soybean farmers (also known as outgrowers) and agro-input dealers in two communities of each of the administrative regions. We selected communities and respondents purposefully to capture diversity in the importance of bean and soybean in seed producers' livelihoods and in the local economy and agro-ecosystems (for example major producing areas versus marginal ones), and in the presence or absence of development initiatives supporting bean or soybean production. Within each community we spoke with seed producing farmers of varying scales and commercial orientations, being sure to capture diversity in terms of gender, location, and participation in membership organisations and development initiatives. We identified individual candidates for data collection in consultation with local extension officers and

through referrals solicited within the community. Exhibit 3-1 shows the composition of our overall qualitative sample by respondent type.

Exhibit 3-1. Qualitative sample by respondent type

Respondent type	Total
National-level seed companies	12
Other seed sector stakeholders (industry, government, NGO, donor, academia)	12
Potential seed producers	
Individual outgrowers for seed companies (small or large farmers)	7
Farmer group outgrowers for seed companies (small or large farmers)	5
Local seed businesses	6
Individual outgrowers for NARO	2
Agro-input dealers	22
Potential seed buyers	
Cooperatives/farmer groups	7
NGOs	2
Commercial farmers	2
Legume offtakers and processors	1
Smallholder farmers (non-outgrowers; see detail below)	47
Total interviews	**125**

To select smallholder farmers (the pilot's primary assumed end-user group) for baseline interviews, we followed a non-probabilistic, multi-stage sampling plan. We selected respondents from among the households in the quantitative sample (described in detail in Section 3.2) to enable purposive sampling from the different categories of interest. Selecting respondents in this way also enabled richer analysis by allowing us to parse and categorize qualitative data based on household characteristics collected in the quantitative survey. We selected a total of 47 smallholder households from sub-populations defined by:

- Household head gender (38 respondents from male-headed households, 11 respondents from female-headed households)
- Respondent gender (to ensure that both female household heads and women in male-headed households were represented; 26 male respondents, 21 female respondents)
- Prior use of quality legume seed (30 respondents with no prior use, 17 respondents with some level of prior use)
- Region (15 in Northern, 10 in Western, 11 in Eastern, 11 in Central).

Our small, purposive sample is intended to capture key differences between sub-populations and a wide range of common experiences and cultural concepts, but should not be construed as statistically representative of a larger population or generalizable.

We interviewed some respondents individually, but we conducted most interviews in small group settings to allow for a larger sample within the available time. Group interviews were segregated by gender to encourage female respondents to respond freely.

Exhibit 3-2. Number of smallholder interview participants (individual and group interviews) by region

As outlined in Exhibit 3-2 and Exhibit 3-3, we applied the sampling plan described above to study sites across Uganda's four major regions (Central, Northern, Eastern, and Western).

Exhibit 3-3. Number of smallholder interview participants (individual and group interviews) by adoption and gendered household type

Quality legume seed adoption level	Gender (respondent/ household head)	Total
No prior use	Male	16
	Female (male-headed household)	8
	Female (female-headed household)	6
Low, medium, or high prior use	Male	10
	Female (male-headed household)	2
	Female (female-headed household)	5
Total		**47**

3.1.2 Data collection and analysis

The evaluation team's Qualitative Lead and Uganda-based Agricultural Economist pre-tested interview guides for non-smallholder respondents and then conducted interviews. Data were collected through face-to-face interviews at the site of each respondent's legume-related operations or at smallholders' homes or common village spaces. Further detail on data handling and quality assurance are presented in Annex A.

We analysed non-smallholder respondent data using descriptive statistical methods and pattern analysis, which permitted identification of patterns and divergences among similar market actors with respect to early hypotheses, and further investigation of emerging and unexpected results. The Pilot Lead and Research Analyst coded and analysed smallholder data using NVivo. We first analysed the coded data using exploratory text analysis techniques to explore common patterns, cultural categories, themes, and outliers. We then used more structured content analysis to explore common and divergent responses between different smallholder groups and to test emergent patterns and findings.

3.2 Quantitative household data

From March to May 2017, we conducted a structured survey of 1714 smallholder households in Uganda, 1499 of which were sampled randomly from a national frame and 215 of which had provided seed samples as part of the seed quality assessment several months earlier. We used this two-part sampling approach because the larger sample of 1499 was selected to be representative of Uganda's farming population in bean-growing regions and thus forms the basis of most of the statistics presented in this report. We also surveyed many of the farmers who had provided seed samples so that we could also investigate the relationship between household characteristics and the quality of seed they use, as determined by the seed quality assessment.

The survey gathered data on respondents' household characteristics; agricultural production; awareness of improved legume varieties, certified seed, and seed companies; legume purchasing and consumption habits and preferences; and income and poverty profiles. We will use these data, along with data from an endline survey of the same households that we plan to conduct towards the end of the pilot's implementation, to measure changes in the adoption of quality legume seed, subsequent changes in yield, consumption, and income from legume sales between baseline and endline. In the current report, we use the baseline survey data to establish baseline levels against which to compare changes in farmer outcomes at endline under Evaluation Questions 2 and 3.

We also gathered GIS data on households' distance from roads and markets as well as key climatic and soil factors, which are likely to impact legume yields and income. We matched the GIS data to household survey data using coordinates corresponding to survey respondents' locations.

3.2.1 Sampling, sample size, and geographic distribution

Because the pilot is nationwide, we designed the household survey sample to be representative of all legume-farming households in the nation, drawing from districts in all regions of Uganda. Ideally, we would survey a random sample of smallholders within many villages, selecting villages with probability of selection proportional to the amount of legume seed planted in those villages. However, there does not exist a sample frame for households, and we do not have village-level data on legume planting. Instead, we used data from Uganda's National Agriculture Census on legume production by district as a proxy for the quantity of legume seed planted.[6] The village-level sampling probability was directly proportional to a district's share of total national legume production. Each village within a district, however, had the same sampling probability because we did not have legume production data for villages. We cannot know ex-ante which of the villages may be targeted by AgResults-related efforts. By drawing a random sample of villages from districts in all regions in the country, we hope to obtain a representative mix of farmers reached by AgResults-related efforts.

After selecting the villages, we used linear systematic sampling to select households for interviews within each village. The field teams selected a starting point (such as a church, school, hospital, or water source) and then sent four interviewers out in four opposing directions. These enumerators walked through the village asking every household at a pre-determined interval to participate, screening out households that had not cultivated land within the past year, as the population of interest was agricultural households only. In this case, each interviewer started with the 5th household and then selected every 10th household along the walk pattern.

[6] National data on legume seed planted are not available, but data on legume production serve as a good proxy.

The preferred respondent was the household member who is primarily responsible for making decisions about the household (i.e., the household head). If the household head was not available immediately or by appointment, the enumerator interviewed the next most important household member in making household decisions (likely the household head's spouse). If appropriate respondents in the household refused to be interviewed or could not be located for an interview after three visits, that household was replaced with the next household in the direction of the walk pattern.

We conducted a power analysis to determine how many households to interview, and arrived at a total of 10 farming households from each of 150 villages, to which we added 300 households from which we collected seed samples for the seed quality assessment described below. The sample size was designed to be large enough to detect 0.14 standard deviation differences between pre- and post-pilot measures with 80-percent certainty. We assume that households in a village will have correlated responses, and look to recent sub-Saharan agricultural estimates of intra-cluster correlation (ICC) coefficients to arrive at a conservative estimate of an ICC of 0.1 for all outcomes (Geyer, Davis, and Narayan 2016). We assume that the pre- and post-pilot outcomes are correlated, with an R-squared of 0.2 in predicting post-pilot outcomes from pre-pilot outcomes. We also assume a sample attrition rate of 20% (i.e., that we will not be able to reach 20% of the baseline survey respondents at the time of the follow-up survey).

With these assumptions, we will be able to detect differences of 0.14 in standard deviations between pre and post measures. For example, if the standard deviation of legume-related income is 8000 Uganda shillings (UGX), there is an 80% chance that we will detect a difference between pre and post smallholder income of 1120 UGX (with a 10% chance of a Type 1 error). For another example, if the current adoption rate of improved seed is 40%, then there is an 80% chance that we will detect a difference between pre and post adoption rates of 7.0 percentage points (with a 10% chance of a Type 1 error).

The final sample size of the survey was 1714 smallholder households, 1499 of which were sampled randomly from a national frame and 215 of which had provided seed samples as part of the seed quality assessment several months earlier (215 of the 300 seed sample households were found and consented to be interviewed).

3.2.2 Data collection and analysis

The evaluation team partnered with the Ugandan firm Wilsken Agencies for quantitative baseline data collection, which took place between March and May 2017. Details on the data collection approach and data quality assurance are presented in Annex A. Following data cleaning, the team performed descriptive and regression analysis using Stata.

3.2.3 Sample characteristics

Exhibit 3-4 presents sample characteristics for households included in the baseline survey, both overall and disaggregated by household head gender. The overall sample was selected to be representative of farming households in Uganda, proportional to legume production by district.

Exhibit 3-4. Sample characteristics

Characteristic	All households (n = 1499)	Male-headed households (n = 1175)	Female-headed households (n = 324)
Household characteristics			
Number of household members***	5.7	5.9	4.9
Number of adult household members***	2.6	2.7	2.2

Characteristic	All households (n = 1499)	Male-headed households (n = 1175)	Female-headed households (n = 324)
Household head average age***	42.8	40.9	49.4
Household head is literate***	69%	76%	45%
Any household member is literate***	95%	96%	90%
Household head completed secondary school or higher***	22%	26%	9%
Any household member completed secondary school or higher***	53%	56%	43%
Any household member belongs to a farmer group or cooperative*	65%	66%	61%
Household has average daily expenditures below $1.25[1]	21%	21%	19%
Agricultural characteristics			
Average area cultivated across Seasons A and B combined (ha)	1.30	1.38	1.02
Planted beans and/or soy across Seasons A and B combined	90%	91%	89%
Planted beans across Seasons A and B combined**	87%	88%	84%
Planted soy across Seasons A and B combined	16%	17%	14%

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.
[1] We calculated this by modifying the original PovertyCounts tool to calculate Purchasing Power Parity at the household level, instead of a sample-wide level.

Seventy-eight percent of households were headed by a male, and 22% by a female. Overall, households had an average of 5.7 members and 2.6 adult members. There were many statistically significant differences between male- and female-headed households at baseline. Households with female heads were typically slightly smaller (4.9 people on average as compared to 5.9 in male-headed households), and had 0.5 fewer adults (2.2 as compared to 2.7 in male-headed households).

The average age of the household head was 43 overall, but was higher for female-headed households (49) than male-headed households (41). About 69% of household heads were literate, including 76% of male household heads but only 45% of female household heads. Most households (95%) had at least one family member who was literate, although this was slightly lower for sampled female-headed households (90%). Nearly one-quarter of household heads (22%) had completed secondary school or higher. This proportion was higher for male household heads in the sample (26%) than household heads (9%). Just over half (53%) of households had at least one household member who had completed secondary school or higher, and a much higher percentage of surveyed male-headed households had at least one member who had completed secondary school (56%) than surveyed female-headed households (43%).

Just under two-thirds (65%) of households had a household member who belonged to a farmers' group, with the percentage slightly higher for surveyed male-headed households (66%) than female-headed households (61%).

The team adapted Abt's Uganda PovertyCounts index tool to estimate households' poverty status.[7] The PovertyCounts tools, which build upon the U.S. Agency for International Development's Poverty Assessment Tools, are short, country-specific household survey tools that use an index of indicators that are highly correlated with household expenditures (a proxy for income) to estimate a household's per capita income. The Uganda version was developed using Uganda's 2009-2010 National Household Survey. Based on this tool, about one out of every five households (21%) in the AgResults baseline sample qualifies as 'poor' at baseline, based on having an estimated mean per capita daily expenditure below the commonly used $1.25 per day poverty line in international purchasing power parity terms. This rate differed little between male-headed households (21%) and female-headed households (19%) in this sample, a difference that is not statistically significant.

Households cultivated an average of 1.3 ha of land during 2016. Most areas in Uganda have two growing seasons, so the figures here represent the combined total cultivated land in Season A (in which planting typically occurs in March or April and harvest occurs in June and July) and Season B (in which planting typically occurs in August and September and harvesting occurs in November and December). Male-headed households in the survey cultivated more land on average (1.4 ha) than female-headed households (1.0 ha), but the difference was not statistically significant.

Most households, 90%, planted legumes in one or both seasons in 2016. Nearly as many (87%) planted beans, while 16% planted soy. In the survey sample, 91% of male-headed households planted legumes, including 88% who planted beans and 17% who planted soy. Proportions were slightly lower for female-headed households in the sample: 89% planted legumes, with 84% planting beans and 14% planting soy. The difference was significant at the 10% level for beans, though it was not significant for soy.

3.3 Data for seed quality assessment

To answer the evaluation question on farmer uptake of 'quality' seeds, it is essential to accurately measure the quality of the seed that ends up in farmers' hands. Some farmers can report which company their seed came from or whether it had an AgVerify label, but (as we discuss in further detail later in this report) most farmers struggle to recall these types of details about their seed. Furthermore, counterfeiting remains a serious issue, so seed that a farmer thinks is quality, certified seed may not be. For these reasons it would be impossible us to verify through self-reporting alone whether a respondent had used quality seed.

Therefore, the evaluation includes seed quality assessments at baseline and endline to enable us to compare the true adoption levels of quality legume seed before and after the pilot. These assessments rely on seed samples drawn directly from smallholders as described below. We contracted with Chemiphar, the seed lab that is responsible for seed quality testing for AgVerify. Chemiphar is the only International Seed Testing Association (ISTA) certified lab in Uganda. Chemiphar was responsible for both sampling and testing.

3.3.1 Sampling, sample size, and geographic distribution

Working with Chemiphar, Abt determined the number of seed samples to collect from smallholders and the process for collecting seed samples for both the baseline and endline

[7] The original PovertyCounts Tool uses a series of validated questions to calculate the daily per capita expenditures of respondents and runs predictive models to create an estimate of the percentage of households spending less than $1.25 per day. The team adapted the tool to estimate each household's individual poverty status.

smallholder surveys. The sample size required depends on the percentage of seeds that smallholders believe to be high-quality seed (i.e., meets the COMESA quality standard) and that actually meets that quality standard, both at endline and at baseline. We conducted a power analysis to select a sample size for which a 95% confidence interval for this percentage is smaller than the expected difference between the baseline and endline percentages of improved varieties of seed that meet quality standards (Abt Associates, 2017). Based on our power calculations, we decided to collect seed samples from 300 households. From each household, Chemiphar determined that a minimum of half a kilogram and a maximum of one kilogram must be collected to ensure sufficient seed for the various tests required.

In addition to statistical precision, the other design goal for the seed quality study was representativeness—we wanted the seed quality assessment to be representative of the overall level of seed quality in Uganda among the seed that farmers think is high-quality. We would ideally have selected a sample of bean and soybean seeds that is representative of all bean and soybean seeds planted by smallholder farmers in Uganda. However, this would have been infeasible in practice. Instead, we used the same process used to select villages and households for the quantitative study, based on data from Uganda's National Agriculture Census, which provides legume production totals at the district level. We determined which districts to sample and the number of villages to sample in each district based on the distribution of legume production in agricultural census data. For logistical reasons, we agreed with Chemiphar to limit the sampled villages to one subcounty in districts where 1–3 villages were to be visited and to two subcounties in districts where 4–7 villages were to be visited. The team used a two-stage process to randomly select subcounties within districts and then randomly select villages within subcounties.

Then, we randomly selected which villages to visit in each district. The probability that a village was selected was proportional to the percentage of the national bean and soybean production from that village's district.[8] From each of the 60 selected villages, Chemiphar's inspectors collected seed from five households that self-reported that they are growing quality legume seed, using a random walk method to find households.

Based on this methodology, the seed sample was distributed as shown in Exhibit 3-5.

Exhibit 3-5. Seed sample geographic distribution

Region	District	Number of villages	Number of samples
Central	Luwero	1	5
	Mukono	1	5
	Wakiso	2	10
	Masaka	3	15
	Mubende	7	35
Eastern	Mbale	3	15
	Amuria	1	5
	Namatumba	1	5
Northern	Apac	2	10
	Gulu	1	5
	Yumbe	2	10

[8] Seed sampling occurred prior to the household survey because it was necessary to collect it from farmers before they planted it (i.e., before the start of the rainy season) in order to be representative of the seed they planted. Conversely, the survey needed to occur later on, after the end of the season, so that information on total production and yield could be collected.

Region	District	Number of villages	Number of samples
	Amuru	5	25
	Oyam	6	30
Western	Kibaale	5	25
	Masindi	4	20
	Kyenjojo	3	15
	Ntungamo	7	35
	Kisoro	1	5
	Kabarole	1	5
	Kabale	3	15
	Isingiro	1	5
Total		**60**	**300**

3.3.2 Seed sample collection and testing

Chemiphar staff members travelled to smallholder households during the August-September 2016 planting season to sample seed directly from 300 households according to the sampling plan above.[9] For this survey, we did not consider attrition, because it is not necessary to sample the same households at the follow-up data collection. The goal of the seed sample study is cross-sectional. After collecting the seed samples, Chemiphar then transported the sampled seed to its lab in Kampala, where it performed testing. All seed was sampled and tested in accordance with ISTA guidelines.

Chemiphar conducted tests on all sampled seed to assess whether it met AgResults (AgVerify) quality standards, which in turn are based on COMESA seed quality standards. The parameters included in the test were:

- Moisture rate (% wet)
- Purity (the percentage composition by weight of the sample being tested and the proportion of pure seeds, other seeds, and inert matter constituting the sample)
- Germination rate (the proportion of the sample comprised of normal seedlings, abnormal seedlings, fresh seeds, hard seeds, and dead seeds).

Seed must meet COMESA standards on all of the above criteria to qualify towards the prize under AgResults. (It was not possible to perform a genetic test, because a genetic test for whether or not legume seed is of an improved variety does not exist.)

[9] Seed sampling occurred prior to the household survey because it was necessary to collect it from farmers before they planted it (i.e., before the start of the rainy season) in order to be representative of the seed they planted. Conversely, the survey needed to occur later on, after the end of the season, so that information on total production and yield could be collected.

4. Baseline findings on evaluation questions

All of the study's evaluation questions concern longer-run outcomes of the legume seed pilot that have yet to unfold. To set a stage for those results, the current report provides research findings on the state of the legume seed market prior to the pilot's launch. Section 4.1 presents findings pertaining to Evaluation Question 1 (concerning the impact of the pilot on private sector involvement in the market), Section 4.2 presents findings pertaining to Evaluation Question 2 (concerning smallholder uptake of quality legume seed), Section 4.3 presents findings pertaining to Evaluation Question 3 (concerning smallholder income), Section 4.4 presents findings pertaining to Evaluation Question 5 (concerning sustainability), Section 4.5 presents findings pertaining to Evaluation Question 6 (concerning scale and cost-effectiveness), and Section 4.6 presents findings pertaining to Evaluation Question 7 (concerning lessons learnt about best practices). Recall that Evaluation Question 4 in the AgResults research agenda, concerning demand for incentivized products, is not relevant to the Uganda pilot so it is not addressed here.

4.1 Evaluation Question 1: What has been the impact of the legume seed pilot on private sector involvement in the development and uptake of quality legume seed?

In this section, following the logic of the SCP framework, we present baseline information regarding private sector involvement in the legume seed market, beginning with analysis of the situation (the underlying market conditions), then moving to firms' strategies in the market given these conditions, the aggregate market structure, and market performance. The results draw on interviews with national seed companies, seed producers, agro-input dealers, potential volume buyers of certified legume seed, and smallholder farmers. The analysis focuses on the national-level seed companies, given their central role in the legume seed market and in the pilot.

4.1.1 Situation

The underlying, or 'basic', conditions of a market (also referred to as its 'situation') are fixed in the short to medium term and include characteristics of supply and demand of a product and its market and the institutional environment. The basic conditions underlying Uganda's legume seed market include weak institutions that increase transaction costs and risks of engaging in the market, unpredictable and price-sensitive demand among buyers, and limited awareness of the potential benefits of certified legume seed among most smallholders. This limited awareness is accompanied by more robust demand for certified seed among those smallholders that are cognizant of its potential benefits. Meanwhile, there is limited awareness of the AgVerify initiative and its potential for ensuring the quality of legume seed on the market, although interviewees were enthusiastic about AgVerify's potential once they learned of its existence. Supply constraints include inadequate availability of breeder and foundation seed, lack of working capital, and a high opportunity cost of money invested in legume seed production. Together, these current market conditions contribute to a risky market environment with limited profitability potential for national seed companies.

Weak institutions increase transaction costs and risk of engaging in the market for certified legume seed. While there are several initiatives—including AgVerify—addressing these problems, their implementation has been protracted. The weak institutional framework has three main components.

First, and foremost, there is no functioning seed certification system in the country. The NSCS is severely underfunded and lacks the capacity to carry out its mandate of certifying seed quality. Its lack of capacity means that there are no meaningful legal controls on the quality of seed sold, which presents significant problems for the market as discussed below.

Second, major underpinnings of the seed sector's legal framework are incomplete, inhibiting private-sector investments in the seed market. While Uganda's 2006 Seed and Plant Act provides a legislative foundation for the development of the seed sector, Uganda's Seed and Plant Act Regulations were only approved and published in February 2017 after being under development and review since 2001. Development and implementation of a national Seed Policy has also been protracted, although it is currently nearing final approval. The incomplete policy limits the extent to which the Seed Act can serve as the legal foundation for seed industry development, curtailing investor confidence and limiting engagement in the value chain. Meanwhile, as of August 2017, AgVerify itself was not yet accredited by the government, significantly affecting seed companies' willingness to participate in it. (Specifically, during field research, several industry members and seed company representatives described perceiving the lack of government accreditation as an indication that the government does not support AgVerify, and they were reluctant or unwilling to go against what they perceived to be the government's implicit guidance in this respect.)

Third, a culture of contract non-compliance prevails in Uganda's agricultural sector. Contracts have the benefits of reducing market players' exposure to risks and smoothing coordination between buyers and sellers. Non-compliance with contracts undermines the development of markets by limiting the options that buyers and sellers have to mitigate risk and improve coordination through individualized agreements. For example, key informants cited specific examples of large-scale buyers (processors and traders) having production contracts[10] fail due to the prevalence of side-selling on the part of farmers. As a result contracting use had dropped off.

This lack of contracting is detrimental to the development of the legume seed market for two reasons. First, it denies farmers the assurance of a market for their product that production contracts would provide, decreasing their demand for productivity-enhancing inputs such as quality seed. Second, production contracts often include provision of critical inputs such as seed, so their absence likely decreases effective demand for large-scale purchases of quality seed by industrial buyers who might otherwise distribute the seed as in-kind credit to contract growers. Similarly, seed companies reported having difficulty enforcing seed production contracts with outgrowers for the same reasons described above, making it difficult for them to ensure that they will have a supply of quality seed. Seed companies also reported difficulty in contracting a supply of breeder and foundation seed, since the institutions responsible for production of foundation and breeder seed either do not accept or do not adhere to such contracts. This curtails their ability to increase their production of quality legume seed.

These three factors combined limit the policy, regulatory, and contractual mechanisms that underlie a robust enabling environment in which both seed buyers and suppliers can be confident that their investments in quality seed will be compensated by consistent and adequate returns.

There is unmet demand—both expressed and latent—for quality legume seed, but a large portion of legume seed buyers have very price-sensitive demand or are sceptical of the potential for quality legume seed to enhance their production. In short,

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[10] Production contracts involve advance provision of inputs or finance by the contract buyer in order to facilitate production, the value of which is difficult to recuperate if the farmer reneges on the agreement to sell to the contract buyer (at which point the value of the in-kind loan would be deducted from the sale value). Marketing contracts, which entail an agreement to buy or sell a product (but not provision of inputs to support production) also fall through when either the buyer or seller reneges on the commitment to buy or sell (depending on whether market prices are above or below the contracted price); however, they do not involve advance provision of inputs or services to support production so entail less risk to the buyer should the contract fail.

legume seed buyers can be characterized as fitting into three major groups—those who are willing to pay for quality legume seed, those whose demand for legume seeds is highly price sensitive, and those who lack awareness of the potential benefits of quality legume seed and therefore are not actively in the market for it.

- **Strong demand for quality legume seed among some buyers.** Our interviews with large-scale buyers of certified legume seed, including commercial farmers, farmer groups, and some institutional buyers, revealed that there is strong demand for quality legume seed among these buyers. These buyers report that the quality and quantity of legume seed available tends to vary from season to season in terms of germination rates, the purity of varieties, and timely availability of seed from preferred suppliers. For example, one major NGO reported that it had procured soy seed and distributed it to constituent farmers in 2013, only to have the seed fail to germinate. Although the NGO managed to obtain a refund from the supplier, the farmers lost the season's production, leading them to stop working with soy despite its being an otherwise potentially profitable value chain for smallholders. Several of these interviewees reported being unable to supply the large volumes of beans sought by traders due to limited availability of quality seed, as well as difficulty in obtaining the specific varieties of legume seed that they sought. Across the board, large-scale buyers reported that they would be willing to pay more for seed if they could be confident of its quality (though their demand would be tempered by seasonal weather projections such as drought predictions).
- **Unpredictable and highly price-sensitive demand among many major buyers.** Some major institutional buyers, including both the government and some NGOs, demand large volumes of certified legume seed, but these purchases are ad hoc, unpredictable, and strongly price sensitive. One major entity, Uganda's National Agricultural Advisory Service (NAADS), is responsible for procurement and distribution of seed as part of Uganda's ongoing Operation Wealth Creation (OWC) program. Likewise, industry experts reported that some NGOs, for example those buying for relief programs in neighboring countries such as South Sudan and DRC, also demand large volumes of certified seed. However, the purchases are not typically announced in advance or, if announced in advance, may not be issued.[11] They are awarded on the basis of low-cost tender competitions with short turnaround times between award of the contract and required delivery of the seed. Low-cost bid awards in the context of weak quality verification as described in the previous section provide seed companies with an incentive to reduce their costs by supplying low-quality seed.

  Smallholder farmer demand for legume seed is also difficult to predict and very price sensitive, albeit for different reasons. Farmer demand is difficult to predict because weak national statistics limit the availability of data to forecast farmers' planting intentions (which could be used as the basis for seed demand calculations). The availability of subsidized or free seed from institutional sources like the OWC and NGO distributions mentioned above also undermines farmer demand for seed from commercial sources. Finally, the fact that legumes are open-pollinated varieties means that seed can be replanted on the farm for several seasons without degrading significantly. Thus, a farmer who purchases seed one year may not purchase it again for several seasons, adding to uncertainty around demand.
- **Lack of awareness of the potential for certified legume seed to enhance legume production.** As detailed under Evaluation Question 2, smallholders' uninformed or sceptical perspectives are the result of a number of factors including

[11] For additional discussion of the destabilizing role of institutional purchases of seed, see (Alliance for a Green Revolution in Africa [AGRA] 2013).

limited exposure to certified seed and mixed results from previously planting certified seed. The mixed results likely stem from various factors including the seed itself being of poor quality, but also the sensitivity of production to numerous factors including environmental conditions, and the fact that benefits of better seed are also dependent on the concurrent use of complementary inputs such as fertilizer. Some key informants interviewed also highlighted that some of the certified seed on the market did not, in fact, feature improved yields so much as other benefits such as shorter growing cycles.

Furthermore, many smallholders are unwilling to invest cash in production of legumes (such as beans) that are produced primarily for their own consumption. Demand from these farmers is also very price sensitive—smallholder farmers tend to be cash poor and often have difficulty purchasing inputs at the start of the season unless some sort of financing is available to them (for example, through a production contract). Their perception of the value of seed is also heavily influenced by the next available alternative—seed from their own production or the grain market; thus, demand for certified legume seed falls off as the differential between seed and grain prices grows. (This can be contrasted to the market for hybrid maize seed, which offers huge yield advantages and for which maize from the market cannot substitute—in this market many farmers evidence a strong willingness to pay for commercially produced certified hybrid maize seed.)

Supply constraints increase costs and reduce production. Major supply constraints fall in three major areas—inadequate availability of breeder and foundation seed, lack of working capital, and high opportunity cost for money invested in legume seed production.

- **Inadequate availability of breeder and foundation seed.** Seed companies reported that limited and uncertain availability of breeder and foundation seed is a major constraint to increasing the production of quality legume seed. Two public organisations—the National Crops Resources Research Institute (operating under NARO) and Makerere University—are charged with developing varieties for beans and soybeans, and making breeder and foundation seed available for multiplication. (Private-sector actors including seed companies can also develop their own varieties, or multiply their own varieties of breeder or foundation seed, and some do this as part of long-term investments in the market.) The limited availability of breeder and foundation seed from public-sector actors is attributed to several factors including the fact that these organisations tend to receive funds for varietal development, but limited support for multiplication of seed. Furthermore, they cite difficulty in forecasting demand given inadequate data on planting forecasts. Additionally, limited capacity for intellectual property rights management and hence royalties limits the incentive to concentrate scarce resources on multiplication of breeder seed.
- **Working capital constraints.** Seed companies also frequently cited limited access to financing, particularly working capital that funds day-to-day operations, as an important factor limiting their production of legume seed. Working capital for legume seed is in short supply for a number of reasons. First, restricted access to financing from the formal banking sector is a major constraint to private-sector investment in Uganda's agricultural sector. Second, seed companies tend to allocate the scarce working capital they have available to their most profitable enterprises—namely hybrid maize.[12] Third, the crop and sales cycle for legume seed exacerbates working

[12] A number of factors conspire to make production costs for legume seed relatively high. In particular, legumes have higher seeding rates per acre than maize (10 kg seed/acre for maize, and 30-40 kg seed/acre for legumes), lower production per acre (hybrid maize produces 150 kg for every kg of seed compared to an average of 30 kg for every kg seed for beans), and lower

capital issues—legumes are short-cycle crops meaning that they are typically harvested 2 months after planting rather than the 4 months that maize requires. Seed companies must pay seed growers for their product soon after harvest or risk having it sold on the grain market or consumed, and consequently carry inventory costs of the seed for months until the next planting season.

- **High opportunity cost of legume seed production.** The short-cycle nature of legume seed production with attendant inventory costs, as described in the preceding paragraph, also increase the opportunity cost of legume seed production relative to maize seed. Likewise, hybrid maize seed is a relatively more profitable product, further increasing the opportunity costs. In short, national seed companies have limited incentives to tie up scarce working capital in legume seed production when more profitable uses for the capital—namely hybrid maize production—are available.

Awareness of AgVerify and its potential role in the legume seed market is limited. Subsidized participation in AgVerify is part of the pilot intervention. AgVerify had already begun operations, focusing on other types of seed (mainly maize), prior to the pilot's launch. Therefore, the evaluation team examined perceptions of AgVerify at baseline because we expected that some actors in the legume value chain may already have been aware of it. Apart from seed companies, nearly all of which were aware of AgVerify at baseline, there was limited awareness of AgVerify among other actors along the legume and legume seed value chains. Among our interviewees, just over one-third of agro-input dealers and potential buyers of AgVerified legume seed, and very few seed growers, had heard of AgVerify. Of particular note was the fact that several agro-input dealers in Container Village in Kampala responded that they did not know of AgVerify seed despite having it prominently displayed in their shops, typically within arm's reach. When questioned further, these respondents typically reported that they might have seen the seal, but did not know what it was for; confused the purpose of the seal with that of Kakasa[13]; or described AgVerify and Kakasa as having the same purpose—'to ensure quality seed.' While few seed growers were aware of the AgVerify initiative, some of them reported that they had many inspectors come to their farms so it was possible that they did take part in AgVerify and did not know it.

Market actors express marked enthusiasm for AgVerify's potential role in spurring development of the legume seed market. After asking respondents if they were aware of AgVerify and what they knew of it, we informed them of AgVerify's purpose and function. When asked whether there was a need for an initiative of this sort, respondents across the value chain responded overwhelmingly positively. Respondents cited a variety of potential benefits including that a rigorous verification system would ensure quality seed, and some respondents commented that, given the prevalence of seed quality issues, ensuring seed quality would uplift the whole industry by increasing value chain actors' willingness to participate in the commercial legume seed market. Agro-input dealers also articulated that the traceability and accountability aspects of AgVerify would reduce the costs they incurred in verifying seed quality and reimbursing farmers who complain of poorly performing seed. Responses from several seed companies and some industry experts constituted notable

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sales prices for the seed (agro-input dealers typically reported selling bean and soy seed for between 4500 and 5000 UGX/kg, while hybrid maize sold for 6000-7000 UGX/kg and as much as 9000 UGX/kg for some varieties).

13 *Kakasa* is a donor-funded voluntary initiative of the Uganda National Bureau of Standards introduced in 2016. *Kakasa,* which means 'verify' in Luganda, uses a scratch code with mobile verification to ensure the authenticity of seeds and agricultural chemicals. In contrast to AgVerify, which ensures both the quality and origin of seeds, *Kakasa* only verifies the product's origin. Key informant interviews with seed company representatives and other industry experts indicated that *Kakasa* would likely continue to be used for agricultural chemicals, while AgVerify was expected to replace *Kakasa* for seeds.

exceptions to the broad support for AgVerify. Scepticism was based in part on the notion that AgVerify was irrelevant to seed companies already producing top-quality seed, and on the belief that it was inappropriate for a private firm to be carrying out what respondents perceived to be a public-sector role. Similarly, several seed company respondents argued that the donor money being invested in AgVerify should be invested in increasing the government's seed certification capabilities.

4.1.2 Strategy

Individuals' and firms' strategic behaviours reflect their attempts to pursue utility and profit objectives given the incentives and constraints established by the market's basic conditions. Strategic behaviour, in the context of the Uganda pilot, includes decisions such as whether and how to invest in the legume seed market, including legume seed procurement, value addition, distribution, and merchandising decisions. Our baseline research identified three overriding traits of national-level seed companies. First, they typically focus on the hybrid maize market and treat legume seed activity as a means of diversifying their portfolios. Second, they are conservative in their legume seed production decisions and differentiate their legume seed product offerings on the basis of quality to respond to the demands of different market segments. Third, national seed companies (and other players in the legume seed value chain) undertake diverse strategies to try to protect themselves from quality shortfalls given the prevalence of low-quality and counterfeit seed in the market. These strategies—particularly those that focus on risk mitigation given the quality issues endemic in the market—support the centrality of the seed quality verification component in the pilot's theory of change.

National seed companies typically focus on hybrid maize, treating legume seed market activity as a means of portfolio diversification. Most national seed companies focus heavily on the profitable hybrid maize market but report that institutional buyers—particularly NAADS—offer an easy, though highly price sensitive, market outlet for legume seed. Several also reported plans to increase soy seed production to meet increasing demand for soy seed both domestically and in regional export markets (such as Kenya and Rwanda) where offtakers and processors demand large volumes of seed.

Legume seed production decisions are based on conservative demand estimates and limited availability of breeder and foundation seed. Given the unpredictability of demand and the limited profitability potential of legume seed compared to hybrid maize, seed companies base their legume seed production decisions on conservative estimates. The limited availability of breeder and foundation seed also limits their legume seed production potential.

Seed companies differentiate legume seed quality and availability to different market segments. Seed companies' conservative production decisions are often inadequate to meet seasonal demand for legume seed. Diverse respondents, including seed company representatives, reported that when inadequate legume seed is available, seed companies characteristically fill out their orders with 'standard seed.' Standard seed is the industry term for legumes purchased from the grain market that are then sorted and treated for sale as certified seed.[14] Seed companies commonly channel the lower quality, standard seed to their lowest-paying customers. They reserve better-quality seed for their preferred customers—those who are willing to pay more for quality seed, and who are consistent, large-volume buyers. Several seed companies interviewed emphasized that they were interested in developing private distribution systems rather than continuing to rely on purchases from the large, price-sensitive institutional buyers such as OWC. In interviews, commercial farmers

[14] Counterfeit or 'fake' seed has been characterized as the single biggest threat to African seed sector development. For additional insight see AGRA (2013) and Bill and Melinda Gates Foundation (2014).

and farmers' organisations reported that by buying directly from the seed companies they are able to get the volume and quality of seed they need, whereas agro-input dealers frequently complained that the seed companies favored other buyers such as farmer groups over them. Agro-input dealers said that seed companies sometimes send mobile distributors directly to farmers' organisations but often fail to fill agro-input dealers' orders.

Market actors adopt procurement and marketing strategies that mitigate risks. Along the legume seed value chain, market actors, including national seed companies, seed traders, and seed buyers, undertake diverse strategies to mitigate their risk of paying for substandard quality legume seed.

Smallholders procure legume seed from known and trusted sources, including their own saved seed, neighbours, LSBs, agro-input dealers with whom they have trusted relationships, and in some cases directly from seed company distributors. Some farmers who were interviewed reported being willing to pay premium prices to acquire improved legume seed; however, this willingness to pay was contingent on confidence that the seed would be good quality, a trait they did not automatically associate with either the public distributions or seed available through commercial channels. Current and potential large-volume seed buyers, such as farmers' groups and commercial farmers, offered an exception to this generalized lack of confidence in the quality of certified legume seed. They reported that they bought directly from the seed companies to ensure the quality of the seed they receive, while still adhering to the general position that the MAAIF certification itself was not adequate to ensure seed quality due to the prevalence of counterfeiting.

Agro-input dealers attempt to offset the risk of financial and reputational losses by verifying the source and quality of seed that they market. In particular, they report purchasing directly from seed company distribution outlets, subjecting seed to simple quality verification (such as germination tests), and keeping careful records of their seed sales to offset the risk of selling substandard seed. When they received complaints about seed quality from smallholders whose sales they had record of, they reported providing refunds at their own expense, as seed companies were unwilling to cover the cost of such returns.

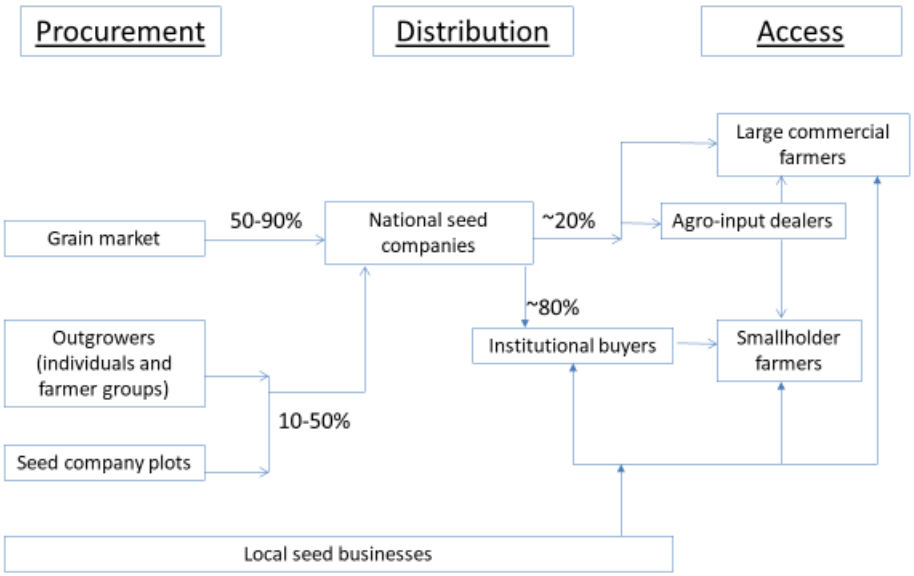
Seed companies also concern themselves with limiting counterfeit sales or adulteration of their products. Approaches to mitigate these issues include using more expensive packaging that is costly to imitate, selling directly to large-volume buyers such as farmers' organisations through mobile distributors, carefully selecting then building relationships with agro-input dealers, and using incentive programs to reward dealers for their sales of quality seed in order to increase incentives to behave ethically. A number of companies also reported participating in anti-counterfeiting initiatives such as the use of mobile verification and scratch-code programs used by *Kakasa* as well as AgVerify.

4.1.3 Structure

Market structure is shaped by the aggregate decisions of many individual firms, and features of the market that are stable in the medium to long term. Structural elements that are commonly addressed in the SCP framework (which is heavily concerned with the competitiveness of markets) include concentration ratios, barriers to entry and exit, and product differentiation, all of which potentiate market power (Caves 1987). In our analysis, we focus on structural facets of the market that help define its functioning from the perspective of value creation along the product value chain. These elements include the numbers and traits of buyers and sellers in the market, the characteristics of production and value creation (such as the technological packages that dominate), the degree and types of product differentiation, barriers to entry and exit, and the major organisational and institutional approaches to vertical coordination. Such structural features tend to evolve over the medium to long term and as such are represented among the basic conditions that influence firms' strategic behaviour.

The structure of Uganda's commercial legume seed market is depicted graphically in Exhibit 4-1 and described below. There are two major sources of quality legume seed—national-level seed companies that supply MAAIF-certified seed, and LSBs that supply Quality-Declared Seed (QDS).[15] Approximately 17 national-level seed companies, most of them based in Kampala, supply certified legume seed in Uganda. These firms tend to be either small or medium enterprises, based on the number of people that they employ—the number of full-time, permanent employees employed by these firms ranges from 9 to 74, and averages 22, for example. They sell their seed to large, institutional buyers (such as OWC and NGOs purchasing for relief distributions and development programs); agro-input dealers; farmers' organisations; and individual (usually commercial) farmers, selling from their head offices, distribution outlets, and in some cases through mobile distributors who deliver seed directly to the buyers. There are more than 140 LSBs located throughout Uganda, selling QDS locally to smallholders and some institutional buyers.

Exhibit 4-1. Uganda's commercial seed market structure



Source: Key informant interviews

National-level seed companies source seed from contracted outgrowers working individually or in farmers' organisations or multiply it on their own land. As described earlier, many national seed companies fill orders for certified legume seed with grain purchased on the open market, particularly for highly price-sensitive buyers who are less rigorous in their quality requirements. Seed company and industry experts estimate that 50–90% of certified legume seed is 'standard seed', the term used for grain that is sold as seed. On average, institutional buyers (NGOs and government) are estimated to account for approximately 80% of formal seed sales, with the 3-year OWC program having dominated these seed purchases since 2015. Seed purchased by NGOs is either exported to countries like DRC and South Sudan as part of relief programs, or distributed to Ugandan smallholder farmers, typically for free or on a subsidized basis as part of agricultural or livelihood development programming.

[15] The QDS system is based on a Food and Agriculture Organization (FAO) initiative to develop local production resources for open-pollinated crops, production of which tends to be de-emphasized by national-level seed companies.

Commercial distributors (agro-input dealers and seed companies selling directly to farmers) account for the remaining 20% of formal seed purchases.

As detailed in Exhibit 4-1, farmers rely primarily on informal sources such as their own harvests, neighbours, or the local grain market for the legume seed that they plant, particularly for beans. Sources of commercial seed account for a small proportion of farmers' seed supply and include LSBs, agro-input dealers, government, and projects.

4.1.4 Performance

The performance of a market is evaluated based on the optimal or desired outcomes that the market is intended to produce. The main performance elements of interest for the Uganda legume seed pilot include whether farmers can access adequate volumes of certified, quality legume seed, whether private-sector activity in the market is sustainable, and whether any particular groups such as women are disproportionately disadvantaged in the market. The pilot hopes to increase national-level seed companies' production and sales of quality legume seed. The motivation for the pilot is that the legume seed market is 'underserved' in the sense that farmers are unable to obtain adequate volumes of quality legume seed to meet their demand. Our baseline research supports this contention.

Our baseline SCP analysis shows that Uganda's legume seed market suffers failures at every level as a result of a plethora of issues (discussed above under 'Situation') that create adverse incentives to market actors, including national seed companies. These adverse incentives lead them to under-produce quality legume seed relative to market and potential demand. Specifically, demand for quality legume seeds is currently low, erratic, and undermined by institutional purchases and distribution, and supply is undermined by lack of foundation seed and capital constraints. Most importantly, institutional failures, particularly with respect to quality certification, policy, and market coordination, impede resolution of supply and demand constraints.

The outcome of these issues is that inadequate volumes of quality legume seed are produced. Furthermore, Uganda's legume seed market is a classic 'lemons' market where the inability to effectively signal or certify quality in the face of intensive price pressures leads to low-quality legume seed driving high-quality seed out of the market (Akerlof 1970). Although institutional innovations such as the AgVerify initiative show potential to alleviate these critical limitations, they have not yet had a substantial impact on the legume seed market's performance.

4.2 Evaluation Question 2: What has been the impact of the legume seed pilot on smallholders' uptake of quality legume seed?

In this section we present our baseline results on farmer uptake (or adoption) of improved legume varieties and quality seed. Note that because an impact evaluation was not possible for the Uganda pilot we will not answer this question exactly as asked. Our performance evaluation will not establish causal attribution of favourable outcomes to the pilot but rather will comment at endline on the *likely contribution* of the pilot to changes in smallholder uptake since baseline.

Recall from Section 1 that 'improved' technically refers to varieties with certain genetic traits, while 'quality' refers to the seed's ability to meet regulatory standards required for certification along parameters of seed purity, germination rate, and moisture content. Recall also that these two designations, while technically not synonymous, tend to go hand-in-hand in Uganda because only improved varieties can be inspected and certified for quality and because many farmers and seed industry actors use the terms interchangeably.

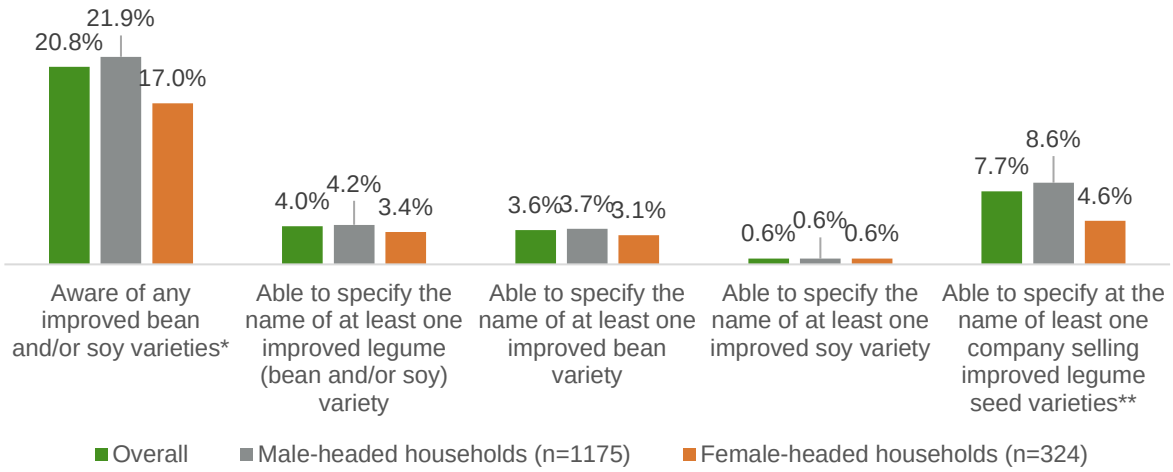
Uptake is a logical consequence of farmers becoming aware of quality seed and developing positive attitudes towards it. Therefore, our evaluation uses a KAP theoretical framework to understand quality seed adoption. In this section, we present findings based on quantitative

survey data collected from farming households between March and May 2017 through the structured survey as well as semi-structured interviews and focus groups held in June 2017. In addition, we present the results of the baseline seed quality assessment undertaken from August to December 2016. We first present findings on knowledge, followed by attitudes and practice (adoption). Then we discuss seed quality and finish by presenting an analysis of the determinants of adoption prior to the pilot.

4.2.1 Knowledge

The survey asked farming households whether they were aware of improved varieties of legumes. If they were, they were asked a series of questions, including which specific improved varieties and companies selling them they were aware of. Exhibit 4-2 shows the responses.

Exhibit 4-2. Knowledge of improved varieties and seed companies among all respondents



Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

In terms of knowledge, 21% of all respondents (22% of male-headed households and 17% of female-headed households, difference significant at the 10% level) reported that they were aware of one or more improved bean and/or soy varieties. These numbers are slightly lower than the number of households that planted a variety that can be classified as improved during 2016 (see Exhibit 4-2), implying that households may not necessarily recognize varieties as improved. For example, some households reported planting Nabe 4, but did not report (or may not have realized) that it was an improved variety.

Only 4% of respondents were able to specify by name a legume variety they knew to be improved, with no statistically significant differences between respondents from male- and female-headed households. A higher percentage of respondents was able to correctly specify at least one improved bean variety (4%) than an improved soy variety (less than 1%). About 8% of households were able to correctly name a company selling legume seed, which was true for a higher percentage of male-headed households (9%) than female-headed households (5%), significant at the 5% level.

In-depth interviews with a sample of farmers (for which the sampling strategy is detailed in Section 3.1) revealed more details about what smallholders knew about certified seed. Respondents who were aware of certified seed frequently reported that it comes in sealed bags with a label or stickers on it and that it is coloured or treated. Some also noted that the kilogram weight of the contents is marked on the package. Respondents did not

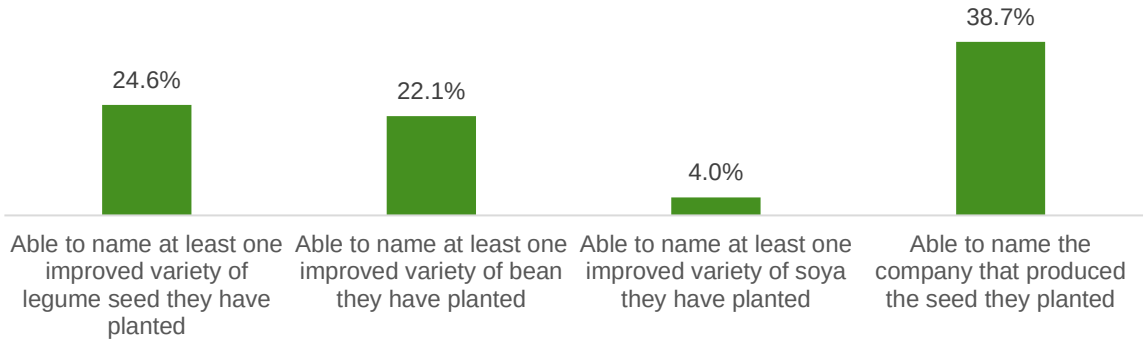
demonstrate knowledge of what the different types of labels and stickers found on packages signify in terms of inspection or quality. Some noted that they could not know what was on various labels because they cannot read, while others said they had not paid attention to the labels or had not seen them in the first place because they received certified seed without its original packaging. Some respondents expressed uncertainty about how to tell that seed is certified. One noted that "as farmers, we don't know whether it's certified or not because we just go to the stores and get the seeds."

Awareness of and knowledge about improved varieties and certified seed differed somewhat along gender lines. While many respondents of both genders reported not knowing much about certified seed, some male respondents mentioned that they had heard about certified seed from friends or about AgVerify on the radio. (Because the in-depth interviews followed the quantitative household survey, some marketing efforts for AgVerify had begun by the time the team conducted these interviews.) Some men expressed specific opinions about such factors as the germination and yield of improved varieties and where they could be acquired. No women mentioned knowledge of AgVerify or certified seed from the radio, but did mention things they had heard or observed personally or from neighbours, such as good germination rates or resistance to various weather conditions. Women were more likely to mention prices when discussing certified seed, with several noting that it was more expensive than local seed and one saying the price tag would not matter as long as the quality was assured. By contrast, only one male respondent independently brought up certified seed prices during the discussion of what he knew or had heard about certified seed in general.

In the household survey, the 21% of households that reported being aware of improved varieties of legume seeds were asked if they had ever *planted* improved varieties. One-eighth (13.3%) of all households reported ever having planted improved varieties of legume seeds (not shown in table), a percentage point lower than the percentage that actually planted improved varieties of legumes during 2016. This is the case because some households reported planting improved varieties such as Nabe 4 in 2016 but did not report that it was improved.

Respondents who reported having ever planted improved legume varieties were asked questions about what varieties they had planted and what company the seed was from. Their responses are included in Exhibit 4-3. Of households that reported planting improved varieties, about one quarter (25%) could specify the exact name of at least one legume they had planted previously. The majority of those able to name at least one legume were able to name at least one variety of bean they had planted (22%) in comparison to soy farmers able to specify the specific variety of soybean they had used (4%). Additionally, 39% of smallholders who had planted improved varieties knew the name of the company that provided the seeds. This is notably higher than the overall proportion of respondents who knew the name of any seed company selling legume seed (8%), suggesting that smallholders who have planted improved varieties typically know more about them than the general population.

Exhibit 4-3. Knowledge of improved varieties and seed companies among the 13.3% of respondents who self-reported ever having planted improved varieties (n = 199)



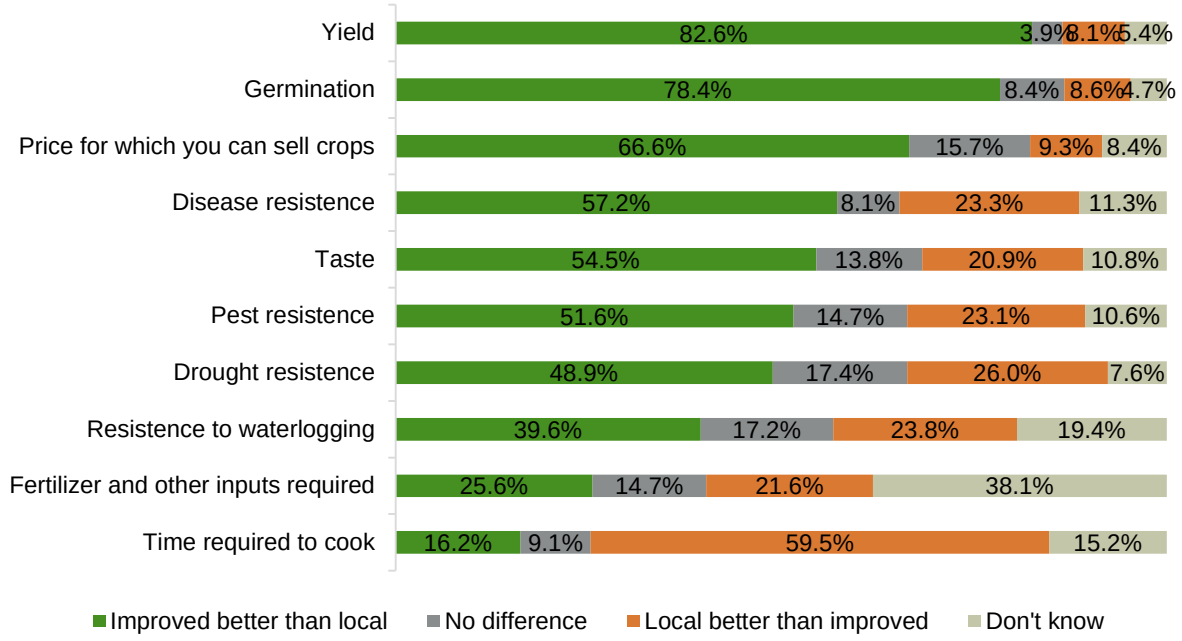
Source: AgResults Uganda Baseline Survey, 2017.

The pilot has the potential to significantly impact smallholder awareness of the different legume seeds available on the Ugandan market, since seed companies may need to invest in awareness creation and marketing if they are to significantly increase their legume seed sales.

4.2.2 Attitudes

The survey included a series of questions on respondents' attitudes or perceptions of improved varieties of legume seeds in comparison to local varieties for the 21% of respondents who reported that they were aware of improved varieties. Further analysis revealed that, of those aware of any varieties, most (73%) were aware of only one variety, while 8% were aware of two, and 19% were aware of more than two. For each improved variety a respondent was aware of, the survey asked whether the respondent felt it was better, worse, or the same as local varieties of seeds along a number of dimensions such as germination, yield, other agronomic characteristics, and taste. The results are shown at the seed level, so if a respondent was aware of multiple improved varieties, each response is included separately in the calculation below. If respondents were aware of improved varieties in general but not of any specific variety, the survey asked them to compare improved varieties in general to local varieties. The responses to these questions are shown in Exhibit 4-4.

Exhibit 4-4. Comparison of improved legume seed varieties of legume seeds to local seeds on various dimensions among respondents who were aware of improved varieties (n = 312)



Source: AgResults Uganda Baseline Survey, 2017.

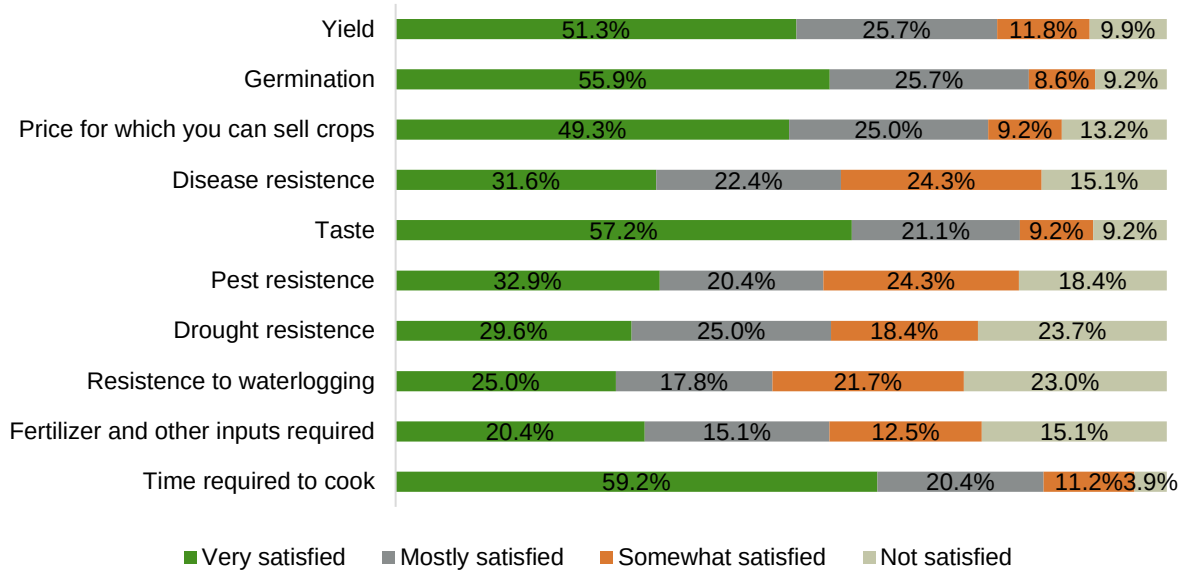
Respondents perceived improved varieties as better than local seeds most frequently in terms of their yield (83%), germination (78%), and 'price for which you can sell crops' (67%). Over half of smallholders reported that improved varieties had better disease resistance (57%), taste (55%), and pest resistance (52%). Note that these figures represent only farmers' perceptions and do not necessarily describe the actual traits of particular improved varieties.

However, some respondents perceived local seeds to be better than improved varieties of seeds in some categories. The majority (59%) thought that improved varieties of seeds took longer to cook than local varieties. Between a fifth and a quarter of respondents thought local seeds were better for most other categories, including drought resistance (26%), resistance to waterlogging (24%), pest resistance (23%), disease resistance (23%), fertilizer and other inputs required (22%), and taste (21%).

Respondents expressed a similar mix of attitudes regarding improved versus local legume seeds in in-depth interviews. While there was no clear pattern of positive or negative attitudes among respondents or categories of respondents, it was notable that most responses were either firmly positive ("for beans, the certified varieties are always good when it comes to yields compared to our local seeds") or negative ("they are of bad quality compared to our local seeds", "[saved seeds are] better than certified seeds because the ones I keep for seeds, they are types that have high-quality yields, unlike the premature ones packaged and given out by the government") Those who had heard about or experienced poor performance of certified seed seemed to have negative opinions of certified seed and improved varieties in general, while only a handful suggested that different batches of seed or different growing conditions could affect performance. Among in-depth interview respondents, there were no major differences in attitudes between respondents who had direct experience with improved varieties and those who did not.

For the main quantitative survey, the 13% of respondents who reported planting improved varieties previously were asked satisfaction questions on a variety of dimensions. Responses were collected on a scale including 'very satisfied', 'mostly satisfied', 'somewhat satisfied', and 'not satisfied.' The questions were asked about each variety of seed the respondent had planted, so some respondents may have responded twice about separate improved varieties of legume seeds, and each is reported separately. Results are shown in Exhibit 4-5.

Exhibit 4-5. Satisfaction on a variety of dimensions after planting improved varieties among respondents who self-reported having ever planted improved varieties (n = 199)



Source: AgResults Uganda Baseline Survey, 2017.

Over half of those who had planted improved varieties in the past reported being very satisfied with time required to cook (59%), taste (57%), germination (56%), and yield (51%), and nearly half (49%) also reported being very satisfied with the price you could receive for crops. Just under one in three reported being 'very satisfied' with pest resistance (33%), disease resistance (32%), and drought resistance (30%), and an additional 20-25% of respondents reported being 'mostly satisfied' for the same categories. Overall, at least half of respondents reported being very or mostly satisfied with improved varieties of legumes on all dimensions except fertilizer and other inputs required (35%) and resistance to waterlogging (43%).

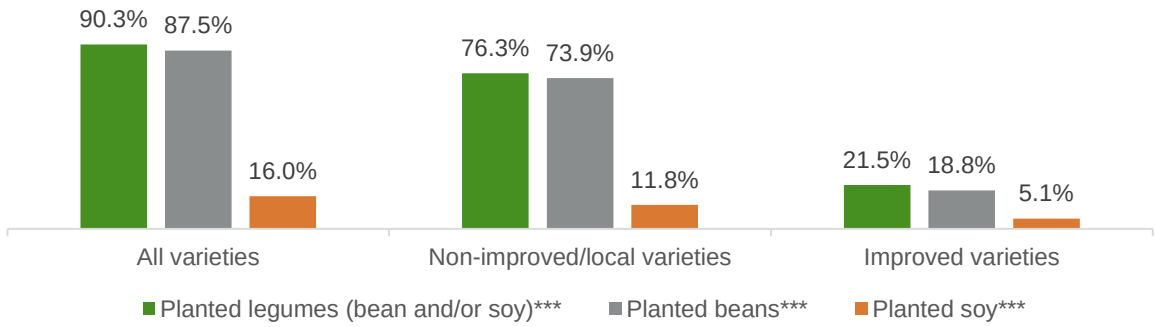
4.2.3 Practice

As shown in Exhibit 4-6, 90% of respondents reported planting beans and/or soy in one or both seasons of 2016. The majority reported planting non-improved varieties of legumes (77%), while 22% reported planting improved varieties.[16] Eighty-eight percent of the households planted beans, and three-quarters (74%) planted non-improved varieties of beans, whereas just under one-fifth (19%) of households planted improved bean varieties. About 16% of households planted soy, with 11% planting non-improved varieties of soy, whereas 5% of households planted improved varieties. While fewer households planted soy, nearly one-third of households that planted soy planted an improved variety of soy, whereas

[16] Many households planted more than one variety of legume, and may have planted both improved and non-improved varieties.

less than one-quarter of households that planted beans planted an improved variety of beans. Note that the improved figures here includes both farmers who reported that the variety they planted was improved and farmers who planted improved varieties but were not aware (or at least did not report) that their varieties were improved, even though they provided the survey enumerator with the name of an improved variety. This is the reason that a higher number of farmers planted an improved variety in 2016 than the number who self-reported that they have ever planted an improved variety.

Exhibit 4-6. Proportion of households planting legumes in 2016 by type of legume (n = 1499)



Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between non-improved/local varieties and improved varieties are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

The proportion of male-headed households in the sample who grew each type of legume in 2016 was similar to the proportion of female-headed households who did so. See Annex B for disaggregation of legume growing by gender of the household head.

To assess how these figures compare to previous data on adoption of improved legume varieties over time in Uganda, we performed descriptive analysis of data from the World Bank's Living Standards Measurement Surveys – Integrated Surveys on Agriculture (LSMS-ISA), a nationally representative panel survey that was conducted in 2009, 2010, 2011, and 2013, as shown in Exhibit 4-7. Since the LSMS-ISA survey was not conducted in the same year as the AgResults quantitative baseline survey (which collected data on the 2016 growing seasons) and since the two survey samples are not representative at the same level (LSMS-ISA is nationally representative, while the AgResults survey sample was drawn proportionally from districts according to legume production), we cannot construct a true time series but can use the LSMS-ISA data to help interpret our results. The AgResults baseline survey found higher levels of legume cultivation in general, as well as cultivation of beans and soy individually, than the LSMS-ISA surveys, likely because the AgResults survey specifically targeted legume-growing areas of Uganda. The AgResults survey also found much higher adoption of improved varieties than the LSMS-ISA surveys. The LSMS-ISA data show adoption of improved varieties by less than 3% of all farmers in Uganda in each year the survey was conducted, far lower than the 22% found for 2016 in the AgResults survey.

Exhibit 4-7. LSMS-ISA time series of legume planting, by legume type and seed type

	2009 (n = 2346)	2010 (n = 2113)	2011 (n = 2211)	2013 (n = 2390)
Household planted legumes	60.4%	62.5%	64.9%	61.4%
Household planted improved legume varieties	2.0%	1.4%	2.6%	2.2%
Household planted beans	59.2%	61.5%	63.2%	60.3%
Household planted improved bean varieties	1.7%	1.2%	1.9%	1.9%
Household planted soy	2.9%	5.0%	5.9%	3.6%
Household planted improved soy varieties	0.3%	0.2%	0.8%	0.4%

The evaluation team hypothesizes several potential reasons that the LSMS-ISA data show far lower adoption than the AgResults data. First, since the AgResults sample was weighted towards legume-growing areas, it stands to reason that households in regions more likely to grow legumes may also be more likely to grow improved varieties of legumes, either because they are more serious about legume production or because seed suppliers target their areas more heavily. Second, the most recent LSMS data came from 2013, a full 3 years prior to the AgResults data. A number of seed sector initiatives started in the interim, including the massive government seed distribution scheme Operation Wealth Creation, which distributes certified legume seed of improved varieties. OWC launched in 2013 and ramped up seed distribution in the run-up to the 2016 presidential election. It is likely that OWC had a major impact on adoption of improved varieties that is captured in the AgResults data. Should the ISMS-LSA data be collected again during the AgResults pilot period, we will use it again at endline to help understand our results.

In the AgResults data, households that planted legumes planted an average of 39 kg of legume seeds in 2016 in Seasons A and B combined, as shown in Exhibit 4-8.

Households that planted beans planted an average of 38 kg of bean seeds in 2016 in Seasons A and B combined.

Households that planted soy planted an average of 28 kg of soy seeds in 2016 in Seasons A and B combined.

Households that planted legumes planted an average of 0.83 ha with legumes, averaging 0.79 ha for beans (if they planted beans), and 0.67 ha for soy (if they planted soy). There were no statistically significant differences in quantity of seed planted, area planted, or quantity planted per hectare between farmers cultivating non-improved local varieties and farmers cultivating improved varieties.

Exhibit 4-8. Average seed quantity and area of legume cultivation in 2016 for farmers growing each legume type (n = 1298)[1]

	Overall	Non-improved/ local varieties	Improved varieties
Quantity of seed planted			
Legumes (bean and/or soy) (kg)	39.44	40.41	33.11
Beans (kg)	38.45	38.01	29.99
Soy (kg)	27.72	24.00	32.13
Area planted			
Legumes (bean and/or soy) (ha)	0.83	0.79	0.91
Beans (ha)	0.79	0.73	0.80
Soy (ha)	0.67	0.52	0.91

	Overall	Non-improved/ local varieties	Improved varieties
Quantity planted per hectare			
Legumes (bean and/or soy) (kg/ha)	47.52	51.15	36.38
Beans (kg/ha)	48.67	52.07	37.49
Soy (kg/ha)	41.37	46.15	35.31

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between non-improved/local varieties and improved varieties are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.
[1] See Annex B for disaggregation by household head gender.

Our analysis did not find evidence of bean or soy production being a primarily female activity within the household. Despite the fact that beans are an important consumption staple, suggesting women might take more responsibility for their cultivation, the opposite was the case. Survey respondents were asked to identify the household member responsible for each plot of land in terms of decision making and labour (see Exhibit 4-9). Female household members were the primary decision makers for 47% of plots on which legumes were planted, and female household members provided the most labour on 45% of legume plots. These findings are consistent with Nakazi et al. (2017), who found that while men owned the majority of plots on which beans were grown (except in female-headed households), ownership of the bean crop and participation in bean production were shared by men and women. The nearly equal split in responsibility for legume production in terms of decision making and labour was also reported in in-depth interviews of smallholder households. In male-headed households, while some interview subjects said that the man makes all agricultural production decisions and a few said the woman is the primary decision maker, most said male and female household members sat together as a family and decided what to plant each season. In most cases, however, respondents reported that the man ultimately makes the decision if there is a disagreement.

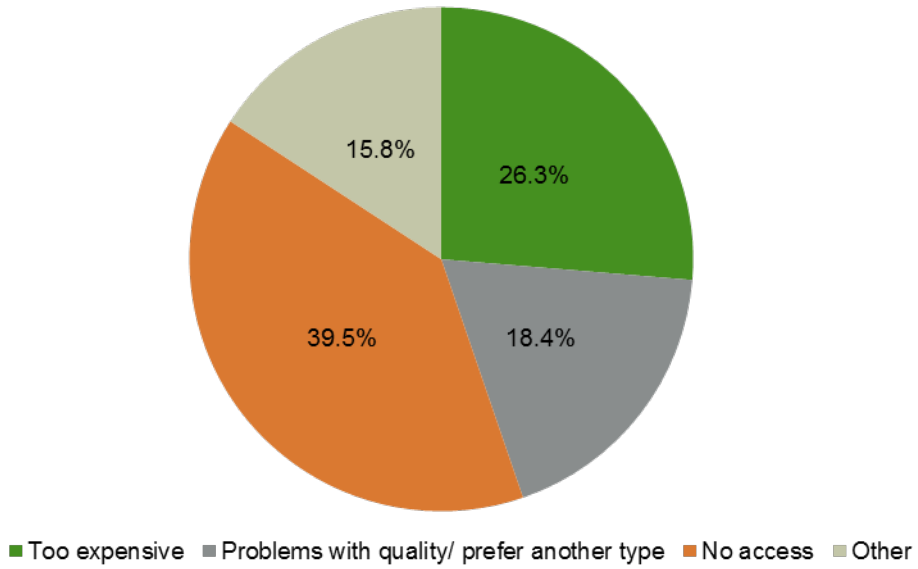
Exhibit 4-9. Division of legume responsibility and labour by gender (n = 3197)

	Male	Female
Household member primarily responsible for making decisions about the plot***	53.2%	46.8%
Household member providing the most labour for cultivating the plot***	54.9%	45.1%

Source: AgResults Uganda Baseline Survey, 2017.
Notes: A hypothesis test was performed for statistics in this table where the null hypothesis was that the proportion of plots for which a female was responsible for making decisions or for providing the most labour for the plot was equal to 0.5 and the alternative hypothesis was that the proportion was not equal to 0.5.
Statistically significant differences between males and females are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

In addition to questions about adoption, the survey also explored whether households had stopped planting any improved varieties of legume seeds, and why they dis-adopted, as is reported in Exhibit 4-10. Dis-adoption is an indication of whether farmers value quality seed enough to seek it out on an ongoing basis—a question tied directly to the success and sustainability of the pilot. About one in five households that reported ever having planted an improved variety (that they knew of) reported dis-adopting that variety—in total, the sample had 38 households who adopted and then dis-adopted, or about 19% of the households that reported having ever adopted. Nearly two in five dis-adopting households (39.5%) reported they could not find or access improved varieties of seeds again, and about a quarter (26%) reported the reason was that improved varieties were too expensive. About one out of every five dis-adopting smallholders (18%) reported they had problems with the quality, did not like the improved variety, or preferred other types of seeds. Sixteen percent reported dis-adopting for other reasons.

Exhibit 4-10. Reasons for dis-adoption of improved varieties (n = 38)



Source: AgResults Uganda Baseline Survey, 2017.

4.2.4 Seed quality

The seed quality assessment results confirmed that much of the seed thought by smallholders to be improved does not actually meet COMESA quality standards. The quality threshold that seed must meet in each of the three dimensions is shown in Exhibit 4-11. Seed sold under AgResults must meet the standard for Certified 1st seed, the same standard used by AgVerify and the NSCS.

Exhibit 4-11. COMESA seed quality standards (Certified 1st)

	Beans, Phaseolus vulgaris L	Soybean, Glycine max L. Merrill
Minimum germination (% of seeds in the sample that germinate)	80%	75%
Minimum pure seed (% of sample that is not foreign matter or other types of seed)	99%	99%
Maximum moisture (moisture content of sample)	14%	12%

Source: COMESA (2014).

All of the seed sampled at baseline was thought to be quality seed by the farmers who provided the samples. Testing revealed that, at baseline, only 39% of that seed met COMESA seed quality standards. Thirty-eight percent of bean samples met Certified 1st seed quality standards, while 43% of soybean samples met Certified 1st and basic quality standards. The rest of the samples thought by smallholders to be quality seed failed to meet the quality standard for certified seed on one or more parameters as shown in Exhibit 4-12 and Exhibit 4-13.

Exhibit 4-12. Proportion of bean seed samples thought by smallholders to be quality seed meeting COMESA quality standards at baseline (n = 270)

	% of samples meeting certified 1st standard
Germination	64%
Purity	75%
Moisture	73%
All parameters combined	**38%**

Source: Uganda AgResults Baseline Seed Quality Assessment, 2016.

Exhibit 4-13. Proportion of soy seed samples thought by smallholders to be quality seed meeting COMESA quality standards at baseline (n = 30)

	% of samples meeting certified 1st standard
Germination	83%
Purity	60%
Moisture	80%
All parameters combined	**43%**

Source: Uganda AgResults Baseline Seed Quality Assessment, 2016.

The implication of the seed quality assessment results is that, while 22% of households reported planting improved varieties in 2016, less than half of the seed actually met the applicable quality standards. This translates into just 9% of households actually planting quality seeds.[17] Hence, AgResults has the potential to impact overall use of quality seeds dramatically. At endline, we will conduct a second seed quality assessment and compare the results to this baseline.

4.2.5 Determinants of adoption

To gain insight into households' decisions to adopt, the evaluation team also sought to understand whether certain types of households were more likely to plant improved legume varieties during 2016. We do acknowledge, however, that households that were more likely to have adopted at baseline may be systematically different from households that will be most responsive to the pilot because the former adopted even in the absence of a large-scale, national intervention. Therefore, while this analysis provides insight into previous adoption, we cannot draw direct conclusions from this analysis about which types of farmers will be most responsive to the pilot.

Determinants of self-reported adoption of quality seed. First, we assessed whether household characteristics, such as demographics, economic status, and farmer group membership are strong predictors of the decision to adopt improved legume varieties (as self-reported). We ran a logit regression with a binary dependent variable that was equal to 1 if a household self-reported having planted an improved variety of quality legume seed in either season of 2016 and equal to 0 if not.[18] Exhibit 4-14 shows the results of this analysis—most importantly the odds ratio, defined as the probability that the group of farmers referenced in the row stub used improved seed divided by the probability of improved seed use for the converse group.

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17 The 9% figure (0.09) is derived by multiplying .0.22, the share of households that thought they were planting quality seeds, by 0.39, the share of that seed meeting the COMESA standards. This assumes that no reverse cases occurred: planting of seeds not thought to be quality that did meet the COMESA standards.

18 Households that did not grow legumes were left out of the analysis.

Exhibit 4-14. Logit regression results for household characteristics associated with reported use of improved legume varieties at baseline, among households that grew legumes (n = 1295)

Variable	Odds Ratio	P-Value	CI-Low	CI-High
Outcome				
Household planted an improved variety of quality legume seed in 2016 (self-reported) (binary variable)				
Demographic Characteristics				
Household head is male	1.414*	0.065	0.978	2.044
Household head age	1.000	0.974	0.991	1.009
Household head completed secondary school or higher	1.046	0.792	0.751	1.455
Household head is literate	1.204	0.272	0.864	1.679
Number of adult household members	0.856**	0.011	0.760	0.964
Number of child household members	0.951	0.148	0.888	1.017
Household deemed poor	1.403*	0.057	0.990	1.988
Mean area cultivated across Seasons A and B (ha)	1.024	0.318	0.978	1.072
Household needed loan in last year	1.23	0.137	0.936	1.618
Asset wealth quintile	1.065	0.224	0.962	1.179
Any household member belongs to a farmer group or cooperative	1.334*	0.065	0.982	1.812
Travel time to 100,000-person market (hrs)	0.990	0.719	0.936	1.047
Northern[1]	2.397***	0.002	1.372	4.188
Western[1]	0.627	0.115	0.352	1.856
Central[1]	1.021	0.946	0.077	0.441

Source: AgResults Uganda Baseline Survey, 2017.
Overall Statistics: Chi-squared = 104.8, and the probability of chi-squared is <0.001. The Pseudo R-squared is 0.0708.
Note: Significance is represented as the following: * .05 < p ≤ .1, ** .01 < p ≤ .05, *** p ≤ .01.
[1] The hypothesis tests of the region variable test whether adoption was more likely in those regions, compared to the Eastern region. Using the variance and covariance of the results from this regression, we also determined that the odds ratio of Northern over Western was 3.819***, the odds ratio of Northern over Central was 2.348***, and the odds ratio of Western over Central was 0.614**. Thus, farmers in the Northern region are more likely to report using improved legume varieties than farmers in any of the other regions; and farmers in the Western region are less likely to report improved varieties than farmers in any other region except Eastern.

Households were 41% more likely to use improved varieties of seeds if they had a male head than if they had a female head (p=.065). As discussed in Section 3.2.3, survey results showed that female-headed households tend to have lower literacy levels, lower levels of educational attainment, and lower participation in farmers' organisations and associations. These socio-economic differences between male- and female-headed households suggest that uptake of quality legume seed could be lower among female-headed households, as they may have less access to the knowledge and resources that are commonly associated with acquisition of seed from commercial sources. In support of this, as discussed in Section 4.2.1, female-headed households in the sample tended to have lower levels of awareness of improved varieties of legume seed, and were less aware of commercial companies as potential sources of legume seed (as reflected by their lower ability to name specific companies selling legume seed, relative to sampled male-headed households).

Households were 14% less likely to use improved varieties of seeds for each additional adult household member (p=.011). In other words, smaller households were more likely to have planted improved varieties. Households were 40% more likely to use improved varieties if they were below the poverty line than if above (p=.057)—this could be the case because

government and NGO seed distribution has been targeted towards poorer households. Farmers were also 33% more likely to use improved varieties of seeds if they belonged to a farmer group or cooperative (p=.065)—this may reflect the fact that government and NGO seed distribution is sometimes facilitated through farmer groups. Farmers living in the Northern region were 140% more likely to report using improved varieties than farmers in the Eastern region (the omitted category; p=.002). In fact, as a footnote to the exhibit indicates, reporting of improved seed use was more likely in the North than in all the other regions of Uganda. The reason for this regional disparity may be the heightened NGO presence and government support in the North, which often includes seed distribution, following years of war until the mid-2000s.

The team also tested the household head's age, education, and literacy, the number of children, the mean area cultivated across seasons, need for loans, asset wealth quintile, travel time to large markets, and living in the Central and Western regions (as compared to the Eastern region), and did not find them to be statistically significant. The Central region did surpass the Western, however.

The evaluation team will assess whether the same characteristics continue to play a role in a household's likelihood of adoption at endline.

Determinants of seed meeting tested quality standards among households reporting adoption of quality seeds. The evaluation team also sought to understand whether certain household characteristics are associated with the use of legume seed that actually met quality standards, based on our seed quality assessment results. As noted earlier, much of the seed packaged and sold as certified, quality seed in Uganda actually fails to meet quality standards. We tested the seeds of respondents who reported that they were using quality legume seeds to see whether those seeds met the applicable quality standards (see Section 3.3 for a more thorough discussion of quality standards and Section 4.2.4 for descriptive statistics of seed quality testing results). We then conducted a regression analysis to identify distinct characteristics of farmers—among those survey respondents who perceived that they had quality seed—whose seed actually met quality standards.

As can be seen in Exhibit 4-15, households that belonged to a farmer group or cooperative were 53% more likely to have used seed meeting quality standards than households that did not belong (p=.021). Also, seed was 247% more likely to meet quality standards for each hour closer a household was to a large market (p=.033). Farmers in the Northern region were 83% less likely to have used seed that met quality standards than households in the Eastern region (p=.059). In fact, as a footnote to the exhibit indicates, use of improved seed use was less likely in the North than in all the other regions of Uganda. This result, in combination with the finding above that Northern Ugandans are more likely to think they are using improved seed, is interesting, though the explanation for this remarkable pattern is not obvious.

Other household characteristics did not have a statistically significant relationship with the likelihood of a household's seed meeting quality standards.

Exhibit 4-15. Logit regression results for household characteristics associated with adoption of quality seed (verified to meet quality standards) (n = 215)

Variable	Odds Ratio	P-Value	CI-Low	CI-High
Outcome				
Legume seed sampled from household was found to meet applicable quality standards based on seed quality assessment results (binary variable)				

Variable	Odds Ratio	P-Value	CI-Low	CI-High
Demographic Characteristics				
Household head is male	0.572	0.389	0.160	2.040
Household head age	0.985	0.507	0.942	1.030
Household head completed secondary school or higher	0.451	0.214	0.129	1.582
Household head is literate	1.347	0.586	0.461	3.929
Number of adult household members	0.850	0.326	0.615	1.175
Number of child household members	1.168	0.155	0.943	1.445
Household deemed poor	1.877	0.240	0.657	5.360
Mean area cultivated across Seasons 1 and 2 (ha)	0.971	0.712	0.832	1.134
Household needs loan	1.101	0.285	0.923	1.314
Asset wealth quintile	1.155	0.756	0.465	2.867
Any household member belongs to a farmer group or cooperative	1.532**	0.033	1.036	2.264
Travel time to 100K market (hrs)	3.467**	0.021	1.210	9.932
Northern[1]	0.172*	0.059	0.028	1.068
Central[1]	1.488	0.598	0.340	6.515
Western[1]	0.585	0.510	0.119	2.879

Source: AgResults Uganda Baseline Survey, 2017.
Overall Statistics: Chi-squared=28.62, and the probability of chi-squared is 0.0180. The pseudo R-squared is 0.167.
Note: Significance is represented as the following: * .05 < p ≤ .1, ** .01 < p ≤ .05, *** p ≤ .01.
[1] The hypothesis tests of the region variable tests whether adoption of quality seed was more likely in those regions, compared to the Eastern region. Using the variance and covariance of the results from this regression, we also determined that the odds ratio of Northern over Western was 0.293*, the odds ratio of Northern over Central was 0.115***, and the odds ratio of Western over Central was 0.393. Thus, among households that believed they used quality legume seeds, those in the Northern region were less likely to have actually used quality seeds than farmers in any of the other regions.

4.3 Evaluation Question 3: What has been the impact of the pilot on smallholders' incomes?

In this section we present baseline findings pertaining to smallholders' legume-related income and consumption. The pilot seeks to impact smallholder income through increased legume yields from higher quality seeds, which would make increased quantities of legumes available to be sold and consumed. It could also lead to lower expenditures on legumes purchased for consumption. Note, however, that because an impact evaluation was not possible for the Uganda pilot we will not answer this question exactly as asked. Our performance evaluation will not establish causal attribution of favourable outcomes to the pilot but rather will comment at endline on the *likely contribution* of the pilot to changes in smallholder incomes since baseline. In this section, we discuss the role of legume production in smallholders' livelihoods prior to the pilot and the extent of smallholders' legume sales at baseline.

4.3.1 Production and yield

Here, we discuss farmers' production and yield of beans and soybeans in 2016. While this report discusses most outcomes in terms of legumes (beans and soybeans combined) as well as isolating outcomes for beans and soybeans separately, we present only the isolated outcomes for beans and soybeans here. Because they are different crops, it would not make sense to calculate combined production and yield for beans and soybean.

We disaggregate by household head gender in this section, rather than disaggregating by improved versus non-improved seed, because the evaluation does not seek to assess the

differences in yield among different types of seed but rather to assess changes in farmer income and yield in general before and after the pilot. However, because the production, yield, and income comparison between improved and non-improved varieties at baseline is potentially of interest to readers, we include these data in Annex B. None of the differences between male- and female-headed households with relation to production and yield are statistically significant, but we discuss them in this section as traits of the survey sample because at endline such differences may emerge as statistically significant at the population level.

In 2016, households that harvested beans produced 240 kg of beans on average (see Exhibit 4-16). Male-headed households had much higher average production of beans (254 kg) than female-headed households (183 kg). Average bean yield was 766 kg/ha. Yields were higher for male-headed households (780 kg/ha) compared to female-headed households (708 kg/ha). This is perhaps a reflection of female-headed households' comparatively smaller cultivated land sizes (1.02 hectares, as compared to 1.38 hectares for male-headed households), as shown in Section 3.2.3.

Exhibit 4-16. Average bean and soy production and yield among households growing each type of legume, by household head gender (n = 1277)[1]

	Overall	Male-Headed Households	Female-Headed Households
Quantity of bean produced (kg)***	240.3	254.2	182.9
Bean yield (kg/ha)*	765.8	779.8	707.5
Quantity of soybean produced (kg)	318.6	326.5	283.7
Soybean yield (kg/ha)	1297.9	1212.5	1668.9

Source: AgResults Uganda Baseline Survey, 2017.
Note: Significant differences between male-headed households or female-headed households are represented as the following: * .05 < p ≤ .1, ** .01 < p ≤ .05, *** p ≤ .01.
[1] See Annex B for disaggregation by improved vs non-improved seed.

Households that produced soybeans harvested an average of 319 kg. Male-headed households in the sample produced 327 kg on average, compared to 284 kg for female-headed households, though this difference is not statistically significant. Average yield was 1298 kg/ha, but the average yield for male-headed households in the sample (1213 kg/ha) was substantially lower than that of female-headed households in the sample (1669 kg/ha, difference also not statistically significant). The reason for this is not entirely clear, though recall from Section 4.2.3 that male- and female-headed households in the sample planted about the same amount of land under soy (0.67 ha and 0.66 ha, respectively), while male-headed households planted considerably more seed than female-headed households (30 kg of soy seed for male-headed households compared to 17 kg of soy seed for female-headed households). The implication is that female-headed households, at least in this sample, are producing soy much more efficiently than male-headed households, though it is not clear why this would be the case.

We will collect self-reported yield data again at endline and compare with the figures in this report to assess changes. We expect that yields for both beans and soybeans may rise with adoption of better seed.

4.3.2 Sales

Of households that harvested legumes, 60% sold part of their harvests in 2016 (see Exhibit 4-17). Of households that harvested beans, 52% sold part of their bean harvest. In keeping with the pilot's understanding that soy is a more commercial crop than beans, 80% of households that harvested soy sold part of their soy harvest. The data are disaggregated by household head gender in the exhibit. A larger proportion of male-headed households

(62%) sold legumes than female-headed households (52%), significant at the 1% level. The same pattern held for beans, with 54% of male-headed households reporting they sold beans compared to 46% of female households, a difference significant at the 5% level. There was no statistically significant difference in the proportion of male- and female-headed households who sold soy.

Exhibit 4-17. Proportion of households selling legumes by household head gender (n = 1277)[1]

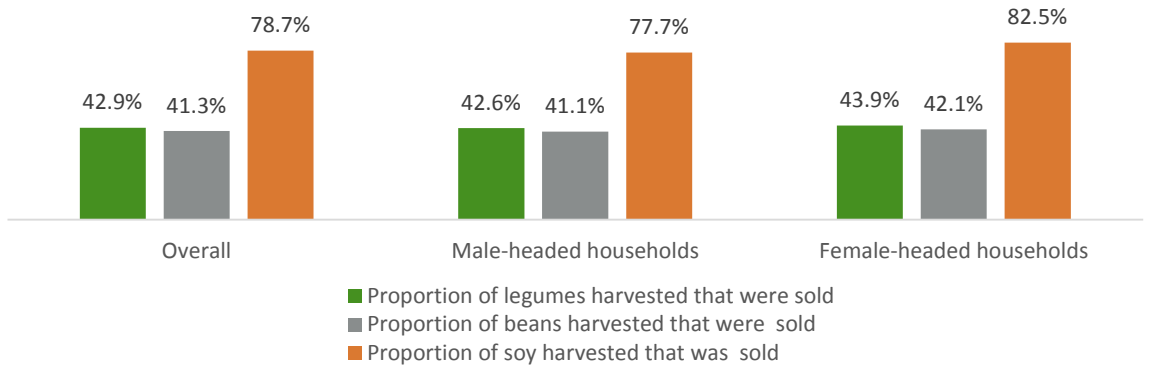
	Overall	Male-headed households	Female-headed households
Percentage of legume-producing households that sold legumes***	60.2%	62.4%	51.8%
Percentage of bean-producing households that sold beans**	52.0%	53.6%	45.7%
Proportion of soy-producing households that sold soy	80.4%	79.9%	82.9%

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.
[1] See Annex B for disaggregation by improved vs non-improved seed.

Households that sold any legumes sold an average of 43% of their legume harvest (see Exhibit 4-18). The proportion of legumes sold was similar for male- and female-headed households in the sample, with male-headed households reporting that they sold an average of 43% of their production while female-headed households reported selling 44%.

When we isolate beans, the results are similar: households that sold any beans from their own harvest sold an average of 41% of their beans. Male-headed households in the sample tended to sell just slightly less (41%) than female-headed households (42%).

Exhibit 4-18. Proportion of legumes sold among households harvesting and selling legumes by household head gender (n = 887)[1]



Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.
[1] See Annex B for disaggregation by improved vs non-improved seed.

Households that sold soy sold a much higher proportion of their production overall, 79%. This is unsurprising given that soy is typically grown as a cash crop rather than for consumption. Male-headed households in the sample again sold a slightly lower proportion of their soy production (78%) than female-headed households (83%).

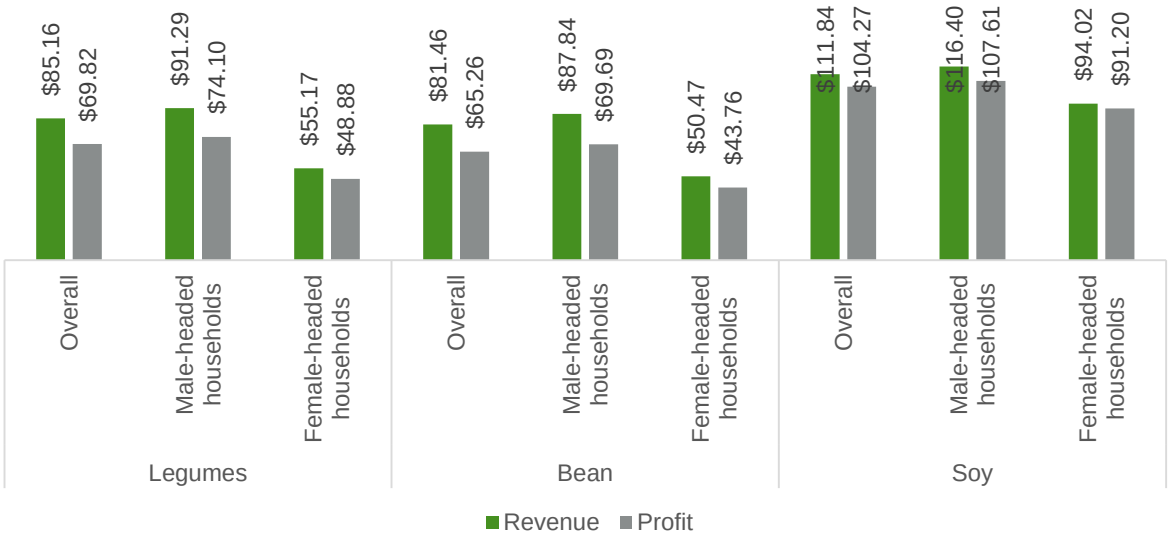
4.3.3 Income

The AgResults evaluation interprets 'incomes' in Evaluation Question 3 to mean shareholders' net incomes—the resources available to fund household consumption or investments once the costs of generating income are removed. For agricultural income, this means profit from farming operations (revenue minus expenditures on farming inputs). For the Uganda pilot evaluation in particular, we define 'income' as profit from legume sales, since legumes are the primary avenue through which the pilot is expected to increase farming households' cash-in-hand. We interpret income this way because improved varieties, if they are grown correctly, may require more inputs and labour than local varieties, and we need to capture that in our analysis. To get at this profit, we first calculate revenue as the total Uganda shillings of legumes sold (aggregated across both seasons in 2016 and converted to U.S. dollars), and we report on revenue in this section in addition to profit. Profit is calculated by subtracting input and labour expenditures attributable to legumes from total legume revenue.

Exhibit 4-19 shows average revenue and profit from legume sales at baseline among Ugandan households that sold portions of 2016 harvests.[19] All figures are conditional on selling some of a particular crop in 2016 (e.g., bean revenue applies only to households that sold beans in 2016). As can be seen, households that sold legumes reported average legume revenues of $85 with an average profit of $70. These totals indicate that legume sales form an important component of households' agricultural income, since the average household income from crop sales in 2016, as reported in the baseline survey, was $268.36. For both types of legumes, male-headed households tended to have higher revenue and profit than female-headed households.

[19] The calculation of profit here includes revenue less expenditures, but it was not possible to take all expenditures (for example, land value and family labour) into account. Our calculation includes costs of all inputs related to producing the crop as well as the cost of hired labour. For family labour, the data do not allow us to assign a monetary value to each day of labour. We report instead on the number of days and will compare family labour spent to produce legumes before and after the pilot. We do not include land, another important input, in our cost calculations. One reason for this is that estimating land value under Uganda's multifaceted land tenure system would be complex and potentially inaccurate. The other reason is that, while it is possible that the pilot could affect the use of inputs and labour, we do not expect the pilot to affect land values or land acquisitions. We report on the amount of land planted under legumes, which could be affected by the pilot, under Evaluation Question 2.

Exhibit 4-19. Legume revenue and profit



Source: AgResults Uganda Baseline Survey, 2017.
For legume revenue and bean revenue, the difference between male- and female-headed households was significant at $p \leq .01$. No other differences between male- and female-headed households were statistically significant.
Note: Calculations of revenue and profit are conditional on having sold beans and/or soy.

Family labour is not included above in the calculation of profit (only hired labour is included) because the data do not allow us to place a monetary value on the labour that family and community members spend to grow legumes. Nevertheless, labour is an important input, since each day of labour spent on the family farm carries the opportunity cost of not earning wages for that day and can therefore be considered part of the overall cost. Labour may be affected by the pilot, since improved varieties may require more labour (e.g., weeding, input application) to reach their full yield potential, and we therefore will compare person-days of labour expended to produce legumes at baseline and endline. During both 2016 seasons combined, as shown in Exhibit 4-20, households spent 158 days on average on all tasks relating to growing legumes (conditional on having grown legumes), spending 145 days on beans (conditional on having grown beans) and 112 days on soy (conditional on having grown soy).

For legumes in general, male households spent an average 165 days on production, while female-headed households spent only 130 days, a statistically significant difference at the 1% level. For beans, male-headed households spent an average of 151 days, while female-headed households spent an average of 121 days, a difference significant at the 1% level. The difference in days of labour spent on soy production was not statistically significant. Annex B presents labour days spent on legume production disaggregated by seed type (improved vs local).

Exhibit 4-20. Person-days of labour expended on legume production in 2016 among households that grew legumes (n = 1150)

	Overall	Male-headed households	Female-headed households
Days of labour spent on legumes***	158.1	165.2	130.0
Days of labour spent on beans***	144.8	150.7	121.1
Days of labour spent on soy	112.0	114.9	98.6

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

4.3.4 Consumption

Bean consumption in all areas surveyed was fairly high, reflecting beans' central role in the rural Ugandan diet. Some households consume soy, but soy consumption is much lower. Almost all households (99%) reported consuming beans in the past year, and just over one in ten households (11%) reported consuming soy in the past year (see Exhibit 4-20). Households that consumed beans reported consuming them an average of 3.6 days per week. Soy-consuming households reported consuming soy an average of 1.2 days per week.

Exhibit 4-21. Rate and average frequency of bean and soy consumption (n = 1499)

	Overall	Male-headed households	Female-headed households
Percent consuming beans in last year	98.7%	98.9%	98.1%
Number of days per week beans consumed (among households with any consumption)	3.6	3.6	3.5
Percent consuming soybeans in last year	10.8%	10.6%	11.7%
Number of days per week soybeans consumed (among households with any consumption)	1.2	1.2	1.0

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

Of all households, 44% reported purchasing beans for consumption in the last year, and 4% reported purchasing soy (shown in Exhibit 4-22). Households that purchased beans reported spending $13.60 on average over the year, a meaningful amount of money for a rural Ugandan household. If bean yields were higher, smallholder households might be able to consume more beans from their own production rather than spending money on beans for consumption. Spending on soy, for the households that purchased it, was small, $2.50 for the year on average.

Exhibit 4-22. Bean and soy purchased for consumption (n = 1499)

	Overall	Male-headed households	Female-headed households
Percentage of households that purchased beans for consumption	44.3%	43.2%	48.1%
Percentage of households that purchased soybeans for consumption*	3.6%	3.1%	5.2%

	Overall	Male-headed households	Female-headed households
Average annual bean expenditure of households that purchased beans for consumption	$13.60	$13.90	$12.00
Average annual soy expenditure of households that purchased soy for consumption	$2.50	$1.87	$3.19

Source: AgResults Uganda Baseline Survey, 2017.
Note: Statistically significant differences between male- and female-headed households are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.

The likelihood of households increasing their bean consumption due to the pilot is unclear—households already report consuming beans fairly often (on half of all days), so it remains to be seen whether increased production, should it occur due to the pilot, would propel them to consume beans even more often. In in-depth interviews, many respondents did express an interest in producing more legumes (especially beans) both for sale and for consumption in the future, expressing competing priorities for saving versus consuming that they must navigate on a continuing basis according to household needs.

4.4 Evaluation Question 5: What evidence exists that the effects of the legume seed pilot will be sustainable in the medium to long term?[20]

Baseline results for Evaluation Questions 1–3 offer insights into the potential for the pilot to sustainably increase availability and uptake of quality legume seed in Uganda. Should such effects occur during the period when AgResults incentives are in place, attention will turn to the *sustainability* of the pilot's effects over the medium to long term following the phase-out of the 'pull' incentive payments. Sustainability will depend heavily on whether the pilot succeeds in addressing the key constraints impeding seed companies' production and sales of quality legume seed. In this section we describe these constraints as identified during the design and baseline phases of the evaluation.

Three factors are likely to be important in determining the medium- to long-term sustainability of the pilot's impact:

- Government accreditation of the AgVerify initiative
- Development of effective demand for quality legume seed
- Seed companies' ability to cost-effectively produce and market adequate volumes of quality legume seed.

Given the overwhelming degree to which the 'lemons' problem of indistinguishably low-quality seed driving high-quality seed out of the market afflicts legume seed transactions in Uganda, and the potential for the AgVerify initiative to offset this 'lemons market' effect, government accreditation of the AgVerify initiative will be critical to the pilot's having any potential sustainable impact. This is particularly important given numerous seed company representatives' comments that the government's failure to institutionalize AgVerify was inhibiting their own investment in the initiative.

The second factor affecting sustainability is the degree to which demand for quality legume seed expands over the course of the pilot. The exact nature of this demand is still to be determined, but it is anticipated that ultimately smallholders must come to appreciate and

[20] As explained earlier, Evaluation Question 4—on impacts on poor consumers' demand—in the standard set used across pilots, regarding impacts on poor (non-smallholder) consumers' demand for derivative food products, does not apply in the case of the Uganda pilot.

value quality-certified legume seed if any expansion of its market caused by the pilot incentives is to sustain.

Turning to the third factor, commercial supply of quality legume seed is also an issue, and many aspects of this are beyond the control of the pilot and seed companies themselves. That is, shortages of breeder and foundation seed, limited working capital, intense price pressures, and legume market dynamics themselves (particularly weather and climate developments that affect production of legume seed) are all factors that must be addressed over time for significant and sustained investment in the market to take place. It will be critical for seed companies to continue to see, beyond the AgResults incentives, a business case for producing quality legume seed, and to develop sustainable marketing and distribution systems to achieve development of demand and farmers' access to seed.

4.5 Evaluation Question 6: What is the evidence on the scale of any effect on private sector investment and uptake, and on the cost-effectiveness of the legume seed pilot as an approach?

This two-part question is best answered after endline data are available to assess the scale, impact, and cost-effectiveness of the pilot. In answering the first part of this question, we will compare the firms' projections about the scale they expect to reach and what they actually attain. Since the pilot is in its first year and the firms are continuing to refine their strategy, we do not yet have adequate data to present the firms' expectations. To address the second part of the question on cost-effectiveness, we will calculate a ratio of pilot cost per unit of impact. Its determination will require estimates of both cost and pilot impact. We will use as our numerator the gross cost of the pilot. As our denominator we will use the results of our analysis for Evaluation Questions 2 and 3; namely, measured change on quality legume seed adoption by smallholders and any attendant increase in smallholders' legume-related income.[21]

4.6 Evaluation Question 7: What lessons can be learnt about best practices in the design and implementation of pull mechanisms?

Consideration of best practices will be an ongoing endeavour throughout the Uganda pilot and will be informed by emerging results from the other AgResults pilot evaluations. At baseline, however, we propose early lessons learnt that inform best practices in the development of viable pull mechanisms.

First, implementation of the Uganda pilot was delayed by a redesign of several of its elements between preparation of the initial business plan, finalized in May 2014, and the pilot's launch in February 2017. All changes to key pilot design elements were approved by the Steering Committee during its March 2016 meeting, and the changes were:

- **Prize structure and timing.** The initial pilot design included only an end-of-pilot prize rather than the annual prize. Seed companies reported that receiving a prize only after 5 years would not address their underlying constraints to increasing production annually. The prize was therefore modified to an annual payout to increase seed companies' motivation to participate. The Steering Committee also approved a cap on each solver's potential prize winnings to ensure that the pilot's prize purse would not be exhausted prematurely. With this change, a solver's eligible sales growth is limited to 20% over the previous year, so while actual sales growth may be higher the payout is capped at an amount the pilot can absorb.

[21] Note: because this is not an impact evaluation, we are able to estimate only the change over time during the pilot period, not the impact attributable to the pilot. Our cost-effectiveness results will thus be indicative only. Nevertheless, it is valuable to compute cost-effectiveness ratios for the key outcomes of interest to determine the scale of costs versus change in smallholder outcomes.

- **Dropping groundnuts from the pilot**. The initial design included groundnuts in addition to beans and soybean. The Steering Committee approved the Secretariat's recommendation to drop groundnuts for several reasons including limited productivity benefits of improved varieties over local groundnut varieties, the small current market for improved groundnut varieties, sensitivity of groundnuts to spoiling during storage, and the lower relative importance of groundnuts in the Ugandan diet compared to beans.
- **Dropping the volume guarantee and addition of cold storage option in place of destroying unsold seed each season.** The pilot initially included a scheme for AgResults to purchase unsold seed at a fraction of the market price at the end of each season due to an assumption that this would help offset seed companies' risks of increasing legume seed production against uncertain demand. The pilot would then destroy the unsold seed. However, the Secretariat found upon further investigation that unsold seed could be preserved in cold storage without losing quality from season to season. Now, seed companies can use the cold storage facility to store any unsold seed until the following season. This change was made to preserve the value of unsold seed rather than removing it from the market and because of tepid seed company interest in the volume guarantee.
- **Addition of the AgVerify requirement**. The Secretariat recommended this change based on the External Evaluator's findings during its initial qualitative assessment (IQA). During the IQA field visit, the evaluation team found overwhelming evidence of Uganda's 'lemons market' for legume seed based on interviews with numerous value chain players and experts. We concluded that if the pilot did not include a quality verification component for the seed, it ran the risk of rewarding seed companies to sell even more low-quality seed rather than catalysing a well-functioning market for certified seed that reliably outperforms what smallholders could get for low or no cost locally. Based on the discovery of the market for lemons, the Evaluator initiated discussions with the Secretariat that resulted in the addition of AgVerify as a requirement for seed companies participating as solvers.

The key observation that the market was a market for lemons came from the evaluation team's comprehensive value chain analysis, which identified a critical gap in the logic underlying the original pilot design. This highlights an important lesson: Develop pull mechanisms on the basis of a careful and comprehensive value chain analysis that considers not only the structure of the underlying value chain (in this case the legume seed value chain) but also the constraints and motivations of actors participating in that value chain and its institutional context. A pull mechanism cannot sustainably shift the supply or demand curve for a particular technology without adequate institutional underpinnings to sustain development of the market being targeted by the pull mechanism—in this case, the market for quality legume seed.

On a related note, the evaluation team's early research also revealed that seed industry actors had critical feedback on certain facets of the pilot design. The pilot redesign largely addressed these concerns, apparently increasing seed companies' enthusiasm for participating in the pilot. An important lesson learnt from this, then, is the need for careful vetting of the pilot design with private sector actors along the value chain, particularly those that are to be targeted as Implementers, as well as other industry experts.

5. Evaluation next steps

The evaluation team will continue to monitor pilot implementation and the evolving implementation context as part of our ongoing qualitative assessment. We will be particularly attuned to adjustments to the pilot design and implementation activities, tracking these and proactively considering how they might affect the pilot's impact. We will also regularly examine the pilot's monitoring data to assess progress towards the pilot's goals. We will note in particular any adaptive management strategies employed as part of implementation, looking at the interplay between pilot progress (as measured by the monitoring indicators), the local context, and pilot implementation decisions.

Beginning in early 2021 (barring unanticipated changes to pilot design that might necessitate a shift in the evaluation timeline) we will prepare for endline data collection and analysis. Endline data collection will occur in mid-2021.

In 2022 and 2023, we will undertake a post-pilot sustainability analysis for the Uganda pilot as well as other AgResults pilots.

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Annex A

This annex presents detail on data cleaning and quality assurance procedures for both quantitative and qualitative baseline data.

Qualitative Data

For qualitative data, interviews with key informants (non-smallholder respondents) were recorded either in writing or using sound recordings (with respondent permission), then transcribed by the Agricultural Economist. Data collection took place in respondents' preferred language assisted by translators as needed. Once entered into Microsoft Excel by the Agricultural Economist, data were conveyed to the Qualitative Lead for cleaning and analysis. The Qualitative Lead cleaned, coded, and analysed the data using Microsoft Excel and SPSS, maintaining ongoing communication with the Agricultural Economist to address any data quality issues and to discuss emerging results.

For smallholder data, the Pilot Lead worked with translators from IPSOS, a Uganda-based data collection firm, to conduct in-depth interviews. Interviews were conducted in English, Luganda, Luo, Runyankole/Rukiga, or Lumasaba as applicable. These interviews were recorded (with respondent permission) and then transcribed and translated into English by IPSOS. The Pilot Lead and Research Analyst coded and analysed the data using NVivo.

Quantitative Data

For the quantitative smallholder survey, Abt and Ugandan survey firm Wilsken pre-tested the survey instrument and built a computer-assisted personal interview (CAPI) tool with carefully programmed skip patterns and constraints to minimize data collection errors. Wilsken and Abt held a week-long data collection training for enumerators, which included a day of piloting where all enumerators completed at least two interviews. A member of the Abt team oversaw the first several days of data collection in person. After that, Abt supervised data collection remotely through weekly email updates as well as weekly phone calls to discuss progress, any issues that may have come up, and how those issues were resolved.

Abt conducted data quality assurance checks on the data such as checking for skip patterns and outliers and worked with Wilsken to call back or revisit households that had any missing, unlikely, or impossible responses. After data collection was completed, Wilsken also conducted back-check visits or phone calls, in which an independent interviewer or supervisor re-asked several key questions from the survey, with 160 households. The back-check question responses had an average match rate of more than 90% with the original interview responses, with more than 95% matching on most questions. While there is no hard-and-fast rule as to what match rate is acceptable, previous experience suggests that this survey's rate was quite good.

In addition to other quality control measures, both Wilsken and Abt conducted consistency checks to ensure that responses were logical and consistent with what we would expect to find. This included checks on impossible combinations of variables (i.e., a person reporting they were 200 years old or information on harvesting a crop the respondent did not report growing). During this process, Abt identified some inconsistencies in local units of land measurement used. In response, Wilsken followed up with all respondents using these local units and converted them into widely recognized units such as acres.

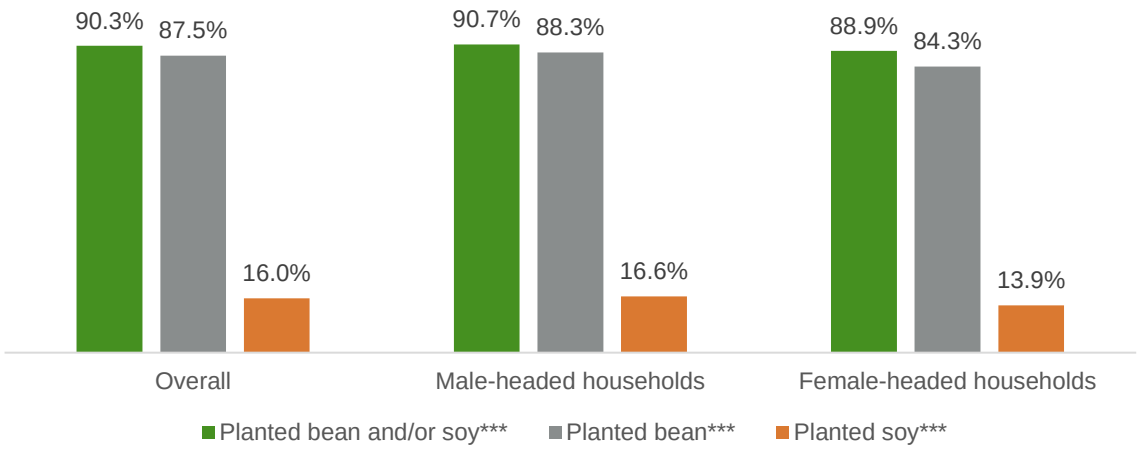
Abt performed all data cleaning, including standardizing units and converting currency amounts into U.S. dollars. For any outliers that appeared to be erroneous or unlikely to the point that they would significantly skew the data, Abt mitigated the impact of the outlier on later analysis by topcoding the data. The process of topcoding included reviewing responses for outliers and replacing those responses with a more viable response that would not skew the data. The rule used for topcoding was to use the response at the highest level possible

that still yielded a plausible range of values. Typically, this response would be the response at the 99th percentile of the distribution of responses, but in a few cases topcoding to the 95th or 90th percentile was done depending on the extent of the outlier.

Annex B

This annex presents additional data disaggregations that may be of interest to readers. In all cases, statistically significant differences between categories (male-/female-headed households or local/improved varieties) are represented as the following: * .05 < p ≤ .1; ** .01 < p ≤ .05; and *** p ≤ .01.:

Exhibit B-1. Proportion of households planting legumes in 2016 by household head gender (n = 1499)



Source: AgResults Uganda Baseline Survey, 2017.

Exhibit B-2. Average quantity and area of legume cultivation in 2016 among households that grew legumes, by household head gender (n = 1298)

	Overall	Male-headed households	Female-headed households
Quantity of seed planted			
Legumes (bean and/or soy) (kg)	39.4	42.8	27.0
Beans (kg)	38.5	41.4	27.2
Soy (kg)	27.7	30.2	17.2
Area planted			
Legumes (bean and/or soy) (ha)	0.83	0.88	0.64
Beans (ha)	0.79	0.83	0.60
Soy (ha)	0.67	0.67	0.66
Quantity planted per hectare			
Legumes (bean and/or soy) (kg/ha)	47.5	48.8	42.0
Beans (kg/ha)	48.7	49.6	45.2
Soy (kg/ha)	41.4	44.9	26.3

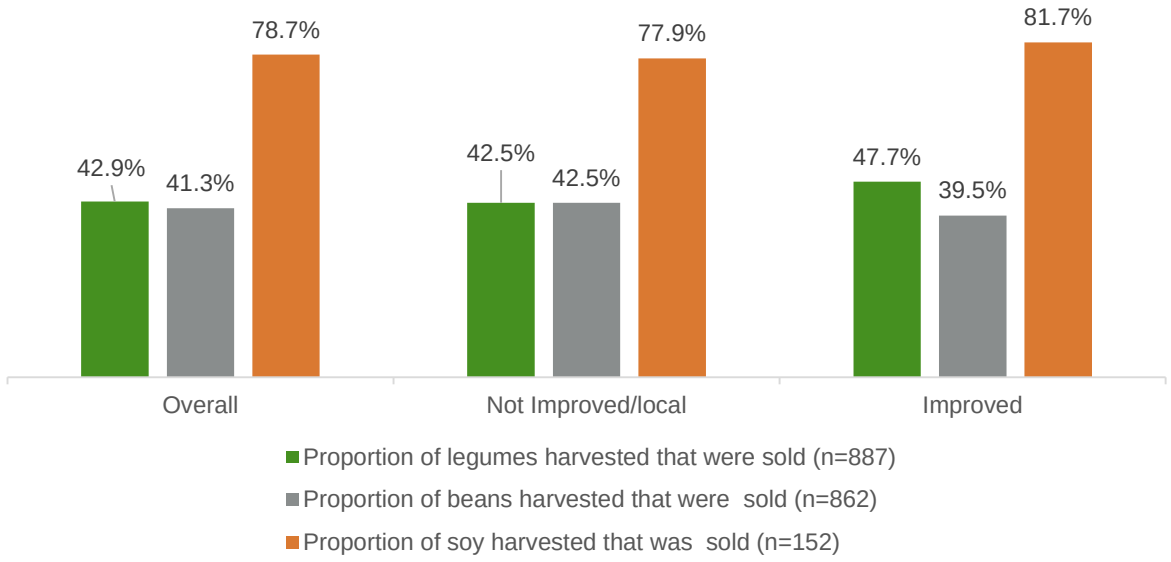
Source: AgResults Uganda Baseline Survey, 2017.

Exhibit B-3. Legume production and yield among households producing legumes, by seed type and type of legume

	Overall (n = 1156 bean, 206 soy)	Non-Improved (n = 974 bean, 147 soy)	Improved (n = 234 bean, 68 soy)
Quantity of bean produced (kg)	240	234	210
Quantity of soy produced (kg)	318	297	322
Bean yield (kg/ha)	730	764	619
Soy yield (kg/ha)	1276	1405	1167

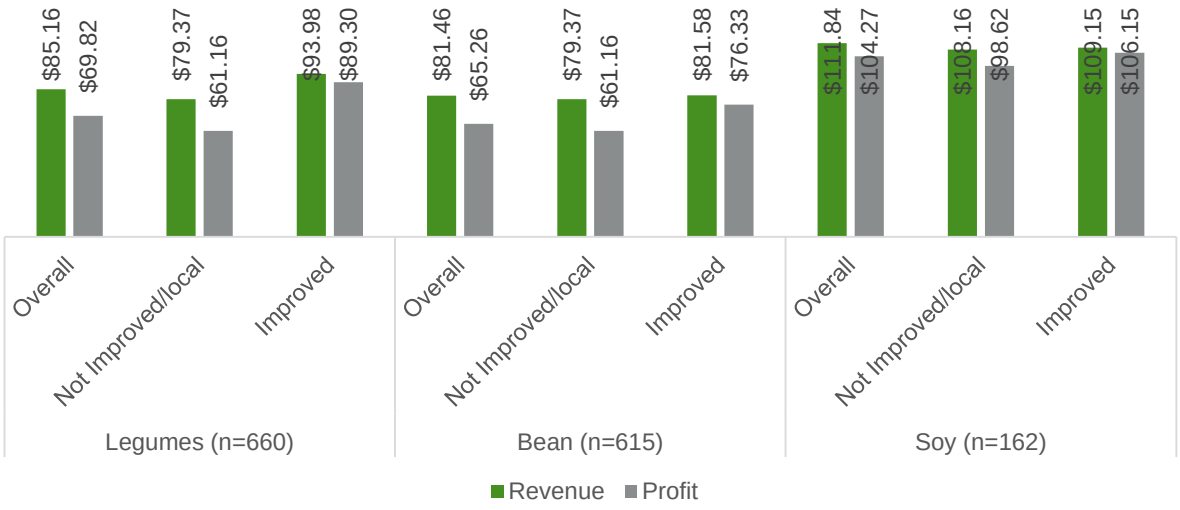
Source: AgResults Uganda Baseline Survey, 2017.

Exhibit B-4. Proportion of legumes sold among households harvesting and selling legumes, by seed type and by type of legume



Source: AgResults Uganda Baseline Survey, 2017.

Exhibit B-5. Legume revenue and profit among households selling legumes by seed type and type of legume



Source: AgResults Uganda Baseline Survey, 2017.

Exhibit B-6. Person-days of labour expended on legume production among households producing legumes by seed type and type of legume (n=1150)

	Overall	Non-improved/local varieties	Improved varieties
Days of labour spent on legumes	158.1	152.8	131.4
Days of labour spent on beans***	144.8	141.7	125.2
Days of labour spent on soy	112.0	109.7	96.7

Source: AgResults Uganda Baseline Survey, 2017.