Policy brief
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Are inputs really so bad?

A study of the quality of the maize seed supply chain in Uganda

In brief

- Researchers and policymakers have argued that poor quality of seeds and fertilisers in Uganda constrains the adoption of modern agricultural inputs by farmers who do not perceive these investments to be profitable.
- Recent studies suggest the adulteration of seeds and quality deterioration along the supply chain as possible causes for the suboptimal agricultural inputs. However, it is unknown if quality deteriorates along the chain, where and why, and if adulteration is the reason.
- The results of this study reveal high levels of physical quality and genetic purity of maize seeds in general. Also, it is not found that quality deteriorates systematically along the supply chain. Instead, quality drops as soon as the seeds leave the breeders and remains unchanged, on average, across the rest of downstream suppliers.
- These findings suggest that the prevalence of low seed quality is likely due to mishandling and poor storage immediately after original sources, rather than intentional counterfeiting or adulteration by lower level sellers.
- These results have significant implications for agricultural policy in Uganda, as existing efforts to enhance seed quality have tended to focus on certification and labeling to reduce the probability of adulteration. Very little effort has been placed by the Government and international community to improve quality control through improved storage and handling.

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Motivation

Agriculture is a critical industry in Africa, mainly for smallholder farmers who grow crops on a subsistence level. Despite the importance of maize, adoption of improved inputs is low. This has been attributed to several factors, including the lack of economic incentives, poor infrastructure, and limited information of the market. Likewise, seed quality is a well-known issue in Uganda, but has not been studied extensively. Evidence suggests that farmers prefer to use home-saved seeds, indicating that they don't perceive the benefits of improved seed to be worth the cost (Tripp and Rohrbach, 2001; Remington et al., 2002; Sperling et al., 2008).

Another potential explanation that has been only partially studied is the possibility that farmers, government, and NGOs are sourcing adulterated seeds, or that seed quality deteriorates within the supply chain[1] before it reaches the farmer. For example, Bold et al. (2017) found that a random bag of fertiliser has significantly missing nutrients and, that under certain strong assumptions, can lead to negative returns for farmers. They also looked at the quality of improved maize[2] seeds and found a similar story.

Our project builds off of this recent work. Our goal is to further explore quality issues and diagnose the main reasons for low quality, if any. We look at whether quality deterioration results from tampering by sellers and if it degenerates along the supply chain, and if it does, at which point quality is worst. Evidence on the factors contributing to poor seed quality can help inform targeted policy interventions to address a potentially significant problem.

Purity and performance tests to assess seeds quality

To assess the quality of seeds, we employ a combination of tests on genetic purity[3], physical purity[4], and seed performance[5]. This set is generally used in quality assurance and regulatory compliance to guarantee seeds' trueness-to-type, freedom of contamination, and the ability to produce normal and healthy plants in the field (Roos and Wianer, 1991).

1. Seed deterioration can be attributed to several factors that come from the seed's genetics or from external factors, such as the field or improper storage conditions at any level of the supply chain that bring stresses to the seed: e.g. abiotic (high moisture, oxygen, and carbon dioxide) and biotic (pathogens or insects), resulting in lower quality.
2. Note that maize is generally considered the best regulated crop. It is one of the most profitable crops and, as farmers need to buy new seeds every year it is the most demanded.
3. In the study we defined genetic purity as the DNA distance across seeds, or how genetically similar they are to each other.
4. We defined physical purity as the percentage of dead seeds and inert matter (rocks, sticks or sand) contained.
5. We defined performance of seed as the rates of germination, moisture levels, and scores of a vigor test. The latter test predicts the percentage of seeds that could grow under ideal conditions and how well they can perform after storage and transportation. They are used to evaluate the impact of adverse storage conditions, mechanical damage, or drying injuries in the seeds' performance.

Seed indicators examined to assess quality

Indicator	Type of test	Brief description
DNA distance	Genetic purity	How similar are seeds across each other
Pure seeds	Physical purity	Percentage of weed-free seed in a lot
Dead seeds	Physical purity	Percentage of dead seeds in a lot
Inert matter	Physical purity	Percentage of the content of sticks, roots, and sand in a lot
Germination rate	Performance	Percentage of seeds that germinate under ideal conditions in a lot
Moisture content	Performance	Content of moisture
Vigor	Performance	Percentage of seeds that germinate under field conditions in a lot
Abnormal seeds	Performance	Percentage of seeds that develop abnormal roots or buds in a lot

We explore a sample of seed lots along the entire supply chain from factory gate to downstream levels6 for 21 varieties of seeds, hybrid and open pollinated varieties (OPV), for maize seeds, a highly cultivated crop in Ugandan agriculture.

In Uganda, the National Crop Resources Research Institute (NaCRRI), Namulonge, is the main supplier of breeder seeds to seed companies. The seed companies then multiply the seed at foundation seed farms or use contract growers. Company-produced seed (labeled seed) is then packed and sold to farmers through a distribution network consisting of company outlets, wholesalers, and retailers.

Data collection, lab testing, and analysis

We used a mystery shopper approach to collect the samples of seeds from all the distribution points along the supply chain in four districts of Uganda: Arua, Lira, Kitgum, and Kampala. The selection of geographical areas was based on the size of the district and oversight from government and NGOs.

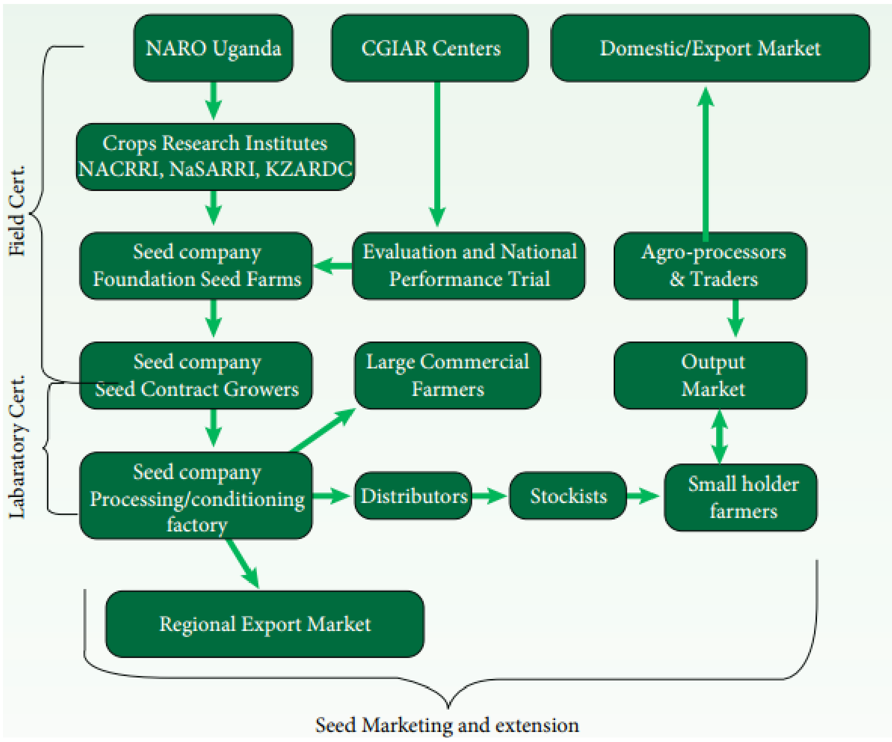
After carefully piloting the mystery shopper methodology, the survey team visited every seed supplier in the district headquarters and traveled to each of the sub-county headquarters. Enumerators entered the shops, identified themselves as local farmers and bought for samples of all the seeds being sold.

All the seeds collected were carefully packed and sent to a seed testing facility in Uganda to examine the seeds' physical purity and performance. To evaluate

6. Wholesalers, retailers, wholesaler/retailers, and outlets.

the first, the lab conducted tests of moisture, vigor, the percentage of pure seeds and dead seeds, and the rate of germination of normal seeds. Likewise, to examine the genetic purity based on DNA distance, ground samples of seeds were shipped from Uganda to a laboratory in Australia.

Figure 1: Seed supply chain in Uganda



Source: Victoria Seeds Ltd

Results

We found, on average, high levels of purity, both genetic and physical, across all levels of the supply chain. Seed samples collected are genetically very similar to each other and presented good physical purity (above 99%), meaning that inert matter (dirt, sand, stones, sticks, and stems) is almost absent7 in the sample. This suggests there is less to be concerned about counterfeiting or adulteration in this study.

'While the results are on average positive, a farmer does face a significant risk in that some bags of seeds are of very low quality when purchased from sellers further down the supply chain'

The results of the lab tests show that the indicators of performance were good at the average level across the sample. However, we found significant variation in several indicators. For example, moisture content was on average at the optimal level (13%), although there is high variation, meaning that for some samples moisture can get as high as 16%. The germination of normal seeds was also good, above 86%, but again it largely varied with some samples only germinating 4% of normal seeds. While the results are on average positive, a

7. On average, content of inert matter in the samples is less than 1%

farmer does face a significant risk in that some bags of seeds are of very low quality when purchased from sellers further down the supply chain.
In Figure 2, we present plots with the results of performance (germination rates, vigor test, content of moisture, and rate of abnormal seedlings). We see that outliers are more common at the wholesaler/retailer level than at the two other points (company outlets and company gates). In general, observations from wholesaler/retailer and outlet compared to gate are spread out and extreme values are more frequent. Figure 3 presents the indicators related to physical and genetic purity (percentage of pure seeds, percentage of dead seeds, percentage of inert matter, and DNA similarity), observations here are more concentrated around the mean, and vary in smaller rangers.

We conclude that, in general, the sample is genetically similar and of good physical quality. We find little evidence of tampering. Performance indicators, such as germination rate and moisture levels, are very similar across the supply chain. However, the variation found in the vigor test scores is striking. More observations coming from the wholesaler/retailer, compared to other sellers, tend to be at the lower levels (less than 45%). The vigor test predicts the performance of seeds after storage and transportation, meaning that the causes for the reduced quality may be possibly linked to poor supply chain management during these stages.

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Key research objectives	Summary of the key findings
Examine the causes for the seed quality issue along the supply chain in Northern Uganda	No evidence of counterfeit seeds was found. Seed samples collected are genetically and physically very similar (above 99%) across observations, and along the supply chain. Reduced quality is likely associated with mishandling of seeds, perhaps leading to suboptimal conditions (like temperature and supply of oxygen) during storage or transportation.
Explore seeds along the supply chain Examine company-labelled seeds to establish whether seed companies produce genetically pure seed or whether contamination occurs during multiplication on foundation seed farms, contract outgrowing, and distributors.	Germination of normal seeds is overall high and very similar across supply chain levels. Seed performance was on average within the benchmark ranges. However, quality of seed highly varies across levels and wholesaler/retailer is the worst in vigor scores (Figure 2).

Figure 2: Results of seed performance

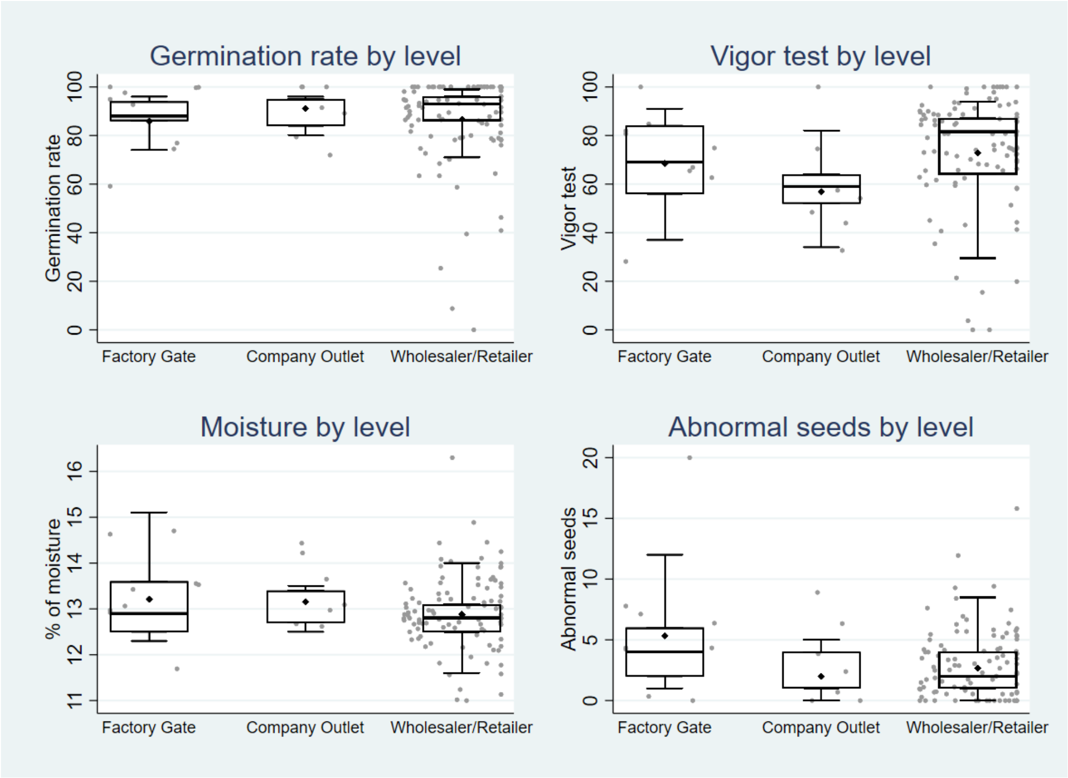
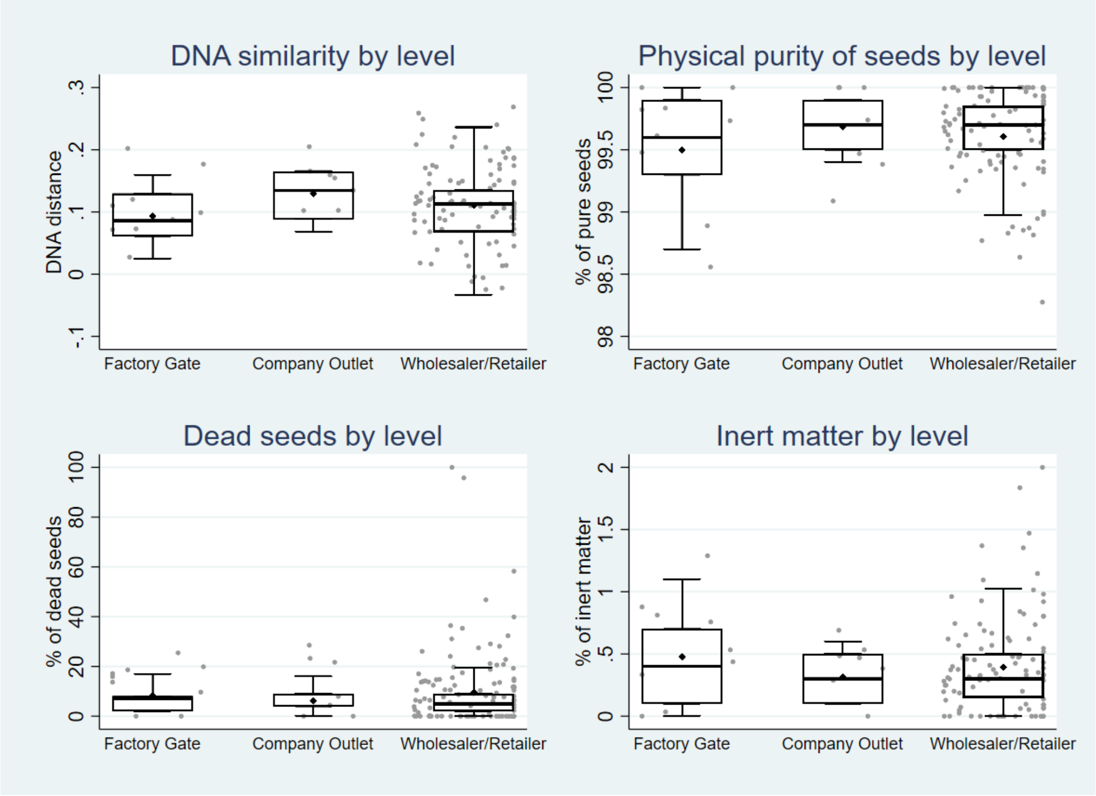


Figure 3: Results of seed purity



Some notes of caution are needed for these results. First, we were only able to trace the supply chain of maize in one year, across four districts. The results are thus potentially limited in their application to other crops, years, and regions. We are also limited in our sample size as we were only able to collect 120 samples in total. A replication of this proof of concept is needed in different locations, seasons, and years. Since 2015, there has been more government involvement in the seed sector. A study across years and locations will allow for confirming the absence of counterfeit seeds more broadly, and whether the issue is improving or not.

Second, it is important to note that germination is not the same as yield. We are not at this time able to say if the germinating seeds produce good quantities. However, given how farmers currently source seeds, this issue is likely less of a concern as the major problems so far have been associated with germination.

Finally, we do not have samples from breeders. This means that we must infer that there is high quality coming from NaCRRI and other initial suppliers and that this drops before the company gate. This assumption affects where the issue is coming from, but not what we find regarding seed quality and differences across the lower supply chain.

If the results we obtained can be generalised, it is possible they could significantly change the way policymakers approach the issue of low quality seeds in Uganda. If adulteration is not the problem, but instead storage and transportation are the major constraints to quality, money currently being spent on certification processes could be better spent. Future work will need to confirm this interpretation is in fact true.

As low adoption rates and seed quality have been a well-known issue in Uganda and the rest of sub-Saharan Africa for decades, the challenges faced by the seed sector are not new, nor are some of the recommendations we provide8. Our study produces evidence of the supply chain, a novel contribution that may help address existing issues of low uptake of seeds in Uganda.

Understanding whether quality issues are due to adulteration, contamination, or mishandling, and at what point in the supply chain these issues occur, is crucial to inform policymakers so they can implement modifications within the supply chain system. There is a lot of attention focused on seed certification, but very little going to quality control. We suggest the following policy recommendations based on our results:

8. Joughin (2014) provides an analysis on why the Ugandan seed market had failed to implement old recommendations to date. The author attributes the lack of interest to develop the industry to short-term political benefits overweighting the policy-making process, translated into long-term plans not being implemented with commitment, and public and private firms' economic interests from the status quo. The "relative stasis" he describes is difficult to break and may be explained by institutional dysfunction, failure of leadership, poor donor coordination, and risk of economic losses from larger farmers.

- **Leverage existing monitoring mechanisms to target quality control interventions along the seeds supply chain**

  The quality issues we observe are consistent with mishandling. Although rules are in place, there are few resources available for regulators, meaning that currently monitoring is almost non-existent. We believe strengthening existing monitoring systems would produce good returns to small scale farmers.

- **Promote collective action within stakeholders**

  Dynamic relationships within stakeholders – suppliers, farmers, and public agencies – are likely key to improving commercial relationships between breeders, farmers, and distributors. For instance, seed companies could work on the mechanisms to inspect quality indicators and then public agencies can monitor that quality standards are met along the supply chain, and at any region. Also, public agencies may work with farmer groups to disseminate simple and reliable information on the quality of seeds, the identification of the new varieties, and their economic benefits.

- **Further studies and replication of this proof of concept**

  In this study, we observed reduced quality at the downstream levels of the supply chain associated with poor management during transportation and storage. Optimal germination is conditioned to several factors, from the seeds' genetics to good technical practices that maintain favorable environment for performance. Thus, we recommend further studies on the agronomic practices and conditions during seed storage and transportation. Future evidence is needed to determine conclusively what is driving low quality seeds in Uganda. The mystery shopper approach served as a method to collect representative samples of seeds with confidence, as if actual farmers would have purchased a bag of seeds, from a census of seed companies across the supply chain in four districts. The replication of this work in different regions, seasons and years will allow for generalising our findings and disentangling the broader seed market.

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