Agricultural Extension Messages Using Video on Portable Devices

Increase Knowledge about Seed Selection and Seed Storage and Handling among Smallholder Potato Farmers in Southwestern Uganda

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ABSTRACT

To feed a growing population, agricultural productivity needs to increase dramatically. Agricultural extension information, with its public, non-rival nature, is generally undersupplied, and public provision remains challenging. In this research, we explore the effectiveness of alternative modes of agricultural extension information delivery. We test whether simple agricultural extension video messages delivered through Android tablets increase knowledge of recommended practices in seed selection, storage, and handling among a sample of potato farmers in southwestern Uganda. Using a field experiment with ex ante matching in a factorial design, we find that showing agricultural extension videos significantly affects farmers’ knowledge. However, our results suggest impact pathways that go beyond simply replicating what was shown in the video. Video messages may also trigger a process of abstraction, whereby farmers apply insights gained in one context to a different context. Alternatively, video messages may activate knowledge farmers already possess but, for some reason, do not use.

Keywords: extension, video, seed selection, storage and handling, knowledge, potato, Uganda
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1. INTRODUCTION

To feed a growing population, agricultural production needs to increase dramatically. The global population is projected to increase to more than 9 billion by 2050. In order to meet the demand for increasingly calorie-intense and complex diets, overall food production would need to increase by some 70 percent between 2005/2007 and 2050 (FAO 2009). However, this increase needs to be accomplished against a background of greater competition for land, water, and energy, and in the context of a changing climate. Therefore, sustainable intensification, whereby modern inputs and improved technologies and practices allow farmers to grow more food from the same area of land while reducing environmental impacts, is imperative (Tilman et al. 2011; Garnett et al. 2013). Indeed, in Asia, the use of modern inputs and techniques on a large scale led to a substantial increase in yields in a relatively short period of time (Mueller et al. 2012). Conversely, yield gaps, expressed as the difference between actual yields and attainable yields, remain large in many parts of the world, and especially in Africa south of the Sahara. Closing these gaps in underyielding locations through the use of modern inputs and improved technologies is expected to boost production, increase food security, and reduce poverty (Godfray et al. 2010).

Use of modern inputs such as inorganic fertilizer and adoption of recommended farming practices such as row planting are generally low in developing countries. There are different reasons why smallholder farmers shun agricultural intensification investments. It may be that the agricultural technology is simply not profitable, so nonadoption is a rational response on the part of the farmer. However, more careful investigation suggests substantial heterogeneity, with some farmers adopting certain practices while others do not. Such selective adoption is indicative of market imperfections (de Janvry, Fafchamps, and Sadoulet 1991), land and labor market inefficiencies, credit constraints, missing insurance markets, and poor infrastructure (Jack 2013). In poor, remote communities, information market inefficiencies are often blamed for underadoption: if an individual does not know that a technology exists, does not know about its benefits, or does not know how to use it effectively, then he or she will not adopt the technology. Since information is a public, nonrival good, governments across the developing world have started providing extension services on a large scale. However, they have done so with mixed success. While most studies have reported positive impacts of extension services, these effects are far from general (Taye 2013), with cost-effectiveness, scaleability and accountability frequently cited as issues (Anderson and Feder 2007). Information and communication technologies (ICTs) have been advanced as a promising way to improve agricultural extension services (Aker 2011). However, to date, most use of ICTs in development has been in the provision of financial services through mobile phones (Duncombe and Boateng 2009), while the potential for agricultural extension has been studied less.

This research contributes to the literature on innovations in agricultural extension services by testing whether showing simple and short videos is a viable alternative to more elaborate, and hence more costly, extension practices. More specifically, we investigate whether simple informational interventions succeed at increasing knowledge among smallholder farmers. To do so, we set up an experiment among Irish potato farmers in the Kigezi subregion in southwestern Uganda, where low seed quality is an important reason for low yields. While providing access to basic pathogen-free foundation seed should remain a key policy priority, current seed systems are too weak to have a significant impact in the short to medium run. Therefore, in a context where farmers rely heavily on recycling of their own seed as planting material for the next season, the selection, storage, and handling of seeds are the main pathways to improve quality. Our interventions therefore focus on positive seed selection (PSS), the practice of keeping the best potatoes as seed material (Schulte-Geldermann, Gildemacher, and Struik 2012), and potato seed storage and handling (PSSH), involving optimal storage of seed potatoes between harvest and planting for the next season.
Our experiment adheres to the highest standards in terms of transparency. For instance, a preanalysis plan that details what sampling methods would be used, what specifications would be run, and what outcome variables would be used was developed before the interventions took place. The experiment was also registered at the American Economic Association’s registry for randomized controlled trials (Van Campenhout, Vandevelde, and Van Asten 2016). Finally, the entire project, including all data, computer code, and documents, is under revision control using Git and mirrored on an online repository (https://bitbucket.org/bjvca/potseedrc). This means all material can be downloaded to rerun the analysis and track changes to the project over time, resulting in a level of transparency that is exceptional in the social sciences.
2. MATERIALS AND METHODS

Experimental Units

We collected baseline from potato farmers in three districts (Kisoro, Kanungu, and Kabale) in southwestern Uganda for the 2013/2014 agricultural season. These districts are very important for potato production, together accounting for about 47 percent of total potato production in Uganda (UBOS 2010). With the assistance of the Uganda Bureau of Statistics, we randomly selected 35 enumeration areas. Within each enumeration area, we then listed all households and determined whether they were growing potatoes. From these lists, potato farmers were randomly selected to be interviewed on a range of socioeconomic variables. For our experiment, we selected 248 farmers from this baseline (see next section).

Approval for the experiment was obtained from the International Food Policy Research Institute’s Institutional Review Board (IRB #00007490: FWA #00005121) on February 2, 2016 (IRB approval number 2016-12-DSGD-M). We also obtained the consent of each farmer who was selected to participate in the study.

Experimental Design

These farmers were then randomly allocated to one of four treatment arms of a 2 x 2 full factorial design. In particular, about half of the farmers received the first treatment (Positive Seed Selection, or PSS see "Treatments," subsection below) and about half received the second treatment (Positive Seed Storage and Handling or PSSH). However, half of this last subset overlapped with the farmers that were treated with PSS. Thus, a quarter of farmers received both the PSS and PSSH treatments, and about a quarter of farmers received no treatment at all.

We used a matched block design, grouping farmers with similarities along a range of characteristics, in keeping with the principle that in small samples, designs based on matching and stratification can significantly improve statistical power (Bruhn and McKenzie 2009). To do so, we randomly selected a farmer from our sample and then located in the sample the farmer closest to the first farmer on a set of predefined characteristics (by minimizing the square root of the sum of the standardized differences of the measures for these characteristics). We repeated this process three times to obtain a block of four farmers from the sample. (To reduce spillover effects, we also maximized the geographical distance between the four farmers within each block.) We then repeated the matching process until all farmers had been assigned to groups of four and the desired sample size is obtained. Finally, we randomly allocated the four treatments (Control, PSS, PSSH, PSS + PSSH) to the four farmers within each block. Our sample size was 248 observations, resulting in 62 blocks.

We matched farmers on 10 variables, 3 of them related to household demographics that are standard in empirical specifications of agricultural household models (Singh, Squire, and Strauss 1986). Household size is an important measure of human capital, particularly in smallholder agricultural settings with imperfect labor markets (Benjamin 1992): age of the household head which captures experience and life-cycle effects: and gender of the household head, important because previous knowledge about modern agricultural techniques and inputs may differ by sex (Doss and Morris 2000). Other variables include the area of potatoes grown, whether the household received extension on potatoes in the past, the logarithm of potato yields, the logarithm of welfare per capita travel distance to the closest farm input dealer or farm supply store, and access to credit.
Inference

The matched design of our experiment is likely to introduce dependence among outcome variables within blocks, so we need to account for clustering during inference (Bruhn and McKenzie 2009). Because the typical approach to deal with this, using cluster-robust standard errors, is known to be biased in small samples, we use randomization inference (RI) (Young 2015). Instead of relying on a theoretical distribution, RI involves comparing the test statistic with the distribution of the test statistic under each possible allocation of treatments. In particular, within each block of four matched farmers, we compute the outcome (that is, the proportion of correct answers on a short quiz) for all six possible permutations of two treatments (because the four treatment arms in the factorial design correspond to two pure treatments). For 62 blocks, this leads to a total of 6^62 permutations, so instead of actually computing all combinations, we base inference on a random subsample of 100,000 permutations for the means tests.

Not accounting for the method of randomization may result in overly conservative standard errors and a significant reduction in power (Bruhn and McKenzie 2009). Therefore, in addition to accounting for clustering through the use of RI, we also run regression models that include fixed effects at the block level. Note that in each block $b = \{b_1, ..., b_{62}\}$, we have four treatments that were randomly assigned. For the main treatments, each block always has two treated and two control observations $t = \{c_1, c_2, r_1, r_2\}$. We estimate average treatment effects $\bar{\beta}$ by regressing the outcome variable $y$ on the treatment indicator $T$ where $T = 1$ if $t = \{r_1, r_2\}$, and 0 otherwise, and on fixed effects for the blocks $(\delta_b)$:

$$y_{t,b} = \alpha + \delta_b + \beta T_{t,b} + \epsilon_{t,b},$$

(1)

where $\alpha$ is a constant and $\epsilon_{t,b}$ is an error term.

Treatments

The interventions rely on two basic information treatments. Simply providing information has been found to be very effective in a range of applications. For example, Jensen (2010) observed that returns on education are perceived much lower than they actually are, and found that students who were told about the higher measured returns completed on average 0.200–0.35 more years of school over the next four years. Dupas (2011) found that providing teenagers with information about the risk of HIV infection relative to one’s partner’s age significantly impacted their sexual behavior. In the context of agricultural extension, Cole and Fernando (2016) found that delivering timely, relevant, and actionable information and advice to farmers reduced knowledge gaps and increased productivity.

The information treatments took the form of video messages shown to farmers on Android tablets. Video, combining both visual and verbal communication methods, also has been found promising in providing low-literacy populations with skills, information, and knowledge on complex technical topics (David and Asamoah 2011; Zossou et al. 2009; Van Mele, Wanvoeke, and Zossou 2010). Steady progress in mobile equipment for video display and increasing mobile phone penetration and Internet connectivity in rural areas have made it easier and cheaper to distribute video content. In addition to increasing knowledge directly, video has also been found to induce behavioural changes in poor countries. While some of this behavioral change is a consequence of the newly acquired knowledge, research by Bernard et al. (2015) suggests that videos featuring role models can also induce behavioral change by affecting the motivation and aspirations of farmers.

The first treatment consists of a video\(^1\) on PSS, in which a potato farmer from the area introduces himself and explains that his experiments over the years have taught him that good-quality planting material is key to becoming a successful farmer (0:00–1:25). He illustrates the benefits of good quality seed by contrasting healthy fields, plants, and tubers to diseased ones (1:25–2:35). The farmer also explains how he used to do it wrong, pulling out the strongest plants first to eat or sell, and hence was left with small and malformed tubers for planting. He explains how this quickly leads to seed degeneration.

\(^1\)https://www.dropbox.com/s/7o5zcrlr1hv3m7/moviePSS.mp4?dl=0.
Next, the concept of PSS is introduced (3:19–4:26). In particular, the farmer explains that, at time of flowering, the tallest plants with at least four stems should be pegged for follow-up. Pegs should be removed when plants get diseased or when they grow slowly (4:26–5:05). At the time of harvest, pegged plants should be harvested first (5:05–5:16). Only egg-sized tubers should be retained for planting material (5:16–5:27). Tubers should look healthy, without cuts or bruises, and it is advised to only keep tubers with at least four eyes (5:27–5:43). The video ends by recapitulating the most important components of PSS. (5:43–7:02). This video was produced in both Rufumbira and Rukiga, the two languages spoken in the study area.

The second treatment comprises a video\(^2\) on PSSH. The first part, in which a farmer introduces himself as a successful potato grower from the region and illustrates the benefits of good–quality seeding material by contrasting healthy fields, plants, and tubers to diseased ones, is similar to the first part in video used in the PSS treatment (0:00–2:08). The farmer also explains that he used to store and handle seeds incorrectly, storing potatoes in sacks or together with other crops in places that were too dark and inadequately ventilated (2:08–3:24). The farmer then introduces PSSH. He first underscores that potatoes should be spread out on racks, or on dried grass on the floor (3:24–4:03). Second, seed potatoes should be stored in a separate room, away from animals and humans (4:03–4:11). Third, seed potatoes should be stored in a well–ventilated place in diffuse lighting conditions and checked regularly for rotten tubers (4:11–5:07). Finally, the farmer advises the use of a cheap organophosphate insecticide for seed preservation and underscores the importance of cleaning all tools used during seed production to avoid contamination (5:07–5:45). Like the PSS video, this one ends by summarizing the most important aspects of PSSH (5:45–7:05). This video was also produced in both Rufumbira and Rukiga. The choice of which techniques and information to highlight in both treatments was based on extensive interviews with potato–growing experts (seed producers, extension officials, agronomists) in the area and on analysis of data previously collected among potato farmers.

It is important to note that the treatment consisted of being shown a video on an Android device at the individual level and farmers did not receive anything beyond the information. Thus, the focus of this experiment is not so much on the merits of using Android tablets but rather on the effectiveness of providing information using video messages. Therefore, a valid argument may be that it would be much more cost-effective to gather a group of farmers in front of a television or projector. We opted for individual screenings for at least two reasons. First, it is difficult to control group dynamics, and learning in a group may be quite different from learning individually. Secondly, gathering a group of people at a public place in a village is bound to attract considerable attention. The event may attract other farmers, some of whom may be selected for the control group, and it would be very difficult to turn them away. To reduce the likelihood of contamination, we thus decided to show the videos in the private homes of the farmers, which is likely to attract much less attention. Showing videos in a group setting would necessitate an encouragement design, requiring a larger sample size (Hirano et al. 2000).

**Outcomes**

We test whether the videos reduced farmers’ knowledge gaps by asking them to take a short quiz. In particular, we asked farmers six multiple–choice questions. All participants, including control farmers, were presented with all six questions. In particular, enumerators visited farmers at their homes and started by explaining the study and asking for consent. Upon receiving consent, some basic data were gathered, mainly to make sure the right farmer was being interviewed and to confirm contact information. Then, depending on the farmer’s treatment group, he or she viewed the video and immediately afterwards took the quiz. For each quiz question, the farmer was instructed to choose the one correct answer out of three possible answers that were read aloud. Two of the six questions are related to topics that were discussed in the PSS treatment. Thus we expected farmers who received the PSS treatment to do better in answering

\(^2\)https://www.dropbox.com/s/bg0ks15uomr70m9/moviePSSH.mp4?dl=0.

Electronic copy available at: https://ssrn.com/abstract=2880727
these questions correctly. Another two questions related to topics covered in the PSSH treatment, and we expected farmers who were provided information in the PSSH treatment to answer these questions correctly. We also included two questions on topics related to PSS and PSSH that were not explicitly covered in the treatment videos. We hypothesize that the incidence of correct answers to these two “control” questions would not differ between the treatment and control farmers.

The two questions that tested knowledge provided by the PSS treatment related to which plants to peg (correct answer: largest plants in the field that look healthy; incorrect alternatives: average–sized plants in the field that look healthy, smallest plants in the field that look healthy) and the size of the tuber to select as planting material (correct: egg-size; incorrect: the larger the better, the smallest ones you can find). The answers will be referred to in the analysis below by variable names sel1 and sel2, respectively.

To test the effectiveness of the PSSH treatment, the first question related to which lighting conditions seed potatoes should be stored in (correct: in indirect [diffuse] light, incorrect: in direct sunlight, in a dark place). The second question asked how seed potatoes should be stored (correct: spread out on racks or on dried grass on the floor; incorrect: in bags that have been thoroughly cleaned, in airtight containers or buckets with a closing lid). The answers to these questions are recorded in variables called store1 and store2, respectively.

Of the questions on topics not explicitly covered in either the PSS or the PSSH videos, the first asked respondents to indicate which of three statements is correct: immediately after harvest, you should thoroughly wash seed potatoes using detergent before putting them in storage (incorrect); (2) immediately after harvest, you should thoroughly wash seed potatoes using clean water before putting them in storage (incorrect); and (3) you should never wash seed potatoes before putting them in storage (correct). While this knowledge is not explicitly covered in the PSSH video, it is related to PSSH. We will refer to this question using the variable gen1. The second question asks farmers where fields for seed potato production should be located: (1) highlands in isolated areas (correct), (2) lowlands with plenty of water (incorrect), and (3) a garden close to the house or in a densely populated area (incorrect). While this knowledge is not explicitly covered in the PSS video, it can be categorized under PSS knowledge. We will refer to this question using variable gen2. This information is summarized in Table 2.1

Obviously, increasing knowledge is only an intermediary outcome in a typical agricultural extension intervention. The ultimate aim is to increase production, and we will eventually estimate this effect once endline data have been collected. However, isolating the effect of providing information on production poses additional challenges. For example, as time goes by, farmers also learn by observing practices from their relatives, friends, and neighbors (Conley and Udry 2010). For example, farmers who appear to learn from video, judging by a low score on the quiz, may learn from neighbors who adopt what has been shown in the video, leading to an overestimation of the effect of information. At the same time, farmers from the control group may start copying behavior from farmers who were shown the video, resulting in an underestimation of the effect of information. We have tried to minimize these problems ex–ante by maximizing the physical distance between farmers receiving different treatments (the details of which can be found in the preanalysis plan), and we will also control for the presence of other farmers included in the study within the social network of a given farmer.

The ability of poor farmers to take on additional risk related to modern input use and technology adoption also determines how increased information translates into actual adoption (Dercon and Christiaensen 2011). Indeed, previous research has suggested that risk considerations matter for observed intensification behavior among potato farmers in Uganda (Van Campenhout, Bizimungu, and Birungi 2016). While randomization in our experiment assures that attitudes toward risk, perceived risk related to intensification, and risk management strategies are balanced between the various treatments, risk aversion may indeed reduce the effectiveness of information in bringing about production increases. However, we feel that an important pathway through which information is likely to affect production is through changing risk perceptions. For instance, showing how to use a new technology is likely to reduce the uncertainty related to the technology’s being new. Showing a video on storage and handling reduces the risk of postharvest losses. We may be able to get an idea of the importance of this impact pathway by investigating whether the information effect differs between farmers who differ in their ability to hedge against risk using risk–management and risk–coping strategies.
Table 2.1 Effect of positive seed selection and proper seed storage and handling treatments on knowledge

| Code | Question                                                                                   | Answer (correct one underlined)                                                                 |
|------|-------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| sel1 | Which plants should you peg for seed selection?                                           | The largest plants in the field that look healthy                                                |
|      |                                                                                           | The smallest plants in the field that look healthy                                               |
|      |                                                                                           | Average–sized plants                                                                            |
| sel2 | What size should a seed potatoes tuber be?                                                | The larger the better                                                                            |
|      |                                                                                           | Size of an egg                                                                                  |
|      |                                                                                           | The smallest ones you find                                                                      |
| store1| Where should you store your seed potatoes?                                                | In direct sunlight                                                                             |
|      |                                                                                           | In a dark place                                                                                 |
|      |                                                                                           | In indirect light (diffuse light)                                                               |
| store2| How should you store your seed potatoes?                                                  | In bags that have been thoroughly cleaned with JIK                                               |
|      |                                                                                           | Spread out on racks or on dried grass on the floor                                              |
|      |                                                                                           | In airtight containers or buckets with a closing lid                                             |
| gen1 | Which of the following statements is correct?                                             | Immediately after harvest, you should thoroughly wash seed potatoes before putting them in storage |
|      |                                                                                           | You should never wash seed potatoes before putting them in storage                              |
|      |                                                                                           | You should never wash seed potatoes before putting them in storage                              |
| gen2 | When picking a field for positive seed selection...                                       | Pick a garden that is in highlands and in an isolated area                                       |
|      |                                                                                           | Pick lowlands with plenty of water                                                               |
|      |                                                                                           | Pick a garden close to your house or in a densely populated area                                 |

Source: Author’s calculations.
Notes: JIK is a household bleach product.
3. RESULTS

We find that showing extension videos on PSS to farmers increases their knowledge related to seed selection that were covered in the video. The first bar chart in Figure 3.1 shows the proportion of farmers that know the largest healthy–looking plants need to be pegged for follow-up for seed selection (sel1). The figure reveals that about 77 percent of farmers who were not shown the PSS video were able to indicate the correct option in the multiple-choice question. Among farmers who saw the PSS video, this proportion increases to 86 percent. The increase is statistically significant (one-sided RI, p = .041). Similarly, the second bar chart in Figure 3.1 reveals that the proportion of farmers who knew that egg–sized tubers are the best seeding material was 89 percent among those who did not receive the PSS treatment and 96 percent among those who did see the video. Again, the increase in knowledge is statistically significant (one-sided RI, p = .042).

Figure 3.1 Effect of PSS and PSSH treatment on knowledge covered in videos

Source: Author’s calculations.
We also find that showing videos on proper potato seed storage and handling (PSSH) increases knowledge about recommended storage and handling practices that were covered in the video. As indicated by the third bar chart in Figure 3.2, only about 60 percent of participants who did not see the PSSH video knew that seed potatoes need to be stored in diffuse light (store1). This proportion increases to 88 percent among farmers who saw the video on PSSH. The increase in the proportion is statistically significant (one-sided RI, \( p < .001 \)). Finally, we find that 95 percent of farmers who were not shown the PSSH video knew that seed potatoes should be spread out on racks (store2). This percentage increases to 97 percent among farmers who did see the PSSH video, but the increase is not significant (one-sided RI, \( p = .372 \)). However, to reduce the influence of outcomes with limited variation, we specified in our pre-analysis plan that variables for which 95 percent of observations are the same value would be discarded.

**Figure 3.2 Effect of PSS and PSSH treatment on knowledge not explicitly covered in videos**

![Graph showing knowledge increase due to PSS and PSSH treatments](https://ssrn.com/abstract=2880727)
We also find that being shown any video has the potential to increase knowledge beyond what is explicitly covered in the video. For example, the first bar chart in Figure 3.2 shows that farmers who received the PSS treatment were also significantly more likely to know that seed potatoes should not be washed before being stored (one-sided RI, \( p < .001 \)). The second bar chart shows that the same treatment also significantly increases the likelihood of a farmer’s knowing that fields for planting materials should ideally be located in highlands, away from human settlements (one-sided RI, \( p = .006 \)). The third bar chart shows that farmers exposed to the PSSH treatment are also more likely to know that seed potatoes should not be washed before being stored (one-sided RI, \( p = .032 \)), and the fourth shows they also know fields for planting materials should ideally be located in highlands (one-sided RI, \( p < .001 \)). This effect is also present when we compare outcomes on knowledge related to one treatment between groups based on the other treatment: farmers who received the PSS treatment scored significantly better on \( store1 \) and \( store2 \) than those who did not, and farmers who received the PSSH treatment scored significantly better on \( sel1 \) and \( sel2 \).

To account for the clustering due to our matched block design, we also run regressions using a within–block specification (see equation 1). The estimates of the average treatment effects can be found in Table 3.1 and are consistent with the findings in the figures. For instance, we see that the PSS treatment induces an increase of 9 percentage points in the proportion of farmers who answer correctly on the first seed selection knowledge question. This is exactly what we found in the simple means comparisons above, but the standard error is slightly higher, leading to a p-value of .05. The effect of PSS on the second question related to seed selection is also estimated at 7 percentage points, and this time the inclusion of block fixed effects reduces the standard error. Also consistent with the means tests, the PSSH treatment has a large and significant effect on knowledge related to storage as measured by the first question, while the effect on the second question is not significant (probably due to limited variation in the outcome variable).

Table 3.1 Effect of PSS and PSSH treatments on knowledge

| Treatment | sel1 | sel2 | store1 | store2 | gen1 | gen2 |
|-----------|------|------|--------|--------|------|------|
| PSS       | 0.09 | 0.07 | 0.28   | 0.02   | 0.13 | 0.17 |
|           | [0.050] | [0.012] | [0.000] | [0.165] | [0.000] | [0.002] |
| PSSH      | 0.07 | 0.08 | 0.29   | 0.02   | 0.08 | 0.28 |
|           | [0.091] | [0.003] | [0.000] | [0.163] | [0.010] | [0.000] |

Source: Author’s calculations.
Note: One-sided p-values are in square brackets and are based on randomization inference, with a random sample of 10,000 permutations used. PSS = positive seed selection; PSSH = proper seed storage and handling.

Again consistent with the Figure 3.2 and Figure 3.3, we illustrate that showing a video not only increases knowledge related to what is featured in the video, but there seems to be a more general knowledge effect. For example, as a result of being shown either of the videos, we find an increase in the proportion of farmers who answer correctly on the questions that were not explicitly covered in the video (\( gen1 \) and \( gen2 \)). Also, we see that farmers who have been shown the PSS video score higher on \( store1 \), a question about PSSH practices. Similarly, the likelihood of correctly answering \( sel1 \) and \( sel2 \), questions on PSS increases by 7 and 8 percentage points, respectively, as a consequence of having been shown the PSSH video.
The results in Table 3.2 may mask heterogeneity in the average treatment effect. In particular, we suspect that farmers with little prior knowledge about PSS, PSSH, or both are more likely to benefit from the information that is contained in the videos. To test this hypothesis, we use information collected during the baseline. We use information on farmers’ reported awareness of the importance of using clean and disease-free planting materials in a regression to control for previous knowledge related to PSS. In addition, we use information on farmers’ awareness that seeds should be stored on dried grass in the shade to control for previous knowledge related to PSSH in the regression. This is done in the regression framework of equation (1) by interacting both of these variables with the treatment indicators. Results are summarized in Table 3.2. Because our study was not designed to identify heterogeneous treatment effects, and our sample size is likely to be too small, we will confine our attention to the variables that display the most variation (sel1, store1 and gen2).

Table 3.2 Effect of PSS and PSSH treatments on knowledge, controlling for previous knowledge

| Variable          | sel1 | store1 | gen2 | gen2 | sel1 | store1 |
|-------------------|------|--------|------|------|------|--------|
| PSS               | 0.31 | 0.13   | 0.36 | [0.017] | 0.36 | [0.011] |
| PSSH              | 0.36 | 0.32   | 0.24 | [0.011] | 0.24 | [0.002] |
| knowPSS           | 0.09 | -0.04  | 0.05 | [0.011] | 0.05 | [0.022] |
| knowPSSH          | 0.12 | 0.00   | -0.23| [0.017] | -0.23| [0.055] |
| knowPSS*PSS       | -0.12| -0.14  | -0.08| [0.055] | -0.08| [0.055] |
| knowPSSH*PSSH     | -0.17| 0.17   | -0.05| [0.832] | 0.17 | [0.689] |
| knowPSS*PSSH      | 0.05 | 0.05   | -0.11| [0.862] | 0.05 | [0.622] |
| noobs             | 235  | 235    | 235  | 235  | 235  | 235    |
| Adj-R-squared     | 0.026| 0.023  | 0.045| 0.069| 0.0114|
| F-statistic       | 1.094| 1.244  | 0.919| 1.168| 1.264| 1.041  |
| p-value F         | 0.320| 0.134  | 0.646| 0.213| 0.118| 0.410  |

Source: Authors.
Notes: One-sided p-values are based on randomization inference, with a random sample of 10,000 permutations used. All regressions include 61 bloc fixed effects.

The first column in Table 3.2 shows that controlling for prior knowledge substantially increases the treatment effect for the PSS treatment on sel1. Among farmers who were not previously aware of the importance of using clean and disease-free planting materials and who did not know that seed potatoes need to be stored on dried grass in the shade, the coefficient estimate is higher than for those who did have prior knowledge (0.31 compared to 0.09). The second column shows a similar response of storage–related knowledge to the PSSH video. Here, the treatment effect increases from 0.29 to 0.36 among farmers who reported having no prior knowledge pertaining to potato seed quality. Contrary to what we found in Table 2.0, showing the PSS video does not seem to affect knowledge on seed selection that was not explicitly covered in the video among farmers who had no prior knowledge on the importance of seed quality. However, column 4 to 6 suggest that even after controlling for previous knowledge, a particular treatment may still increase knowledge about a subject not explicitly covered in the video.
4. DISCUSSION

We find that showing simple agricultural extension videos to individual potato farmers on portable devices significantly increases knowledge related to seed selection and seed storage and handling among potato farmers. In particular, showing a video that explains PSS increases the likelihood that farmers know about the methods explained in the video. Similarly, showing a video that demonstrates proper seed storage and handling (PSSH) increases the likelihood that farmers know about the information explained in the video. This finding suggests that agricultural extension videos are an effective tool for accurate transmission of homogeneous information from a technical source to a low–literacy population, for instance when a technical expert or high–quality trainer is not available or too expensive.

In addition to a direct effect, we also find that showing a video displaying methods related to a particular aspect of potato growing increases knowledge in general. For instance, showing a video about PSS methods increases knowledge related to seed selection that is not explicitly shown in the video, such as where the field for seed production should be located. Similarly, showing a video about PSSH also increases knowledge related to storage and handling that is not covered in the video, such as the importance of keeping potatoes dry. Even more, we find that showing a video on one topic, for instance on seed selection, increases knowledge in another topic, such as seed storage & handling.

There are different reasons for such indirect effects. First, they may be due to poor design of our treatments. One treatment may contain information that unintentionally gives the farmer clues about knowledge we explicitly show in the other treatment (and thus associate with the other treatment). For example, when the PSS video explains that tubers should look healthy and one should keep only tubers with at least four eyes (5:27–5:43), the farmer in the video is shown to be selecting from potatoes that are stored on racks in diffuse light. This may give viewers clues about proper storage and handling, increasing their likelihood of picking the correct option for the question that was intended to measure the information given on PSS (store2).

Second, the above may suggest that farmers go beyond simply repeating what is shown in videos, and engage, to some degree, in a process of abstraction (learning concepts from examples) whereby they apply insights gained in one context in a different context. For example, recommending that potato seeds be stored away from other crops, animals, and humans, as is done in the PSSH treatment (4:03–4:11), may inform farmers about the abstract concepts of hygiene and separation in the context of seed potatoes. This in turn might prompt farmers to pick the answer from gen2 most in line with those concepts, namely that the potato seed field should ideally be in a remote place high in the mountains. In cognitive psychology, this type of learning is known as schema abstraction, which posits that knowledge represents an abstraction of different memory traces, each representing a specific experience in our lives (Hintzman 1986). In this sense, our videos can be interpreted as an experience that teaches farmers something about relevant concepts in their profession.

Third, and perhaps most interestingly, it may be possible that farmers already possess some of the information needed to identify the correct alternative in the multiple–choice questions, but that a video is needed to trigger the farmer to actually use this information when confronted with the multiple choice questions. For instance, it may be that a farmer is aware of the recommended practice (through having received extension services in the past for, instance), but bases his or her actual response on what the customary practice is. Being shown a video in which a fellow farmer talks about the virtues of a range of modern techniques may serve as a visual and auditory cue for the information the farmer already possesses. This finding is consistent with knowledge about the cognitive capacities of human beings (Tulving 1972). In particular, it suggests the usefulness of video messages to trigger associative recognition and cued recall, which involves retrieval of memory or recognition of previously encountered events, objects, or people with the help of cues and associations (Tulving and Pearlstone 1966; Mandler 1980). Alternatively, being shown a video may confirm the knowledge the farmer has, making him or her more confident to use it. In this way, a simple reminder may both validate information a farmer has but has not applied, or may serve to make it more salient. This is consistent with the finding that receiving information from a trusted source positively affects take–up of rainfall insurance among smallholders in India (Cole et al. 2013).
Our findings suggest that videos are likely to become an indispensable part of the agricultural extension tool kit. They also suggest that specific videos aimed at transferring narrow technical information are effective. In addition, video messages that show more general information, such as the importance of nutrient management or general hygiene to combat pests and diseases, may even be more important. Such videos may provide visual and auditory stimuli that lead to cognitive processes of schema abstraction and cued recall. The act of recalling instead of studying creates new and longer–lasting connections between concepts (Carrier and Pashler 1992). In addition, our research suggests that videos should be context specific, featuring model farmers to maximize the potential of videos to leverage knowledge farmers already possess but may not be confident enough to use.
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