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Can mobile phone-based animated videos induce learning and technology adoption among low-literate farmers? A field experiment in Burkina Faso

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ABSTRACT

This article explores an innovative approach to deliver information about new agricultural technology that combines a versatile and potentially lower cost method of developing animated videos with another low-cost method of sharing it on mobile devices (i.e. mobile phone). It describes a randomized controlled field experiment conducted in Burkina Faso to evaluate the effectiveness of animated videos shown on mobile phone compared with the traditional extension method (live demonstration) in inducing learning and adoption of two post-harvest technologies among low-literate farmers. Results suggest that video-based training was as effective as the traditional method in inducing learning and understanding. For technologies that farmers were already aware of animated video shown on the mobile phone was also as effective as live demonstration in inducing adoption. However, in transferring new technologies, the traditional method was more effective in inducing adoption at $p < .10$, but not at $p < .05$. Potential role of mobile phone-based videos as part of the agricultural extension system is discussed.

KEYWORDS

Agricultural extension; animated video; mobile phone; information and communication technology (ICT); randomized controlled trial (RCT); technology adoption

1. Introduction

Globally every year, substantial resources are invested by the public sector on agricultural research to generate new knowledge, technologies and practices targeted towards small-scale farmers living in developing countries (Beintema, Stads, Fuglie, & Heisey, 2012). As a result of these concerted efforts, there exist a number of innovative solutions in the scientific literature and can help improve the lives of people in developing nations.[1] Yet, much of this remains in a form (e.g. articles in scientific journals, research reports and extension

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bulletins) that does not reach the true target audience at a scale required to generate impact. This is due to a variety of constraints, including the low literacy level on the part of the target audience, and a weak and often an ineffective agricultural extension system that is not able to scale up and scale out the transfer of scientific knowledge to a large number of end users living in remote rural areas in developing countries (Davis, 2008; Feder, Willett, & Zijp, 2001; Oladale, Koyoma, & Sakagami, 2004).[2] Two such innovative and scientific solutions investigated in this paper are the triple bag grain storage technology and the solar disinfestation method. Both control post-harvest damage caused by insects which results in significant losses of staple food crops around the world.

The rapid spread of information and communication technologies (ICTs) in developing nations over the past decade, especially the adoption of mobile phones by farmers in rural areas offers a unique opportunity to address these challenges of transferring knowledge and information to a large number of people living in remote rural areas. The low per unit cost of establishing and maintaining contacts with end users through mobile phone has spurred many innovative ideas and initiatives by the public, non-governmental organization and private sector in developing countries to provide informational products and services targeted to farmers living in rural areas via text and voice messaging, and the transmission of pictures and videos (see e.g. Aker, 2010; Cole & Fernando, 2012; Fafchamps & Minten, 2012; Mittal & Mehar, 2012; Zhang, Wang, & Duan, 2016).

Africa has been a pioneer in the use of mobile devices for banking and financial services (Bankole & Bankole, 2016; Business Tech, 2014). African countries have also seen a number of innovations in the application of ICT for agricultural development. For example, a mobile agricultural value-added service that provides continuously updated market prices of agricultural products has been successfully used in Niger (Aker, 2008). The potential of mobile phone as a tool for agricultural extension has also been demonstrated in Burkina Faso and Mali (Sousa, Nicolay, & Home, 2016). Likewise, Baributsa, Lowenberg-DeBoer, and Djibo (2010) showed the potential of mobile phones for the dissemination of technical agriculture information to farmers in Niger.

In developing countries where many people living in rural areas are low-literate learners, mobile devices such as cell phones, iPads and tablets represent an important new way by which educational content can be effectively and easily delivered in different languages and conveyed in the form that is pictorial and spoken rather than written (Bello-Bravo et al., 2011). Two major options that currently exist for the development of materials for viewing on video-capable mobile devices include live action films and animations. Live action films with local actors has an important advantage in that local people see others in their same local environment. However, once produced, the potential to scale out these films across different cultural groups may be limited. Animations, in contrast, have lower logistical costs (i.e. no transportation for movie production team), can easily be produced in diversity of languages through voice overlays (i.e. are versatile and can be adapted to different cultural contexts easily and at low cost), and can be developed through networks of individuals (often volunteers) located in different regions around the world that can share all the necessary materials through the World Wide Web (Bello-Bravo et al., 2011).

In this article we explore one of the innovative ideas of combining this highly versatile method of developing animated videos with a low-cost method of sharing it on mobile phones to deliver knowledge and information about triple bag grain storage and solar disinfestation technologies to low-literate adult farmers. This approach can potentially help bridge the gap between research and impact by using ICT and a community's own social networks (i.e. personal relationships, video viewing clubs (VVCs), schools and farmer organizations) as mediums to transfer scientific knowledge at a low cost to a large number of farmers in developing countries. The success of this approach, however, critically depends on the effectiveness of the animated educational material in inducing learning and behavior change among low-literate farmers. Whether the animated videos are less, more or equally effective in affecting learning and behavior change as the traditional extension method of technology dissemination based on live demonstration is the subject of investigation of this article.

Specifically, the article describes the results of a randomized field experiment conducted in Burkina Faso to evaluate the effectiveness of two animated educational videos shown on mobile phones in inducing learning about the post-harvest cowpea drying and storing technologies among low-literate farmers. The experiment was implemented in 48 villages across 2 major cowpea growing provinces in Burkina Faso, where all the cowpea farmers received training on two methods of cowpea grain storage with different level of prior exposure and awareness among the farmers in the study area – triple bag storage technology (high level of prior exposure) and solar disinfestation method (low level of prior exposure). Half of the villages were randomly assigned to receive this training through live demonstration by the extension agents and the other half were randomly assigned to receive training on these technologies from the same extension agents but only using animated videos on the mobile phone. The key research question addressed by this experiment is: how effective is the animated educational video in inducing learning about the post-harvest cowpea drying and storing technologies among low-literate farmers? Beyond learning, this article also examines the effect of the training methods on behavior change reflected in the first-time adoption of the technology/practice being conveyed through the educational videos.

Since the adoption of a technology can be constrained if the required inputs/materials are not available to farmers in rural areas, the field experiment was designed to eliminate this confounding factor for one of the technologies promoted, by making sure the input (i.e. plastic bags) was available for purchase either in the village or at the extension agent's office located at some distance away from the village (on average about 12 km across study villages). The experiment was also designed to test the effectiveness of animated videos in inducing learning and adoption when it is used to promote relatively new information (i.e. the solar disinfestation technology) versus a technology that was already promoted before and there is already some level of awareness and adoption in the community (i.e. the triple bag technology).

Overall, the analyses of this study indicate generally comparable results on the effectiveness of animated videos shown on the mobile phone compared with the traditional extension method on most indicators of learning and adoption. The implications of these results on the suitability and role of mobile phone (or other devices) based videos in promoting agricultural technologies are discussed in this article.

2. Rationale for this research

Prior evidence on the effectiveness of animated videos or different extension methods in promoting technology adoption is limited. Bindlish and Evenson (1997) evaluated the impact of one single extension method, the training and visit (T&V) extension method, in Africa but the effectiveness of the method was evaluated based on descriptive analysis only. The study by Moussa, Otoo, Fulton, and Lowenberg-DeBoer (2009) examined the effect of radio messages in augmenting the effectiveness of an extension program focused on village demonstrations in promoting the adoption of cowpea grain storage technology in West Africa. Their results indicate that adoption was positively affected by the extension program and radio messages do augment the effectiveness. The study by Baributsa et al. (2010) describe a one-month long (non-randomized) experiment in Zinder region of Niger to assess the dissemination potential of a seven-minute live action mobile phone video on cowpea storage using hermetically sealed bags. The mobile phone video was provided to two community radio stations, two extension agents and three pilot farmers. The study found that after one month, 118 people from 50 villages had received the video, mostly via Bluetooth. The study mainly focused on whether and how the mobile phone video spread among farmers rather than its effectiveness in inducing learning and technology adoption.

David and Asamoah (2011) explored the effectiveness of VVCs as a method of training women farmers in Ghana on cocoa-integrated crop and pest management. Although, their results suggest that the VVC was an effective training method for providing low literacy populations with skills, information and knowledge on complex technical topics, it was based on survey data collected from a small sample of 32 women farmers trained by the project using the VVC method and 30 women farmers from 2 villages that were not trained by the project. Studies have also been conducted in Niger, Nigeria and Benin to understand the reception of some specific educational animated videos as a learning tool (Bello-Bravo, Agunbiade, Dannon, Tamo, & Pittendrigh, 2013; Bello-Bravo & Baoua, 2012; Bello-Bravo, Nwakwasi, Agunbiade, & Pittendrigh, 2013). Results from these pilot studies suggest that animated videos are a well-received approach as a training tool in agriculture and prevention of diseases amongst populations with diverse literacy levels. However, all these pilots have been conducted on a small scale with about 30–60 respondents.

This article goes beyond the previous studies by using a randomized field experiment with a representative sample of cowpea producers in the selected districts. Our finding that information technology can be effective in inducing learning and behavior change among low-literate farmers contributes to debates on the role of modern ICT across different areas of development literature, spanning education, extension and agricultural development. First, it provides evidence on the potential use of animated videos as a tool for adult education. Second, it explores the use of mobile phones as an ICT to disseminate science-based knowledge among low-literate learners, and third, it compares the effectiveness of alternate extension methods to reach a large number of farmers and promoting the use of simple technologies that can potentially increase their economic welfare.

We first describe the problem and the science-based solution to the problem represented in the educational videos, followed by the description and results of the field experiment conducted in Burkina Faso, and the discussion of implications for further research and development agenda focused on developing innovative and cost-effective strategies to deploy educational materials conveying science-based technological solutions to problems faced by a large number of farm households in the developing world.

3. Research setting and design

Cowpea bruchids (*Callosobruchus maculatus*) can cause damage to cowpea (*Vigna unguiculata*) seeds in storage, resulting in post-harvest losses (Ouédraogo et al., 1996). To avoid the crop loss, many farmers sell their cowpea soon after harvest when the price is low. This not only reduces income for farmers but also makes the household more vulnerable as they cannot afford to buy back cowpeas during the lean period, when the prices are typically higher than when they sell soon after harvest. Control methods such as insecticides and fumigants can be used to control this pest, but growers in Africa often do not have access to these chemicals, or cannot afford them. Improper use of these insecticides can also cause problems of food safety and negatively impact health. These constraints and challenges are also common across other staple crops grown by small holder farmers in Africa and other parts of the developing world.

To address this problem researchers have tested and come up with several non-chemical approaches, which include (i) heating the grain to a temperature hot enough to kill the insects and the insect eggs using a solar heater; (ii) triple bagging the grain in plastic sacks (hermetic sealing), (iii) mixing ash with the grain in storage containers, (iv) treating the grain with botanicals such as neem, (v) storage in sealed containers and (vi) the use of resistant cultivars. These techniques have been developed and well-recognized among the scientific community for a long time (Dales, 1996; Ilesanmi & Gungula, 2010; Kitch, Ntoukam, Shade, Wolfson, & Murdock, 1992; Murdock, Seck, Ntoukam, Kitch, & Shade, 2003; Sanon, Dabiré-Binso, & Ba, 2011; Seck, Longnay, Haubruge, Marlier, & Gaspar, 1996; Wolfson, Shade, Mentzer, & Murdock, 1991). For example, the triple bagging technology of cowpea storage was developed by Purdue scientists through USAID funded Bean/Cowpea Collaborative Research Support Program (CRSP) in the 1990s and efforts have been invested in recent years to disseminate this technology through special donor-funded projects (e.g. the Purdue Improved Crop Storage (PICS) project funded by the Bill and Melinda Gates Foundation) (Dabire, Sanon, Ba, Yelemu, & Baributsa, 2014; Murdock & Baoua, 2014).

Recently, as part of the “Scientific Animations without Borders™” (SAWBO) project (http://sawbo-animations.org/home), researchers at the University of Illinois, Michigan State University, and their partners have developed animated videos on some of these technologies to increase accessibility of this knowledge for educators to work with low-literate farmers around the world. All animations are created as instructional videos, in order to expose users to concepts and illustrations of steps that should be taken to deal with a specific challenge. They are not designed to be persuasive; that is, they are typically not advertisements to encourage people to adopt a given technology. In this study, we focused on two of these animated videos that describe the solar disinfestation and the triple bagging methods to control cowpea bruchids. Solar disinfestation method involves drying the cowpea grains spread over a black plastic, then covering with a transparent plastic and exposing them to the sun prior to storage (Murdock et al., 2003). This animation did not contain a comparison of the cowpea seeds between non-treated and treatment conditions and it did not contain an argument as to the economic advantages of using this approach. The triple bagging (also known as hermetically sealed bagging) method involves storing grain in two layers of high-density polyethylene plastic bags plus one layer of bag with a stronger material (i.e. woven nylon or polypropylene). Each bag is tied shut with a twine or string as described in Murdock and Baoua (2014). This animation contained a comparison between results of stored cowpeas using this approach against no treatment, showing the farmers the significant potential for this approach to reduce post-harvest losses and gave a brief argument as to the financial advantage of using such an approach. The video on solar disinfestation is 1 minute 55 seconds in duration and the video on triple bagging is 2 minutes 50 seconds long. Both these videos can be downloaded from the Internet (on You Tube and SAWBO) and are available in French and many local languages spoken in West Africa (e.g. *Moore and Dioula* spoken in Burkina Faso).

The advantages of these two techniques are that they are low cost, simple and quick; effective when properly used; easy to explain and to disseminate, and there is a possibility of reusing the materials for multiple seasons. Additional benefits of triple bagging include no use of pesticide; the grains are ready to be consumed when the bags are opened; good for storage of small and large quantities of cowpea; and the bags can be stored in homes. The use of triple bagging method has shown to reduce grain loss from seed damage by 65–90% (Baoua, Margam, Amadou, & Murdock, 2012; Sanon et al., 2011), and the solar disinfestation method results in almost 100% mortality of the bruchids (Kitch et al., 1992; Murdock et al., 2003). Despite these advantages, adoption of these storage techniques has been limited because farmers are not aware of the technology, do not understand how to implement the technology or do not have access to plastic material or bags required to use these methods (Ibro et al., 2014; Moussa, Lowenberg-DeBoer, Fulton, & Boys, 2011; Moussa, Tahirou, Coulibaly, Baributsa, & Lowenberg-DeBoer, 2014). Given the need to reach a large number of farmers over a vast geographic region it is thus important to utilize the most effective extension methods available. The experiment described in this study was designed to precisely address this need at a pilot scale.

3.1. Experimental design and data collection

The experiment includes a combination of two treatments or a $2 \times 2 = 4$ treatment arms as described in Table 1. The first set of treatment groups (labeled 1 and 2) varies the method of information dissemination (video vs. traditional extension method) to address the following research question: how effective is the animated educational video in inducing learning about the post-harvest cowpea drying and storing technologies among low-literate farmers? Treatment group 1 received the training through animated videos shown on the extension agent's mobile phone in a small group or one-on-one basis and group 2 received the training through the traditional method of live demonstration given by the extension agent. In the case of triple bag technology, PICS bags were used during demonstration. In treatment 1, after the training was over, the extension agent copied the videos in all the farmer-owned mobile phones, and left behind a DVD and a

Table 1. Definition of treatment groups in the field experiment.

		Training method	
		1: Animated video	2: Traditional extension method
Availability of bags	A: In the village	Group 1A	Group 2A
	B: at extension agent's office	Group 1B	Group 2B

handset with the video for community use. These were available to any farmer that wanted to watch or copy the videos post-training. The second set of treatment groups (labeled A and B in Table 1) varies the convenience of accessibility of bags to address the following research question: does learning induce the adoption of technology if availability is not a constraint but there is a small cost of inconvenience? For this second research question, the focus is only on the triple bag technology, which was expected to have more demand than solar disinfestation technique because of its prior promotion in the region. In treatment A villages, after the training the extension agent left 100 sets of PICS bags with the village head who sold them to interested farmers at market price (i.e. Franc CFA 1100/set of triple bag). In treatment B villages, the extension agent only provided to the participants information that the bags are available for purchase from the extension agent's office. Interested farmers had to travel there and purchase the PICS bag at market price (CFA 1100/set).

Overall, the experiment was designed to test the following two hypotheses.

H_1: Traditional method of extension to disseminate the information/technology will be more effective in inducing learning and adoption than the use of animated videos on the mobile phone.

H_2: Availability of bags in the village (easy accessibility) will lead to more adoption of the triple bag technology.

The experiment was conducted in two provinces in Burkina Faso where cowpea is an important staple food crop. This includes Sourou, which is the second largest cowpea producing province with 6.6% share in national cowpea production, and Passore, which is the fourth largest cowpea producing province with 5.5% share in total cowpea production in the country. Three districts were purposively selected from each of these two provinces based on the importance of cowpea production: Yako, Samba and Arbolle from Passore and Toeni, Tougan and Kiembara from Sourou. Each district is under the leadership of one extension agent. Eight villages were randomly selected from each of the six districts and then two villages per district were randomly assigned to treatment arms 1A, 1B, 2A and 2B by the research principal investigators of this study (Table 2). Thus the field experiment consists of 48 villages in total with 12 villages under each treatment arm (1A, 1B, 2A and 2B) or 24 villages under each treatment group (1 and 2, A and B).

Table 2. List of villages included in the field experiment and assigned to different treatments.

		Villages assigned to different groups			
Province	Districts selected	Treatment 1A	Treatment 1B	Treatment 2A	Treatment 2B
Passore	Samba	Thebo	Manezago	Ilialé	Bouré
		Kies	Koussana	Rouly	Kassila
	Arbole	Bendogo	Bingo	Karéo	Dagho
		Koakin	Sikouinsi	Tancé	Donsin
	Yako	Gollo	Baskare	Rallo	Petit-Samba
		Tindila	Roumtenga	Sabo	Sassa
Sourou	Tougan	Namassa	Boaré	Tougan	Goron
		Papale	Diouroum	Da	Wattinoma
	Kiembara	Gorgaré	Goueré	Kiembara	Bangassogo
		Kouygoulo	Zabo	Kirio	Gan
	Toeni	Domoni	Dounkou	Kwaremenguel	Ganagoulo
		Gome (ville)	Sané	Louta	Ouorou

The extension agents in-charge of the selected districts were key in implementing these four treatments as per the random assignment described above. They were well-trained on the experimental aspects of this research, the importance of consistency in adhering to the design elements of each treatment (i.e. randomization), technical aspects of the two post-harvest technologies, the use of animated videos, how to use mobile phones to share videos, and the pre-training baseline data collection of training participants. Each extension agent was assigned two treatment villages across the four groups (total eight villages per extension agent) to control for any systematic bias introduced by the extension agent himself/herself in the implementation and outcome of the treatments.

The training using the two methods took place between 3 and 11 November 2012 across all 48 villages. All the cowpea farmers in a selected village were invited to participate in these training sessions, which were offered by the extension agents on a one-time basis. Pre-treatment data on awareness, knowledge and use of the solar disinfestation and triple bag methods were collected from up to 20 participants per village prior to the training. Post-training household-level survey data to capture the pre-intervention trainee, household and farm characteristics, experience and use of the 2 storage technologies and post-training behavior change were collected from a subset of 12 farmers randomly selected from the list of 20 training participants for whom pre-training awareness and knowledge data were collected. The post-training household-level and community-level surveys were conducted in January 2013, about 8–10 weeks after receiving the treatments. The pre- and post-training data collected from 569 participants and the village-level characteristics data collected from the 48 community-level surveys are the basis for the analysis reported in this article. Sample characteristics of this overall data set used in this study are reported in Table 3.

4. Pre-intervention balance between treatment groups

Tables 4 and 5 show the pre-intervention balance of the two main types of treatment groups defined by the method of training received (i.e. Group 1 and 2) and availability of bags in the village vs. extension office (i.e. Group A and B) for the household, village-level and trainee characteristics. Differences in several household and trainee characteristics for the treatment groups suggest that the randomization was not totally successful in creating comparable groups along observable dimensions. Households differ in ownership of assets, household size, dwelling characteristics, access to agricultural information/advice and markets, quantity of cowpea produced per household and per hectare, quantity of cowpea grain harvested in 2012 planned for storage as food or seed, number of months cowpea grain reserves typically last after harvest, and contribution of revenues from cowpea grain sales to household income (Table 4). The sampled households across the two treatment groups, however, share similar characteristics in terms of number of mobile phones owned (about 1.4 per household), percentage of households that own mobile phones with video viewing capability (47%), and amount spent per month on mobile phone use (3200 CFA = US$6.4).

The two treatment groups also differ in village characteristics and several trainee characteristics. Not surprisingly, a large proportion of villages where this experiment was conducted had already received prior training on post-harvest storage technology (i.e. triple bag). A significantly greater number of villages in treatment group 2 and

Table 3. Overall sample characteristics.

	Mean	Std. dev.
Number of respondents in a given treatment group (N)	*569*	
Household (HH) asset index (PCA based on number of units)	0.093	1.74
HH size (number of members)	12.75	6.67
Number of female members in the HH	6.60	4.04
Number of HH members 17–40 years old	4.42	3.10
Number of motorcycles/cycles owned per HH	0.82	1.08
Tropical Livestock Units owned per HH	4.92	5.56
Crop sales is the main source of income (% of HHs)	0.52	0.50
Percentage of HHs who live in houses with cement floors	0.42	0.49
Percentage of HHs who live in houses with metal roof	0.36	0.48
Distance from the house to the nearest market to sell cowpea (km)	4.87	5.83
Distance from the house to the nearest highway (km)	11.7	15.6
Percentage of HHs owing mobile phones with video capability	0.47	0.50
Amount spent by a HH on mobile phone use per month ('000 CFA)	3.20	3.32
HH uses mobile phone to access agricultural information/advise (%)	0.20	0.40
HH uses mobile phone to access information on pest control (%)	0.15	0.36
Cowpea area planted in 2012 per HH (ha)	0.78	0.64
Cowpea production in 2012 per HH (kg)	316	237
Cowpea yield in 2012 per HH (kg/ha)	545	404
Harvested grain in 2012 planned for storage as food and seed (kg)	113	83
Number of months cowpea grain reserves typically lasts after harvest	7.89	3.84
Number of villages (N)	*48*	
Extension office is located in the village (%)	0.23	0.42
% of villages that had received prior training on triple bag technology, according to the village head	0.65	0.48
% of villages that had received prior training on other post-harvest treatment to kill insects, according to the village head	0.46	0.50
Number of trainee respondents sampled for the survey (N)	*569*	
% with no formal school education	0.24	0.43
Mean number of years of formal schooling experience	1.30	2.69
Gender of trainee (% male)	0.71	0.45
Average age	43.9	12.5
Number of years of farming experience	21.3	12.9
Number of years respondent has lived in the village	33.4	17.4
Trainee is a member of a farmer organization (% yes)	0.47	0.50
Awareness of triple bag method prior to training intervention	0.60	0.49
Awareness of solar method prior to training intervention	0.60	0.24
Used solar disinfestation method in the past (%)	0.46	0.50
Used triple bag method in the past (%)	0.04	0.19
Respondent owns a mobile phone (%)	0.62	0.48
Knows how to play video on mobile phone (%)	0.47	0.50
Trainee is the main cowpea decision-maker (%)	0.82	0.38
Trainee is involved in farm production decisions (%)	0.88	0.33
Trainee is involved in crop storage decisions (%)	0.83	0.38

Group B had received prior training on triple bag technology (70–75%) compared with Group 1 and Group A (58–61%), respectively (Table 5). The mean number of participants in the two training methods (1 and 2) was also significantly different. As expected, on average it took significantly less time to explain the two storage technologies using the mobile phone-animated video method (2.11 hours) than using the traditional extension method (2.31 hours) (Table 5).

The results reported in Table 4 confirm the low level of literacy among farmers who participated in the training program. Trainee participants surveyed in Group 1 (video-based training) had completed on average one year of formal school education, and 80% had not received any formal education at all. Farmers with zero years of formal education are considered low-literate farmers in this study. Compared to Group 1, a significantly

Table 4. Pre-intervention mean comparison of treatment groups: household characteristics.

	Training method			Availability of bags		
	Group 1 (video)	Group 2 (traditional)	*T*-test	Group A (village)	Group B (extension)	*T*-test
Number of respondents in a given treatment group (N)	*283*	*286*		*285*	*284*	
Household (HH) asset index (PCA based on number of units)	−0.03	0.21	*	0.34	−0.21	***
HH size (number of members)	12.2	13.2	*	13.8	11.5	***
Number of female members in the HH	6.3	6.9	*	7.4	5.5	***
Number of HH members 17–40 years old	4.3	4.5		4.7	4.0	***
Number of motorcycles/cycles owned per HH	0.72	0.91	**	0.95	0.66	***
Tropical Livestock Units owned per HH	4.97	4.87		5.7	4.0	***
Crop sales is the main source of income (% of HHs)	52.3	51.8		52	53	
Percentage of HHs who live in houses with cement floors (%)	38	46	*	44	39	
Percentage of HHs who live in houses with metal roof (%)	38	35		33	41	*
Distance from the house to the nearest market to sell cowpea (km)	5.60	4.15	***	3.86	6.11	***
Distance from the house to the nearest highway (km)	11.1	12.2		11.3	12.2	
Percentage of HHs owing mobile phones with video capability (%)	47	47		47	47	
Amount spent by a HH on mobile phone use per month ('000 CFA)	3.09	3.32		3.38	3.00	
HH uses mobile phone to access agricultural information/advise (%)	14	25	***	20	19	
HH uses mobile phone to access information on pest control (%)	11.4	18.6	**	14.9	15.2	
Cowpea area planted in 2012 per HH (ha)	0.82	0.74		0.80	0.77	
Cowpea production in 2012 per HH (kg)	334	297	*	304	330	
Cowpea yield in 2012 per HH (kg/ha)	579	512	*	485	619	***
Harvested grain in 2012 planned for storage as food and seed (kg)	115	110		116	109	
Number of months cowpea grain reserves typically lasts after harvest	7.47	8.3	**	8.8	6.8	***

Note: Results are weighted to reflect the total number of trainee participants across treatment villages.
*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

lower percentage of trainee farmers in Group 2 (traditional extension training method) had zero years of formal education (72%). Although the farmer trainees across the sample are low-literate, the group that received traditional extension training method was relatively more literate (on average had 0.5 years more formal school education) than the group that received training through animated videos on mobile phones (Table 5).

In terms of prior awareness and use of triple bag or solar disinfestation technologies, there was no significant difference across Groups 1 and 2. On average about 60% of farmers who attended the training sessions were aware of the triple bag method and about 17% of farmers had used this technology in the past. As against this, only about 6% of farmers were aware of the solar disinfestation method and about 1.5% had used this method in previous seasons (Table 5). The high awareness and use of triple bag method of cowpea storage compared to solar disinfestation is not surprising given the

Table 5. Pre-intervention mean comparison of treatment groups: village and trainee characteristics.

	Training method			Availability of bags		
	Group 1 (video)	Group 2 (traditional)	*T*-test	Group A (village)	Group B (extension)	*T*-test
Number of villages (N)	*24*	*24*		*24*	*24*	
Extension office is located in the village (%)	14	31	***	29	15	***
% of villages that had received prior training on triple bag technology, according to the village head	61	70	**	58	75	***
% of villages that had received prior training on other post-harvest treatment to kill insects, according to the village head	37	54	***	39	53	***
Number of trainee respondents sampled for the survey (N)	*286*	*283*		*285*	*284*	
% with no formal school education	80	72	**	77	74	
Mean number of years of formal schooling experience	1.0	1.5	**	1.2	1.4	
Gender of trainee (% male)	78	65	***	65	79	***
Average age	44.4	43.4		43.7	44.1	
Number of years of farming experience	22.2	20.3	*	20.6	22	
Number of years respondent has lived in the village	36	31	***	32	35	**
Trainee is a member of a farmer organization (% yes)	45	49		51	44	
Awareness of triple bag method prior to training intervention (%)	58	62		60	61	
Awareness of solar method prior to training intervention (%)	6.9	5.9		4.7	8.4	*
Used solar disinfestation method in the past (%)	5.2	2.6		1.7	6.5	***
Used triple bag method in the past (%)	49	43		44	49	
Respondent owns a mobile phone (%)	64	61		56	70	***
Knows how to play video on mobile phone (%)	46	48		45	48	
Trainee is the main cowpea decision-maker (%)	85	80		82	83	
Trainee is involved in farm production decisions (%)	91	84	***	85	91	**
Trainee is involved in crop storage decisions (%)	83	83		79	87	**

Note: Results are weighted to reflect the total number of trainee participants across treatment villages.
*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

past efforts by the PICS project in promoting the use of this technology in many countries in West Africa, including Burkina Faso (Baributsa et al., 2014; Murdock, Baributsa, & Lowenberg-DeBoer, 2014).

In the year prior to the implementation of this study (i.e. 2011), about 23% of farmers in Group 1 and 19% in Group 2 had used insecticides to control cowpea storage pests. The use of "plastic jugs with lid" (*bidon* in French) was cited as the most common method of cowpea grain storage in 2011. This method of cowpea storage was used by 63% of trainees in Group 2 (that received the traditional extension method) compared to 52% of trainees in Group 1 (that received training through mobile phone video) (Table 5).

Overall, the pre-intervention balance test results presented in Tables 4 and 5 emphasize three important points pertinent to this field experiment. First, these results indicate that the randomized treatment groups share many similar characteristics, but also differ in some key characteristics that can influence learning and adoption outcomes. For example, the gender, age, education, prior exposure to similar training, experience in using mobile phone or videos, can influence the individual's ability to learn and grasp the technical content of the training offered. Similarly, these same factors, as well as characteristics of the household and villages can influence adoption behavior. For example, the household size, gender and age composition and ownership of mobile phone can determine the availability of labor, social networks, access to information and technology savviness of the household that can influence technology adoption decisions. The wealth status (as measured by assets and land holding) can similarly determine a household's purchasing power and risk attitudes that can influence technology adoption behavior. Similarly, village characteristics such as distance to the markets or extension services can influence access to information by residents of that village, which in turn can influence their technology adoption decisions. Thus, it is important to control these confounding factors in estimating the treatment effects, and justifies their inclusion in the regression analysis approach used in this paper. In other words, a simple comparison of the mean outcomes reported in Tables 6 and 7 and discussed below may not give completely unbiased estimates of the treatment effects.

To check whether taken together, these characteristics imply that a specific treatment group is better or worse off than the other, we also estimated the linear probability model (LPM) and probit models by regressing the two treatment variables (i.e. training method

Table 6. Training intervention characteristics, and learning and adoption outcomes: mean comparison between two training methods.

	Training method		
	Group 1 (video)	Group 2 (traditional)	*T*-test
Characteristics of training intervention in targeted villages	*N* = 24	*N* = 24	
Distance between the village and the location where the trainer (extension agent) was based (km)	14.6	17.0	***
Number of training participants per village	32	34	*
Time spent to explain two methods during training (hours)	2.11	2.31	**
Training time spent per trainee (hours)	0.069	0.077	**
Indicators of understanding the content of training	*N* = 283	*N* = 286	
Percentage of trainees who reported understanding the triple bag method after training	91%	83%	***
Percentage of trainees who reported understanding the solar method after training	86%	81%	
Indicators of adoption of technology and correct application of knowledge acquired among adopters			
Number of trainee households that had cowpea grain to dry/store post-training	*N* = 155	*N* = 176	
% that adopted triple bag technology post-training	65	67	
% that adopted solar technology post-training	15	21	
% of users reporting correct sealing method of triple bag *(N = 100, 107)*	99	99	
% of users reporting using bags with no holes *(N = 100, 107)*	90	93	
% users reporting drying cowpea grain for the correct time frame (2 hours) when using the solar method *(N = 25, 35)*	69	41	**
Indicators of first-time adoption of the two technology			
Number of trainee households that had cowpea grain to dry/store post-training AND had previously NOT used triple bag technology	*N* = 47	*N* = 67	
% that adopted triple bag technology first time	35	52	*
Number of trainee households that had cowpea grain to dry post-training AND had previously NOT used solar technology	*N* = 146	*N* = 169	
% that adopted solar technology first time	11	19	*

Note: Results are weighted to reflect the total number of trainee participants across treatment village.
*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

Table 7. Comparison of adoption outcomes when the triple bags were accessible in the village versus in the extension office.

	Ease of accessibility of bags		
	Group A (in village)	Group B (extension office)	*T*-test
Adoption of triple bag technology post-training	*N* = 156	*N* = 175	
% of trainee households that had cowpea grain to dry/store post-training	71%	61%	**
First-time adoption of triple bag technology	*N* = 49	*N* = 65	
% of trainee households that had cowpea grain to dry/store post-training AND had previously NOT used triple bag technology	50%	40%	

Note: Results are weighted to reflect the total number of trainee participants across treatment villages.
*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.

and availability of bags) on a set of all the characteristics (X_i) included in Table 3 to test the joint hypothesis that coefficients of all the independent variables equal to zero. The *F*-test in the case of the LPM and the chi-squared test in the case of the probit model rejected the null hypothesis confirming that the two groups are statistically significantly different on several characteristics. For some "good" variables the difference was in favor of the treatment group that received the traditional method of training (for e.g. prior training in storage methods, use of mobile phones to access agricultural information, proximity to market, percentage of households that live in houses with cement floors, etc.) but for some other "good" variables the difference was in favor of the treatment group that received video-based training (e.g. proximity to highway, number of hectares and Tropical Livestock Unit owned, and membership in a farmer group). Thus, it is difficult to assess based on these tests which treatment group is more or less likely to have positive learning outcomes or adopt a technology given these pre-treatment differences, and point to the need for controlling for these confounding factors in netting out the treatment effects.

Second, these results point to the importance of cowpea in the rural household economy of Burkina Faso, which reinforces the importance of promoting improved technologies for cowpea, including, technologies for post-harvest grain storage to reduce crop losses. Lastly, the results confirm different levels of pre-treatment awareness and use of the two technologies promoted in this experiment, which allows testing the effectiveness of animated videos on learning and adoption outcomes when it is used to promote new technology/information (i.e. solar disinfestation) versus reviewing or refreshing the concepts farmers were already exposed before (i.e. triple bag).

5. Training intervention characteristics and mean comparison of learning and adoption outcomes

The main objective of the field experiment was to see how effective the animated videos shown on the mobile phone are in inducing learning compared with the traditional extension method based on live demonstration. Both these training methods were implemented in a group setting and lasted on average about two to two and half hours (Table 6). On average 30–34 participants per village participated in this training and trainers spent on average 4.1–4.6 minutes per trainee (Table 6). Two types of indicators are used to compare the effectiveness of these two training methods in inducing learning among farmers. These include indicators of "understanding the content of training" and indicators of "application of knowledge acquired." The mean outcomes of these indicators are reported in Table 6. Both these indicators are self-reported assessments by the farmers in the post-treatment survey interviews. The first type of indicator captures farmers' overall impression of how easy or difficult it was to understand the content of the information delivered through the training method he/she received. This was asked to all the 569 farmers interviewed during the post-treatment survey. Among the group of farmers who received training using the traditional extension method (Group 2), 83% reported understanding the triple bag method and 81% reported understanding the solar disinfestation method. As against this, 91% and 86% of farmers who were shown the animated videos reported understanding the triple bag and the solar disinfestation method, respectively. In the case of the triple bag technology, the 8% difference in the mean outcome of understanding is statistically significant.

The second type of learning indicator used in this study captures farmers' application of the key concepts/messages as reflected in how correctly or incorrectly farmers who adopted a given technology implemented the following steps – heating the cowpea for the right duration of time (i.e. two hours) when using the solar disinfestation technology, checking that bags had no holes prior to storing the grain in triple bags and sealing the triple bags correctly. These are technical, yet critical steps in ensuring the effectiveness of the storage methods used and were important messages conveyed in both the videos and the live demonstrations. As shown in Table 5, 69% of farmers who used the solar disinfestation method after receiving the video-based training (Group 1) reported drying the cowpea for the correct time frame, which was significantly more than 41% of famers reporting the correct time frame in the group that had received the training through traditional method (Group 2). Compared with the solar disinfestation method, the level of comprehension as reflected in the correct application of a key step was much higher among farmers who used the triple bag method. Among farmers who used the triple bag storage method post-training, about 83% and 89% of farmers in Groups 1 and 2, respectively reported checking and ensuring that there were no holes in the bag when storing the cowpea grain in the triple bags (Table 6). Also, 99% of farmers across both the treatment groups reported individually tying each of the bags to hermetically seal them, which was the correct method of using the triple bag storage technology. On both these technical steps, the difference in the mean outcome was not statistically significant.

Another objective of this study was to assess the effect of the two training methods in inducing the overall adoption and first-time adoption of the two technologies. The mean comparison of the adoption of the triple bag and solar technologies among those who had cowpea grains to store post-training is also reported in Table 6. The overall adoption of triple bag and solar disinfestation technologies among the group of farmers who had cowpea grain to store after training is about 65% and 15%, respectively. There is no statistically significant difference in the mean adoption outcomes across the two training methods (Table 6). Focusing only on farmers who were potential first-time adopters (i.e. excluding farmers who had previously used the triple bag or solar technology), results indicate a significantly higher percentage of farmers adopting the triple bag technology for the first time in treatment group 2 that had received training through traditional method (52%) versus those in treatment group 1 (35%) that received video-based training (significant at a $p < .10$ but not at $p < .05$). Similarly, the first-time adoption of the solar disinfestation method was more in Group 2 (19%) than in Group 1 (13%) (significant at $p < .10$ but not at $p < .05$).

In the case of the triple bag technology, the field experiment was also designed to ensure that bags were available for purchase either in the village or at the nearest extension office, so that non-availability of bags was not a constraint to adoption by farmers. The average effects of the ease of accessibility of bags on the adoption and first-time adoption of the triple bag technology among farmers who had grain to store post-treatment are reported in Table 7. The mean comparison of the adoption outcomes indicates that making the bags available in the village, which implied easy access to the bags, lead to higher overall adoption (71%) and first-time adoption (50%) of the triple bag technology, which was 10 percentage points higher than the average adoption rate observed in the treatment group where farmers had to incur an inconvenience cost of traveling to the extension office to purchase the bags. This difference was significant in the case of overall adoption but not for the first-time adoption of the triple bag technology (Table 7).

6. Estimation strategy

Given the results that randomized treatment groups differ in many characteristics that can influence the mean outcomes, the average treatment effects noted in Tables 6 and 7 and presented in the previous section may be biased. We thus use the LPM noted in Equations (1) and (2) to control for other confounding factors in estimating the impact of the animated videos on learning and adoption outcomes, respectively.

$$L_i = a_i + \beta_i \boldsymbol{T} + \theta_i \boldsymbol{X} + \varphi_i \boldsymbol{R} + \psi_i \boldsymbol{V} + \varepsilon_i, \tag{1}$$

$$A_j = a_j + b_j \boldsymbol{T}^k + c_j \boldsymbol{Z} + d_i \boldsymbol{R} + f_i \boldsymbol{V} + e_j, \tag{2}$$

where, L is the learning outcome, A is the adoption outcome, $\boldsymbol{T}$ is the treatment variable, $\boldsymbol{X}$ and $\boldsymbol{Z}$ are the vectors of farmer, household and other observable characteristics described in Table 3 that can influence L and A, respectively, $\boldsymbol{R}$ and $\boldsymbol{V}$ are vectors of dummies to capture the trainer and village fixed effects, respectively, and ε and e are the error terms. Subscript i represents the learning indicators of understanding and application (described in Table 6), and subscript j represents the two adoption indicators – overall adoption and first-time adoption. In the case of model (2) superscript k denotes the two treatments included in the experiment – method of training (video vs. traditional) and availability of bags (in the village vs. extension office). The coefficients of interest are β and b, which capture the average impact of treatment 1 (animated video shown on mobile phone) as compared to treatment 2 (traditional extension method of live demonstration), and of treatment A (availability of bags in the village) as compared to treatment B (availability of bags in the extension office), when other confounding factors are held constant. The error terms ε and e capture unobserved farmer ability or idiosyncratic shocks. In all model estimations standard errors are clustered at the village level. Despite some limitations noted in the literature (e.g. Amemiya, 1977, Horrace and Oaxaca, 2006) there are two reasons why we use LPM as the base model for all the regressions. First, is the simplicity of interpretation of coefficients. Second and more importantly, to control for potential pre-treatment differences in means between Groups 1 and 2 or Groups A and B we prefer the fixed effect models (1) and (2), which control for unobservable differences across trainers (i.e. extension agents that delivered the training) and villages. These models could not be estimated using non-linear models such as Probit and Logit because of the large numbers of dummy variables to control for the fixed effects.

To overcome potential issues of selection based on observable characteristics and for robustness check, we combine the LPM models (1) and (2) with techniques that match the two treatment groups for a given intervention. Following Rosenbaum and Rubin (1983), a propensity score (PS), p was estimated as the conditional probability of assignment to a treatment condition given a set of observed covariates, X.

$$p = pr(T = 1|X). \quad (3)$$

As Rosenbaum and Rubin (1983) show, by definition treatment and comparison groups with the same value of the PS have the same distribution of the full vector X. It is thus sufficient to only match exactly on the PS to obtain the same probability distribution of X for individuals in the two groups. Therefore, we use the estimated PSs to first match the distribution of farmers in Group 1 (video-based training) with the farmers in Group 2 (traditional extension method), and then estimate Equations (1) and (2) for matched observations in the common support. Similarly, for the availability of bags, we use PSs to match the distribution of farmers in Group A (bags available in the village) with the farmers in Group B (bags available at the extension office), and then estimate Equation (2) using the matched samples.

The matching was done for each sub-sample noted in Tables 6 and 7 for which the different treatment effects are estimated. For example, when estimating the impact of the training method on the understanding of the technology, the matching model included all 569 observations. For estimating the effect of the training method on technology adoption, the matching model included households that had grain to store (i.e. 331 observations), and for estimating the effect of the training method on first-time adoption of technology, the matching model included households that had grain to store and had not previously used the technology (i.e. 114 observations for triple bag and 315 observations for solar disinfestation). Similarly, for the learning outcomes, the matching model only included households that had adopted that technology post-training (i.e. 207 observations for the triple bag technology and 60 observations for the solar disinfestation technology).

The PSs were calculated using three different matching techniques – one-to-one, kernel, and nearest neighbor 4 (with caliper 0.1). A wide range of variables representing different categories of individual, household and village characteristics were included to capture as much unobserved bias in the samples as possible. The results of the PS matching based on the nearest neighbor method for some of the outcome variables is presented in Appendix 1. These graphs show the comparison of standardized percentage mean bias across covariates included in the PS matching model for the matched and unmatched samples for four types of outcome variables. The graphs indicate that matching was successful in substantially reducing the mean and median bias between the two treatment groups across the covariates included in the model.

For each type of matching (i.e. one-to-one, nearest neighbor and kernel) two models were estimated. In model 1, we estimate Equations (1) and (2) using PSs as weights (referred as inverse PS weighted regression or WR). Subjects in treatment group 1 received weight $1/p$, and subjects in treatment group 2 received weight $1/(1-p)$. A WR minimizes the weighted sum of squares and allows addition of covariates to the regression model to improve precision. This method has been applied in many different contexts as an identification strategy to estimate causal effects (Aker, 2008; Behrman, Cheng, & Todd, 2004; Freedman & Berk, 2008; Hirano & Imbens, 2001). In model 2, the estimated PSs are used as an additional control variable when estimating Equations (1) and (2) (Aker, 2008; Guo & Fraser, 2015). For models 1 and 2, the results across the three types of matching method were very similar, and thus we only report the results for WR and PS based on nearest neighbor matching.

Since the set of observations that fall in the common support depends on which group is considered treatment and which one is considered comparison group, for additional robustness check, PSs were also estimated by matching the comparison of treatment group 2 (or B) with comparison Group 1 (or A). Regression models 1 and 2 based on this reversed definitions of treatment and comparison groups were also estimated and results presented for the main treatment variable.

7. Results

Table 8 presents the results of Equation (1) for treatment type 1 (method of training) for self-reported understanding of the technology. After controlling for the confounding factors, the positive effect of animated video-based training is sustained for both the indicators of understanding the content of training. A significantly more percentage of farmers in the treatment group that were shown the animated videos responded that it was easy to understand the triple bag (8%) and solar disinfestation (16%) technology than farmers in the treatment group that received this training through live demonstration. For understanding the triple bag technology, this effect is positive, but smaller and not statistically significant in the two matching models (WR and PS). In the case of understanding the solar disinfestation technology the effects are statistically significant in both the WR and PS models (Table 8). These positive results reject hypothesis one and show the potential effectiveness of animated videos in inducing the basic understanding of the content of the two videos to an audience that has low literacy or may not be exposed to watching animated videos for educational or entertainment purpose. Other factors that are positively associated with the understanding of one of these videos in a significant way include prior use of triple bag storage method, belonging to a household that owned at least one mobile phone with video viewing capability, and farmer's familiarity with playing video on a mobile phone. Being a cowpea decision-maker and membership is a farmer group had a negative impact on inducing understanding of the triple bag technology; but being a cowpea decision-maker and a member of a farmer group had significantly positive effect. In the case of solar disinfestation technology, membership in a farmer group was positively associated with an increased understanding of this technology; but male farmers who knew how to play videos on the mobile phone were associated with a negative effect on the understanding of the solar disinfestation technology when trained using mobile phone videos compared with female farmers with such knowledge (Table 8).

Table 8. Impact of training method on self-reported understanding of the technology, post-training: results of LPMs.

	Understanding of triple bag technology			Understanding of solar disinfestation technology		
	LPM	WR	PS	LPM	WR	PS
Received animated video-based training	0.076*	0.052	0.020	0.161***	0.160***	0.126***
	(0.039)	(0.043)	(0.042)	(0.056)	(0.056)	(0.046)
Prior use of triple bag	−0.004	−0.002	−0.038	0.085**	0.080**	0.066*
	(0.018)	(0.019)	(0.025)	(0.039)	(0.039)	(0.035)
Prior use of solar disinfestation	−0.052	−0.079	−0.072	−0.003	−0.039	−0.013
	(0.062)	(0.075)	(0.070)	(0.064)	(0.060)	(0.067)
Attended formal school (literate)	0.029	0.059	−0.034	0.175	0.091	0.122
	(0.069)	(0.068)	(0.071)	(0.134)	(0.090)	(0.123)
Male farmer	0.059	0.048	0.045	0.069	0.036	0.055
	(0.049)	(0.049)	(0.045)	(0.059)	(0.062)	(0.057)
Age (years)	0.008	0.005	0.007	0.005	0.001	0.005
	(0.006)	(0.004)	(0.006)	(0.005)	(0.004)	(0.005)
Member of a farmer group	−0.115**	−0.081	−0.096*	0.231	0.221**	0.243*
	(0.056)	(0.052)	(0.055)	(0.142)	(0.106)	(0.144)
Cowpea decision-maker	−0.139***	−0.106***	−0.178***	0.053	0.070	0.022
	(0.045)	(0.040)	(0.055)	(0.116)	(0.099)	(0.113)
Farmer trainee owns mobile phone	−0.005	0.001	−0.001	0.019	0.029	0.022
	(0.021)	(0.020)	(0.022)	(0.031)	(0.038)	(0.033)
HH owns mobile phone with video viewing capability	0.029	0.044*	0.003	0.049	0.065	0.033
	(0.029)	(0.023)	(0.037)	(0.052)	(0.048)	(0.062)
HH monthly expense on mobile phone usage	0.008	0.005	0.012*	−0.003	−0.008	−0.001
	(0.006)	(0.005)	(0.006)	(0.009)	(0.011)	(0.009)
Farmer knows to play video on mobile phone	0.191**	0.168**	0.183***	0.119	0.167	0.103
	(0.073)	(0.063)	(0.066)	(0.084)	(0.100)	(0.093)
Literate × male farmer	−0.035	−0.053	0.021	−0.071	−0.074	−0.026
	(0.044)	(0.051)	(0.052)	(0.083)	(0.071)	(0.078)
Literate × age	0.001	0.000	0.001	−0.002	0.000	−0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Member of a farmer group × decision-maker	0.122**	0.078	0.116**	−0.203	−0.182*	−0.206
	(0.053)	(0.052)	(0.055)	(0.141)	(0.108)	(0.139)
Knows to play video × age	−0.002**	−0.002**	−0.001*	0.000	−0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Own video viewing phone × monthly expense	−0.002	−0.001	−0.002	−0.006	−0.008	−0.007
	(0.003)	(0.004)	(0.004)	(0.004)	(0.006)	(0.005)
Knows to play video × male farmer	−0.060	−0.050	−0.065	−0.107*	−0.088*	−0.109**
	(0.044)	(0.034)	(0.043)	(0.053)	(0.045)	(0.053)
PS			0.257**			0.189
			(0.104)			(0.128)
Observations	569	546	546	569	546	546
R^2	0.741	0.767	0.748	0.573	0.603	0.574
Correct prediction	97%	97%	97%	92%	92%	92%

Notes: All regressions include constant trend, trainer and village fixed effects, and controls for the square of continuous variables age and monthly expense on mobile phone. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

Table 9 reports the effect of animated video-based training on two indicators of application of knowledge gained by those that adopted the technology, post-training. Here the results point to the positive effect of the traditional method in inducing the correct application of the storage techniques – that is, using bags with no holes and drying the grain for two hours when using the solar method. However, this effect was statistically not significantly different from the effect of video-based training method across all models, which means we are not able to reject nor accept hypothesis one.

Table 9. Impact of training method on self-reported correct application of storage technologies: results of LPMs.

	Reported using bags with no holes			Drying cowpea for the correct time frame (2 hours)		
	LPM	WR	PS	LPM	WR	PS
Received animated video-based training	−0.121	0.042	−0.099	−0.812	−0.755	−0.466
	(0.262)	(0.220)	(0.281)	(0.618)	(1.125)	(2.355)
Prior use of triple bag	0.044	0.064	0.095*	0.200	0.305	0.344
	(0.061)	(0.053)	(0.055)	(0.233)	(0.288)	(0.268)
Prior use of solar disinfestation	−0.048	−0.062	−0.086	0.050	0.278	0.302
	(0.049)	(0.074)	(0.085)	(0.189)	(0.249)	(0.334)
Attended formal school (literate)	0.014	0.123	0.168	0.146	−2.036	−3.175
	(0.399)	(0.366)	(0.400)	(0.604)	(1.995)	(2.361)
Male farmer	0.012	−0.018	0.039	0.567*	0.224	0.179
	(0.115)	(0.094)	(0.152)	(0.311)	(0.555)	(0.249)
Age (years)	0.005	0.009	0.011	0.039	0.037	0.052
	(0.014)	(0.013)	(0.021)	(0.050)	(0.106)	(0.082)
Member of a farmer group	0.054	0.135	0.021	0.939***	0.924***	0.635
	(0.203)	(0.142)	(0.199)	(0.080)	(0.194)	(0.991)
Cowpea decision-maker	0.042	−0.065	−0.099	1.015	0.513	1.797
	(0.295)	(0.149)	(0.237)	(0.681)	(1.496)	(5.534)
Farmer trainee owns mobile phone	0.001	−0.027	−0.014	−0.239	−0.066	−0.210
	(0.060)	(0.067)	(0.091)	(0.152)	(0.296)	(0.607)
HH owns mobile phone with video viewing capability	−0.072	−0.023	−0.141	−0.066	−0.253	0.592
	(0.111)	(0.100)	(0.130)	(0.354)	(0.501)	(3.260)
HH monthly expense on mobile phone usage	0.049*	0.039*	0.042	−0.057	0.129	0.112
	(0.025)	(0.022)	(0.027)	(0.095)	(0.280)	(0.318)
Farmer knows to play video on mobile phone	0.092	−0.120	0.008	1.700	4.231**	3.600
	(0.210)	(0.206)	(0.235)	(1.164)	(1.558)	(3.275)
Literate × male farmer	0.149	0.090	0.113	0.673**	2.725	3.899*
	(0.206)	(0.221)	(0.262)	(0.256)	(2.152)	(2.133)
Literate × age	−0.006	−0.006	−0.009	−0.026**	−0.027**	−0.026**
	(0.009)	(0.008)	(0.008)	(0.010)	(0.009)	(0.010)
Member of a farmer group × decision-maker	−0.068	−0.125	−0.026	−0.874**	−0.771**	−0.477
	(0.218)	(0.140)	(0.199)	(0.322)	(0.316)	(0.748)
Knows to play video × age	−0.001	0.000	0.000	−0.023	−0.022	−0.022
	(0.004)	(0.004)	(0.004)	(0.023)	(0.033)	(0.027)
Own video viewing phone × monthly expense	−0.001	−0.001	0.007	0.011	−0.097	−0.120**
	(0.011)	(0.012)	(0.015)	(0.060)	(0.096)	(0.046)
Knows to play video × male farmer	−0.052	0.049	−0.004	−0.638	−2.355	−2.441*
	(0.052)	(0.094)	(0.086)	(0.473)	(1.493)	(1.175)
PS			0.100	-		0.909
			(0.115)			(2.794)
Observations	207	175	175	60	42	42
R^2	0.337	0.604	0.457	0.739	0.886	0.871
Correct prediction	94%	98%	96%	97%	93%	93%

Notes: All regressions include constant trend, trainer and village fixed effects, and controls for the square terms of continuous variables age and monthly expense on mobile phone. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

Beyond the learning outcomes, we examine the effectiveness of the training method on the adoption of the two technologies promoted. Tables 9 and 10 present results for the overall adoption and first-time adoption of triple bag and solar disinfestation technologies, respectively, by the sampled trainee farmers, post-training. After accounting for other confounding factors, the effect of video-based training method is positive on the adoption of triple bag technology, but it is not statistically significant in any model estimation used (Table 10). The effect of the training method is also not

Table 10. Impact of training method on the adoption of triple bag technology: results of LPMs.

	Overall adoption			First-time adoption		
	LPM	WR	PS	LPM	WR	PS
Received animated video-based training	0.163	0.036	0.205	0.040	−0.078	0.100
	(0.157)	(0.257)	(0.169)	(0.382)	(0.451)	(0.339)
Prior use of triple bag	0.123**	0.147**	0.102*			
	(0.061)	(0.066)	(0.061)			
Attended formal school (literate)	0.037	0.194	−0.031	−0.206	−0.452	−0.445
	(0.251)	(0.305)	(0.280)	(0.526)	(0.604)	(0.569)
Male farmer	−0.052	−0.012	−0.074	−0.172	−0.146	−0.059
	(0.115)	(0.113)	(0.110)	(0.230)	(0.265)	(0.263)
Age (years)	0.014	0.011	0.008	0.010	0.016	0.018
	(0.009)	(0.012)	(0.011)	(0.030)	(0.036)	(0.033)
Member of a farmer group	0.073	−0.057	0.064	0.253	0.237	0.303
	(0.093)	(0.101)	(0.100)	(0.214)	(0.153)	(0.242)
Cowpea decision-maker	−0.087	−0.185	−0.150	0.120	0.123	0.130
	(0.083)	(0.117)	(0.091)	(0.141)	(0.141)	(0.184)
Farmer trainee owns mobile phone	0.048	0.003	0.044	0.402**	0.434**	0.416*
	(0.077)	(0.065)	(0.064)	(0.197)	(0.195)	(0.231)
HH owns mobile phone with video viewing capability	0.064	0.108	0.030	0.138	0.126	0.103
	(0.088)	(0.117)	(0.091)	(0.279)	(0.357)	(0.344)
HH monthly expense on mobile phone usage	0.039*	0.037	0.046**	−0.076	−0.119	−0.067
	(0.023)	(0.027)	(0.022)	(0.087)	(0.109)	(0.087)
Farmer knows to play video on mobile phone	0.163	0.137	0.156	0.059	0.023	0.111
	(0.229)	(0.241)	(0.229)	(0.744)	(0.740)	(0.815)
Literate × male farmer	−0.118	−0.457*	−0.096	0.233	0.234	0.407
	(0.226)	(0.264)	(0.247)	(0.396)	(0.340)	(0.385)
Literate × age	0.004	0.006	0.006	0.001	0.005	0.003
	(0.004)	(0.005)	(0.004)	(0.009)	(0.012)	(0.010)
Member of a farmer group × decision-maker	−0.027	0.156	0.020	−0.402	−0.375**	−0.457*
	(0.070)	(0.111)	(0.073)	(0.243)	(0.172)	(0.262)
Knows to play video × age	−0.004	−0.007	−0.003	0.001	−0.004	0.002
	(0.005)	(0.006)	(0.005)	(0.015)	(0.016)	(0.016)
Own video viewing phone × monthly expense	−0.008	−0.009	−0.014	−0.056	−0.035	−0.035
	(0.016)	(0.018)	(0.015)	(0.042)	(0.058)	(0.046)
Knows to play video × male farmer	0.122	0.267	0.117	0.067	0.255	−0.112
	(0.154)	(0.223)	(0.159)	(0.509)	(0.540)	(0.550)
PS			0.280**			0.367
			(0.119)			(0.548)
Observations	331	319	319	114	111	111
R^2	0.551	0.554	0.564	0.799	0.799	0.801
Correct prediction	84%	85%	85%	93%	95%	94%

Notes: All regressions include constant trend, trainer and village fixed effects, and controls for the square terms of continuous variables age and monthly expense on mobile phone. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

statistically significant for first-time adoption of triple bag technology (Table 10). Thus, we are not able to either reject or accept the hypothesis that training farmers through live demonstration was more effective in inducing adoption of triple bag technology than the video-based training (Table 10). This sobering results also point to the multi-faceted nature of factors that influence behavior change. In the case of triple bag technology, prior use of this technology was consistently the most significant variable across all model estimations. This may also indicate that in the case of triple bag technology, farmers who were going to adopt had already selected into adoption, and there was little room for inducing more adoption, despite high technical understanding of the technology.

In the case of solar disinfestation technology, the general trend was that the traditional extension method was more effective in inducing overall adoption (by 33–38%) and first-time adoption (by 23–39%). However, for most of the models, the differences were not statistically significant at p<.05, except for one model (WR for overall adoption) which was significantly different at p<.05 1% (Table 11). The observed difference in the relative effectiveness of the traditional method compared to video-based method for the two storage technologies could be due to the "novelty" effect. As noted in Table 4, only 6% of farmers were aware of the solar disinfestation method vs. 60% were aware of the triple bag technology prior to the training intervention. Thus, on average, the solar

Table 11. Impact of training method on the adoption of solar disinfestation technology: results of LPMs.

	Overall adoption			First-time adoption		
	LPM	WR	PS	LPM	WR	PS
Received animated video-based training	−0.330*	−0.383**	−0.330*	−0.389*	−0.217	−0.275
	(0.166)	(0.189)	(0.171)	(0.219)	(0.325)	(0.362)
Prior use of solar disinfestation	0.257***	0.190**	0.280***			
	(0.084)	(0.089)	(0.086)			
Attended formal school (literate)	0.571*	0.407**	0.653*	0.605*	0.389*	0.656*
	(0.310)	(0.198)	(0.343)	(0.322)	(0.222)	(0.344)
Male farmer	−0.014	−0.032	0.011	−0.001	0.019	0.026
	(0.091)	(0.096)	(0.088)	(0.086)	(0.100)	(0.090)
Age (years)	−0.015	−0.003	−0.014	−0.011	−0.006	−0.011
	(0.009)	(0.012)	(0.010)	(0.011)	(0.010)	(0.013)
Member of a farmer group	−0.075	−0.091	−0.108	−0.089	−0.006	−0.083
	(0.101)	(0.092)	(0.086)	(0.104)	(0.112)	(0.113)
Cowpea decision-maker	0.091	0.034	0.112*	0.100	0.070	0.129
	(0.063)	(0.066)	(0.065)	(0.071)	(0.068)	(0.084)
Farmer trainee owns mobile phone	0.005	0.017	−0.006	0.008	−0.020	−0.026
	(0.038)	(0.046)	(0.037)	(0.044)	(0.047)	(0.048)
HH owns mobile phone with video viewing capability	−0.040	−0.090	0.010	−0.023	−0.033	−0.007
	(0.098)	(0.139)	(0.099)	(0.119)	(0.108)	(0.122)
HH monthly expense on mobile phone usage	0.010	0.024	0.007	0.005	0.029	0.026
	(0.029)	(0.033)	(0.031)	(0.030)	(0.040)	(0.041)
Farmer knows to play video on mobile phone	−0.089	−0.031	−0.044	−0.099	−0.002	−0.065
	(0.112)	(0.157)	(0.149)	(0.110)	(0.089)	(0.123)
Literate × male farmer	−0.282	−0.192	−0.319	−0.287	−0.179	−0.304
	(0.188)	(0.137)	(0.195)	(0.202)	(0.176)	(0.206)
Literate × age	−0.007	−0.006*	−0.008	−0.008	−0.005	−0.009*
	(0.005)	(0.003)	(0.005)	(0.005)	(0.003)	(0.005)
Member of a farmer group × decision-maker	0.001	−0.007	0.029	0.014	−0.040	0.007
	(0.103)	(0.097)	(0.089)	(0.109)	(0.116)	(0.115)
Knows to play video × age	0.001	0.001	−0.000	0.001	0.001	0.001
	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Own video viewing phone × monthly expense	0.028	0.025	0.032	0.024	0.021	0.020
	(0.023)	(0.022)	(0.023)	(0.028)	(0.024)	(0.029)
Knows to play video × male farmer	−0.019	−0.017	−0.059	−0.021	−0.076	−0.046
	(0.079)	(0.080)	(0.082)	(0.088)	(0.097)	(0.090)
PS			−0.199**			−0.119
			(0.091)			(0.181)
Observations	331	319	319	312	296	296
R^2	0.558	0.566	0.559	0.536	0.552	0.544
Correct prediction	92%	92%	92%	93%	93%	94%

Notes: All regressions include constant trend, trainer and village fixed effects, and controls for the square terms of continuous variables age and monthly expense on mobile phone. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

disinfestation technology was relatively "new" than the triple bag technology across these communities. This difference in the novelty of information being conveyed could have contributed to the difference in the relative effectiveness of traditional extension method vs. video-based training in inducing adoption for the two technologies considered. Moreover, we cannot rule out that the differences in the effectiveness of the two videos may have also been influenced by the presentation style and content of the two videos; the triple bagging video contained information on how this process reduces post-harvest losses as compared to non-treatment and the solar disinfestation animation did not contain such a comparison.

Prior use of a given technology had significant positive effect on the overall adoption of both the technologies. In the case of triple bag, owing a mobile phone had a positive effect on first-time adoption. On the other hand, having a formal school education (which is a measure of literacy) was found to be a significant predictor of the overall and first-time adoption decision of the solar disinfestation method (Table 11).

Table 12 presents the results of Equation (2). It estimates the effect of "availability of bags" in the village on the overall and first-time adoption of triple bag technology. After controlling for other explanatory factors, the results indicate that making the bags available in the village increased the overall adoption of the triple bag technology by 9–22% and first-time adoption by −13% to 64%. However, these effects are not statistically significant, which means we are not able to reject or accept hypothesis two. The average distance traveled by farmers to purchase the bags available at the extension agents' office was 12 km. This indicates that some farmers are willing to pay an inconvenience cost of traveling to another location to purchase the bags, as long as they are made available. Some of the same factors that are associated with the adoption of triple bag technology across the training treatment groups 1 and 2 are also important in explaining the adoption of triple bag technology across treatment groups A and B (Table 12). The direction of association of these variables on the adoption decision is also consistent with the results reported in Table 10 for the training treatment.

Table 13 presents different treatment effects when the definition of the treatment and comparison groups are reversed in the calculation of the PSs that are used in matching model 1 (WR) and model 2 (PS as a control variable). Regression models in which the group that received training through the traditional method is considered the treatment group and the group that received video-based training is considered the comparison group, result in coefficients that have opposite signs (as expected) and have slightly different effect size, but yield similar results in term of statistical significance or insignificance (Table 13). This is also the case for the treatment effect for availability of bags. The results of the model based on a treatment variable defined as the group that had to travel to the extension office to purchase the bags and comparison group as the group where bags were available in the village show no statistically significant difference in the adoption and first-time adoption of triple bag technology (Table 13).

8. Discussion: the role of mobile phone-based videos as a tool of extension

Model estimations that take into account other confounding factors, and the trainer and village fixed effects have neither rejected nor accepted the null hypotheses (H_1 and H_2) for triple bag technology. But for solar technology, the evidence points to the rejection of null hypothesis for one of the learning outcomes (i.e. understanding), acceptance of the null

Table 12. Impact of availability of bags in the village on overall adoption and first-time adoption of triple bag technology: results of LPMs.

	Overall adoption			First-time adoption		
	LPM	WR	PS	LPM	WR	PS
Received animated video-based training	0.163	0.090	0.224	0.639	−0.132	0.050
	(0.157)	(0.275)	(0.211)	(0.657)	(0.553)	(0.505)
Prior use of triple bag	0.123**	0.125	0.132*			
	(0.061)	(0.080)	(0.068)			
Attended formal school (literate)	0.037	−0.051	0.253	−0.206	−1.787	−1.187
	(0.251)	(0.322)	(0.265)	(0.526)	(2.141)	(1.606)
Male farmer	−0.052	−0.009	0.062	−0.172	0.129	0.143
	(0.115)	(0.158)	(0.113)	(0.230)	(0.429)	(0.367)
Age (years)	0.014	0.009	0.016*	0.010	−0.053	−0.025
	(0.009)	(0.014)	(0.010)	(0.030)	(0.049)	(0.043)
Member of a farmer group	0.073	0.196	0.062	0.253	0.532*	0.373
	(0.093)	(0.187)	(0.105)	(0.214)	(0.270)	(0.395)
Cowpea decision-maker	−0.087	−0.014	−0.165	0.120	0.221	0.020
	(0.083)	(0.179)	(0.128)	(0.141)	(0.348)	(0.338)
Farmer trainee owns mobile phone	0.048	0.057	0.067	0.402**	0.469*	0.496
	(0.077)	(0.106)	(0.075)	(0.197)	(0.259)	(0.337)
HH owns mobile phone with video viewing capability	0.064	0.091	0.056	0.138	0.699	0.202
	(0.088)	(0.129)	(0.090)	(0.279)	(0.584)	(0.571)
HH monthly expense on mobile phone usage	0.039*	0.016	0.007	−0.076	−0.314*	−0.184
	(0.023)	(0.024)	(0.019)	(0.087)	(0.168)	(0.123)
Farmer knows to play video on mobile phone	0.163	0.129	0.199	0.059	−0.225	−0.261
	(0.229)	(0.345)	(0.245)	(0.744)	(0.874)	(0.744)
Literate × male farmer	−0.118	−0.382	−0.424*	0.233	1.913	1.115
	(0.226)	(0.258)	(0.222)	(0.396)	(1.845)	(1.261)
Literate × age	0.004	0.012**	0.006	0.001	−0.003	0.002
	(0.004)	(0.005)	(0.004)	(0.009)	(0.014)	(0.012)
Member of a farmer group × decision-maker	−0.027	−0.111	0.019	−0.402	−0.574	−0.458
	(0.070)	(0.151)	(0.088)	(0.243)	(0.346)	(0.382)
Knows to play video × age	−0.004	−0.007	−0.007	0.001	0.006	0.009
	(0.005)	(0.008)	(0.006)	(0.015)	(0.019)	(0.016)
Own video viewing phone × monthly expense	−0.008	0.015	0.003	−0.056	−0.071	−0.050
	(0.016)	(0.017)	(0.014)	(0.042)	(0.081)	(0.059)
Knows to play video × male farmer	0.122	0.230	0.198	0.067	−0.288	−0.068
	(0.154)	(0.225)	(0.152)	(0.509)	(0.526)	(0.530)
PS			0.241*	-		0.398
			(0.138)			(0.561)
Observations	331	294	294	114	87	87
R^2	0.551	0.561	0.562	0.799	0.812	0.837
Correct prediction	84%	83%	84%	93%	97%	95%

Notes: All regressions include constant trend, trainer and village fixed effects, and controls for the square terms of continuous variables age and monthly expense on mobile phone. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

hypothesis for the adoption of technology, and neither rejection nor acceptance of the null hypothesis for the correct application of the technology and first-time adoption. For hypotheses one, results suggest that the traditional method of training and information dissemination was an effective way to disseminate the solar disinfestation method, which was a relatively novel technology that only 6% of farmers were aware of prior to the training. However, in the case of technology/information that farmers were already exposed before through traditional method, such as the triple bag storage technology, animated video shown on the mobile phone was equally effective as live demonstration in reinforcing the messages and inducing learning and adoption. This is an important finding that points to the potential role of mobile phone-based videos,

Table 13. Impact of training method and location of bag availability on different learning and adoption outcomes: robustness check using the reversed definition of the treatment dummy in estimating PSs for the two matching models.

Treatment variable	WR	PS	WR	PS
	Understand triple bag		Understand solar disinfestation	
Received training through traditional method (1 = yes)	−0.044	−0.010	−0.147**	−0.113**
	(0.045)	(0.041)	(0.060)	(0.047)
	Using bags with no holes		Drying cowpea for correct timeframe	
Received training through traditional method (1 = yes)	0.063	0.210	0.023	−0.208
	(0.293)	(0.341)	(0.921)	(1.153)
	Overall adoption of triple bag		First-time adoption of triple bag	
Received training through traditional method (1 = yes)	0.039	−0.211	0.123	−0.057
	(0.190)	(0.173)	(0.503)	(0.384)
	Overall adoption of solar disinfestation		First-time adoption of solar disinfestation	
Received training through traditional method (1 = yes)	0.348**	0.306**	0.322	0.409*
	(0.154)	(0.140)	(0.199)	(0.219)
	Overall adoption of triple bag		First-time adoption of triple bag	
Bags available at extension office (1 = yes)	−0.151	−0.221	−0.537	−1.162
	(0.252)	(0.162)	(1.563)	(1.260)

Notes: All regressions include constant trend, trainer and village fixed effects, and other controls as in the regression models reported in Tables 7–11. Robust standard errors clustered by villages in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

including animated videos in promoting agricultural technologies as an integral part of the extension system. This finding is consistent with the results of a study conducted in India where the use of video in addition to the traditional extension approach significantly increased the adoption of certain agricultural technologies over the sole T&V-based extension method (Gandhi, Veeraraghavan, Toyama, & Ramprasad, 2009). Similar findings have also been highlighted in Uganda for women farmers, and in Benin (Bentley, van Mele, Okry, & Zossou, 2014; Cai, 2013; Cai, Rodriguez, & Abbot, 2014).

What is encouraging is the high or comparable level of understanding and comprehension reported by the farmers who saw the videos on the mobile phone as those reported by farmers who were trained using live demonstration for both the technologies. There are a variety of mechanisms through which the mobile phone-based videos could have the observed positive effects on farmer learning and adoption. First is the on-demand accessibility to the video beyond the one-time training session. In our sample, 70 respondents in treatment group 1 reported watching the mobile phone video on the triple bag and 181 respondents reported watching the video on solar technology after the training. This repeat viewing, facilitated by the mobile phone, improves comprehension and reinforces learning and behavior change. Others have reported similar effects of watching videos, albeit not necessarily on the mobile phone (Bentley et al., 2014; Oladele, 2008). According to Bentley and van Mele (2015), watching a video featuring the management of *Striga* has helped farmers understand that soil fertility is key to controlling *Striga*, and has encouraged them to start experimenting. This learning and behavior change mechanism is evident from the positive and in some cases significant correlation of these outcomes with – copying (i.e. transferring the video on one's mobile phone), viewing, showing and sharing the videos to others, post-training (Table 14). For example, 12% and 20% more farmers in treatment group 1 who copied the videos on their mobile phone post-training understood the triple bag and solar disinfestation technology, respectively. Adoption of solar technology was 10% more among farmers who viewed the videos, post-training than those that did not. Similarly, 8% more farmers who viewed the videos, post-training reported drying the grain for the correct time frame (2 hours) than those that did not watch the video after the training (Table 14). Viewing the videos (i.e. repeat viewing), showing the videos on the mobile phone and sharing the video to others is also positively and significantly associated with increased self-reported understanding of the solar disinfestation technology (Table 14). Within treatment group 1, showing and sharing videos is also positively associated with increased adoption of triple bag technology. These observed learning and adoption effects could also be just the effect of the mobile phone technology. For example, the study by Aker, Ksoll, and Lybbert (2012) found that the addition of a mobile phone-based component in an otherwise standard adult education program in Niger substantially improved learning outcomes. Thus, it is possible that in this study, the associated learning that occurred on how to use the mobile phone to access, view, show and share the video may have itself acted as a mechanism that induced learning and comprehension about the technology.

A second potential mechanism through which mobile phone-based videos could have the observed positive effects on farmer learning and adoption could be the interaction effect of this technology. For example, the accessibility of the video on the mobile phone facilitates sharing the video with others, which increases interactions and discussion about that technology among farmers' own social networks, which in turn reinforces learning and behavior change. Among the sampled farmers from treatment group 1, 75 farmers reported that they had copied the videos on their mobile phones after the training session. On average, each of these farmers had shown the videos to other eight people

Table 14. Correlation between farmers' use of mobile phone-based video post-training and outcome variables: results for treatment group 1.

	Farmers in treatment group 1 reporting the following …			
Outcome variables	Copied video	Viewed video	Showed video	Shared video
Understand triple bag	0.116*	0.155	0.095	0.004
	(0.067)	(0.124)	(0.056)	(0.002)
Understand solar	0.196***	0.222*	0.160**	0.007**
	(0.068)	(0.113)	(0.058)	(0.003)
Adopt triple bag	−0.006	0.139	0.423***	0.025***
	(0.112)	(0.087)	(0.086)	(0.007)
Adopt solar	−0.026	0.101*	0.085	0.004
	(0.035)	(0.057)	(0.058)	(0.004)
First-time adopt triple bag	0.002	−0.037	0.055	0.003
	(0.031)	(0.036)	(0.063)	(0.005)
First-time adopt solar	−0.012	0.063	0.068	0.002
	(0.028)	(0.051)	(0.051)	(0.002)
Used bags with no holes	−0.006	−0.046	−0.055	−0.009
	(0.041)	(0.034)	(0.072)	(0.005)
Dried grain for 2 hours	−0.016	0.082*	0.054	0.003
	(0.026)	(0.044)	(0.061)	(0.004)

Note: Standard errors in parentheses.
***$p < .01$.
**$p < .05$.
*$p < .1$.

and transferred the videos on three farmers' mobile phones in the two-month time period after the training took place.

The sharing of videos among farmers as observed in this study points to the potential role of mobile phone-based videos in scaling up the dissemination of scientific information in rural areas using farmers' own social network. Within two months after the training, the videos that were copied on 75 trainee farmers' mobile phones, were shown by farmers to 566 other farmers, and transferred on 239 other mobile phones. About 17% of farmers who shared the videos reported sharing it with farmers from other villages. This result reinforces the finding of the small experiment conducted in Niger on how mobile phone video spread from farmer to farmer, mostly through Bluetooth technology (Baributsa et al., 2010), and point to the potential role this technology can play in scaling the dissemination efforts.

The difference in the effectiveness of the two videos on the adoption outcome may have been also influenced by the presentation style and content (e.g. the video on triple bag storage method showed what happens to the grain if a farmer used the triple bag technique compared to not using that method; but the solar disinfestation video did not include such comparison). However, this experiment was not designed to assess the effectiveness of these elements of the video-based messaging. More research is needed to evaluate this potential influencing factor in inducing learning and behavior change when using a video-based training approach. Another limitation of this study is that in this experiment we did not include a control group that did not receive any treatment. Hence, the effectiveness of the two methods evaluated in this experiment is relative to each other. Research on evaluating the effectiveness of extension workers or videos in disseminating technologies will require comparison with a control group that received no training, something we hope future research can address.

9. Conclusion

Educational videos deployed on mobile phones (or other mobile devices such as iPads, tablets and small laptop computers) are a new tool for facilitating communication for human behavioral changes. Integrating such tools in agricultural extension system can potentially improve the adoption of innovations by farmers in developing countries. Videos have several advantages over other methods of extension. First of all, they allow for the standardization of information for accurate transmission from a technical source. Second, in situations where high-quality trainers and extension agents are not available, videos, if designed as short duration films, can be transmitted on mobile phone from farmer to farmer through Bluetooth technology, increasing the potential for scalability. Third, they are suitable for low-literate population as they combine visual and verbal communication methods rather than written communication through a print media. Lastly, in the case of animated videos, they can be easily adapted to different languages and cultural settings, thus increasing the scaling up potential of a video globally. Thus, videos hold great promise as an extension tool for less developed countries, if they can be shown to be an effective medium for transmitting skills, information and knowledge to farmers living in the rural and remote areas of the world. This study was designed to test whether this promise holds up in the case of two animated videos disseminated to cowpea farmers in Burkina Faso.

Results of the randomized field experiment reported in this article suggest that the animated videos shown and transmitted through mobile phone can be as effective as the traditional method for reinforcing the skills, information and knowledge on complex technical topics that farmers were already exposed through other interactions. This is the case with the triple bag technology, which has been widely disseminated in the study area by the extension system through donor-funded projects in the last 5–10 years. However, in transferring new technologies or technologies that farmers had low prior awareness and experience using it, such as the solar disinfestation technology, the traditional method of training and information dissemination may have a slight advantage in inducing the overall and first-time adoption. Alternatively, there may be a need to redesign or alter animations to include information that is persuasive to encourage adoption or show comparison of effects with and without technology use, and not just provide technical details as to how to perform the given technique.

These mixed, but encouraging results indicate that integrating this method of transferring scientific information to farmers (i.e. through videos on mobile phones) with the traditional extension method can be a cost-effective method of scaling out new technologies based on farmers' own knowledge sharing networks. The mixed component of our results indicates the need for further research to understand how to develop animations that both increase learning and contain a persuasive component to encourage adoption. Additionally, the question remains on finding cost-effective business models of incorporating the ICT-based methods for delivering knowledge and information to a large number of farmers. More research is also needed to address this question.

Additionally, the mixed results also point to the complex and multi-faceted nature of factors that influence technology adoption decisions by farmers. Extension and training can help disseminate information and impart technical understanding of a technology; but learning and understanding are not sufficient conditions for inducing farmers to adopt the technology. Among the farmers of this study population, prior use of the technology was consistently the most significant explanatory variable across all the adoption model estimations for both the technologies. This indicates that farmers who were going to adopt had already selected into adoption, and there was little room for inducing more adoption, despite high technical understanding of the technology. In other words, the results point to potentially decreasing marginal effect of the training intervention in influencing adoption decisions.

To ensure that the adoption of a technology is not constrained by the lack of availability of inputs, the field experiment also included randomizing the location at which the plastic bags were available for purchase by the farmers after the training. In some villages, the bags were made available in the village and in others, farmers were told that the bags were available at the extension agent's office, which required the inconvenience and cost of traveling to that office if farmers wanted to purchase the bags. Results of this study indicate that availability of bags in the village did not lead to significantly more adoption of triple bag technology; the effect was the same as the intervention where bags were available in the extension office, which shows that farmers are willing to travel and invest time to purchase the bag, as long as they are accessible. This study shows that farmers in the study area were willing to travel on average 12 km to purchase the bags. This is also an important finding for developing market strategies that address the last-kilometer input delivery challenges faced in many parts of the developing world.

Notes

1. Examples of simple and innovative ideas (in addition to the two techniques focused in this study) include the tumbling method of pest control (Quentin, Spencer, & Miller, 1991), the rapid wetting method to reduce cyanogen from cassava flour (Bradbury & Denton, 2010), and the use of raised bed cropping practices (Roth, Fischer, & Meisner, 2005).
2. Other important reason could be that these innovative ideas may not work under farmers' conditions and constraints. Thus the set of innovative solutions that actually work and are rigorously demonstrated to be profitable in a real-world setting may be a subset of all the ideas and solutions proposed in the scientific literature.

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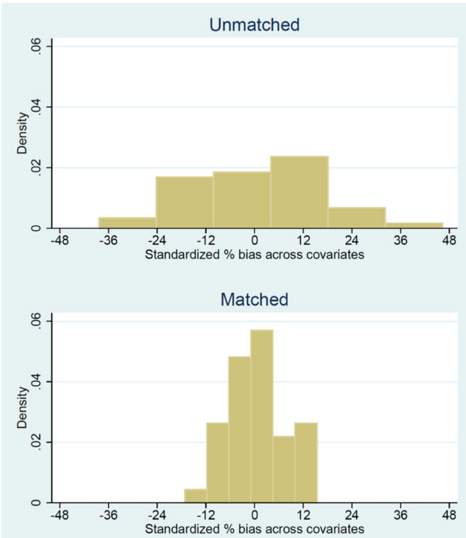
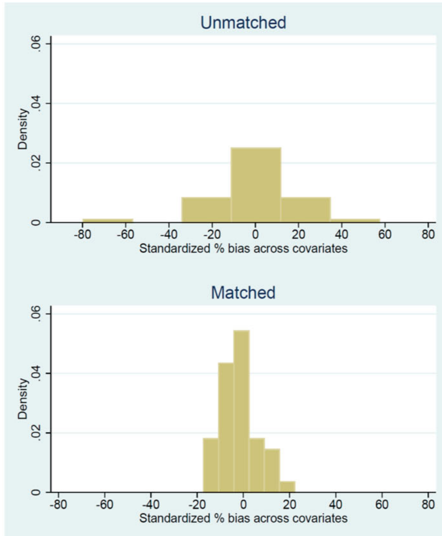
Appendix 1. Results of propensity score matching for key outcome variables – comparison of standardized percentage mean bias across covariates before and after matching.

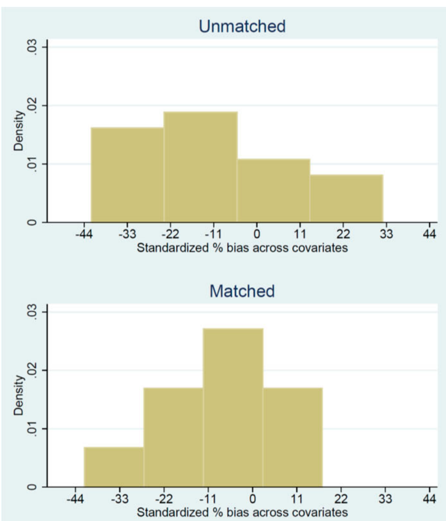
'Understanding' outcome.



Overall adoption.



First-time adoption (triple bag).



First-time adoption (solar disinfestation).