Accelerating technical change through video-mediated agricultural extension: Evidence from Ethiopia[1]

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Abstract

This study assesses the effects of video-mediated agricultural extension provision on farmers' knowledge and adoption of improved agricultural technologies and practices in Ethiopia. The study focuses on a program piloted by the Ethiopian Ministry of Agriculture and Natural Resources (MoANR), Digital Green, and regional bureaus of agriculture in the four largest regional states of Ethiopia. Focus is placed on two main questions: (i) to what extent does video-mediated extension lead to increased farmer uptake of improved agricultural technologies and practices by smallholder farmers; and (ii) is agricultural extension targeted at both spouses of the household more effective than when targeted at the household head only. The study relies on a randomized controlled trial (RCT) design to explore three priority crops (teff, wheat, maize) and three technologies (row planting, lower seeding rate, and fertilizer top dressing). The trial was implemented in 350 *kebeles* during the 2017 *meher* (rainy) season in four regional states. Using a sample of 2,422 households, we find clear evidence that video-mediated extension is more effective than the conventional training-and-visit system in achieving key outcomes. Specifically, we find that video-mediated extension reaches a wider audience than the conventional extension approach and leads to higher levels of agricultural knowledge and uptake of technologies in those *kebele*s selected for video-mediated extension. While our results do point to greater participation and greater knowledge of spouses in *kebeles* where both spouses were targeted for the video-mediated extension, we do not find clear evidence that the spouse-inclusive approach translated into higher uptake of the subject technologies and practices.

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1 Introduction

Despite a rapidly expanding body of analytical insight on the application of information and communications technologies (ICTs) to smallholder agriculture in developing countries, there are still many questions regarding the effectiveness of novel ICT-mediated approaches (Nakasone and Torero, 2016; Aker, 2011). This is particularly the case with ICT-mediated agricultural extension and advisory services that aim to improve the ways in which farmers manage crops, livestock, and natural resources. While several prior studies have explored the impact of simple, low-cost text and voice messaging services provided to farmers via mobile phones, more sophisticated approaches have received far less attention. These include the use of videos to convey information to farmers using various intermediation agents such as community organizers or extension workers, and intermediation tools such as portable projectors and tablet computers.

The video medium offers several advantages over traditional information dissemination approaches used by extension agents. First, video can be tailored and customized to localized information needs via the strategic use of languages, actors, music, settings, and other variables that may appeal directly to the viewing audience. Second, video can allow for consistent content delivery, thereby reducing errors in conveying information about crop timings, input quantities, or other variables that require more accuracy than an extension agent may be able to retain and communicate correctly. Third, videos can be produced at a relatively low fixed cost, which increases the approach's cost effectiveness as the number of viewers increases. Thus, whether used alone or in tandem with conventional extension approaches, video can be a powerful medium.

To date, two studies have sought to unbiasedly measure the relative effectiveness of using videos to promote agricultural technologies and practices. Both were conducted in partnership with Digital Green, an international NGO pioneering video-mediated extension approaches. In 2007, a small-scale randomized controlled trial conducted in India suggested that Digital Green's approach was ten times more cost-effective than training-and-visit approaches in terms of promoting farmers' adoption of technologies (Gandhi et al. 2007). This was followed by a large-scale randomized controlled trial covering 420 villages in India's state of Bihar to assess the effectiveness of the Digital Green approach in promoting System of Rice Intensification (SRI) practices among smallholder farmers. Findings indicate that the probability of adoption increased by 0.05 for those who viewed Digital Green videos, which is a 50% increase over the 10% adoption rate observed in the control group (Vasilaky et al., 2015).

The present study seeks to complement this evidence by assessing the effect of video-mediated extension on farmers' agricultural practices in Ethiopia. We use Digital Green's scaling-up efforts with the Ethiopian Ministry of Agriculture and Natural Resources (MoANR) and regional bureaus of agriculture to identify rigorous insight into the impact of the video-mediated extension approach with a randomized controlled trial (RCT) implemented in 350 *kebeles*[1] during

[1] *Kebele* is the smallest administrative unit in the country, typically covering 10 to 25 villages.

the 2017 *meher* (rainy) season.[2] The evaluation was conducted in the four regional states of Ethiopia that together account for most of the country's agricultural production.

The study aims to contribute evidence in support of ongoing reforms within Ethiopia's extension system—reforms that have been pursued as both small experiments and large programmatic changes during the past three decades (Davis et al., 2010). A pillar of these reforms has been the large increase in agricultural extension agents (Development Agents (DAs): over the past 10-15 years, approximately 73,000 DAs have been trained and 18,000 Farmer Training Centers (FTCs) constructed. This investment reflects the Government of Ethiopia's effort to accelerate agricultural growth, a commitment set forth under the broad umbrella of Ethiopia's Growth Transformation Plan (GTP), the country's guiding strategy for economic growth and poverty reduction.

Our results show clear evidence that Digital Green's video-mediated extension approach led to increases in extension's reach and greater knowledge among farmers about several improved agricultural technologies and practices that feature prominently in MoARN's extension program and those of the regional bureaus of agriculture. Specifically, we find that video-mediated extension reached a wider audience than the standard extension approach, likely due to increased interest by farmers in the medium. In turn, we find a higher level of knowledge—greater technical understanding of the focal agricultural technologies and practices—among farmers in those *kebele*s selected for video-mediated extension.

Our results also show clear evidence that the video-mediated extension approach led to increases in the uptake of improved agricultural technologies and practices by farmers. Following government priorities, we focus on three main crops (teff, wheat, and maize) and three technologies (row planting, lower seeding rate, and fertilizer top dressing). For each crop, we find that video-mediated extension led to a 3 to 10 percentage point increases in uptake of key technologies. Compared to control group levels, these increases represent up to a 35% increase in uptake of a given technology for a given crop.

While our results also point to greater participation and greater agricultural knowledge of spouses who also received the video-mediated extension, we do not find clear evidence that targeting both spouses translated into higher uptake of technologies. We also find no immediate evidence of video-mediated extension on higher-order outcomes such as crop yields, output, or area under cultivation, although these will be the subject of further analysis as additional data are collected.

The remainder of this paper is organized as follows. Section 2 provides background and context for this study. Section 3 presents the main research question, focusing on the potential effect of video-mediated extension provision based on prior studies and the links between gender and extension services. Section 4 presents the experimental set-up of the study: the interventions, experimental design, sampling, timing, and empirical strategy. Section 5 presents and discusses the main results of the study. Section 6 offers concluding remarks and highlights important policy implications.

[2] Throughout this paper, dates are referred to using the Gregorian calendar. Ethiopia uses the Julian calendar, under which the study period ran from 2009 to 2010.

2 Background

Since 2014, Digital Green and the Government of Ethiopia have been piloting the introduction of a video-mediated approach to agricultural extension provision. The approach aims to increase the growth rate of yields and output for major food staples by encouraging farmers to adopt productivity-enhancing agricultural technologies and practices. It is expected to both augment and accelerate the adoption process at a relatively low cost per farmer by integrating locally produced content in local languages and actors with Ethiopia's existing extension infrastructure. An early assessment of Digital Green's approach in Ethiopia based on monitoring data from the pilot phase suggests considerable potential in the approach—particularly in its ability to provide localized content and reach women farmers (Bernard et al., 2016).

Based on the strengths of results from the pilot phase, Digital Green is currently scaling up their project area in Ethiopia to 68 *woredas*. This scaling-up effort provides an opportunity to provide rigorous insights and evidence on the effectiveness of Digital Green's video-mediated extension approach. Under this study design, *kebele*s in the scaling-up effort were randomly assigned to one of three arms: a control group that received standard extension services from DAs usually targeted at household heads; a treatment group that received video-mediated extension services by DAs, targeted at the same individuals as the standard extension package; and a second treatment group that received video-mediated extension services that targeted both the household head *and* his spouse. This design allows us to estimate the impact of Digital Green's video-mediated approach on several outcomes of interest including (i) awareness and understanding of specific agricultural technologies and practices; (ii) uptake of the technologies on one's field in the ensuing agricultural season; and (iii) whether impact varies when extension is targeted to both male and female spouses in each participating household instead of the one, typically male, member per household. We rely on a sample of 2,422 household surveys collected in February-March 2018 to estimate *Intent to Treat* (ITT) impacts of video-mediated extension.[3]

Recent studies highlight the effectiveness of video-based messages to affect individual behaviors. The overall result is that videos tend to be powerful means to affect viewers' behavior in various aspects of life (see Bernard et al. (2016) for a review). Videos can provide messages that are tailored to individual's information needs. They may also (and perhaps more importantly) feature a character that individuals can relate to which may further lead to emotional engagement supporting behavioral change. Studying existing broadcasts, Chong and La Ferrara (2009) and Jensen and Oster (2009) for instance show that exposure to TV soap operas featuring strong women and smaller families led to reduced fertility and increased women's autonomy in Brazil and India, respectively. But videos may also be purposefully designed to convey particular messages targeted at issues such as financial literacy (Berg and Zia, 2013), or HIV prevention (Banerjee et al., forthcoming). In Ethiopia, Bernard et al. (2014) show that screening short documentaries featuring rural individuals who affected their life outcomes through perseverance and hard work, led to significant changes in viewers perception and future-oriented behavior.

[3] By ITT, we imply that the effect is estimated by comparing all farmers in treatment and control *kebele*s, irrespective of whether they effectively attended a video screening. ITT estimates are directly policy-relevant, in that they provide estimates of an intervention's overall impact on the targeted population.

The present study further contributes to the literature, providing further evidence of the effectiveness of video-based messages this time in the field of agriculture.

These results further contribute to the emerging literature on the role of ICT to support agriculture growth in developing countries. To date, most studies have focused on evaluating simple, low-cost text and voice messaging services provided to farmers over mobile networks, and most often for price-related information (see Nakasone and Torero (2016), and Aker (2011) reviews). Fewer studies examine the role of ICTs in the provision of production-related information. Exceptions include the use of short message services containing information on crop management advice and weather forecasts in India (Fafchamps and Minten, 2012), integrated pest management practices in Ecuador (Larochelle et al., 2017), agronomic advice in India (Cole and Fernando, 2014) and advice on timing of sugarcane farm operations in Kenya (Casaburi, et al., 2014); animated videos on post-harvest management in Burkina Faso (Maredia et al., 2017) and insecticidal neem use in Benin (Bello-Bravo et al., 2018); and interactive crop advisory services via mobile phones in India (Fu and Akter, 2012). Results from these studies vary from no effects of the ICT-based approach on production and yields (Fafchamps and Minten, 2012) to significant changes in input and technology use (Cole and Fernando, 2014). Our results contribute to this work by presenting new evidence on the use of localized videos to convey information to farmers, to augment extension services, and to effect changes in crop management decisions—a combined topic of study that has received relatively little attention in this growing literature.

3 Research questions

Our study is primarily targeted at two broad research questions, each with direct implication for the design of public policies to support agricultural development in Ethiopia and elsewhere:

- To what extent does video-mediated extension lead to increased farmers' uptake of agricultural technologies?
- Is agricultural extension targeted at both spouses of the household more effective than when targeted at the household head only?

Video-mediated extension. There are two independent reasons supporting the use of localized video content (Bernard et al., 2016). The first reason is relatively straightforward: locally produced content can be tailored to the specific information needs of local individuals and communities. Several studies demonstrate the importance of locally relevant information, drawing attention to evidence from studies in the economics on education (Jensen, 2012), entrepreneurship (Jensen, 2010) and agriculture (Hanna et al., 2012). Psychologists similarly find a positive relationship between locally relevant information and public health (Bull et al., 1999; Marcus et al., 1998), weight gains (Campbell et al., 1994), smoking habits (Prochaska et al., 1993; Shiffman et al., 2000), and education (Kim and Keller, 2008).

The second reason relates to the idea that persuasion—the ability of an intervention to change behaviors toward some desired outcome—depends on the way messages are framed so that individuals can relate to it. In particular, people tend to receive, accept, and internalize messages better from those whom they recognize as similar to them. Social psychologists, in particular, suggest that attitudes and behaviors are strongly affected by the experience of others in one's immediate environment (Bandura, 1977, 1986). With video content, exposure to role models with whom a viewer identifies can substitute for an individual's experience or the experience of actual peers and may be a particularly powerful way of framing a message to promote attitude and behavior change.

Overall, the economic and psychological literature suggest both that information targeted to an individual's specific needs is more effective than broader messaging, and that videos featuring role models similar to viewers across multiple dimensions of character or identity reinforce persuasiveness. As such, one would expect to observe larger effects of video-mediated extension when the viewer and the character featured share a greater number of characteristics. Women, for instance, may be more responsive to stories featuring successful women; poorer individuals may be more affected by stories of individuals starting from a similarly impoverished background; and inhabitants of a given location may react more promptly to videos featuring individuals from the same locality.

In the present study, we compare video-based extension as promoted by Digital Green in Ethiopia, to standard Ethiopian extension approach based on regular training-and-visit system. Though the focused technologies are different, this comparison aligns with the design of another evaluation of the Digital Green approach in the State of Bihar, India. Together, the studies will enable the assessment of the external validity of results in different contexts.

Gender and extension. The specialization of labor along gender lines is often used to justify the targeting of the dissemination of certain technologies to men (e.g., cereal crop production technologies) and others to women (e.g. nutrition and health-related technologies). This implicitly assumes that, for a given technology, the spouse of the targeted individual is not involved in the adoption decision or does not contribute labor to the implementation of the technology. However, evidence suggests that adoption of many technologies, whether related to agriculture or nutrition, is the outcome of an intra-household decision-making process (e.g. Udry, 1996; Doss and Morris, 2001). This may in turn be influenced by the extent to which spouses have access to similar information. Evidence also suggests that for many technologies in many contexts, both men and women provide labor despite conventional views that the technology's use is gender specific.[4] Thus, targeting information to one spouse may contribute to lower-than-optimal adoption rates if the non-targeted spouse does not have the same level of information.

Yet, despite their high labor participation rates in agriculture, women often lack access to extension. In a study on the adoption of improved maize technologies in Ghana, Doss and Morris (2001) find that women are less likely to adopt technologies, and that their low adoption rates are correlated with a lack of access to complementary inputs and information. In particular, they find that women receive more than four times fewer visits by extension agents than their male counterparts, although the authors recognize that this may be related to women having less access to land to start with. In the eastern part of Democratic Republic of Congo, Lambrecht et

[4] For instance, while Ethiopian women are rarely the primary decision makers on agriculture-related practices, they do provide significant amount of labor. The most recent evidence suggest that women contribute 29% of the agricultural labor force in Ethiopia: 26% for land preparation, 26% for planting and weeding-related activities, and 37% for land preparation (Palacios-Lopez et al., 2015).

al. (2016) study the relative impact of male versus female targeting of extension services on the adoption of improved legume varieties, row planting, and mineral fertilizer by farm households. Studying the correlation between adoption and the gender of the recipient of extension services, they find that that joint male and female program participation leads to the highest adoption rates in male-headed households, and that women's participation in extension is particularly conducive to adoption of labor-intensive technologies.

At this stage however, the literature on the potential impact of increasing women's access to extension services remains weak. In a recent paper, Doss (2015) revisits the argument that the social rates of return on investments in agricultural development are higher when those investments are targeted to women. Reviewing the empirical literature, Doss (2015) finds only meager evidence to support these claims, not the least because none of the supporting studies rely on convincing identification strategies in their empirical specifications, in turn implying that the results are best interpreted as correlations but not causal relationships. Instead, she suggests that research should focus on identifying where the best returns to investments are found by relying on gender disaggregation as useful analytical categories since farming and food preparation are deeply gendered activities. In other words, Doss (2015) states that "whether or not specific interventions should explicitly target women rather than men, it is clear that a gender-blind approach to designing interventions will miss out on key constraints, opportunities, and impacts."

In Ethiopia, because women play an important role in agriculture, there is considerable scope to consider the interaction between extension and women. Palacios-Lopez et al. (2015) estimate that women contribute 29 percent to agricultural labor in the country as a whole, and 26, 26 and 37 percent to land preparation, planting and weeding activities, and harvesting activities respectively. Women—not just women-headed households but also women who are part of male-headed households—are potentially key to the adoption of new technologies that are being promoted through video-mediated extension. However, their access to extension services in Ethiopia has been historically limited (Mogues et al., 2009; Ragasa et al., 2013; Buchy and Basaznew, 2017).

Several recent studies have documenting the effect of targeting agricultural extension to women; on input use, technology adoption, productivity, and incomes, though often as a secondary topic of inquiry (see Ragasa et al. (2013) for a review). However, none to our knowledge document the effect of targeting both spouses in beneficiary households in a manner similar to the gendered treatment introduced in this study and described in further detail below.

4 Empirical Setup

Digital Green's video-mediated extension in Ethiopia

This study assesses the effect of video-mediated agricultural extension promoted by MoANR and Digital Green on farmers' knowledge and adoption of improved agricultural technologies and practices. To do so, it compares how farmers respond to the same information regarding improved technologies and practices when this information is disseminated through the standard training-and-visit extension approach or when the approach is supported by video mediation.

As with any real-life policy, the video-mediated intervention was not limited to simply producing and screening videos for farmers. Rather, the intervention comprised three interlinked components: bringing farmers together in small development groups, conducting videos screening with development groups that were facilitated by extension agents , and verifying the uptake of the practices in the field.

Organizing farmers in small groups: Most farmers in Ethiopia are members of a development group, which is a semi-formal administrative structure within each *kebele* comprised of 25-30 farm households and designed as a grassroots forum for discussion of local development issues. The *kebele* is the primary level at which both administrative activities and agricultural extension is organized in Ethiopia. DAs assigned to a given *kebele* have access to these development groups, and thus use them as forums to introduce and discuss new agricultural technologies and practices. These technologies and practices are typically based on recommendations from MoARN and the regional bureaus of agriculture.

Video-mediated discussions with extension agents: The cornerstone of Digital Green's intervention is a video-mediated approach. Digital Green works with partners—*woreda* extension staff such as subject matter specialists and local NGOs where appropriate—to produce short videos featuring local farmers speaking in local languages about the subject technologies and practices. These videos were screened using USB-charged PICO projectors by local DAs assigned to the *kebele*. Videos were screened with development groups (or several development groups if necessary) in a manner designed to facilitate effective learning and discussion. Specifically, DAs would screen the videos several times during the meeting, and would pause the videos at certain intervals to entertain questions or provide additional details. DAs would augment their facilitation with input from model farmers belonging to the development group(s) present at the screening. These screening sessions would be conducted several times during the season in a manner that synchronized the video content with the crop calendar.

Adoption monitoring, and verification: The Digital Green approach is designed so that DAs and Digital Green staff can follow-up with farmers on their adoption of technologies and practices presented in the videos, either by querying farmers directly or verifying adoption visually. This follow-up feeds into Digital Green's connect online-connect offline (COCO) system for project monitoring, evaluation, and learning (Bernard et al., 2016).

Experimental design

This study uses a three-arm stratified cluster randomized controlled trial implemented in the four main regions in Ethiopia during the 2017 *meher* (rainy) season. Stratification was done at the level of the *woreda*. Clusters are defined at the *kebele*-level, which is the primary level at which agricultural extension is organized in Ethiopia. Within each *woreda*, *kebeles* were randomly allocated to one of three groups:

T0) A control group (denoted "Control") in which the Government of Ethiopia's conventional extension approach is targeted at the (typically male) household;

T1) A treatment group (denoted "Regular DG") in which Digital Green's standard video-mediated approach (described above) is targeted at the (typically male) household head; and

T2) A treatment group (denoted "DG + spouse") in which Digital Green's standard video-mediated approach is targeted at both the household head and his spouse.

In each group, the same suite of agricultural technologies and practices was promoted. In other words, Digital Green's video-mediated approach did not affect the choice of technologies promoted through the Ethiopian extension system. The homogeneity of agricultural technologies promoted ensures that we are evaluating the medium used for promotion rather than the content that is being promoted. We focus on three main technologies (row planting, lower seeding rates, and application of fertilizers, specifically urea top dressing) promoted by the extension system for the three main cereals in Ethiopia (teff, wheat, and maize). By focusing on selected technologies and crops we ensure comparability of adoption rates and other outcomes within and across *woredas*. Table 1 summarizes the experimental design and the variation in intervention by treatment status.

Table 1 Experimental design and interventions

	Treatment status		
	Control (conventional extension approach)	Digital Green approach (Regular DG)	Digital Green approach + spouse (DG + Spouse)
Extension message			
Source	MoANR	MoANR	MoANR
Delivery method	Mainly words (heterogenous)	Video-mediated (homogenous)	Video-mediated (homogenous)
Customization to local context	Low	High	High
Leveraging peers			
Trainer	DAs	DAs+ peers	DAs+ peers
Group size	Small to high	Small	Small
Target group	Household heads	Household heads	Household heads and spouses
Monitoring and follow-up	Rarely	Frequently	Frequently

Source: Authors.

Sampling

The study relied on Digital Green's 2017 saturation plan in 68 *woredas* across the four main regions of Ethiopia—Amhara, Oromia, SNNP, and Tigray. The sample households were selected using a four-stage sampling process.

1. *Defining the study population.* In the first stage, we purposefully selected 30 *woredas* for the RCT based on three criteria: (i) *woredas* that were not saturated or fully covered by the Digital Green intervention prior to the 2017 *meher* season; (ii) *woredas* where Digital Green planned to expand to new *kebeles*; and (iii) *woredas* that would not be fully saturated during the

2017/18 expansion (to ensure the presence of within-*woreda* control *kebeles*). *Woredas* with less than nine potential expansion *kebele*s for the 2017/18 *meher* season were excluded from the study.

2. *Stratification of the treatment at* woreda *level.* In the second stage, we randomly selected *kebele*s from *woredas* with more than 15 eligible *kebele*s. Within each *woreda*, selected *kebeles* were randomly allocated to one of the three treatment arms such that each arm contained an equal number of *kebeles*.

3. *Stratification of the sample by development group distance*. Even though the *kebele* is the lowest administrative unit in Ethiopia, it typically comprises several development groups. Given the limited number of PICO projectors available for video screenings, it was usually infeasible for DAs to reach all development groups in a *kebele* with the video. Anecdotal evidence suggested that in such cases, DAs would likely focus their effort on the development groups close to the FTC. To assess the effectiveness of Digital Green's approach on farmers, regardless of their location, we encouraged DAs to first focus their effort on 10 development groups—five of which were selected from the closest development groups (where distance to the FTC was less than the median), and five from development groups located further away (where distance to the FTC was greater than the median).

4. *Sampling farmers*. For the last stage, we randomly selected seven households from each *kebele*: 2 from the closest development group, 2 from the furthest development group, and 3 from the development group situated at the median distance from the FTC. Focusing on farmers within the ten development groups significantly increased the statistical power of the study. It ensured that a large share of the surveyed farmers targeted for treatment at the *kebele*-level, did in fact participate in it. As discussed later, the participation rate remains limited even under this sampling procedure.

Overall, as shown in Table 2, the total sample comprises 30 *woreda*s, 350 *kebele*s, and 2,422 farm households.

Control group specificities. The selection of farmers to be surveyed followed the same procedure in both treatment and control *kebele*s. As shown below, this ensured comparability of farmers across groups. Our design sought not to affect, in any possible way, the way extension was carried out in *kebele*s in the control group. For this reason, we did not encourage DAs to focus their attention on ten development groups as we did in the treatment group *kebeles*. We discuss the implication of this difference below.

Table 2 Sample size

Variables	Control	DG + Spouse	Regular DG	Total
Total number of *woreda*s	30	30	30	30
Total number of *kebele*s	118	117	115	350
Total number of households	812	812	798	2422

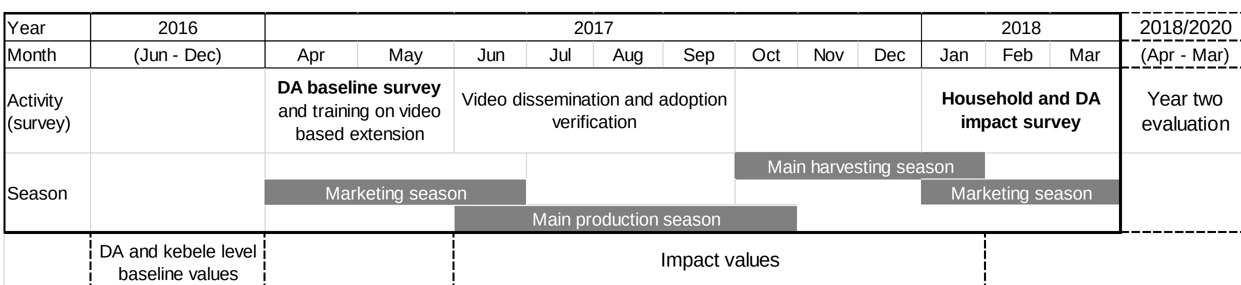
Source: Authors.

Timeline

Figure 1 summarizes the timeline of Digital Green's intervention and the accompanying RCT. We first conducted a baseline survey of all DAs working in our study *kebeles* during April and May 2017, which was right before the 2017/18 *meher* production season. The DA baseline survey collected information on their profiles, motivation, workload, and *kebele* level production numbers for the previous year. After the baseline, we conducted extensive training on the RCT design for *woreda*-level Bureau of Agriculture functionaries and DAs in collaboration with Digital Green. It is worth mentioning that the training on the study design was held immediately before the video production and dissemination trainings conducted by Digital Green.

After these trainings, the intervention was implemented by *woreda*-level subject matter specialists and DAs with support from Digital Green throughout the main production period of the *meher* season (June-September 2017). We also conducted a rapid assessment of the implementation process during the initial implementation in order to provide feedback to Digital Green on implementation progress. The household survey and DA follow-up survey were conducted January-March 2018, after harvest.

Figure 1 Timeline of intervention and evaluation



Source: Authors.

Experimental integrity

Balance of initial characteristics

We assess the extent to which random assignment of the treatment generated comparable treatment and control groups at different levels—*kebele*, household head, spouse, and DA. First, we run balance tests on baseline levels of our main outcome variables of interest, measured using farmer recall data. As shown in Table 3, there is no statistically significant difference between the treatment groups for most outcome variables. We observe a small difference between Control and Regular DG on teff seeding rates and row planting and between Control and DG + spouse for wheat seeding rate (Table 3). The balance test for household head-, spouse-, and DA-level covariates and *kebele* characteristics are reported in *Table A1—Table A4* in the appendix. The results in these tables indicate that the control and treatment groups are comparable both at the household and *kebele* level.

Compliance with treatment assignment

Next, we test whether field implementation of the intervention complied with the research design. We do this by assessing the extent to which sample households participated in the intervention. The results in Table 4 indicate relatively low levels of compliance for treatment households. A total of 41 percent and 42 percent of households in the Regular DG regular and DG + spouse groups participated in least one video-mediated extension activity, respectively. On the other hand, the level of contamination of the intervention in the Control is low—only 4 percent of the sample households from the control group participated in video-mediated extension training. Table 4 also assesses the participation rates in video-mediated extension by crop and video topic. We find no discernable differences in participation patterns by crop and topic.

Table 3 Balancing tests on main outcome variables

Variables	Entire sample	Regular DG	DG Spouse	Control	DG Reg-Control	DG Spouse-Control	DG Spouse-DG Reg
Before 2017/18 *meher* HH tried (___) for **teff**							
Lower seeding rate	0.320	0.342	0.340	0.278	0.064*	0.062	-0.002
	(0.467)	(0.475)	(0.474)	(0.448)	(0.036)	(0.038)	(0.038)
Row planting	0.167	0.169	0.192	0.139	0.030	0.053	0.023
	(0.373)	(0.375)	(0.394)	(0.346)	(0.031)	(0.033)	(0.033)
Urea top dressing	0.361	0.385	0.382	0.318	0.067*	0.064	-0.003
	(0.480)	(0.487)	(0.486)	(0.466)	(0.039)	(0.041)	(0.041)
Before 2017/18 *meher* HH tried (___) for **wheat**							
Lower seeding rate	0.282	0.284	0.309	0.251	0.033	0.058*	0.025
	(0.450)	(0.451)	(0.462)	(0.434)	(0.030)	(0.032)	(0.032)
Row planting	0.224	0.227	0.233	0.213	0.014	0.020	0.006
	(0.417)	(0.419)	(0.423)	(0.410)	(0.036)	(0.035)	(0.036)
Urea top dressing	0.347	0.346	0.361	0.334	0.012	0.027	0.015
	(0.476)	(0.476)	(0.481)	(0.472)	(0.036)	(0.038)	(0.038)
Before 2017/18 *meher* HH tried (___) for **maize**							
Lower seeding rate	0.400	0.407	0.401	0.392	0.016	0.010	-0.006
	(0.490)	(0.492)	(0.490)	(0.488)	(0.040)	(0.040)	(0.041)
Row planting	0.480	0.474	0.478	0.489	-0.015	-0.011	0.004
	(0.500)	(0.500)	(0.500)	(0.500)	(0.048)	(0.048)	(0.048)
Urea top dressing	0.396	0.400	0.400	0.389	0.011	0.011	0.000
	(0.489)	(0.490)	(0.490)	(0.488)	(0.045)	(0.046)	(0.045)
Crop management	0.405	0.407	0.399	0.408	-0.000	-0.009	-0.008
	(0.491)	(0.492)	(0.490)	(0.492)	(0.043)	(0.043)	(0.043)
Observations	2,422	798	812	812	1,610	1,624	1,610

Note: For columns 1-4, standard deviations in parentheses. For columns 5-7, standard errors clustered at the *kebele* level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 4 Videos watched by topics and treatment groups

	Total	Control	DG + Spouse	Regular DG
Attended at least one video-based extension or training (%)	29	4	42	41
Video on teff land preparation (%)	12	1	17	20
Video on teff seed selection and seeding rate (%)	12	0	17	18
Video on teff row planting (%)	16	1	23	24
Video on teff transplanting (%)	9	0	13	13
Video on fertilizer application (Urea top dressing) on tef plots (%)	14	1	20	21
Video on teff harvest and storage (%)	10	1	14	15
Video on wheat land preparation (%)	15	1	21	24
Video on wheat seed selection and seeding rate (%)	17	1	24	25
Video on fertilizer application (Urea top dressing) on wheat plots (%)	19	1	27	27
Video on wheat crop management (%)	15	0	22	23
Video on wheat harvest and storage (%)	13	1	18	20
Video on maize land preparation (%)	13	1	18	19
Video on maize seed selection and seeding rate (%)	14	1	21	22
Video on fertilizer application (Urea top dressing) on maize plots (%)	16	1	24	22
Video on maize crop management (%)	15	1	21	22
Video on maize harvest and storage (%)	10	1	15	16
Observations	2422	812	812	798

Source: Authors' calculations.

Empirical strategy

Intent to treat estimates

Our empirical strategy closely follows the study design through simple comparisons of mean outcomes across treatment and control groups. We focus here on *Intent to Treat* estimates. To estimate the ITT impacts, we include all sample households—whether or not they were actually "treated" (i.e., received extension services)—in our analysis. Thus, we estimate the impact of offering an intervention to the group for whom it was intended. Our analysis is restricted to ITT for two reasons. One is statistical. To estimate the *Treatment Effect on the Treated* (TOT)—the impact of the intervention on those who were actually "treated"—one needs to assume an absence of spillovers from participants to non-participants within a given *kebele*. Given the nature of how information is shared between peers within a *kebele*, we posit that such an assumption is incorrect. The other reason is operational. From a policy perspective, ITT estimates are often more relevant as they measure average changes in outcomes across all individuals that are targeted by the intervention. Given that 100 percent compliance is nearly impossible in the real world, ITT estimates are a good proxy for the impacts one can expect outside our experimental scenario.

We rely on standard Ordinary Least Square (OLS) estimates, described as follows:

$$y_i = \alpha + \beta T_k + X_i'\delta + \mu_w + \varepsilon_i \qquad (1)$$

where y_i denotes the level of outcome y measured at the household level i (for instance whether the household has tried row-planting of a wheat plot over the study period). The variable T_k

indicates the treatment status of *kebele* k where the household lives. The variable X is a vector of household- and development group-level characteristics that account for baseline imbalances between groups and augments the overall power of our estimates. These include distance to nearest FTC, whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. We account for *woreda*-level stratification of our design through μ_w, a set of *woreda*-level fixed effects. Last, we account for treatment assignment at the *kebele* level by clustering our standard errors at that level.

Differential treatment effects

As indicated in the experimental design, our study has two treatment arms that measure the differential impact of video-mediated extension when it is targeted only to heads of households (Regular DG) and when it includes both the heads and spouses in the same household (DG + spouse). This differential effect is estimated following Equation (2) below:

$$y_i = \alpha + \beta^1 T_k^1 + \beta^2 T_k^2 + X_i'\delta + \mu_w + \varepsilon_i \qquad (2)$$

where T_k^1 is treatment for Regular DG and T_k^2 is treatment for DG + spouse. We also test for the equality of coefficients between Regular DG and DG + spouse (i.e., $\beta^1 = \beta^2$) to assess the additional effect of treating spouses in households where the head of the household is treated.

Selection issues and robustness tests

Selection into crops: Because a given technology may not have the same constraints or relevance across crops, for most outcomes we consider the intervention's impact restricted to the sample of households growing one of the three focus crops (teff, wheat, or maize). If treatment allocation affected crop choices however, the sub-sample of households growing a particular crop may no longer be fully comparable across treatment groups, which could bias the treatment estimates. We expect these effects to be limited, as Digital Green's intervention occurred relatively late in the season, at a time when most households had already made their choices about crops to be grown. This is further supported by results in Appendix Table A5 where we assess whether one's decision to grow each of the three crops is affected by one's treatment status. We find no evidence to support this.

Selection into extension: As described above, DAs in treatment groups were encouraged (not forced or monitored) to first focus their video-extension effort to 10 development groups, from which we later sampled households to be surveyed. This design may lead to an over-representation of extension participants in our treatment groups as compared to the control group. Further, if DAs in the control group targeted their effort to particular types of development groups (for instance, those closer to FTCs), extension participants may not be fully comparable across samples. While our main estimation strategy relies on the above described ITT, we also test for the robustness of these results when restricting the sample to those development groups effectively reached by treatment or control DAs (that is, those development groups where at least one farmer received advice from a DA). However, our results are not meaningfully affected by it, such that the obtained ITT results are unlikely to be driven by selection and can be interpreted as Digital Green's ITT impact.

5 Results and Discussions

This section presents the main results from estimating Equations (1) and (2) above, on a series of outcomes including access to extension; improvements in knowledge about the subject technologies and practices; and the uptake or trialing of the subject technologies and practices. For each, we present a graphical representation of the overall treatment effect, alongside details on the separate treatment effects for "DG regular" and "DG + spouse" in a related table.

Impact on access to extension and agricultural knowledge

We find clear evidence of increased access to extension by farmers in *kebeles* selected for video-mediated extension. This is reported in columns 2, 4, and 6 of Table 5. These results indicate a farmer in a treated *kebele* is, on average, 10.8 percentage points more likely to have received DA advice regarding teff cultivation than a farmer in a control *kebele*. With 45.3% of the farmers having received such advice in the control *kebeles*, the effect of DG's video-mediated approach represents a 10.8/45.3=23.8% increase over the control *kebeles*. This effect is not limited to farmers cultivating teff: comparable if not larger effects are found for farmers cultivating wheat and maize. In the case of wheat, treated farmers are 15.6 percentage points more likely to have received DA advice, a 36.7% increase over control farmers. For maize, treated farmers are 12.4 percentage points more likely to have received DA advice, a 24.9% increase over control group farmers.

We find similar results when we restrict our sample to those development groups where at least one farmer received advice from a DA, indicating that the intervention did not lead to a change in the type of development group that DAs decided to work with, but rather to a change in their reach to farmers within these groups. Findings from qualitative research conducted as part of this study suggest that video screenings in rural areas tend to enhance DAs' capacities to organize farmers at a given location and time.

Columns 1, 3 and 5 of Table 5 further disaggregate these results between the "regular DG" and "DG + spouse" treatment groups. We do not find evidence of differential treatment effect across these groups—where the respondent is the head of the household—as indicated by the reported tests of equality of coefficients. Table 6 reports similar estimates, but uses responses provided by spouse of the household head. These results indicate that the "DG + spouse" treatment led to a significant increase in spouses' access to DA advice, even when the "regular DG" did not. Specifically, spouses in the DG + spouse group are 4.7 percentage points more likely to have received DA advice on wheat, a 25.1% increase over spouses in the control group. Similarly, for maize, spouses in the DG + spouse group are 5.3 percentage points more likely to have received DA advice, a 20.1% increase over spouses in the control group.

Table 5 Access to DA advice by crop, household head

	Teff		Wheat		Maize	
	DA directly provided advice/training		DA directly provided advice/training		DA directly provided advice/training	
DG + spouse	0.112***		0.163***		0.113***	
	(0.0275)		(0.0282)		(0.0313)	
Regular DG	0.103***		0.149***		0.135***	
	(0.0282)		(0.0296)		(0.0303)	
Test of equality (F)	0.1		0.22		0.56	
Test of equality (Prob > F)	0.756		0.637		0.454	
Any DG		0.108***		0.156***		0.124***
		(0.0243)		(0.0247)		(0.0270)
Constant	0.466***	0.466***	0.473***	0.474***	0.514***	0.514***
	(0.0332)	(0.0332)	(0.0324)	(0.0324)	(0.0323)	(0.0324)
Control mean	0.453	0.453	0.425	0.425	0.497	0.497
Observations	1,540	1,540	1,492	1,492	1,332	1,332
R-squared	0.341	0.341	0.372	0.371	0.351	0.350

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place.
*** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 6 Access to DA advice by crop, spouse

	Teff		Wheat		Maize	
	DA directly provided advice/training		DA directly provided advice/training		DA directly provided advice/training	
DG + spouse	0.0283		0.0465*		0.0527*	
	(0.0272)		(0.0258)		(0.0280)	
Regular DG	0.0108		0.0377		0.00205	
	(0.0275)		(0.0272)		(0.0256)	
Test of equality (F)	0.51		0.11		4.06	
Test of equality (Prob > F)	0.477		0.746		0.045	
Any DG		0.0194		0.0421*		0.0278
		(0.0244)		(0.0228)		(0.0239)
Constant	0.279***	0.279***	0.207***	0.207***	0.282***	0.281***
	(0.0286)	(0.0286)	(0.0256)	(0.0256)	(0.0282)	(0.0283)

Control mean	0.242	0.242	0.185	0.185	0.262	0.262
Observations	1,334	1,334	1,284	1,284	1,165	1,165
R-squared	0.292	0.292	0.300	0.299	0.281	0.279

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories). *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Given these results, we investigate the extent to which increased access to extension translates into greater knowledge on improved agricultural technologies and practices. Table 7 reports results on farmers' scores on a knowledge tests made up of 17, 16, and 16 questions related to teff, wheat, and maize, respectively. Results are reported in percentage increase in the knowledge test scores.

On average, farmers in the control group *kebeles* responded correctly to 37–43 % of the questions, depending on the crop. Our results point to small increase in knowledge by farmers in the treatment groups, with an order of magnitude of 1–2 %. These results are only statistically significant for the sub-group of teff producers. Note, however, that results in Table 7 suggest some potential differences across our two treatment arms. In particular, while the "Regular DG" treatment led to no increase in knowledge scores for farmers cultivating wheat, "DG + spouse" did lead to an increase in knowledge scores for household heads.

So far, our results suggest that DG's video-mediated extension approach led to an increased reach of farmers by DAs, which translated into small increases in knowledge. As expected, these effects are broadly similar across treatment groups when one considers household head respondents. However, they are significantly higher in the "DG + spouse" group, when one considers spouse respondents. This supports existing evidence that agricultural extension in Ethiopia is mainly targeted at household heads only. In the following sections, we investigate whether this may be a source of inefficiency.

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Table *8* reports results for the same estimations applied to spouses' response. As one would expect, we find that "DG + spouse" led to positive and significant effect on spouses' knowledge, while "DG regular" did not. This effect is however limited to farmers cultivating teff and wheat only. In the case of teff, spouses in the DG + spouse group scored 1.4 percent more than those in the control group, a 4.3% increase over the control group. Similarly, for wheat, spouses in the DG + spouse group scored 1.6 percent more than those in the control group, an increase of 4.8% over the control group.

Table 7 Impact on content knowledge score by crop, Household head

	Teff		Wheat		Maize	
	Knowledge score (percent)		Knowledge score (percent)		Knowledge score (percent)	
DG + spouse	1.918**		1.961**		0.847	
	(0.811)		(0.912)		(0.878)	
Regular DG	1.699**		0.296		1.034	
	(0.755)		(0.910)		(0.891)	
Test of equality (F)	0.08		3.53		0.04	
Test of equality (Prob > F)	0.775		0.061		0.843	
Any DG		1.808***		1.144		0.939
		(0.684)		(0.795)		(0.748)
Constant	37.74***	37.74***	38.97***	39.00***	43.70***	43.69***
	(0.855)	(0.854)	(0.938)	(0.939)	(0.995)	(0.997)
Control mean	37.455	37.455	38.289	38.289	43.750	43.750
Observations	1,540	1,540	1,492	1,492	1,332	1,332
R-squared	0.176	0.176	0.137	0.135	0.209	0.209

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' calculations.

So far, our results suggest that DG's video-mediated extension approach led to an increased reach of farmers by DAs, which translated into small increases in knowledge. As expected, these effects are broadly similar across treatment groups when one considers household head respondents. However, they are significantly higher in the "DG + spouse" group, when one considers spouse respondents. This supports existing evidence that agricultural extension in Ethiopia is mainly targeted at household heads only. In the following sections, we investigate whether this may be a source of inefficiency.

Table 8 Impact on content knowledge score by crop, Spouse

	Teff		Wheat		Maize	
	Knowledge score (percent)		Knowledge score (percent)		Knowledge score (percent)	
DG + spouse	1.398*		1.609*		0.506	
	(0.773)		(0.961)		(1.037)	
Regular DG	0.499		0.693		0.775	
	(0.824)		(0.910)		(1.089)	
Test of equality (F)	1.19		0.99		0.08	
Test of equality (Prob > F)	0.276		0.320		0.783	
Any DG		0.943		1.150		0.638
		(0.686)		(0.815)		(0.944)
Constant	33.39***	33.38***	34.98***	34.99***	40.64***	40.64***
	(0.831)	(0.831)	(0.912)	(0.912)	(1.041)	(1.038)
Control mean	32.154	32.154	33.826	33.826	40.225	40.225
Observations	1,334	1,334	1,284	1,284	1,165	1,165
R-squared	0.231	0.231	0.176	0.176	0.269	0.269

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories). *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Impact on technology uptake

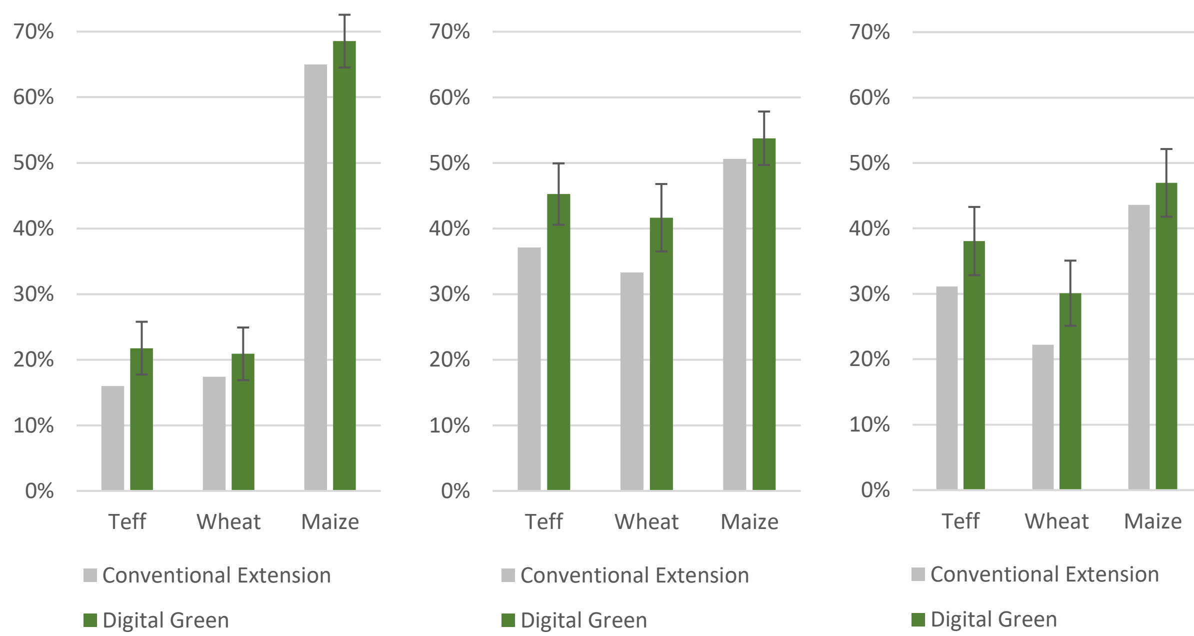
Next, we turn to farmers' uptake of key agricultural technologies promoted as part of the broad MoANR extension program: row planting, lower seeding rates, and urea top dressing. All three technologies are recommended for the cultivation of teff, wheat, and maize. In fact, some have been promoted for a rather long time in Ethiopia (e.g., fertilizer application and maize row planting), while others have been part of extension recommendations only recently (e.g., wheat and teff row planting). We therefore expect to find differential effects of the intervention across the three crops.

Overall results are presented in Figure 2, where we see an overall positive impact of DG's video-mediated approach on farmers' decision to at least try the proposed technology during the past 2017/18 *meher* season—what we refer to here as "uptake." Effects are somewhat comparable in magnitude across crops and technologies, ranging from about a 3 percentage point increase in uptake to about 10 percentage points. Relative to the control group, these increases represent substantial differences. For example, these increases reflect a 5% increase in the uptake of row planting among farmers cultivating maize, and a 35% increase among farmers cultivating teff. Similar patterns are found for lower seeding rates and urea top dressing, with larger increases observed for teff and wheat relative to maize.

We provide additional details on these results in Table 9, Table 10 and Table 11. In Table 9, we further report the share of cultivated area on which farmers applied row planting. Results broadly confirm those obtained from the binary uptake variable. We find an increase of 0.067 and 0.053 in the share of teff and wheat area row planted, respectively. This translates to a 48% and 23% increase over the control group for teff and wheat, respectively. In effect, our results show that conditional on deciding to try the technology, farmers tend to apply it to the entire area that they planted with the associated crop.

In all three tables, we further disaggregate results according to treatment arms. We do not find evidence of statistically significant treatment effects. This suggest that while more spouses had access to extension under the "DG + spouse" treatment arm as reported earlier, and while they have tended to learn more from it, this did not translate in changes in households' technology adoption decision above and beyond that of the "regular DG" treatment arm. These results are supported by plot-level estimates of the uptake of row planting in Table A6. There, we further interact our treatment variable with the gender of plot owner. Our results show no clear sign of a "DG + Spouse" effect where the spouse is the (partial) owner of the plot.

Figure 2: Uptake of agricultural technologies, by crop



a. Row planting   b. Lower seeding rate   c. Urea top-dressing

Source: Authors' calculations.

Table 9 Adoption of row planting by crop, Household head

	Teff				Wheat				Maize			
	Row planting		Share of area row planted		Row planting		Share of area row planted		Row planting		Share of area row planted	
DG + spouse	0.0547**		0.0643***		0.0403*		0.0555**		0.0297		0.000290	
	(0.0241)		(0.0209)		(0.0223)		(0.0246)		(0.0233)		(0.0258)	
Regular DG	0.0604**		0.0702***		0.0293		0.0503*		0.0414*		0.00671	
	(0.0241)		(0.0200)		(0.0255)		(0.0259)		(0.0248)		(0.0248)	
Test of equality (F)	0.07		0.1		0.2		0.05		0.22		0.06	
Test of equality (Prob > F)	0.795		0.754		0.652		0.829		0.641		0.807	
Any DG		0.0576***		0.0673***		0.0349*		0.0529**		0.0355*		0.00345
		(0.0215)		(0.0182)		(0.0206)		(0.0222)		(0.0205)		(0.0217)
Constant	0.135***	0.135***	0.135***	0.135***	0.182***	0.183***	0.232***	0.232***	0.653***	0.653***	0.760***	0.760***
	(0.0242)	(0.0242)	(0.0217)	(0.0217)	(0.0244)	(0.0244)	(0.0250)	(0.0250)	(0.0291)	(0.0292)	(0.0280)	(0.0280)
Control mean	0.160	0.160	0.140	0.140	0.174	0.174	0.226	0.226	0.650	0.650	0.795	0.795
Observations	1,540	1,540	1,540	1,540	1,492	1,492	1,492	1,492	1,332	1,332	1,332	1,332
R-squared	0.457	0.457	0.463	0.463	0.426	0.426	0.531	0.531	0.398	0.398	0.371	0.371

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 10 Adoption for row planting by crop, Spouse

	Teff		Wheat		Maize	
	Row planting		Row planting		Row planting	
DG + spouse	0.0459*		0.0250		-0.0376	
	(0.0239)		(0.0226)		(0.0275)	
Regular DG	0.0519**		0.0186		-0.0374	
	(0.0219)		(0.0235)		(0.0271)	
Test of equality (F)	0.08		0.07		0	
Test of equality (Prob > F)	0.780		0.786		0.993	
Any DG		0.0489**		0.0218		-0.0375
		(0.0202)		(0.0199)		(0.0231)
Constant	0.134***	0.134***	0.193***	0.193***	0.686***	0.686***
	(0.0215)	(0.0216)	(0.0215)	(0.0215)	(0.0227)	(0.0227)
Control mean	0.119	0.119	0.148	0.148	0.676	0.676
Observations	1,334	1,334	1,284	1,284	1,165	1,165
R-squared	0.361	0.361	0.353	0.353	0.406	0.406

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories). *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 11 Adoption of lower seeding rate by crop, Household head

	Teff		Wheat		Maize	
	Lower seeding rate		Lower seeding rate		Lower seeding rate	
DG + spouse	0.0639**		0.0854***		0.0331	
	(0.0306)		(0.0293)		(0.0296)	
Regular DG	0.0755**		0.0723**		0.0341	
	(0.0305)		(0.0304)		(0.0312)	
Test of equality (F)	0.15		0.17		0	
Test of equality (Prob > F)	0.696		0.677		0.974	
Any DG		0.0697***		0.0790***		0.0336
		(0.0266)		(0.0254)		(0.0264)
Constant	0.344***	0.344***	0.213***	0.214***	0.468***	0.468***
	(0.0332)	(0.0332)	(0.0297)	(0.0298)	(0.0372)	(0.0372)
Control mean	0.311	0.311	0.222	0.222	0.436	0.436
Observations	1,540	1,540	1,492	1,492	1,332	1,332
R-squared	0.173	0.173	0.217	0.216	0.198	0.198

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 12 Adoption of lower seeding rate by crop, Spouse

	Teff		Wheat		Maize	
	Lower seeding rate		Lower seeding rate		Lower seeding rate	
DG + spouse	0.0435		0.0590**		-0.0142	
	(0.0301)		(0.0277)		(0.0356)	
Regular DG	0.0368		0.0188		-0.0224	
	(0.0301)		(0.0297)		(0.0358)	
Test of equality (F)	0.05		1.74		0.05	
Test of equality (Prob > F)	0.816		0.188		0.815	
Any DG		0.0401		0.0389		-0.0183
		(0.0264)		(0.0244)		(0.0312)
Constant	0.273***	0.273***	0.208***	0.209***	0.412***	0.412***
	(0.0300)	(0.0300)	(0.0260)	(0.0259)	(0.0342)	(0.0342)
Control mean	0.245	0.245	0.178	0.178	0.403	0.403
Observations	1,334	1,334	1,284	1,284	1,165	1,165
R-squared	0.194	0.194	0.173	0.171	0.178	0.178

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories). *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 13 Adoption of urea top dressing by crop and maize crop management, Household head

	Teff		Wheat		Maize			
	Lower seeding rate		Lower seeding rate		Lower seeding rate		Crop mgt	
							0.0238	
DG + spouse	0.0887***		0.0748**		0.0250		(0.0253)	
	(0.0292)		(0.0294)		(0.0248)		0.0378	
Regular DG	0.0744***		0.0926***		0.0385		(0.0267)	
	(0.0266)		(0.0306)		(0.0253)			
							0.3	
Test of equality (F)	0.25		0.37		0.23		0.584	
Test of equality (Prob > F)	0.621		0.545		0.632			
								0.0307
Any DG		0.0815***		0.0835***		0.0316		(0.0226)
		(0.0239)		(0.0262)		(0.0208)	0.517***	0.516***
Constant	0.331***	0.331***	0.277***	0.277***	0.473***	0.473***	(0.0302)	(0.0303)
	(0.0299)	(0.0299)	(0.0307)	(0.0307)	(0.0277)	(0.0278)		
							0.517	0.517
Control mean	0.371	0.371	0.333	0.333	0.506	0.506	1,332	1,332
Observations	1,540	1,540	1,492	1,492	1,332	1,332	0.360	0.359
R-squared	0.287	0.287	0.285	0.285	0.439	0.439	0.0238	

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table 14 Adoption of urea top dressing by crop and maize crop management, Spouse

	Teff		Wheat		Maize			
	Urea top dressing		Urea top dressing		Urea top dressing		Crop management	
							0.0238	
DG + spouse	0.0417		0.0415		-0.0166		-0.00374	
	(0.0263)		(0.0289)		(0.0266)		(0.0285)	
Regular DG	0.0103		0.0200		0.00423		0.00522	
	(0.0267)		(0.0275)		(0.0268)		(0.0296)	
Test of equality (F)	1.31		0.57		0.53		0.1	
Test of equality (Prob > F)	0.253		0.450		0.467		0.751	
Any DG		0.0259		0.0307		-0.00637		0.000667
		(0.0227)		(0.0244)		(0.0226)		(0.0254)
Constant	0.295***	0.295***	0.278***	0.278***	0.504***	0.505***	0.454***	0.454***
	(0.0267)	(0.0267)	(0.0274)	(0.0274)	(0.0252)	(0.0252)	(0.0301)	(0.0300)
Control mean	0.319	0.319	0.297	0.297	0.504	0.504	0.463	0.463
Observations	1,334	1,334	1,284	1,284	1,165	1,165	1,165	1,165
R-squared	0.290	0.289	0.280	0.279	0.397	0.397	0.366	0.366

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories). *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

6 Discussion, policy implications, and conclusions

Overall, several important findings emerge from our evaluation of the video-mediated extension approach employed by MoARN, Digital Green, and the regional bureaus of agriculture across Ethiopia's four largest regions. First, the approach has a demonstrated capacity to reach a wider audience than the conventional training-and-visit approach employed by DAs and *woreda*-level extension staff, with gains observed particularly for spouses of the (typically male) heads of household. Second, the approach leads to higher levels of knowledge about the subject crops, technologies, and practices, again with gains observed for spouses.

Third, the video-mediated extension approach results in increased uptake of improved agricultural technologies and practices that are central to the extension program of MoARN and the regional bureaus of agriculture. For each crop, our estimates indicate that the approach led to a 3 to 10 percentage point increases in uptake of the subject technologies (row planting, lower seeding rate, and urea top dressing) for teff, wheat, and maize. These increases represent up to a 35% increase in uptake of a given technology for a given crop when compared to control group levels. Targeting both spouses rather than the household head with video-mediated extension does not, however, result in higher uptake rates.

As with all empirical studies of this nature, there are important caveats to these findings. First, the results presented here are preliminary findings. Further exploration and analysis is needed of the specific pathways through which video-mediated extension is influencing the observed outcomes.

Second, we recognize that self-reported data from farmers on plot size and crop output often lead to measurement error; recent evidence from Ethiopia demonstrates the extent and magnitude of this problem in sharp relief (Abate et al. 2015; Abay et al., 2018). As such we find no immediate evidence of video-mediated extension on outcomes such as crop yields, output, or area under cultivation. These topics and issues will be the subject of further analysis, and may require the collection of a second (mid/endline) round of data augmented by crop cuts or other measurements.

Third, many of the technologies and practices investigated here are themselves the subject of continuous agronomic research. While row planting, lower seeding rates, and urea top dressing are generally demonstrated to increase yields and outputs on farmers' fields, the variability in their returns—both in terms of productivity and profitability—may be non-trivial. Further research on this front would reveal additional information about the constraints to adoption that are simply not addressed in this study.

Despite these caveats, it is also critically important to recognize the policy relevance of these findings. These findings provide clear evidence of the potential contribution of video mediation to existing extension practice in Ethiopia. While other studies of ICTs in agriculture typically focus on standalone interventions divorced from public extension programming, this study captures the impact of an ICT application that is fully integrated into existing practice. In short, this study directly demonstrates the capacity of ICTs to enhance, and not replace, public extension systems.

As Ethiopia continues to advance reforms across its extension system, these findings provide much-needed evidence on what works—and for whom—in the arena of innovative extension methods and tools. The openness of both the Ministry of Agriculture and Natural Resources and the regional bureaus of agriculture to experimentation with video-mediated extension indicates just how far such evidence can be used to shape future programming.

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8 Appendix

Table A1: Balance test for household level covariates

	Entire sample	Regular DG	DG Spouse	Control	DG Reg-Control	DG Spouse-Control	DG Spouse-DG Reg
HH size	5.919	5.965	5.892	5.900	0.065	-0.009	-0.073
	(2.184)	(2.199)	(2.180)	(2.175)	(0.145)	(0.147)	(0.151)
Male HH head	0.902	0.897	0.906	0.901	-0.004	0.005	0.009
	(0.298)	(0.304)	(0.291)	(0.298)	(0.016)	(0.017)	(0.017)
HH age	45.842	45.905	45.983	45.639	0.266	0.344	0.078
	(12.937)	(13.018)	(12.922)	(12.887)	(0.731)	(0.727)	(0.692)
HH head literacy	0.496	0.461	0.484	0.542	-0.081**	-0.058*	0.023
	(0.500)	(0.499)	(0.500)	(0.499)	(0.036)	(0.034)	(0.033)
Distance to the nearest (minutes):							
Asphalt road	104.566	109.654	102.070	102.062	7.593	0.009	-7.584
	(106.259)	(106.500)	(98.762)	(112.995)	(9.336)	(9.568)	(8.819)
Dry season road	27.526	32.089	27.804	22.762	9.327**	5.042	-4.285
	(47.453)	(46.983)	(57.774)	(34.229)	(3.610)	(3.490)	(4.087)
All weather road	30.420	35.858	28.926	26.569	9.289**	2.357	-6.932*
	(41.725)	(48.275)	(37.565)	(38.074)	(3.689)	(3.074)	(3.709)
Market	69.817	76.397	68.836	64.330	12.067**	4.506	-7.561
	(60.745)	(70.273)	(54.714)	(55.630)	(5.419)	(5.016)	(5.471)
Admin. Center	131.30	125.748	118.174	149.889	-24.141	-31.716	-7.574
	(613.75)	(82.509)	(88.301)	(1,053.322)	(38.775)	(38.912)	(8.428)
Agri. coop	51.368	51.128	53.067	49.905	1.223	3.161	1.939
	(87.814)	(50.014)	(102.73)	(100.007)	(5.161)	(5.926)	(5.162)
Input dealer	57.614	60.797	57.514	54.586	6.211	2.927	-3.283
	(69.096)	(55.374)	(88.514)	(58.179)	(5.105)	(5.414)	(5.440)
FTC	31.173	31.551	31.484	30.490	1.061	0.994	-0.067
	(36.432)	(45.669)	(30.293)	(31.532)	(2.364)	(2.047)	(2.309)
DA house/office	32.935	34.888	32.065	31.884	3.004	0.181	-2.823
	(38.153)	(34.721)	(31.008)	(46.837)	(2.639)	(2.300)	(2.373)
RuSACCOs	81.535	79.698	77.355	87.520	-7.822	-10.165	-2.343
	(197.206)	(69.368)	(73.141)	(325.515)	(13.091)	(13.236)	(6.784)
Microfinance	103.627	105.906	105.084	99.931	5.975	5.153	-0.822
	(89.296)	(73.910)	(107.40)	(82.942)	(7.588)	(8.812)	(8.199)
Bank	116.153	123.218	114.353	111.009	12.209	3.345	-8.865
	(100.111)	(126.556)	(84.725)	(83.191)	(9.007)	(8.532)	(9.159)
Number of parcels	3.691	3.663	3.687	3.723	-0.060	-0.036	0.024
	(2.150)	(2.072)	(2.160)	(2.217)	(0.183)	(0.184)	(0.175)
HH cultivated teff	0.636	0.655	0.635	0.617	0.038	0.018	-0.020
	(0.481)	(0.476)	(0.482)	(0.486)	(0.048)	(0.048)	(0.049)
Number of teff plots	1.068	1.080	1.124	1.000	0.080	0.124	0.044
	(1.244)	(1.234)	(1.327)	(1.163)	(0.116)	(0.120)	(0.124)
HH cultivated wheat	0.616	0.617	0.617	0.615	0.002	0.002	0.000
	(0.486)	(0.487)	(0.486)	(0.487)	(0.049)	(0.048)	(0.050)
Number of wheat plots	0.866	0.866	0.823	0.909	-0.043	-0.086	-0.043
	(0.928)	(0.934)	(0.828)	(1.012)	(0.097)	(0.090)	(0.087)
HH cultivated maize	0.550	0.564	0.555	0.531	0.033	0.025	-0.008
	(0.498)	(0.496)	(0.497)	(0.499)	(0.051)	(0.048)	(0.048)
Number of maize plots	0.701	0.703	0.691	0.708	-0.005	-0.017	-0.012
	(0.759)	(0.711)	(0.726)	(0.835)	(0.081)	(0.080)	(0.071)
Observations	2,422	798	812	812	1,610	1,624	1,610

Note: Note: For columns 1-4, standard deviations in parentheses. For columns 5-7, standard errors clustered at the *kebele* level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Authors' calculations.

Table A2 Balance test for spouse level covariates

	Entire sample	Regular DG	DG Spouse	Control	DG Reg-Control	DG Spouse-Control	DG Spouse-DG Reg
Spouse age	37.129	36.804	37.389	37.196	-0.391	0.193	0.584
	(10.421)	(10.226)	(10.277)	(10.758)	(0.658)	(0.661)	(0.575)
N	2,008	670	669	669	1339	1338	1339
Spouse received formal education	0.332	0.321	0.330	0.344	-0.024	-0.014	0.010
	(0.471)	(0.467)	(0.471)	(0.476)	(0.036)	(0.034)	(0.035)
Cultivated ___ in 2017/18 *meher*							
Teff	0.641	0.662	0.642	0.618	0.044	0.024	-0.020
	(0.480)	(0.473)	(0.480)	(0.486)	(0.050)	(0.050)	(0.050)
Wheat	0.617	0.623	0.612	0.615	0.008	-0.003	-0.011
	(0.486)	(0.485)	(0.488)	(0.487)	(0.050)	(0.050)	(0.052)
Maize	0.560	0.568	0.582	0.529	0.039	0.053	0.014
	(0.497)	(0.496)	(0.494)	(0.500)	(0.052)	(0.051)	(0.051)
Before 2017/18 tried ___ for teff							
Lower seeding rate	0.232	0.236	0.250	0.210	0.025	0.040	0.014
	(0.422)	(0.425)	(0.433)	(0.408)	(0.036)	(0.038)	(0.036)
Row planting	0.137	0.139	0.165	0.108	0.031	0.057*	0.027
	(0.344)	(0.346)	(0.372)	(0.311)	(0.030)	(0.031)	(0.031)
Urea top dressing	0.277	0.277	0.296	0.258	0.020	0.038	0.019
	(0.448)	(0.448)	(0.457)	(0.438)	(0.039)	(0.040)	(0.038)
Before 2017/18 tried ___ for wheat	0.206	0.205	0.211	0.202	0.003	0.009	0.006
Lower seeding rate	(0.405)	(0.404)	(0.408)	(0.402)	(0.028)	(0.031)	(0.031)
	0.176	0.173	0.181	0.174	-0.001	0.007	0.008
Row planting	(0.381)	(0.379)	(0.385)	(0.380)	(0.034)	(0.035)	(0.036)
	0.275	0.267	0.292	0.265	0.002	0.027	0.024
Urea top dressing	(0.446)	(0.443)	(0.455)	(0.442)	(0.036)	(0.039)	(0.038)
Before 2017/18 tried ___ for Maize							
Lower seeding rate	0.328	0.337	0.328	0.320	0.017	0.008	-0.009
	(0.470)	(0.473)	(0.470)	(0.467)	(0.041)	(0.040)	(0.040)
Row planting	0.437	0.429	0.447	0.435	-0.006	0.012	0.018
	(0.496)	(0.495)	(0.498)	(0.496)	(0.051)	(0.050)	(0.049)
Urea top dressing	0.350	0.347	0.343	0.360	-0.013	-0.017	-0.003
	(0.477)	(0.476)	(0.475)	(0.480)	(0.046)	(0.045)	(0.045)
Crop management	0.327	0.332	0.318	0.331	0.001	-0.014	-0.015
	(0.469)	(0.471)	(0.466)	(0.471)	(0.045)	(0.043)	(0.043)
N	2,082	692	696	694	1,386	1,390	1,388

Note: Note: For columns 1-4, standard deviations in parentheses. For columns 5-7, standard errors clustered at the *kebele* level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table A3 Balance test for DA level covariates

	DG + Spouse (n=312)	DG Regular (n=316)	Control (n=268)	F-test of differences in means
DA's basic demographics				
Gender (1=Male)	0.72	0.76	0.76	0.489
Age (in completed years)	28.1	27.5	27.5	0.524
Qualification after secondary education				
Certificate (1=Yes)	0.23	0.25	0.26	0.771
Diploma (1=Yes)	0.55	0.52	0.55	0.725
Degree (1=Yes)	0.20	0.21	0.17	0.536
Number of years of schooling (number)	14.4	14.3	14.1	0.036
Total years of experience as a DA	5.99	5.39	5.33	0.370
Years of experience in the current *kebele*	1.91	1.90	1.80	0.837
Own smart phone (1=Yes)	0.43	0.50	0.44	0.284
Computer literate (1=Yes)	0.39	0.43	0.41	0.483
DA grew-up in the same locality (1=Yes)	0.09	0.06	0.10	0.146
DA grow-up farming (1=Yes)	0.89	0.92	0.89	0.260
Distance from home to FTC (minutes)	58.7	65.4	62.8	0.536
Extension delivery methods				
Extension approaches				
Door-to-door (1=Yes)	0.94	0.94	0.95	0.758
Farm-to-farm (1=Yes)	0.99	0.99	1.00	0.080*
Community meetings (1=Yes)	0.98	0.99	0.99	0.922
Dev't group meetings (1=Yes)	0.97	0.97	0.98	0.442
Demonstration (1=Yes)	0.93	0.92	0.93	0.887
Training at FTC (1=Yes)	0.92	0.86	0.88	0.102
Extension delivery techniques				
Word (speech/writing) (1=Yes)	0.99	0.99	0.99	0.864
Picture and images (1=Yes)	0.50	0.53	0.54	0.585
Audio (sounds) (1=Yes)	0.18	0.15	0.16	0.545
Video (sounds and pictures) (1=Yes)	0.10	0.06	0.06	0.132
Incentives				
Salary (net fixed monthly salary in '000 birr)	2.35	2.24	2.23	0.216
Housing allowance (1=Yes)	0.41	0.38	0.43	0.720
Transport allowance (1=Yes)	0.06	0.03	0.03	0.312
Health allowance (1=Yes)	0.01	0.01	0.02	0.166
Annual leave taken in 2017 (No. of days)	2.71	2.02	2.67	0.400
Received promotion in the past three years (1=Yes)	0.41	0.42	0.37	0.534
Satisfied with existing incentive structure (1=Yes)	0.21	0.25	0.35	0.008***
Workload				
Number of dev't groups being served (No.)	16.1	15.7	16.1	0.925
Number of actual working days per week				
During typical planting week	5.56	5.37	5.44	0.238
During typical harvesting week	4.80	4.72	4.73	0.806
During the slack season	3.74	3.86	3.76	0.738
Number of actual working hours per day				
During typical planting week	9.44	9.36	9.22	0.689
During typical harvesting week	8.23	8.23	8.00	0.606
During the slack season	6.23	6.36	6.21	0.854
Time allocation (%)				
Field/farmers home	21.1	20.7	20.1	0.725
Providing training (at FTC or anywhere)	15.1	13.5	15.5	0.016**
Receiving in-service training	7.75	8.29	7.86	0.419
Office (meeting, preparing report)	9.39	8.97	9.01	0.621
Administering credit repayment	6.17	6.37	6.34	0.892
Collecting agricultural data	8.31	9.46	8.41	0.068*
Administering taxes	5.76	6.29	6.37	0.373
Supplying agricultural inputs	10.5	10.7	10.8	0.903
Mobilizing farmers for community works	12.2	12.4	12.0	0.793
Involved in *kebele*'s agri. planning (1=Yes)	0.97	0.93	0.96	0.135

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Source: Authors' calculations.

Table A4 Balance test for *kebele* level covariates

	DG + Spouse (n=112)	DG Regular (n=112)	Control (n=110)	F-test of differences in means
Population size (No. of HHs)	805.3	823.1	1056.2	0.058*
Cultivated land area (hectares in ‘000, 2017)	1.1	1.1	1.0	0.881
Total length of paved road (km)	11.9	34.7	8.96	0.248
Total length of unpaved road	13.7	22.8	17.5	0.491
Number of local markets in the *kebele*	1.79	1.01	0.60	0.118
Distance to the nearest daily market (km)	11.7	12.6	6.48	0.000***
Number of grain traders in the *kebele*	10.0	9.26	14.5	0.109
Number of input dealers in the *kebele*	1.64	1.04	0.59	0.389
Number of seed producers in the *kebele*	23.5	19.0	28.1	0.673
Number of agricultural coops in the *kebele*	2.32	1.27	1.54	0.318
Number of MFI	1.69	2.10	1.83	0.901
Number of commercial banks	0.15	0.11	0.29	0.522
Number of milling machines	2.62	1.87	2.70	0.069*
Number of privately owned tractors	0.96	0.22	1.03	0.049**
Number of privately owned harvesters	0.71	0.24	0.43	0.331
Mobile signal in the *kebele* (1=Yes)	0.84	0.88	0.93	0.081*
Share of household own mobile phone (%)	71.7	61.5	63.3	0.401
Access to electricity (1=Yes)	0.37	0.36	0.41	0.660
Number of male Development Agents (DAs)	2.27	2.37	2.34	0.764
Number of female DAs	0.95	0.90	0.79	0.369
Total number of DAs	3.23	3.28	3.13	0.671

Note: *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table A5 The effect of treatment assignment on crop choice (teff, wheat, and maize)

	Teff				Wheat				Maize			
Variables	Cultivated teff	Cultivated teff	Teff area cultivated (ha)	Teff area cultivated (ha)	Cultivated wheat	Cultivated wheat	Wheat area cultivated (ha)	Wheat area cultivated (ha)	Cultivated maize	Cultivated maize	Maize area cultivated (ha)	Maize area cultivated (ha)
DG + spouse	0.0132		0.0894*		0.00849		-0.0320		0.0219		0.000706	
	(0.0368)		(0.0483)		(0.0315)		(0.0432)		(0.0296)		(0 .0208)	
Regular DG	0.0420		0.00930		0.00539		-0.0376		0.0272		0.0334	
	(0.0382)		(0.0467)		(0.0307)		(0.0420)		(0.0313)		(0.0228)	
Treatment=any		0.0273		0.0493		0.00697		-0.0347		0.0245		0.0168
		(0.0326)		(0.0422)		(0.0265)		(0.0383)		(0.0266)		(0.0183)
Constant	0.619***	0.619***	0.588***	0.588***	0.585***	0.585***	0.555***	0.555***	0.547***	0.547***	0.310***	0.309***
	(0.0333)	(0.0333)	(0.0626)	(0.0626)	(0.0280)	(0.0280)	(0.0352)	(0.0351)	(0.0287)	(0.0287)	(0.0209)	(0.0208)
Control mean	0.617	0.617	0.605	0.605	0.615	0.615	0.540	0.540	0.531	0.531	0.326	0.326
Observations	2,422	2,422	1,540	1,540	2,422	2,422	1,492	1,492	2,422	2,422	1,332	1,332
R-squared	0.244	0.243	0.301	0.299	0.354	0.354	0.243	0.243	0.361	0.361	0.371	0.370

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories), whether household head received formal education, distance to nearest dry season road, distance to nearest all-weather road, and distance to nearest market place. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table A6 Adoption of row planting at a plot level by crop

	Teff				Wheat				Maize			
	Row planted				Row planted				Row planted			
DG + spouse	0.0495**	0.0247			0.0372	0.0691*			-0.0120	-0.105**		
	(0.0211)	(0.0285)			(0.0230)	(0.0397)			(0.0236)	(0.0414)		
Regular DG	0.0513***	0.0760***			0.0400	0.0571			-0.00545	-0.0423		
	(0.0190)	(0.0291)			(0.0265)	(0.0439)			(0.0250)	(0.0380)		
Test of equality (F)	0.01	3.04			0.02	0.09			0.07	2.23		
Test of equality (Prob > F)	0.913	0.082			0.901	0.762			0.797	0.137		
Spouse is part or whole owner of parcel		-0.0121		-0.0121		0.00666		0.00655		0.00555		0.00559
		(0.0213)		(0.0213)		(0.0320)		(0.0320)		(0.0268)		(0.0268)
Spouse is part or whole owner of parcel x DG + Spouse		0.0355				-0.0456				0.131***		
		(0.0330)				(0.0419)				(0.0443)		
Spouse is part or whole owner of parcel x Regular DG		-0.0337				-0.0263				0.0557		
		(0.0319)				(0.0462)				(0.0395)		
Any DG			0.0504***	0.0497**			0.0386*	0.0624*			-0.00879	-0.0712**
			(0.0182)	(0.0251)			(0.0222)	(0.0372)			(0.0207)	(0.0337)
Spouse is part or whole owner of parcel x Any DG				0.00200				-0.0354				0.0906***
				(0.0276)				(0.0394)				(0.0347)
Constant	0.142***	0.149***	0.142***	0.149***	0.260***	0.254***	0.260***	0.254***	0.804***	0.803***	0.804***	0.803***
	(0.0183)	(0.0209)	(0.0184)	(0.0210)	(0.0240)	(0.0327)	(0.0240)	(0.0327)	(0.0216)	(0.0303)	(0.0216)	(0.0303)
Control mean	0.131	0.131	0.131	0.131	0.211	0.211	0.211	0.211	0.837	0.837	0.837	0.837
Observations	2,587	2,587	2,587	2,587	2,096	2,096	2,096	2,096	1,697	1,697	1,697	1,697
R-squared	0.417	0.418	0.417	0.417	0.485	0.485	0.485	0.485	0.378	0.388	0.378	0.386

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories) and plot area. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

Table A7 Applied DA advice at the plot level by crop

	Teff				Wheat				Maize			
	Applied DA advice				Applied DA advice				Applied DA advice			
DG + spouse	-0.0426	-0.146**			-0.0144	-0.0306			-0.0536**	-0.0829		
	(0.0371)	(0.0605)			(0.0307)	(0.0541)			(0.0261)	(0.0519)		
Regular DG	-0.0581*	-0.0819			-0.0492	-0.0469			-0.0450	-0.0582		
	(0.0340)	(0.0545)			(0.0311)	(0.0532)			(0.0281)	(0.0501)		
Test of equality (F)	0.25	1.68			1.12	0.11			0.11	0.24		
Test of equality (Prob > F)	0.617	0.196			0.291	0.738			0.736	0.622		
Spouse is part or whole owner of parcel		-0.0399		-0.0399		-0.0109		-0.0104		0.0405		0.0405
		(0.0520)		(0.0520)		(0.0458)		(0.0458)		(0.0402)		(0.0401)
Spouse is part or whole owner of parcel x DG + Spouse		0.150**				0.0234				0.0411		
		(0.0655)				(0.0600)				(0.0597)		
Spouse is part or whole owner of parcel x Regular DG		0.0384				-0.00397				0.0222		
		(0.0596)				(0.0588)				(0.0565)		
Any DG			-0.0503	-0.115**			-0.0324	-0.0397			-0.0494**	-0.0696
			(0.0321)	(0.0523)			(0.0262)	(0.0478)			(0.0240)	(0.0444)
Spouse is part or whole owner of parcel x Any DG				0.0958*				0.0109				0.0305
				(0.0565)				(0.0531)				(0.0494)
Constant	0.395***	0.419***	0.395***	0.419***	0.452***	0.459***	0.452***	0.458***	0.733***	0.707***	0.733***	0.707***
	(0.0325)	(0.0484)	(0.0325)	(0.0484)	(0.0344)	(0.0507)	(0.0344)	(0.0507)	(0.0309)	(0.0421)	(0.0308)	(0.0421)
Control mean	0.390	0.390	0.390	0.390	0.417	0.417	0.417	0.417	0.729	0.729	0.729	0.729
Observations	2,587	2,587	2,587	2,587	2,096	2,096	2,096	2,096	1,697	1,697	1,697	1,697
R-squared	0.213	0.217	0.213	0.215	0.216	0.216	0.215	0.215	0.269	0.273	0.269	0.273

Note: Robust standard errors in parentheses, clustered at the *kebele* level. *Woreda* fixed effects. Controls for distance to nearest FTC (categories) and plot area. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.