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Does training location matter? Evidence from a randomized field experiment in Rural Indonesia

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Abstract

Informal network helps disseminate agricultural knowledge in the rural area where formal extension is lacking. However, how the interplay between formal training and informal network promotes technology adoption is still under-studied. This paper aims to examine the effects of training locations upon knowledge and adoption of agricultural techniques via strengthened informal and formal social networks. We administer agricultural training of identical contents in farmers' hometown and in more remote but advanced locations and arrange farmers to travel to the respective locations. Then, we examine locational heterogeneity effects upon conservation and plant-rehabilitation techniques, and social network variables with formal extension services, informal network, and between participants and non-participants. Only farmers trained in the most remote location increase the size and depth of social network with their peers, extension expert, and non-participants upon returning from training. These changes in social networks may encourage them to adopt the technology. While formal training is important for knowledge diffusion, informal network is the key for successful adoption, and these networks are strengthened via training held in the most remote location.

Keywords: Technology adoption, Sustainability, Impact evaluation, Social network, Information diffusion, Randomized controlled trial

JEL Classification Codes: O1, O2, Q22

Introduction

The majority of the world's poor lives in rural areas and is engaged in subsistence agriculture (Bank 2007); hence, initiatives aimed to improve their well-beings are often geared toward improving agricultural practices as a means of increasing productivity, efficiency, and income (Parvan 2011; Mendola 2007). At the same time, environmental problems have been acknowledged as one of the fundamental factors causing low agricultural productivity for smallholders farming (Morton 2007), threatening the food security for the growing population (Godfray et al. 2010). Technological improvements in sustainable agriculture are found to drive advances in labor productivity (Minten and Barrett 2008), incomes (Hailu et al. 2014), food security (Vermeulen et al. 2012), and general economic growth (Sanders et al. 1996); however, technologies are often not adopted immediately and thoroughly in a population (Maertens and Barrett 2012).

For the smallholders, pursuing the fastest route to improved productivity without compromising environmental integrity can be done via the implementation of the resource-conserving agricultural technologies (Fan et al. 2011).

Agricultural training and formal extension serve as a means to overcome information-related barriers to technological adoption (Feder and Umali 1993; Hussain et al. 1994). While training has generally positive effects on adoption (Noltze et al. 2012; Sidibé 2005), what works best in practice can differ from what is taught as best practices in formal trainings, especially in remote villages when local contexts matter (Vasilaky 2012). In these cases, personal networks can play roles to disseminate the locally-appropriate information (Boahene et al. 1999; Lyon 2000; Katungi et al. 2008). When farmers test and localize the taught practices and ultimately create usable knowledge, that information can be transmitted via personal networks (Conley and Udry 2010; Munshi 2004). These interactions may induce social learning which, according to Mobius et al. (2015), consists of diffusion of information and aggregation of information into an individual's correct knowledge or beliefs. The process of social learning may change farmers' beliefs about the return of certain agricultural techniques, while at the same time teach them the practical knowledge to implement different technologies.

However, social network research oftentimes comes with three shortcomings:

1. Estimating the effects of social networks on technology adoption is not a straightforward process, as the reference points of knowledge, the direction of interaction, and the frequency of contacts would be a challenge to measure.
2. Inferring causal social interaction effects from correlations in individuals' behavior is challenging, thus the difficulty to isolate the specific knowledge being dispersed within the interaction.
3. Individuals may interact and change behavior simultaneously, generating a "reflection problem," which makes it difficult to separate endogenous from exogenous effects. These limitations result in having very few empirical studies that document how networks actually function to disseminate information, with notable exception in Banerjee et al. (2013) among others.

Our paper tries to address these limitations through a randomized experiment which examines the effects of training location heterogeneity upon resource-conserving technology diffusion and adoption through the changes in various social network variables, taking a case of Indonesia. Training is administered to the half of the randomly selected sample of 312 farmers from 14 villages, and impact evaluation is carried out using one baseline and two post-program surveys. We estimate the effects of the training on agricultural technology, in particular soil and water conservation practice and grafting techniques, to the participants. We then decompose the effects of training into two steps, namely whether farmers actually know the technology and whether they consequently adopt and implement the technology.

For the first shortcoming, we categorized our sample farmers into several groups and gave information for certain groups so that the reference points of knowledge are clear. Further, we collected detailed information on interaction among farmers in our survey. The training is administered to the half of the randomly selected sample of 312 farmers using one baseline and two post-program surveys. The trainings were organized in three different geographic locations, namely (1) in their hometown, (2) in a different district but still the same island (hereafter, intra-island), and (3) in a different and more advanced island (hereafter, inter-island). We then identify to what extent social networks influence diffusion and adoption of technology of the participants and non-participants, by defining several reference groups: (i) among the participants in the same and different training location, (ii) between participants and extension services and peer-farmers, and (iii) between participants and non-participants. In this way, we can rigorously estimate the reference point of information, namely the participants trained in varying locations, and establish the direction of information sharing towards their various size and depth of social contacts upon returning from the training.

Addressing the second limitation, training taught participants knowledge regarding sustainable practices, namely soil and water conservation practice and grafting techniques. As the knowledge taught at the training is specific, we may be able to isolate the particular knowledge being dispersed within the participants' networks upon returning, while at the same time examine to what extent location effects matter. This way, apart from isolating the knowledge, we can also examine whether training location matters in diffusing the specific knowledge within participating farmers' locality.

And finally, for the third, we decompose the change of behavior into knowing the technology and consequently adopting it as dependent variables, to deal with the "reflection" problems. As training location assignment is randomized, we can infer that any behavior changes may be exogenously attributed to the location effects. To our knowledge, this is the first study ever conducted in incorporating training location effects that are exogenous, upon social learning with formal and informal networks, and the spillover to non-trained farmers that tend to be endogenous.

We found that while training increased the probability of knowing conservation techniques by 15 percentage points, only inter-island participants improved the probability of adopting conservation techniques and the pooled grafting and conservation methods, both by 18 percentage points. Farmers trained in inter-island location are found to increase their size of social network with peer-farmers and non-training participants, and the frequency of contact with extension services. Thus, we can infer that the strengthened networks may activate social learning with peers and experts, which result in the adoption of standalone conservation methods and the pooled techniques. Positive information spillover from participants to the non-training participants is detected, though the effects are seemingly adversarial for adoption.

The rest of the study is organized as follow: the "Conceptual framework" section describes the hypothesis, the "Agriculture Characteristics in Indonesia" section describes study sites, the "Methodology: data collection and estimation strategy" section presents the methodology comprise data collection and estimation strategy, the " Estimation results " section draws the estimation result, and the "Conclusion and discussion" section discusses the conclusion and policy implication.

Conceptual frameworks

We primarily aim to examine the effects of training location heterogeneity upon knowledge and adoption of agricultural techniques via strengthened social networks. To serve the purpose, we compare technology adoption and various social network variables between groups who trained in their home location versus those who trained in more remote places namely intra-island and inter-island locations. We specifically formulate four null hypotheses for empirical analysis, as follows:

Null Hypothesis I: There is no significant difference in knowledge acquisition between trained and non-trained farmers, controlling for other relevant determinants

We posit that in general, training will only increase participants' knowledge relative to non-participants. Training may contribute to wider information source for participants who are not informed, validation of better practices for participants who are informed, and finally strengthen the beliefs regarding certain values for the already-informed participants. Education and training enhance farmers' ability and willingness to make successful changes to their management practice (Kilpatrick 2000). Past notable studies show positive impact of training on the diffusion of pest management (Anderson and Feder 2004; Yorobe Jr et al. 2011), integrated production and pest management (Witt et al. 2008), irrigation (Hussain et al. 1994), crop management (Vasilaky 2012), composting (Beaman and Dillon 2018), agroforestry management (Pratiwi and Suzuki 2018), and increased interest in agricultural practices which results in positive attitudes on farming activities (Blattman and Annan 2011).

Null Hypothesis II: There is no significant location effect in technology adoption between training conducted nearby and in the most remote and advanced location

While knowledge acquisition may not differ across location, we hypothesize that only training held in the most remote location will drive adoption. Location, apart from representing distance, is also accounting for more advanced development in the agricultural practices. In this case, we also expect farmers trained in inter-island location to have revised their expected returns of using the technologies from observing the practices in the more developed region, hence the higher likelihood for adoption. For farmers living in an isolated village, taking part in a formal training situated outside their hometown may form stronger bonding with fellow participants coming from different villages in the inter-island training category, relative to those trained in their hometown or nearby. Farmers living in a remote village tend to have homogenous opinion and behavior within than between groups (Monroe et al. 2014), so when these farmers connect with fellow farmers from the different villages during the training programs, they would be exposed to alternative ways of thinking and behaving. These interactions during training may bridge the lack of ties between different communities in different villages and connect the hole from one community to another individual and/or network to access more innovation and non-redundant information (Burt 2004).

Reagans et al. (2004) described how interactions among people with non-overlapping networks outside of their circle improved productivity. With more intense opportunity to network with participants coming from different villages, we expect inter-island training participants to adopt more innovative way of thinking, thus more inclination to adopt the improved practices. While there are different kinds of adoption (see Feder et al. (1985) and Parvan (2011)), this paper focuses on both singular and package of technologies and treats adoption as dichotomous variables due to the nature of the technologies. Apart from looking at an individual technology, we also look at the technology bundles, analyzing which bundles are adopted by which types of participants and whether training location has any impact on it.

Null Hypothesis III: There is no significant location effect in deepening social network and intensity with peers and experts

Participants who attend training in the most remote location may acquire stronger networks with their fellow farmers in their locality and extension official, after they return. This is because they intend to showcase what they have learned and witnessed during the training in the most remote and advanced location. Many empirical studies utilizing micro-level data documented that farmers learned from each other's experimentation (Bandiera and Rasul 2006; Udry and Conley 2005; Conley and Udry 2010; Foster and Rosenzweig 1995). These indicate that individuals have to be aware of the product before they can adopt, which is more likely when more of their friends can tell them about it, and the adoption decisions of informed individuals might be influenced by the decisions of their friends (Banerjee et al. 2013). Social networks with peers can affect adoption via training in two ways. First, participating farmers may learn from the training regarding the information of the improved practices and travel experiences during the trip. Upon return, they may want to showcase their improved skills to the networks in the locality, by implementing the technology firsthand before enforcing others to adopt as well. Second, participants may have revised their attitudes regarding the technologies, thus more inclination for adoption when they see their neighbors already practicing them.

Upon returning from the training programs, we also expect farmers to have developed network with extension officials. Extension officials are regarded as the advanced source of information in the rural area, and may help supplying farmers with more information during their experimentation with technologies thus changing their perception and attitudes on the technologies. For technologies that require some level of technical knowledge, having direct and frequent contact with extension services increases the acquisition of relevant knowledge (deGraft-Johnson et al. 2014), thus exerting significant influence over technology adoption decisions (Cramb and Culasero 2003; Klerkx et al. 2010; Prell et al. 2010).

Null Hypothesis IV: There is no significant location effect which drives knowledge spillover to non-training participants

Knowledge taught during the training may be dispersed to non-training participants after the training, as they may be likely to share about their experiences attending the training program. As participants trained in the most remote place may be exposed longer to the more advanced development in agricultural practices, they are likely to have more information and perspectives dispersed into their local community upon returning from the training. As information is embedded in social interactions (Granovetter 1985), knowledge is transferred from training participants to non-participants. Previous evidence is found in the case of a microfinance services in India, when a participant is seven times as likely to inform another household as a nonparticipant (Banerjee et al. 2013).

Agriculture characteristics in Indonesia

Coffee and cocoa have been two of Indonesia's most important export commodities (Kaplinsky 2004), which national production is dominated by smallholders, overpowering big state plantations and large private estates (Dietsch et al. 2004). However, the majority of these farmers often lack the financial means to optimize their production capacity, resulting in declining production due to aging trees and diseases, in addition to climate change phenomena such as floods and drought. Coffee and cocoa farming needs more concern toward the aspect of conservation as a vital precondition of the key sustainability in the future (Fitriani et al. 2018). In recent years, the government has undertaken ambitious reforms intended to revitalize coffee and cocoa plantations as well as to increase capacity building among smallholder farmers.

Lampung province is one of the biggest producing area for Robusta coffee, with major production concentrated in Tanggamus and West Lampung regions. Our survey is administered in Tanggamus as the highest coffee and cocoa producing districts in Lampung and due to the accessibility and professional contacts. Smallholder farmers in the district generally practice traditional farming systems, with aging plantation inherited over generations. Due to their old age, these plants are prone to nematodes as well as infestations by fungi, unwanted weeds, and other potentially harmful organisms. Official agricultural extensions across Indonesia are carried out in the form of "farmers group," usually comprise 20 to 30 farmers cultivating the same crops and living in the same neighborhood or village (Neilson 2008). Extension officials are assigned to each group to monitor farmers' advances at least once a month through monthly group meeting and primarily to disseminate new advances in agricultural technologies or improved practices to the farmers.

In 2006 and 2008 respectively, extension officials introduced bud grafting and side-cleft grafting (hereafter, "grafting" methods), respectively, to increase plants' resistance to nematodes and to combine plants' good traits to revitalize them. These rehabilitation techniques are performed by removing or replacing the existing unproductive trees via side or bud grafting. Side grafting involves utilizing scions from plants known for high yields and quality beans for side grafting to existing unproductive trees. To foster successful grafting and budding, farmers have to use healthy wood with active buds and make sure the bud wood is of the right age and thickness for the rootstock. Farmers are encouraged to perform the composting holes or infiltration pits as the medium of water absorption and containment for plant remains such as pruned leaves or leaf litter (hereafter, "conservation" technique. These rectangular holes of 20 to 50 cm depth have two main widely recognized functions: increasing soil fertility and preventing soil loss through erosion. According to farmers, the techniques improve the "winds of the roots," reflecting the soil aeration benefits to the roots of the coffee plants (Agus et al. 2002). Further, the decomposition of plant materials contained inside can lead to the formation of organic matter and humus, contributing to the soil fertility. These processes result in a high organic matter content of the soil, which is desirable for optimal health of the plants. Extension officials pushed for both practices as part of the nationwide government program to boost productivity of coffee and cocoa farming.

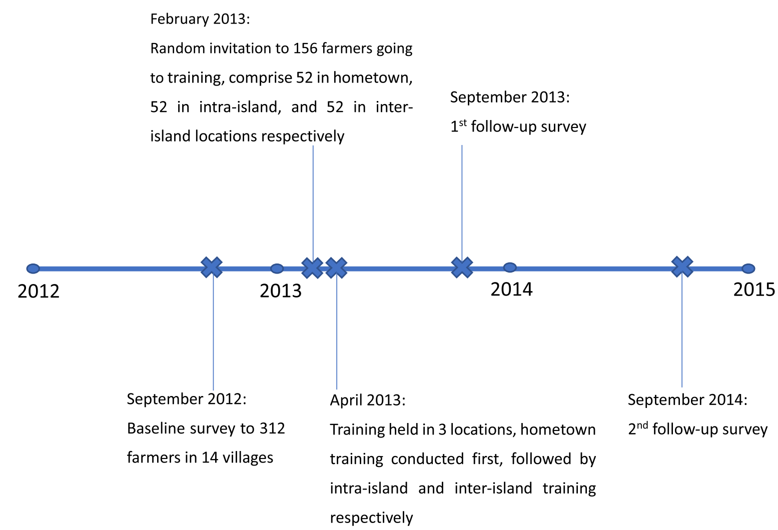

Fig. 1 Research timeline

Methodology: data collection and estimation strategy

Data collection

We administered the baseline survey in September 2012, followed by two years post-evaluation survey in September 2013 and 2014, respectively. As shown in Fig. 1, the study spanned 3 years. Surveys are undertaken through the following steps. First, we chose two top producing coffee and cocoa sub-districts in Tanggamus, namely Pulau Panggung and Sumberejo. Second, we used 2008 census data from local agricultural office that listed 36 active Farmers Group in those sub-districts, in which we randomly chose 16 as our main sample. These 16 Farmers Group listed 398 households as members in 2008, which initially became our main sample. In 2012, we managed to carry out face-to-face questionnaire administration to 312 households (78% out of 398 listed in census data). The survey collected basic socioeconomic characteristics, farming practices, agricultural technology level, and the social network data.

The baseline survey revealed that even though farmers have in fact heard of the agricultural technology examined in this study, they are still reluctant to adopt such practices in entirety. Extension agents also testified that farmers have low motivation to change their current farming practices despite having tried many approaches to encourage farmers to implement better farming practices, including monthly group meetings. We then carried out agricultural training to the randomly selected farmers due to several considerations: First, we considered variations of extension-agent coverage; attention given by extension agents to farming communities varies across groups and villages. Second, no farmer in the district has undertaken institutionalized training. Training, given by professionals from the national research institute, is usually offered to extension agents. These extension workers are then expected to disseminate this information to the farmers. In this light, we aim to examine whether giving institutionalized training directly to farmers has stronger impact upon their adoption behavior. Third, farmers in the district are unlikely to travel frequently to the nearest big city. Interviews revealed that the majority rarely travel even to the nearest big city (Bandar Lampung), a journey that takes 3 hours by bus. The district's farmers are unlikely to be exposed to new experiences and environments. This study explores whether changing how the training is implemented (i.e., holding it at distant places) affects farmers' inclination for adoption.

In February 2013, we rolled the lottery draw to the farmers, to randomly allocate half of the total 312 respondents to join a 3-day training program. The first day of the training program was dedicated to coffee cultivation, the second day was intended for cocoa cultivation, and the third day was aimed at field trip to coffee- and cocoa-pilot farm in each training location. We carried out the training in April 2013, in three different locations: (1) in Tanggamus, the district where the farmers reside (hereafter, hometown); (2) in Kalianda, South Lampung, a more developed district around 170 km from Tanggamus but still in Lampung province (hereafter, intra-island); and (3) in Garut and Ciamis, the districts producing coffee and cocoa, respectively, on neighboring, more developed Java Island (hereafter, inter-island). These locations represented not only the distance and better facilities but also the reputation as the famous coffee and cocoa producing areas.

When farmers took the lottery draw, they got assigned directly which training place that they can go. Of the total 156 farmers, each 52 farmers were randomly assigned to one of the three training locations. Table 1 shows the actual number of training participants, which is 120 out of the 156 invited farmers, or around 79%. Specifically, 39 farmers (75%) were able to participate in the training in their hometown, 39 (75%) attended training in the intra-island location that is still located in the same province, and 42 (81%) participated in the inter-island training, respectively. The farmers participating in intra-island and inter-island training spent 4 days and three nights in total in the training centers, enabling them to interact intensely with their fellow participants. The farmers were transported by land using buses, and the trip took 5 h to reach the intra-island training venue and 1 day to reach the inter-island location. Farmers spent a total of four days outside their villages for those trained in the intra-island location and 5 days for those trained in the inter-island location. The experiment was conducted carefully as the farmers' safety and wellbeing is paramount. Accommodation, food, and travel insurance during the trip and the training were provided.

Two professional trainers from the Indonesian Coffee and Cocoa Research Institute (ICCRI) were invited to provide lectures during the first two days. The trainers provided both training materials and short quiz questions. The trainers and training-program materials were identical at each location. We ensured that all training locations offered similar environments. The in-class training materials for coffee and cocoa on the first and second days consisted of basic cultivation training, including crop management, concepts of agricultural technology such as side-cleft and bud grafting (grafting techniques) and dead-end

Table 1 Training participation

	Non-invited respondents	Invited by lottery		Training Participation rate
		Participating respondents	Non-participating respondents	
Training in hometown		39 (12.5%)	13 (4.2%)	75%
Training in intra-island		39 (12.5%)	13 (4.2%)	75%
Training in inter-island		42 (13.5)	10 (3.2%)	81%
Total	156 (50%)	120 (38.5%)	36 (11.5%)	
Grand total	312 (100%)			

Table 2 Descriptive statistics of the invited and uninvited farmers

	All	Invited for training	Non-invited for training	Mean difference invited vs non-invited for training
Household characteristics				
Age of household head	45.48 (11.58)	44.35 (10.96)	46.57 (12.07)	– 2.22***
Years of schooling of household head	8.36 (3.39)	8.31 (3.23)	8.42 (3.55)	– 0.117
No of adult in the family (15 – 64 years old)	2.83 (1.11)	2.74 (1.064)	2.911 (1.14)	– 0.166**
Log of cultivated farmland	– 0.105 (0.748)	– 0.109 (.714)	– 0.101 (0.780)	0.008
Log of estimated animal value	10.59 (6.499)	10.519 (6.566)	10.661 (6.441)	– 0.141
Log of farm income	16.11 (1.24)	16.15 (1.21)	16.07 (1.26)	0.076
Dummy of hired labor (= 1 if yes)	0.80 (0.01)	0.809 (0.021)	0.802 (0.0166)	0.00744
Native (= 1 if yes)	0.067 (0.251)	0.085 (0.279)	0.050 (0.218)	0.035**
Second generation migrant (= 1 if yes)	0.623 0.484	0.618 (0.486)	0.628 0.483	– 0.010
No. of mobile phone	1.608 (1.14)	1.57 (1.14)	1.637 (1.139)	– 0.058
No. of motorbike	1.394 (0.932)	1.44 (0.988)	1.34 (0.87)	0.103*
Plot characteristics				
Distance to farmland (in minutes)	22.09 (46.16)	24.66 (62.01)	19.62 (21.88)	5.04
Community characteristics				
Walking distance to unpaved road (in minutes)	1.96 (5.18)	1.73 (3.97)	2.18 (6.10)	– 0.456
Walking distance to paved road (in minutes)	3.74 (7.37)	4.07 (7.97)	3.419 (6.74)	0.657
Total no of observation	933	357	576	

Standard deviations are in parentheses
***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively

trench (conservation technique). The third day primarily consisted of a pilot-farm visit. At the pilot farm, the trainers showed the correct ways to perform grafting practices, as well as giving practical information on how to maintain a plantation using the situation in the pilot farm as an example. The farmers could also observe many ways to maintain their farmland by making dead-end trench.

Table 2 displays the general household characteristics of the invited and uninvited groups to confirm our randomization process. On average, invited farmers are two years younger than the non-invited farmers and have fewer adults in the family. They are also more likely to be native of Lampung and possess a motorbike. Education, income, and community characteristics do not differ between invited and uninvited farmers.

Post-evaluation surveys were conducted twice, first in September 2013 then in September 2014. In total, we managed to obtain a panel dataset covering three years. Table 3 shows whether adoption behavior changed due to training participation on average. After

Table 3 Descriptive statistics of the technology diffusion and adoption prior to and after the training

Variables	All farmers		Difference (all farmers)	Training participants		Difference (training participant)	Non-training participants		Difference (non-training participant)	Difference (training participant vs non-training participant)	
	(Before training) year of 2012	(After training) year of 2013 and 2014		(Before training) year of 2012	(After training) year of 2013 and 2014		(Before training) year of 2012	(After training) year of 2013 and 2014		(Before training) year of 2012	(After training) year of 2013 and 2014
Knowing soil and water conservation technique (1 = yes)	0.878 (0.327)	0.920 (0.270)	0.042**	0.871 (0.335)	0.948 (0.222)	0.076**	0.882 (0.322)	0.903 (0.295)	0.020	− 0.011	0.044**
Knowing grafting (1 = yes)	0.897 (0.304)	0.891 (0.312)	− 0.0064	0.915 (0.025)	0.941 (0.235)	0.025	0.885 (0.023)	0.859 (0.348)	− 0.026	0.0305	0.081***
Adopting soil and water conservation technique (1 = yes)	0.75 (0.429)	0.826 (0.379)	0.069**	0.747 (0.436)	0.857 (0.350)	0.109**	0.762 (0.426)	0.805 (0.396)	0.033	− 0.014	0.052*
Adopting grafting (1 = yes)	0.845 (0.361)	0.827 (0.377)	− 0.017	0.857 (0.351)	0.865 (0.342)	0.0084	0.838 (0.368)	0.804 (0.396)	− 0.043	0.018	0.060*
Knowing WH and grafting (1 = yes)	0.823 (0.382)	0.850 (0.356)	0.027	0.831 (0.375)	0.899 (0.301)	.067*	0.817 (0.387)	0.820 (0.384)	0.002	0.014	0.079***
Adopt WH and grafting (1 = yes)	0.684 (0.465)	0.736 (0.441)	0.051*	0.672 (0.471)	0.781 (0.414)	.109**	0.692 (0.462)	0.708 (0.455)	0.015	− 0.02	0.073**
Observation	311	622		119	238		192	384			

Standard deviations are in parentheses
***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively

Table 4 Summary statistics of farmers' network

	All farmers (participants and non-participants)			All participants			Participants attended hometown training			Participants attended intra-island training			Participants attended inter-island training			Non-participants		
	Before training (2012)	After training (2013 and 2014)	Diff	Before training (2012)	After training (2013 and 2014)	Diff	Before training (2012)	After training (2013 and 2014)	Diff	Before training (2012)	After training (2013 and 2014)	Diff	Before training (2012)	After training (2013 and 2014)	Diff	Before training (2012)	After training (2013 and 2014)	Diff
Number of sources of agricultural information who went to the same training location				0.563 (0.860)	0.441 (0.67)	– 0.12	0.512 (0.913)	0.358 (0.580)	– 0.153	0.605 (0.886)	0.473 (0.60)	– 0.131	0.571 (0.800)	0.488 (0.813)	– 0.083			
Number of sources of agricultural information who went to the different training location				0.890 (0.95)	0.760 (1.04)	– 0.13	0.948 (1.122)	1 (1.319)	0.051	0.973 (0.884)	0.684 (0.79)	– 0.29*	0.761 (0.849)	0.607 (0.918)	– 0.154			
Number of sources of agricultural information who did not go to the training				3.74 (3.13)	3.327 (2.35)	– 0.42	4.051 (3.24)	3.050 (2.14)	– 1**	3.63 (2.79)	3.47 (2.49)	– 0.157	3.57 (3.351)	3.452 (2.421)	– 0.119			
Network with training participants	1.41 (1.51)	1.11 (1.22)	– 0.3***	1.47 (1.28)	1.227 (1.27)	– 0.25*	1.46 (1.41)	1.37 (1.42)	– 0.08	1.62 (1.27)	1.20 (1.12)	– 0.41*	1.36 (1.15)	1.10 (1.23)	– 0.26	1.36 (1.64)	1.04 (1.18)	-0.32***
Network with people invited to training	1.75 (1.82)	1.35 (1.33)	– 0.4***	1.82 (1.65)	1.43 (1.33)	– 0.4**	1.76 (1.92)	1.54 (1.49)	– 0.22	1.92 (1.36)	1.39 (1.18)	– 0.52**	1.80 (1.66)	1.37 (1.32)	0.43	1.71 (1.91)	1.30 (1.33)	-0.40***
Observations	312	624		120	240		39	78		39	78		42	84		192	384	
Know extension agent[1]	0.877 (0.33)	0.874 (0.33)	– 0.003	0.86 (0.35)	0.89 (0.31)	0.03	0.87 (0.338)	0.85 (0.365)	0.02	0.868 (0.342)	0.868 (0.342)	0	0.83 (0.377)	0.95 (0.215)	0.11*	0.89 (0.31)	0.86 (0.34)	0.02
Know extension agent and have contact at least once every 2 weeks[1]	0.225 (0.42)	0.202 (0.40)	– 0.022	0.210 (0.41)	0.260 (0.44)	0.050	0.256 (0.442)	0.256 (0.442)	0	0.210 (0.413)	0.210 (0.41)	0	0.166 (0.377)	0.3095 (0.467)	0.142*	0.234 (0.42)	0.166 (0.37)	-0.07**
Observations	311	622		119	238		39	78		38	76		42	84		192	384	

Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively
[1]Only available in 2012 and 2013

the training, training participants reported a significant increase in all of the parameters of diffusion and adoption of agricultural techniques as well as in all packages of the technologies.

Lastly, Table 4 illustrates various social network variables. After the training, hometown and intra-island training participants talked less with their sources of information who did not attend training and who belonged to a different training group, respectively. In contrast, inter-island training participants met with agricultural extension officials significantly more frequently.

Estimation strategy

We support the regional government's effort to promote the commodity revitalization program by increasing farmers' awareness of grafting and conservation techniques and to promote adoption of those practices. In the estimation strategy, we decompose technology adoption into diffusion of agricultural information and implementing the actual techniques. Diffusion is defined as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2010) and is a prerequisite of technology adoption. The dependent variables are (1) knowing the technology and (2) adopting technology predicated on the condition of knowing it. "Knowing" means having knowledge of how to implement the techniques, while "adopting" means having successfully implemented the technologies in one's own farmland. Both are dichotomous and constructed as dummy variables.

As is always the case with impact-evaluation studies, participation in training is likely to cause a self-selection bias. Although we randomly invited farmers to each training locale, and Table 3 shows that on average no differences present between invited and non-invited farmers, the decision of whether to participate in training is ultimately the farmer's choice and thus the model may suffer from endogeneity in this variable. To examine the pure effect of training participation, we employ the Local Average Treatment Effect (LATE) model as introduced by Imbens and Angrist (1994) and instrument the participation status with random invitation status. Thus, we report the treatment effect on the treated (TOT) rather than the intention-to-treat (ITT) effects[1]; thus, the TOT results reflected the compliers only.

In the case of binary dependent variable, we opted to use the Linear Probability Model (LPM) framework. As our main objective is only intended to approximate the average causal effect of the treatment, LPM approach may suffice as the marginal effects are straightforward to work with panel data (i.e., $\frac{\Delta Pr(y_{i,t}=1 \mid x_{i,t}, \ c_i)}{\Delta x_{j,it}} = \beta_j$) and therefore easier to interpret the results (see, e.g., Miguel et al. (2004) and Wooldridge (2010)). However, we acknowledge the limitation of the LPM, for instance, that the error term cannot be independent of any regressors, even exogenous regressors, unless X consists of a single binary regressor[2]. Among the models tested are the fixed-effect and random-effects instrumental variable (IV) models. However, due to the Hausman

[1]The results of ITT, which are very similar to the TOT estimation we present here, are available upon request.

[2]This arises because for any given X, ε must equal either 1 − X β or − X β, which are functions of all elements of X.

test result, which supported the validity of employing the random-effects model, in addition to the ability to fit more into the data and the analysis, we employ the random-effects-IV model as follows:

Estimation 1

$$\begin{aligned} KnowTECH^{j}_{i,t} = \alpha &+ \beta_1 Training_{i,t}{*}Post2013 + \beta_2 Training_{i,t}{*}Post2013{*}Location_l \\ &+ \beta_3 Post2013 + \beta_4 Training_{i,t} + \beta_5 Training_{i,t}{*}Location_l \\ &+ \beta_6 Farmers\ Group\ Dummy_i + \beta_7 Ethnicity\ Dummy_i + u_i + w_{i,t} \end{aligned}$$

Estimation 1 corresponds to the first null hypothesis to test whether there is no significant difference in knowledge acquisition between training and non-training participants, where j is the measured crop technologies (j = conservation technique and grafting methods) and i is the household head in year t. The dependent variable is "Knowing" the technology for grafting and conservation techniques as a standalone technology and a pooled technology when an individual knows both practice in package. The independent variable is the interaction term between the training participation dummy and the year of post-2013, which supports the aim of revealing the training effects upon adoption, and the interaction term of the training participation dummy, the year of post-2013 and location l dummy (hometown, intra-island, and inter-island), whose purpose is to examine the effects of location heterogeneity. Variables contained training participation dummy are instrumented with randomized invitation status dummy.

Estimation 2

$$\begin{aligned} AdoptTECH^{j}_{i,t} = \alpha &+ \beta_1 Training_{i,t}{*}Post2013 + \beta_2 Training_{i,t}{*}Post2013{*}Location_l \\ &+ \beta_3 Post2013 + \beta_4 Training_{i,t} + \beta_5 Training_{i,t}{*}Location_l \\ &+ \beta_6 Farmers\ Group\ Dummy_i + \beta_7 Ethnicity\ Dummy_i \\ &+ u_i + w_{i,t}\ if\ KnowTECH_{i,j} = 1 \end{aligned}$$

Estimation 2 corresponds to the second null hypothesis, testing whether no significant differences are found in adoption between training in nearby and most remote place. We estimate the effects of training on the adoption of agricultural techniques, namely soil and water conservation practice and grafting methods, on the condition of knowing them. The dependent variable is the dummy variable of "Adopting" the technology predicated on the condition of "knowing" it. Adopting means having ever implemented the techniques in their farmland, depending upon the condition of knowing them previously. Similar with Estimation 1, we estimate the adoption as a standalone technology, and the pooled technology when an individual adopts both in package on condition of knowing both.

To examine the factors driving the difference in technology adoption, we analyze how farmers' social networks have changed due to training. For this we have the following model:

Estimation 3

$$\begin{aligned} Network_{i,t} = \alpha &+ \beta_1 Training_{i,t}{*}Post2013 + \beta_2 Training_{i,t}{*}Year\ of\ 2013{*}Location_l \\ &+ +\beta_3 Training_{i,t}{*}Year\ of\ 2014{*}Location_l + \beta_4 Post2013 \\ &+ \beta_5 Training_{i,t} + \beta_6 Training_{i,t}{*}Location_l + \beta_7 Farmers\ Group\ Dummy_i \\ &+ \beta_8 Ethnicity\ Dummy_i + u_i + w_{i,t} \end{aligned}$$

Estimation 3 corresponds to the third null hypothesis, examining how location effects may affect social networks variables. Social networks variables may show variation across the years post-training, for instance, the depth and intensity of social networks may peak after the training ends (year of 2013), but not so much afterwards (2014). To capture this variation, we decompose post2013 (post-training) year into 2013 and 2014 to see the variation of network intensity across the year.

The dependent variable is various social network variables (i) among participants going to the same or different training location, (ii) between participants and non-participants, and (iii) between participants and extension officials. In the survey, we asked farmers about their personal ties in agriculture, which we treat as proxies for their network. To report on these variables, farmers have to recall the names of people outside their household from whom they seek advice, can learn from, or from whom they can generally obtain useful information about farming practices, particularly about coffee and/or cocoa. Then, after farmers mentioned the name, we asked the follow-up questions about the relationship with these contacts, the frequency and mode of contacts, and the proximity of living. These variables capture three categories of personal-network variables as follows:

1. Network between training participants with other participants

We estimate these variables from farmers' personal ties information by identifying whether these mentioned ties have in fact gone to the same training group or different training group. Apart from estimating the number of personal ties coming from fellow training participants, we also examine the possibility of whether participants increase their communication intensity with these people.

2. Network between training participants and non-participants

Using similar variable construction with above, we also examine whether participants increase the number of their personal ties with non-participating farmers. Apart from the size, we also examine the depth of network via frequency of contacts.

3. Network between participants and extension officials

In addition to peer networks, we also investigate whether personal ties identified as extension agents are mentioned and nominated by participants as their personal ties. Extension agents are chosen because they are accessible and regarded as more advanced sources of information than fellow farmers. In this report, "knowing" extension agents should be mutual, that the farmers should be able to call the named agents right away as needed and the agents should be able to identify the nominating farmers.

Estimation 4

$$\begin{aligned} KnowTECH^{j}_{i,t} = \alpha &+ \beta_1 Network\ with\ Training\ Participants\ in\ different\ locations_{i,t} * Post2013 \\ &+ \beta_2 Network\ with\ Training\ Participants\ in\ different\ locations_{i,t} \\ &+ \beta_3 Post2013 + \beta_6 Farmers\ Group\ Dummy_i + \beta_7 Ethnicity\ Dummy_i \\ &+ u_i + w_{i,t}\ if\ \ non\text{–}training\ participants = 1 \end{aligned}$$

Estimation 4 corresponds to the fourth null hypothesis, testing whether no significant location effects are found which drive knowledge spillover to non-training participants.

We examine training spillover on technology diffusion and adoption to non-participants exclusively post-training. The variable of interest number of personal ties who went to the respective training location after the training, which in this case, is captured in "Network with training participants in different locations * Post2013." To obtain the variables, we utilized farmers' personal ties report and identified whether these contacts have gone to the respective training locations. These network variables may possibly be endogenous because those who adopt the agricultural technologies may be influential thus already having more networks to begin with. Furthermore, this variable is treated as a dependent variable in previous analysis. To deal with endogeneity, social network with training participants is instrumented with social network with farmers who received invitation to the training, as invitation to attend the training is randomized.

Estimation results

Effects of training on agricultural technology diffusion

The effects of training on the knowledge of agricultural technologies individually and in package are shown in Table 5. In column 1, training irrespective of the location managed to have significantly improved participants' knowledge of conservation techniques by 14.6 percentage points. With this, we can reject Null Hypothesis 1 but this should be done cautiously, as a significant positive effect of training on diffusion is found only for conservation methods, not grafting.

Effects of locations on agricultural technology adoption

When accounted for the effects of locations, results in Table 5 column 3 indicate that inter-island training drive the package of knowledge and practice of conservation techniques by 19 percentage points. The trends for inter-island training are similar to adoption of conservation techniques individually on condition of knowing it and the adoption of both conservation and grafting techniques in package on condition of knowing them, both by 18 percentage points. These together indicate that the inter-island training helped participants reach the next stage of actually implementing the knowledge by adopting the practices. Therefore, Null Hypothesis II can be rejected as positive effects of inter-island location are found for adoption.

Several reasons entail why location effects matter for adoption. First, a positive Hawthorne effect may be in operation for inter-island training participants. They may feel more motivated by the new experience they obtained by visiting more advanced location than by the training itself. They could possibly have become more open-minded and innovative, which thus provides the households with a new perspective on performing agricultural techniques. Second, as location also accounts more advanced agricultural practices, the pilot farm situation in the most remote place may have altered farmers' expected returns of agricultural techniques. What they witnessed in the farmland as well as the advanced development of the area may have altered the way farmers think about the technologies thus revising the expected return of adoption after they understand how people in the more developed area do things differently. Third, the inter-island training participants may have spent longer time to network with fellow participants during the training, which may have enabled them to exchange more ideas and compare practices among them.

Table 5 Effects of locational heterogeneity in the training on technology diffusion and adoption

Variables	(1) Knowing conservation technique	(2) Knowing grafting methods	(3) Knowing conservation and grafting techniques	(4) Adopting conservation technique if knowing = 1	(5) Adopting grafting methods if knowing = 1	(6) Adopting conservation and grafting techniques if knowing both = 1
Training * Inter-island * Post 2013	-0.115	0.0180	0.0405	0.183**	0.0785	0.182*
	(0.0782)	(0.0834)	(0.0971)	(0.0920)	(0.0716)	(0.103)
Training * Intra-island * Post 2013	-0.114	-0.0494	-0.103	0.0651	0.0938	0.117
	(0.0812)	(0.0876)	(0.102)	(0.0964)	(0.0743)	(0.107)
Training * Post 2013	0.146**	0.0924	0.0986	-0.0363	-0.0785	-0.0837
	(0.0649)	(0.0699)	(0.0814)	(0.0764)	(0.0601)	(0.0853)
Training in inter-island (= 1 if yes)	0.167**	-0.0178	-0.000656	-0.0295	-0.00503	-0.00320
	(0.0748)	(0.0751)	(0.0885)	(0.0865)	(0.0694)	(0.0975)
Training in intra-island (= 1 if yes)	0.111	0.00958	0.0359	-0.00552	-0.0450	0.00466
	(0.0771)	(0.0787)	(0.0928)	(0.0904)	(0.0719)	(0.101)
Training (= 1 if yes)	-0.107*	0.00361	-0.00139	0.00858	0.0325	0.0152
	(0.0614)	(0.0624)	(0.0735)	(0.0713)	(0.0579)	(0.0807)
Year of 2013 (= 1 if yes)	0.0285	-0.0353	0.00803	0.0105	-0.0195	0.0203
	(0.0274)	(0.0290)	(0.0338)	(0.0322)	(0.0256)	(0.0364)
Year of 2014 (= 1 if yes)	0.00359	-0.0289	-0.00180	0.00833	0.00692	0.0260
	(0.0275)	(0.0291)	(0.0338)	(0.0326)	(0.0257)	(0.0369)
Constant	0.913***	0.906***	0.821***	0.833***	0.753***	0.646***
	(0.0637)	(0.0607)	(0.0724)	(0.0695)	(0.0598)	(0.0802)
Observations	891	923	923	794	827	779
Number of hhid	308	308	308	303	306	301
Ethnicity fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Farmers group fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
F test of null R^2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
P value of Hausman test	0.7193	1.000	1.0000	0.0445	0.0000	0.0021
R squared	0.105	0.102	0.119	0.0845	0.0978	0.113

Estimation is based on LATE random-effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by invitation result. Hometown dummy is instrumented by invitation for training in hometown. Intra-island dummy is instrumented by invitation for intra-island training. Inter-island dummy is instrumented by invitation for inter-island training

Some explanations persist regarding why an individual adoption of conservation techniques is stronger than that of the grafting methods for the inter-island training participants. First, inter-island training participants have higher knowledge awareness of conservation techniques by 17 percentage points to begin with, compared to that of the grafting. Training may have significantly reinforced their beliefs and perception regarding the benefits of conservation practices hence the adoption. Second, grafting is more technical and complicated, as it must be done in a very specific time-frame, while the conservation method is not time-specific. Grafting is also more time consuming, as farmers have to maintain the joint plant, which is prone to attracting insects and germs. However, when the technologies were bundled, participants who went to inter-island training tend to adopt both conservation and grafting techniques at the same time by 18 percentage points. This indicates that those who adopt conservation technique may have been more likely to adopt grafting at the same time. Conservation practice is simpler than grafting, so it may serve as an introductory technology for the farmers before they decided to advance to more complicated technologies. Inter-island training participants may also learn about the higher profitability of using both techniques in package. Once they adopt the conservation practice, the uncertainty and perceived risk of grafting methods are somehow reduced and the learning curve to adopt the subsequent technology is less steep, hence the adoption in package.

Effects of locations upon social network variables

We investigate further why being trained at an inter-island location has led farmers to adopt the technologies by examining the changes in their social networks, with estimation results shown in Table 6. Columns 1 to 3 show results only for training participants' sample, and columns 4 and 5 exhibit results for all farmers. No significant location effects are found to strengthen the bonding among fellow participants from the same training group or from the different training groups. However, inter-island training participants seem to increase the number of personal ties who are non-participants by 1 contact post-training though the link is non-directional. Similar trends are shown in column 4, where inter-island training participants are more likely to know extension officials by 19.5 percentage points, followed by the increased contact at least once every two weeks by 31.4 percentage points post-training (column 5). This increase in communication intensity with their agricultural experts and non-participants after training may have accelerated the adoption of technologies for inter-island training participants. Thus, Null Hypothesis III can be rejected, as significant location effects are found in driving stronger networks with peers and extension officials.

The results are rather counterintuitive, as we initially expected inter-island location participants to increase their bonds with fellow participants from the same training group upon returning due to more time spent with them. However, that is not the case in this study, as they may have networked longer with fellow participants during training, but not after training. The significant networks results could be attributed to two causes: First, inter-island training-group farmers may be perceived as being more knowledgeable among their peers; hence, they may become more popular among people who did not go to the training. In this perspective, non-trained farmers are probably the ones who first approach these trained farmers to get more information regarding agricultural practices. Second, inter-island training participants may intend to showcase their training results following their return from a more developed island.

Table 6 Effects of training on the size and depth of social networks

Variables	(1) Number of agricultural information source who went to the same training location	(2) Number of agricultural information source who went to the different training location	(3) Number of agricultural information source who are not training participants[1]	(4) Knowing extension agent[2,4]	(6) Knowing extension agent and having frequent contact[2,3,4]
Training*Year2013*Intra-island	0.0506	-0.286	0.607	0.0514	0.159
	(0.214)	(0.259)	(0.766)	(0.114)	(0.142)
Training*Year 2013*Inter-island	0.172	-0.104	0.377	0.195*	0.314**
	(0.209)	(0.253)	(0.748)	(0.108)	(0.135)
Training*Year 2014*Intra-island	-0.00607	-0.395	1.078		
	(0.214)	(0.259)	(0.766)		
Training*Year 2014*Inter-island	-0.0311	-0.308	1.385*		
	(0.209)	(0.253)	(0.748)		
Training in intra-island (1 = yes)	0.281	-0.153	-0.392	-0.103	-0.143
	(0.180)	(0.221)	(0.596)	(0.0852)	(0.106)
Training in inter-island (1 = yes)	0.225	-0.282	-0.447	-0.0422	-0.144
	(0.174)	(0.213)	(0.577)	(0.0813)	(0.101)
Year of 2013	-0.0769	0.128	0.0513	-0.0128	-0.0705
	(0.150)	(0.182)	(0.538)	(0.0351)	(0.0436)
Year of 2014	-0.231	-0.0256	-2.051***		
	(0.150)	(0.182)	(0.538)		
Training*Post2013				-0.0605	-0.0378
				(0.0913)	(0.113)
Training (1 = yes)				0.00772	0.0633
				(0.0674)	(0.0838)
Constant	0.388	0.930***	5.688***	0.974***	0.120
	(0.286)	(0.352)	(0.883)	(0.0716)	(0.0891)
Observations	357	357	357	616	616
P value of Hausman test	1.0000	1.0000	1.0000	0.3190	1.0000
Ethnicity FE	Yes	Yes	Yes	Yes	Yes
Farmers group FE	Yes	Yes	Yes	Yes	Yes
F test of null R^2	0.0378	0.0000	0.0000	0.0943	0.0003
R squared	0.1328	0.3039	0.2177	0.0833	0.1252

Estimation is based on late random-effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively

All training dummy is instrumented by all lottery result. Dummy of hometown is instrumented by invitation for training in hometown. Dummy of intra-island is instrumented by invitation for intra-island training. Dummy of inter-island is instrumented by invitation for inter-island training[1]May or may not be farmers

[2]Knowing is mutual and goes both ways = yes

[3]Have contact at least once every 2 weeks = yes

[4]Only available in 2012 and 2013

They perceived that they had gone through a more advanced experience than farmers from the other training groups. They were probably more inclined to tell people about what they learned, hence the more intense communication with non-participants. The findings supported Pratiwi and Suzuki (2017) who show that popular farmers tend to be a problem solver, as the number of interactions they have with others enable them to check their beliefs and preferences, thus modify their practices accordingly.

Table 7 Effects of locational heterogeneity of training on information spillover on non-training participants

Variables	(1) Knowing conservation technique	(2) Knowing grafting methods	(3) Adopting conservation technique if knowing = 1	(4) Adopting grafting methods if knowing = 1	(5) Knowing conservation and grafting techniques	(6) Adopting conservation and grafting techniques if knowing both = 1
Numbers of network who went to inter-island training * Post 2013	0.0505	0.0982*	− 0.0787	− 0.0176	0.139**	− 0.123*
	(0.0573)	(0.0557)	(0.0609)	(0.0508)	(0.0656)	(0.0686)
Numbers of network who went to intra-island training * Post 2013	0.0434	0.0718	− 0.0505	0.0640	0.0964	0.0114
	(0.0728)	(0.0712)	(0.0801)	(0.0658)	(0.0840)	(0.0892)
Numbers of network who went to training * Post 2013	− 0.0279	− 0.0585	0.0512	− 0.0157	− 0.0645	0.0647
	(0.0406)	(0.0396)	(0.0441)	(0.0366)	(0.0467)	(0.0500)
Numbers of network who went to inter-island training	− 0.0168	− 0.0755	0.0319	0.00810	− 0.0898	0.0586
	(0.0528)	(0.0512)	(0.0557)	(0.0461)	(0.0607)	(0.0626)
Numbers of network who went to intra-island training	− 0.0580	− 0.0565	0.00949	− 0.00949	− 0.104	− 0.0460
	(0.0592)	(0.0580)	(0.0642)	(0.0526)	(0.0686)	(0.0699)
Numbers of network who went to training	0.0319	0.0712**	− 0.00871	0.0128	0.0778*	− 0.0159
	(0.0371)	(0.0362)	(0.0395)	(0.0328)	(0.0428)	(0.0446)
Year of 2013	0.0482	0.0240	− 0.00745	− 0.0352	0.0428	− 0.0409
	(0.0377)	(0.0369)	(0.0411)	(0.0346)	(0.0433)	(0.0471)
Year of 2014	0.00650	0.0348	0.0102	0.0369	0.0214	0.00827
	(0.0362)	(0.0355)	(0.0401)	(0.0333)	(0.0416)	(0.0459)
Constant	0.822***	0.903***	0.852***	0.762***	0.807***	0.708***
	(0.0783)	(0.0751)	(0.0874)	(0.0719)	(0.0928)	(0.101)
Observations	537	543	476	491	543	464
Ethnicity fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Farmers group fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
F test of null R^2	0.000863	0,00000	0.00000	0.00000	0.00000	0.00000
P value of Hausman test	0.8196	0.9559	0.0896	0.3915	0.8237	0.0102
R squared	0.111	0.147	0.182	0.151	0.147	0.198

Estimation is based on LATE random-effects instrumental variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all invitation result. No of information sources who are training participants are instrumented with no of information sources who are selected to participate according to invitation result

Effects of locations upon information spillover from training participants to non-participants

Spillover effects from training participants to non-training participants post-training are examined in Table 7, which only consider the non-participants sub-sample.

Columns 2 and 7 show that for the non-training participants, having one personal contact going to inter-island training significantly increased the knowledge of grafting methods and both technologies in package by 10 and 14 percentage points, respectively. Previously, we show that farmers trained in inter-island location are found to have more personal ties who are non-training participants. We actually show that these ties managed to drive the knowledge of grafting and pooled technologies. This finding corroborated Banerjee et al. (2013) regarding potentially large effects from program participants to non-participants. The spillover effect on grafting methods is even higher than the effects of training on participants. These may have caused the effects of training on knowledge of grating methods negligible for the treatment group. Grafting is considered more complicated than conservation techniques and perceived to be more profitable as it served to combine unproductive trees with new scions of high-yielding varieties for increased productivity. Non-participants may perceive this information as more valuable than mere conservation techniques, hence are more receptive to this knowledge instead. We can reject Null Hypothesis IV, as significant location effects are found to drive knowledge spillover to non-training participants.

However, the diffused knowledge did not appear to drive adoption for the non-participants. Having connections with an inter-island training participant results in the decrease in probability of adopting both techniques by 12 percentage points. Under this circumstances, risk preferences and learning may be more influential determinants for technology adoption than peer-group influence (Baerenklau 2005). For non-participants, once they are more well-informed on the technologies, they would be likely to get aware on the risk associated with them. Several reasons come at play on this counterintuitive result: first, participants trained in inter-island location is more likely to get informed of the technology while at the same time observe the expected returns from such technologies during the training, thus revising their expected returns at the same time. Non-participants on contrary did not have the opportunity to witness the expected returns firsthand, hence the aversion to the risk despite knowing the technologies. Second, uncertainty pertaining to the future profitability of technological innovation tends to decline as more potential adopters experiment with it through time (Feder and O'mara 1981). In this case, the adopters may have yet to reach the "critical mass" to accelerate others to adopt, or the time constraints may come at play—that the non-participants have yet to observe the profitability of using such technologies.

Conclusion and discussion

This paper shows that agricultural training may have helped improve farmers' knowledge of conservation technique. However, upon examining location effects, only training held in the most remote place managed to spur technology adoption of conservation techniques and the bundled package of conservation and grafting methods. Examination on social networks suggests that inter-island training participants enlarged their personal ties with non-training participants and increased quality of contact with extension officials. While inter-island training participants are found to positively diffuse agricultural information with non-training participants, these effects seem to be adversarial on the adoption decision of non-participants though the effects are weak.

This study offers important implications for policy-makers: the interplay between informal and formal institutions, namely networking with peers and experts simultaneously, through formally conducted training in a certain location, may have strongly contributed to changing participants' mindsets regarding agriculture technology adoption, particularly for conservation and combined practices of grafting and conservation. Future agricultural training should place more emphasis the specific training environment while still ensuring the quality of the training's content. Training environment could be reinforced by having them carried out in different geographical location away from participants' hometown and ideally are more advanced. During the training, participants should ideally spend time for networking among themselves, so that they may obtain insights regarding others' preferences. While formal training or government extension services are important for familiarity of agricultural technology, a set of relationship among agrarian actors should be strongly taken into consideration, as these informal sources of information are possibly the strong enforcer to push technology adoption in the rural community.

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Authors' contributions

AP carried out the review and development of the key concepts, fieldwork, data collection, and data analysis and produced a draft manuscript. AS helped in improving the content, analysis, and writing of this manuscript, providing further insights in all of the sections, and finalizing the manuscript. Both authors read and approved the final manuscript.

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Availability of data and materials

The dataset supporting the conclusions of this article is included in the Additional file.

Competing interests

The authors declare that they have no competing interests.

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