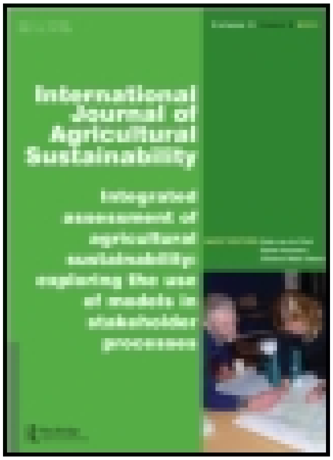

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Enhancing farmers' capacity for botanical pesticide innovation through video-mediated learning in Bangladesh

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Despite the general success of farmer-capacity-building methods such as Farmer Field School in promoting pest management innovations, only those farmers directly involved benefit. How can agricultural extension enable farmer-to-farmer learning about botanical pesticides beyond such schools? We wanted to know how different learning methods, such as video shows and workshops, change farmers' knowledge, attitudes and practices about botanical pesticides. This paper explains how video engages men and women farmers in spreading botanical pesticides across 12 villages in Bogra District, north-western Bangladesh. We conducted ex ante and ex post surveys among farmers from November 2009 to September 2010. For data analysis, we used *t*-test and McNemer and Wilcoxon sign rank tests. Our findings suggest that video improves the ability of both male and female farmers to communicate about pest management among themselves and with other stakeholders, as 'intricate ethno-agricultural practices'. Video-mediated learning sessions are more effective than conventional workshop training in enhancing farmers' knowledge about botanical pesticides, changing their attitude and finally taking a decision to adopt these methods. In other words, video is capable of communicating complex issues such as the biological and physical processes that underlie pest management innovations. From our case, we conclude that agricultural extension is more effective with the use of facilitated video learning and that this process clarifies complex agro-ecological principles, bias and normative perceptions of the learners. Also, video-mediated learning is not only transferable across villages, but also works well in combination with other media, such as radio, television and mobile phones.

Keywords: botanical pesticide; farmers' learning; video; participatory research; local innovation; Bangladesh

Introduction

In many low-income countries, sustainable agriculture is caught between escalating demands for crop yields and ensuring ecological sustainability (IAASTD, 2009; Mengistie, Mol, Oosterveer, & Simane, 2014; Pretty, 2005; UNEP, 2011). Yet, the last decade of the post-green revolution period of 1990–2002 observed an exponential increase (175%) in synthetic pesticides without a corresponding gain in rice production (25%) in Bangladesh (Datta & Kar, 2006). Although Bangladesh's national agricultural policy (NAEP, 1997) has long upheld ecological and environment-friendly farming practices, a number of studies show similar trends of growing synthetic pesticide use for major crop production, such as rice and vegetables (Mohiuddin, Hossain, Rahman, & Palash, 2009; Rahman, 2003). In some South Asian countries, the average frequency of synthetic pesticide application for vegetables ranges from 10 to 20 times per season, with up to 80

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applications per season for some crops (e.g. eggplant) (Gallagher et al., 2005). This is also the case for Bangladesh where it is now well known that the excessive use of synthetic pesticides has negative effects on the environment and human health (FPMU, 2012; Robbani, Siddique, Zaman, & Nakamura, 2007).

Several studies explain why ecological pest management as alternatives to synthetic pesticide applications was less successful than initially hoped (Alam, 2000; Pretty & Bharucha, 2014; Pretty & Waibel, 2005; Toleubayev, Jansen, & Van Huis, 2011; Van Hoi, Mol, Oosterveer, & van den Brink, 2009). On the supply side, reasons include the lack of technical advice in handling often labour-intensive alternatives, limited analysis of the business cases of biological pesticide control measures as well as a thriving and persistent 'shadow pesticide market' of discounted but unauthorized products. On the user side, it turned out that the spillover effects of farmers' capacity building programmes for utilizing alternative pest management methods are less compared to the active promotion of commercial pesticides of village stores (Hashemi & Damalas, 2011; Robinson, Das, & Chancellor, 2007; Williamson, Ball, & Pretty, 2008). Moreover, crop protection innovation is mostly considered as development, transfer, adoption and diffusion of crop protection technologies with relatively less attention paid to the interaction among different stakeholders of crop protection systems (Schut, Rodenburg, Klerkx, van Ast, & Bastiaans, 2014). Improvements of farmer knowledge and capacity development approaches are important policy considerations for intensification of sustainable agricultural practices (Pretty & Bharucha, 2014).

While the battle between synthetic pesticides and alternative pest management approaches prevails this paper argues that if effectively facilitated farmers will make use of their knowledge and skills to solve pest management problems themselves (Bentley, 1992; Price, 2001). Research shows that farmers have the capacity to overcome pest outbreaks in major cash crops by mobilizing their own ideas and resources (e.g. knowledge of new pest resistant varieties and related social and economic opportunities) without encountering long-term food and economic crises (Hall & Clark, 2010). Farmers, especially women, have long used plants as traditional pesticides (Hamid, 2004; Howard, 2003; Kashem & Islam, 1999). Past research underscores local knowledge of plants as a vital component of sustainable pest management programmes (Coulibaly, Mbila, Sonwa, Adesina, & Bakala, 2002; Morales & Perfecto, 2000; Orozco & Lentz, 2005). Moreover, the growing market value of plant- and bio-pesticide products signals that botanical pesticides are entering into the commercial market and are increasingly available to farmers (Dubey, Kumar, Singh, & Shukla, 2009).

How can agricultural extension support the capacity of farmers to tackle the prevailing challenges of identifying alternative pest management approaches and subsequently sharing them on a larger scale? Various authors argue that sustainable agriculture requires experiential learning that amplifies communication and facilitation of actors who usually belong to different domains of knowledge and authority (Leeuwis & Pyburn, 2002; Van de Fliert, 2003). Farmer Field Schools (FFSs), approaches that involve groups of farmers with a common interest to study 'why' and 'how' of a particular topic, foster such experiential learning among farmers (van den Berg & Jiggins, 2007; van de Fliert, Dung, Henriksen, & Dalsgaard, 2007). Although impacts on target communities have been significant, challenges prevent extending the impacts cost-effectively beyond those directly involved in FFSs. It is now evident that FFSs dealing with pest management in Asia and Africa have had limited success in farmer-to-farmer exchange of learning outcomes and spillover effect beyond the pilot villages (Davis, 2006; Feder, Murgai, & Quizon, 2004; Mariyono, 2009; Minh, Larsen, & Neef, 2010; Tripp, Wijeratne, & Piyadasa, 2005).

This is an important limitation of FFSs from the perspective of enhancing farmers' innovation capacity – the ability of farmers to develop and apply new and better ways of managing available resources by utilizing their own knowledge and expanding it to other farmers and development partners, such as scientists and agricultural extension (Hall & Clark, 2010; Hartwich, Pérez, Ramos, & Soto, 2007; Roling, Hounkonnou, Offei, Tossou, & Huis, 2004). But what would be a suitable strategy to scale up local innovations beyond the pilot scale? And, what would be suitable extension and communication methods to reach out to more farmers, especially women and disadvantaged social groups? Some scholars argued for intensification of FFSs, and cost-recovery mechanisms through a privatized funding scheme (Braun, Jiggins, Röling, van den Berg, & Snijders, 2006; Witt, Pemsl, & Waibel, 2008). It involves, however, considerable cost to reach out to the vast majority of smallholders through face-to-face extension in many low-income countries, including Bangladesh. These high-cost implications show the need for alternative and complementary ways to promote sustainable agricultural practices given the limited availability of trained human resources. We argue that participatory video (PV) enables farmers to identify and share botanical pesticides within an FFS framework. PV is a process of engaging marginalized clients (e.g. resource-poor female farmers, pastoralists and landless farm labourers) in groups by articulating individual and collective voices, skills and developing contents through filming (Lie & Mandler, 2009; Shaw & Robertson, 1997; Witteveen & Lie, 2009).

Earlier studies of the farmer-to-farmer video and PV-mediated learning approach highlight the potential of video to build rural women's capacity for sustainable local seed innovation in Bangladesh (Chowdhury, Hambly Odame, & Hauser, 2010; Van Mele, Zakaria, Begum, Rashid, & Magor, 2007). Videos made through participatory processes proved effective in enabling interactive and democratic learning pathways for resource-poor women in the west African and south Asian rice seed system (Chowdhury, Van Mele, & Hauser, 2011; Van Mele, Wanvoeke, & Zossou, 2009; Zossou et al., 2009a). These studies confirm that video-mediated learning not only enhances experiential learning processes for individual farmers but also encourages processes of social learning. Experiential learning theory (Kolb, 1984) is widely used to support individual learning processes where an individual learns in an inductive way from action through reflection to generalization (Leeuwis & Van den Ban, 2004; Schneider, Ledermann, Fry, & Rist, 2010). Innovation does not take place at the level of an individual farm; rather it involves different actors and leads to the reconfiguration of relational patterns. Social learning captures the fact that a change is connected with individual and/or collective cognitive changes of various kinds. It is Bandura (1977) who introduced the concept of 'social learning' to explain how the social structure affects individual learning while, at the same time, learners change their environment. The process of social learning addresses how groups of individuals are engaged in sharing and reflecting on knowledge gained through experience or action. It enhances farmers' capacities for critical inquiry in which learners do not gain knowledge by only finding out about the world, but by also actively and collectively engaging in building alternatives as a challenge to the dominant mode of organization for production (Kroma, 2006). PV is a potential tool that encourages learning by offering 'direct' and 'mediated' experience – those who participate in video development encounter direct experience and the final film supports learning in a mediated way for those who do not participate directly in the process of developing the film (Chowdhury, 2011; Ferreira, Ramírez, & Lauzon, 2009; Witteveen, Put, & Leeuwis, 2010).

Inspired by the policy suggestion on embedded use of media in participatory extension for agricultural development (Bentley, 2009; Pretty & Bharucha, 2014; Pretty et al., 2010), this paper describes how we facilitated learning about botanical pesticide in a north-western village in Bangladesh, and subsequently developed a video incorporating learning outcomes. We then assess whether video-mediated group learning is an effective way of sharing experiences and enabling farmers' learning on local botanical pesticide innovation beyond the pilot village. Unlike earlier studies, the case shows that video-mediated learning is equally effective for enhancing knowledge of resource-poor men and women and changing their attitude towards and decision regarding adoption of botanical pesticide. We argue that facilitation benefits the video-mediated learning process by clarifying complex agro-ecological principles, bias and normative perceptions of the learners, and ultimately leading to effective learning outcomes.

Context and location

This is a follow-up study to earlier research in Bangladesh which compared two styles of PV – scriptless and scripted video – and how these could be combined to enhance farmers' innovation capacity (see Chowdhury et al., 2010 for details). The research concluded that scriptless video, a style that adopts no pre-defined script and allows participation of farmers in technical intricacies of camcorder handling, is effective for building self-reliance and ownership of the process (Chowdhury et al., 2010). The scripted video, which adopts a pre-defined script and allows no participation of farmers in the technical intricacies of camcorder handling, results in effective video for farmer-to-farmer learning. Hence both styles could be combined, using the former style to enable a self-motivated participatory process and the latter to capture learning outcomes of the process, and then to enable learning of other farmers beyond the pilot village. We used the scriptless style to record opinions from farmers, extension agents and field workers of development organizations, pesticide dealers and researchers about pest management issues including local innovations from farmers in Kamarpara – a village in northwest Bangladesh. The video sessions served to organize group discussions in the form of visual problem analysis (Witteveen & Enserink, 2007). Group discussions (Figure 1, Phase 1) motivated farmers to undertake participatory research on a botanical pesticide in December 2008. Farmer participatory research (FPR) activities continued until October 2009, and a video was developed (using scripted style) based on the key learning topics identified in November 2009 (Phase 3, Figure 1). We organized group learning sessions using this video in several villages in Bogra district (Table 1). In this paper, we focus on the assessment of the video-mediated group learning sessions (Phase 4).

Methodology

FPR on botanical pesticide in Kamarpara

Bangladeshi farmers traditionally used plants to deter field and storage insects and pests. Some farmers in the north-western region continue to use a wide range of plants for pest management (Kashem & Islam, 1999; Rashid, Rahman, Kelly, & Jeffery, 2006). We worked with farmers who participated in the earlier study in the village, and initiated botanical pesticide experiments. Farmers identified six plants that they often use to prevent pests of grains and vegetables. These are

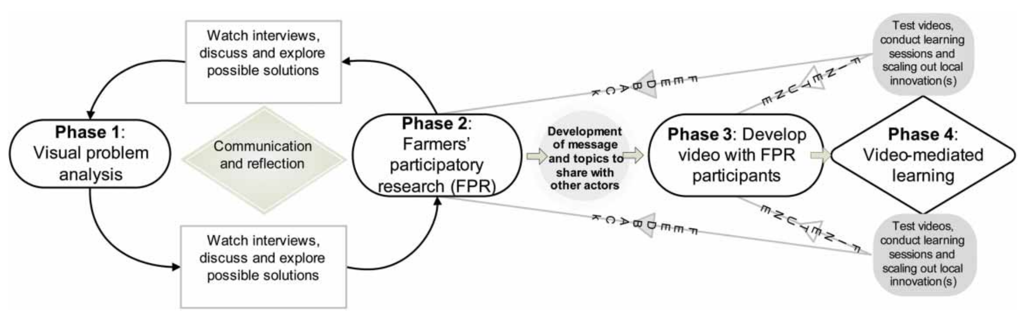

Figure 1. Phases to combine FPR with video-mediated learning sessions (modified from Van Mele, 2006).

Table 1. Key steps and farmers' ideas about botanical pesticide innovation.

Topics	Key steps and ideas
Motivations, and key learning	Chemical poses environmental, health and economic risks. Avoid chemical pesticide to protect crops. Farmers have capabilities to experiment and explore alternatives. Botanical pesticide is as effective as chemicals. Always consider the latter as the last option to combat pests
Collection and preparation of plants	To prepare 5 litres of pesticide, collect 1 kg each of neem leaves, barks and seeds (if available), pithraj leaves, barks and seeds (if available) and biskatali (whole plants), 0.25 kg each of tobacco and basok leaves, and whole plants of thankuni. These plants are grown near the homestead. Since it is a tradition to consume tobacco leaves with betel leaf, every family buys some from the nearby local market. Chop the plant parts into small pieces and crush the seeds and bark
Preparation of the pesticide	Add plant mixture in a mud or aluminium pot. Boil the mixture with about 3–4 litres of water for about 15–20 minutes. Conceal the opening of the pot by covering the lid with the mud. This avoids odour and facilitates fermentation. Store it in a shady place, preferably outside the main house for about 15–20 days until the mixture turns into a yellowish brown colour. Sieve the mixture with a fine sieve or cotton cloth two to three times. Store the extract in a container. After sieving, dry the fermented plant parts for at least three to four days. The dried plant parts can be used to deter pests in seed storage.
Application	Mix an amount of 50 ml extract with 10 litres water to apply in 15–20 decimals of crop field. Start applying the botanical pesticide one to two times per week before the infestation of any insect pest in the field (precautionary application). Follow available crop hygiene and mechanical pest management practices, for example line sowing, weeding, cleaning infested plant parts, etc. Increase intensity of botanical spray to two to three times per week if there is a severe pest attack. If it does not work, only then apply recommended chemical pesticide to control the pest. When the pest is controlled, do not apply chemical pesticide and continue applying botanicals instead. Apply the dried fermented plant mixture in the storage of seed and crops.

neem (*Azadirachta indica*), biskatali (*Polygonum hydropiper*), pithraj (*Aphanamixis polystycha*), tobacco (*Nicotiana tabacum*), thankuni (*Centella asiatica*) and basok (*Adhatodu vasica*). The farmers' hypothesized that a pesticide developed from the mixture of plants might be more effective than a single plant product. Although it is rare to ferment plant parts for extraction, based on experience, farmers combined boiling and fermentation to ensure better extraction of the botanical ingredients of plants and increase the effectiveness of the final product (see Table 1).

FPR activities were carried out in close collaboration with a farmers' organization called Marginal Farmers' Development Association, Kamarpara. A research team, comprising four researchers affiliated with the Rural Development Academy (RDA), Bogra, and Bangladesh Agricultural University, Mymensigh, including the first author facilitated the entire research process. A farmers' team comprising three men and two women collaborated as farmer facilitators. Farmers tried the botanical pesticide in crops such as eggplant, country bean (*Dolichos lablab*) and chilli. We followed farmers' managed participatory research that allows simple observations and record keeping. Thirty-five farmers (20 men and 15 women) in the village participated in this research between December 2008 and October 2009. Participant farmers met once each month and discussed their observations on pest incidences, challenges and effectiveness of the botanical pesticide. According to their observations, botanical pesticide is effective to control certain pests, such as eggplant borer (*Leucinodes orbonalis*), aphids (*Aphis gossypii* and *Aphis craccivora*), jassids (*Amrasca biguttula*) bean borer (*Maruca vitrata*) and thirps (*Thirps palmi* and *Magalurothrips usitatus*). They also reported a higher growth or stimulant effect (better size and colour of crop) from the pesticide. In storage, the pesticide is effective to control weevil and moth of rice and vegetable seeds.

Video development and learning sessions

We developed a script drawing on the key learning outcomes of the FPR. Participatory script research was conducted to include observation, records and experience of the research (FPR) participants. The script guides the video development in a well-structured format to share farmers' experience with their peers (see Figure 1). We made use of the zooming-in and zooming-out (ZIZO) approach for communicating technologies effectively to the poor (Van Mele, 2006). ZIZO re-presents practice by framing the issues from the farmers' perspective. The video incorporated motives, process and outcomes of FPR (Table 1) that demonstrated farmers' interest, ideas and ability for innovation rather than ready-made technology.

We selected 16 villages in 3 sub-districts (Sajahanpur, Sherpur and Bogra Sadar) of Bogra to participate in this study. Farmers of these villages cultivate vegetables (e.g. bean and eggplant) both in winter (rabi) and in summer (kharif) seasons, in addition to rice as a staple crop. There has been a rapid change in rural areas of Bangladesh with video shops and cable TV network being present in the nearby local markets. Therefore, villages had easy access (owned by a group member or renting it from the market) to TV and a video player. In each village, we conducted well-being analysis (Pretty, Guijt, Scoones, & Thompson, 1995) in order to select resource-poor men and women who were interested to participate in this study (Table 2). We also conducted facilitated and non-facilitated video shows and conventional 1-day community training workshops in 12 villages (Table 2) as ways to share results of participatory research. We organized no learning sessions in four villages. The villages were selected at a distance from each other to avoid influencing effects of one learning session on another. The control villages further ensured that the results could be attributed to different types of learning interventions.

Data collection and analysis

According to the model of cognitive agent as applied to the pest management education (Braun et al., 2006; Röling, 2005), and the pest belief model (Heong & Escalada, 1999), knowledge, attitude and practices (KAP) are key variables to explain behavioural change. We followed ex ante and ex post design (Heong et al., 2008; Tin et al., 2010; Van Mele et al., 2007) to assess farmers' changes in KAP in different learning sessions.

Table 2. Types of learning sessions.

Types of learning sessions	Number of villages (groups of 15–20 farmers per village)		Baseline survey (ex ante)	Post-test survey (ex post)
	Men	Women		
Video	2	2	November 2009, including KAP questions	KAP survey, September 2010 and key informant interview in April 2013
Video followed by discussion	2	2		
Workshop	2	2		
Control	2	2		

We developed a structured questionnaire, which contained KAP questions related to key steps and message conveyed through different learning sessions. For knowledge and practice questions, the respondents had choices of 'Agree'/or'Yes', and 'Not agree'/or'No'/or'Not sure'. Responses to correct (intended) and wrong answers were given scores of '1' and '0', respectively. Some knowledge and practice questions were followed by an open question. We used a three-point Likert-type scale to determine attitude. We formulated the statements in a reversal system (Thurstone & Chave, 1929) and edited these carefully following the criteria suggested by Edwards (1969). Positive statements indicate favourable attitude, and negative statements indicate unfavourable attitude towards the subject. If respondents agreed to a positive statement, they received a score of three. Scores of '1' and '2' were given for disagreements and neutral responses (e.g. undecided), respectively. Rating scores were reversed for agreements and disagreements to negative statements.

The baseline survey was conducted in November 2009 and the ex post survey after a year during September and November 2010. Data were collected by the first author and three trained data enumerators. Informal interviews were conducted in video and workshop villages during January to March 2010. The interviews and observations help to understand changes of knowledge and attitude, and to observe how participants applied the learning. In April 2013, key informant interviews were conducted with seven purposively selected farmers. The interviews helped to understand how farmers continue to use the videos, spillover effect, motivation and interest to further know about the topics.

Data were entered into the Microsoft Excel spreadsheet, and then transferred into the SPSS (version 15) software to run analysis. Data were analysed using descriptive statistics presented in the tables and figures. Based on the types of variables (measurement level), McNemmer chi-square test, Wilcoxon sign rank test and paired *t*-test were used to understand significant changes in KAP. Farmers' statements and narratives were recorded in a field diary, coded and inputted manually into the analysis according to their relevance to the interpretation of a phenomenon addressed in the study.

Findings

Farmers' awareness and knowledge of botanical pesticide

Results suggest that facilitated video shows are effective in enhancing knowledge of women and men about the reasons, procedures and benefit of botanical pesticides with no significant changes in control villages (Table 3). Interviews and observations of learning events indicate that non-facilitated videos and workshops are less effective in improving farmers' understanding about consequences of chemical pesticide on environment, health and pest resistance. Also, conventional lectures appear to have a limited effect on participants' comprehension of the interaction of chemical pesticides with the farm ecosystem. Instead when farmers watched the video followed by discussion, explanation of fellow farmers and scientist about pesticide-ecosystem interactions developed a better understanding of the consequences of chemical pesticides.

While asked about benefit of synthetic pesticide farmers mentioned that it completely destroyed insects and diseases. More often, they attribute failures of synthetic pesticides to control pests to their adulteration or incorrect products or too low dosages of these chemicals. This attribution provides the rationale for farmers trying one synthetic pesticide after another. The video helps farmers to link their understanding that pest outbreaks, despite synthetic pesticide use, are common experiences of other farmers. Also, the video provides visual evidences of the negative health and environmental impacts; for instance, an image of dead frogs in contaminated water from pesticide runoff. Video stimulated discussion and problem-solving for

Table 3. Knowledge of respondents about botanical pesticide in pest management, before (November 2009) and after (September 2010) different types of learning sessions.

		Women (%) mentioned target answers in different learning groups								Men (%) mentioned target answers in different learning groups							
		Video only ($N = 33$)		Video and discussion ($N = 34$)		Workshop ($N = 35$)		Control ($N = 35$)		Video only ($N = 36$)		Video and discussion ($N = 38$)		Workshop ($N = 39$)		Control ($N = 38$)	
Questions	Target answer	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. Do you know that chemical pesticide affect environment and health?	Yes[a]	36.4	54.5	29.4	55.9*	25.7	45.7	37.1	40	47.2	61.1	52.6	71.1**	35.9	51.3	42.1	42.1
2. Do you agree that insects and pests grow capacity to resist chemical pesticides after some years?	Agree	18.2	30.3	20.6	44.1**	14.3	22.9	11.4	14.3	33.3	50*	39.5	60.5**	35.9	41	31.6	31.6
3. Is it necessary to apply chemical pesticide always as precaution to pest infestation in the crop field?	No[a]	48.5	60.6	38.2	55.9*	40	48.6	42.9	42.9	30.6	38.9	28.9	47.4*	25.6	35.9	28.9	28.9
4. Do you know any plant that deters pests in the field?	Yes[a]	36.4	66.7**	32.4	94.1**	40	60	31.4	28.6	27.7	38.9	28.9	71.1**	30.8	43.6	31.6	31.6
5. Do you know how to prepare/use plants as pesticide?	Yes[a]	6.1	54.5**	14.7	58.8**	8.6	40**	22.9	14.3	13.9	36.1*	15.8	55.3**	10.3	23.1	18.4	18.4
6. Do you know how botanical pesticides deter pests?	Yes[a]	15.2	33.3	20.6**	61.8**	8.6	25.7	17.1	14.3	19.4	47.2*	26.3	65.8**	17.9	30.8	21.1	21.1
7. Does crop hygiene (cleaning infested plant parts) control pests?	Yes	45.5	72.7*	55.9	85.3**	42.9	68.6**	40	45.7	36.1	72.2**	31.6	76.3**	30.8	51.3**	42.1	44.7
8. Do you know any botanical pesticide/plant that deters pests in storage?	Yes	36.4	75.8**	29.4	76.5**	22.9	42.9*	40	40	25	33.3	23.7	42.1*	12.8	23.1	15.8	15.8
9. Does botanical pesticide harm beneficial insects and animals?	No	24.2	39.4	17.6	38.2**	20	31.4	20	20	30.6	44.4	21.1	36.8*	25.6	38.5	10.5	10.5
10. Does botanical pesticide harm the environment and health?	No	27.3	45.5*	20.6	50**	22.9	40*	28.6	31.4	25	41.7*	26.3	55.3**	33.3	48.7*	36.8	36.8
11. Do you agree that birds, some insects and even frogs benefit us by controlling insect pests of crops?	Agree	24.2	33.3	23.5	47.1**	28.6	40	28.6	25.7	27.8	38.9	31.6	57.9**	38.5	51.3	15.8	18.4

Note: Values with '*' are significantly different at $p < .5$; values with '**' are significantly different at $p < .01$ with the McNemar X^2 test.
[a]Followed by an open question.

both women and men watching how pests grow resistance to pesticides in a similar way a farmer gradually becomes stronger over time from fieldwork (e.g. in the video a farmer demonstrated how he grew resistant to pain from routinely building up his muscles from digging the soil). Explanations from their peers in visual ways, sharing stories of routines and traumas in the field not only stimulated discussion but also provoked hilarious laughter. Discussions followed by video are more effective to communicate a complex phenomenon, for instance, why certain chemicals do not also work against other insects infecting human (e.g. mosquitoes).

In video and workshop villages, the number of women and men who know how to prepare the botanical pesticide increased significantly. This indicates that both conventional and video-mediated learning approaches are effective in enhancing knowledge of botanical pesticide preparation. Observations and follow-up questions indicate that verbal instruction and visuals of key sequential steps and processes of local innovations helped to provide learning to transfer the technique. More participants mentioned that they knew all steps and reasons for combining boiling and fermentation in villages where video was shown compared to those in villages with workshop only. Video mediates learning better than face-to-face extension. When extension workers explained different steps of pesticide preparation in the workshop villages, interruptions routinely take place, which interfere with the transfer of knowledge and its sequence (e.g. principles to combine boiling and fermentation, steps to remove mud and dirt from the extract). Furthermore, based on the workshops, participants were left with the impression that they were supposed to use only the plants and steps discussed in the lectures. Participants tended to cite names of the plants that were mentioned during lectures in the workshop villages. However, the video stimulated farmers' cognitive and affective domains which helped them to recall similar plants that deter crop pests (Figure 2). For instance, when participants watched *bishkatali* in its natural conditions, they could remember and identify other plants grown in the similar conditions such as *datura* (*Datura sirumarium*) or *durva* (*Cynodon dactylon*) that they or their ancestors often use to control pests.

Farmers know that botanical pesticide deters crop pests (Table 3), but they do not know the principles. Most farmers attribute the qualities of botanical pesticides as 'to kill pests in crops' (Figure 3). In video villages, farmers developed a better understanding of how botanical pesticide controls pests. The approach that combines visual media and face-to-face discussion is more useful to change this kind of wrong perception and enhance understanding of the implicit principles of fellow farmers' innovations (Figure 3). The findings are similar for other aspects, such as pest protection and environmental benefits of botanical pesticides and beneficial insects (Table 3). Although the message sequences including fellow innovators' own words and expressions in the video are effective in conveying scientific principles,

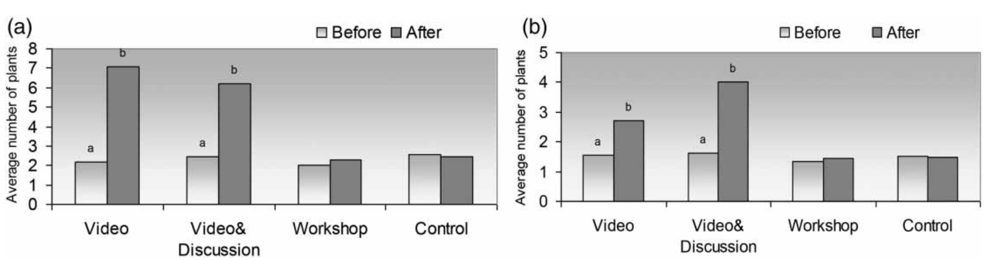

Figure 2. Number of plants that (a) women and (b) men know, before (November 2009) and after (September 2010) different types of learning sessions. Respective bars with different letters in a learning session represent significantly different values with paired t-test at $p < .01$.

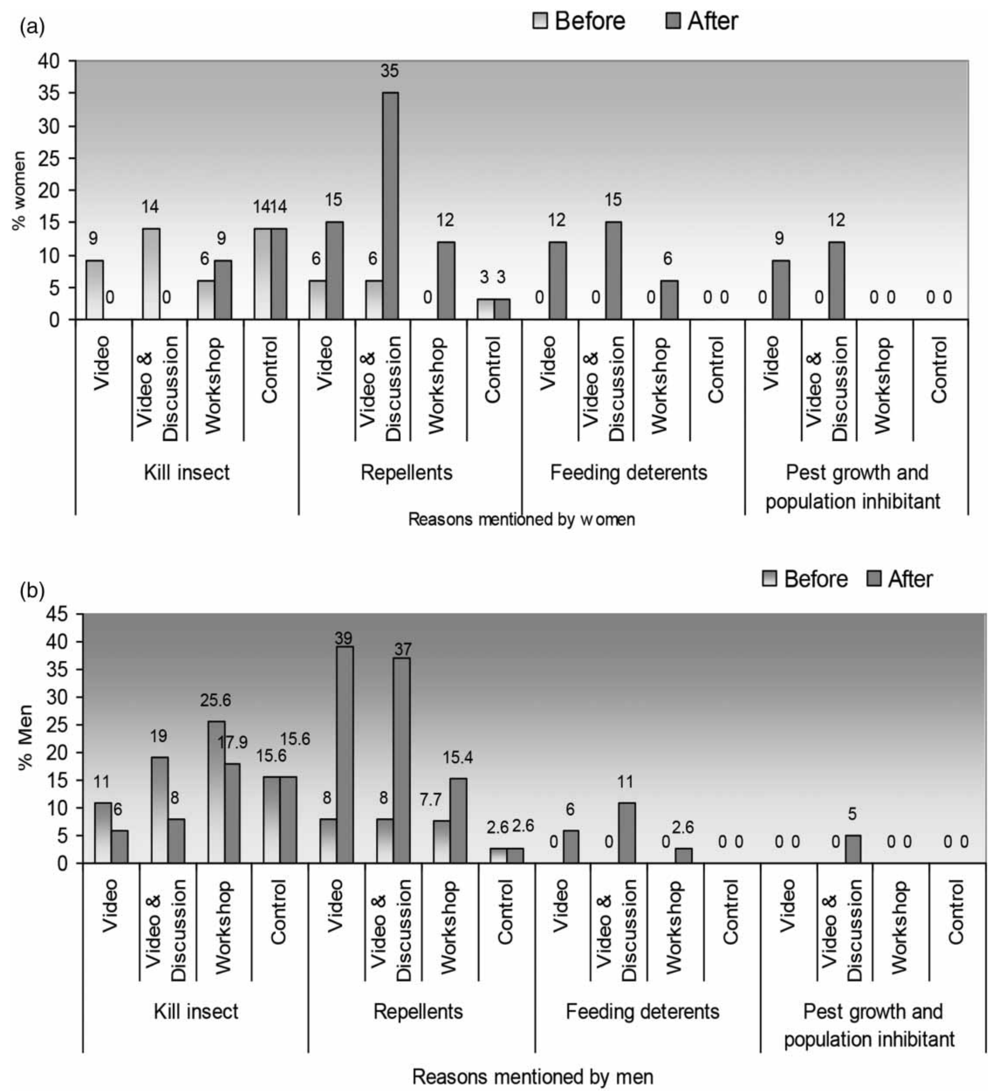

Figure 3. Explanations of (a) women and (b) men of how botanical pesticide deter pests, before (November 2009) and after (September 2010) different types of learning sessions.

facilitation through face-to-face discussion has an additional value for understanding the principles. Farmers believe that botanicals might also harm beneficial insects. When they understood underlying biological and physical principles of botanical pesticides, their perception changed. Significantly, more men and women in villages with facilitated video shows perceived that botanicals do not harm beneficial insects compared to those in workshop and control villages. A participant in one of the video villages replied how video contributed to her learning,

> Watching (farmers) in video remind us how we used *neem* to repel away insects such as mosquitoes. *Vesog* (botanical extract) should also be effective in the same way by deterring insects and pests from the field

Both video and conventional lectures are useful to convey simple messages (e.g. crop hygiene helps to control pests) and messages that portray topics relevant to the local gender division of labour in farming as well as personal experiences and observations (e.g. women traditionally perform post-harvest of crops and seeds). Women's groups showed an increase in knowledge about the use of botanicals in storage compared to men. Some aspects of the discussion, however, were not specific to gender and this could be observed and discussed. For example, male and female farmers' observations and visual evidence of birds eating insects embedded in the video helped to raise interest and understanding of how beneficial animals control pests.

Influencing farmers' attitude towards botanical pesticide use

The findings show that facilitated video shows modified attitudes of women and men are favourable in almost all aspects of the botanical pest management innovations with no significant changes in the control villages (Table 4). Both the video-mediated approach and face-to-face extension changed farmers' attitude towards botanical extracts based on their past positive experiences (e.g. cost, time and effectiveness of deterring pests). For instance, farmers usually believe that plants can prevent pests and these are available at almost no cost. Since women perform most domestic work, they considered the collection of plants grown near the homestead as a positive aspect of the activity.

Despite the chemical hazards, many farmers harvest crops immediately after pesticide spray is applied in the field. Farmers do so to obtain quick returns on the harvested crops. Both women and men were motivated to change their existing mindset when they watched other farmers who experienced similar realities, but were inspired to change to safer botanical pesticide methods. However, the video may not effect this change alone. Facilitated discussion has an additional significant impact. Some participants agreed to the opinions and realities of their peers and explanations of the scientists who warned about chemical hazards and yet, farmers still evaluated this information as not being relevant to their local conditions, including the stake that pesticide businesses have in local agricultural markets. After showing the video in a village, a participant raised this doubt in discussion,

> If this botanical pesticide would work for all, the pesticide business (synthetic pesticide available in village shops) would collapse. (…) we should not take a risk of relying on these alternatives.

Many pesticide dealers in villages also encourage synthetic pesticide application. Interviews with farmers reveal that there is a common disposition towards a precautionary use of synthetic chemicals to avoid risk of possible pest infestation in the field. Farmers' risk aversion tendencies hinder changing their attitude. The learning video did not intend to highlight the stake of the pesticide businesses. The video, however, followed by discussion on values, interests and goals of system actors, opened up and enabled clarification of related factors in farmers' pest management decision-making. The same farmer replied during a follow-up visit,

> I have not thought about hidden interest of the pesticide dealers (…), now I get the point why we should try out local alternatives and botanicals as precautions.

Although farmers believe that local and alternative practices are effective to control pests in a cost-effective way, they consider this practice to be labour intensive. They believe chemical pesticides are ready-made and less labour intensive solutions. However, the video countered this opinion and stimulated participants to reflect on the experience of their fellow farmers. In the

Table 4. Attitude of respondents about botanical pesticide in pest management, before (November 2009) and after (September 2010) different types of learning sessions.

		Women (%) responded in different learning groups								Men (%) responded in different learning groups							
		Video only ($N = 33$)		Video and discussion ($N = 34$)		Workshop ($N = 35$)		Control ($N = 35$)		Video only ($N = 36$)		Video and discussion ($N = 38$)		Workshop ($N = 39$)		Control ($N = 38$)	
Statements	Response options	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
1. (−) It is better to think about production than environment and human health	Agree	48.5	42.4	50	23.5*	65.7	60	54.3	48.6	55.6	47.2	60.5	34.2**	56.4	51.3	50	47.4
	Undecided	36.4	27.3	11.8	11.8*	11.4	8.6	20	25.7	33.3	36.1	23.7	21.1**	35.9	28.2	28.9	31.6
	Disagree	15.2	30.3	38.2	64.7*	22.9	31.4	25.7	25.7	11.1	16.7	15.8	44.7**	7.7	20.5	21.1	21.1
2. (+) We should first try available alternatives of chemical to control pests in crop	Disagree	36.4	21.2	26.5	8.8**	40	14.3	37.1	37.1	38.9	25	39.5	21.1**	46.2	38.5	44.6	42.1
	Undecided	33.3	45.5	41.2	20.6**	25.7	54.3	34.3	37.1	41.7	50	39.5	28.9**	30.8	35.9	36.8	39.5
	Agree	30.3	33.3	32.4	70.6**	34.3	31.4	28.6	25.7	19.4	25	21.1	50**	23.1	25.6	18.4	18.4
3. (+) Botanical elements are effective means to deter pests	Disagree	27.3	15.2*	23.5	14.7**	34.3	11.4*	34.3	28.6	25	19.4**	34.2	18.4**	51.3	38.5*	39.5	42.1
	Undecided	33.3	21.2*	35.3	5.9**	25.7	34.3*	28.6	34.3	55.6	22.2**	31.6	13.2**	33.3	25.6*	44.7	42.1
	Agree	39.4	63.6*	41.2	79.4**	40	54.3*	37.1	37.1	19.4	58.3**	34.2	68.4**	15.4	35.9*	15.8	15.8
4. (+) I would rather try botanical pesticide as a precautionary measure to possible crop pest infestation	Disagree	51.5	36.4	44.1	23.5**	54.3	40	45.7	40	41.7	33.3	50	34.2**	33.3	30.8	42.1	42.1
	Undecided	27.3	39.4	26.4	11.8**	25.7	34.3	34.3	40	36.1	38.9	28.9	23.7**	46.2	38.5	34.2	34.2
	Agree	21.2	24.2	29.4	64.7**	20	25.7	20	20	22.2	27.8	21.1	42.1**	20.5	30.8	23.7	23.7
5. (−) Preparation of botanical pesticide is labour intensive	Agree	63.6	42.4**	64.7	32.4**	65.7	48.6	48.6	45.7	69.4	27.8**	63.2	18.4**	53.8	43.6*	39.5	39.5
	Undecided	27.3	24.2**	20.6	14.7**	14.3	20	28.6	31.4	11.1	19.4**	28.9	15.8**	33.3	33.3*	34.2	34.2
	Disagree	9.1	33.3**	14.7	52.9**	20	31.4	22.9	22.9	19.4	52.8**	7.9	65.8**	12.8	23.2*	26.3	26.3
6. (−) Use of botanical pesticide does not contribute to reducing cost of crop protection	Agree	33.3	15.2*	41.2	17.6**	34.3	14.3*	34.3	25.7	30.6	11.1**	47.4	23.7**	43.6	35.9*	50	50
	Undecided	15.2	15.2*	20.6	5.9**	28.6	20*	28.6	34.3	38.9	30.6**	31.6	21.1**	30.8	20.5*	23.7	23.7
	Disagree	51.5	69.7*	38.2	76.5**	37.1	65.7*	37.1	40	30.6	58.3**	21.1	55.3**	25.6	43.6*	26.3	26.3
7. (+) Family members can utilize off-time to collect plants and prepare pesticide	Disagree	42.4	27.3**	38.2	14.7**	37.1	25.7*	37.1	34.3	25	16.7	31.6	21.1**	38.5	35.9*	31.6	34.2
	Undecided	27.3	21.2**	32.4	11.8**	48.6	51.4*	42.9	42.9	33.3	25	42.1	10.5**	30.8	20.5*	28.9	26.3
	Agree	30.3	51.5**	29.4	73.5**	14.3	22.9*	20	22.9	41.7	58.3	26.3	68.4**	30.8	43.6*	39.5	39.5

8. (+) Farmers have ability to conduct experiments on local pest management alternatives	Disagree	48.5	30.3*	52.9	20.6**	54.3	42.9	51.4	48.6	50	38.9*	44.7	18.4**	53.8	43.6	52.6	50
	Undecided	24.2	33.3*	29.4	14.7**	37.1	48.6	31.4	34.3	30.6	36.1*	42.1	26.3**	30.8	38.5	26.3	28.9
	Agree	27.3	36.4*	17.6	64.6**	8.6	8.6	17.1	17.1	19.4	25*	13.2	55.3**	15.4	17.9	21.1	21.1
9. (−-) It is bothersome to apply botanicals in seed storage	Agree	48.5	30.3*	52.9	20.6**	54.3	42.9	51.4	48.6	58.3	52.8	52.6	39.4*	56.4	53.8	57.9	57.9
	Undecided	24.2	33.3*	29.4	14.7**	37.1	48.6	31.4	34.3	19.4	11.1	31.6	26.3*	33.3	25.6	23.7	23.7
	Disagree	27.3	36.4*	17.6	64.6**	8.6	8.6	17.1	17.1	22.2	36.1	15.8	34.2*	10.3	20.5	18.4	18.4
10. (−) Practices of crop hygiene (cleaning infested plant parts) are labour intensive	Agree	57.6	51.5	50	44.1	62.9	54.3	54.3	54.3	63.9	58.3	36.8	39.5	51.3	43.6	52.6	52.6
	Undecided	30.3	21.2	20.6	17.6	20	20	28.6	28.6	27.8	30.6	42.1	15.8	41	35.9	23.7	26.3
	Disagree	12.1	27.3	29.4	38.2	17.1	25.7	17.1	17.1	8.3	11.1	21.1	44.7	7.7	20.5	23.7	21.1

Notes: (+) Indicates positive and (−) indicates negative statements. B denotes 'Before' and A denotes 'After'. Values (within the same learning group) with '*' being significantly different at $p < .5$; values with '**' being significantly different at $p < .01$, with the Wilcoxon sign rank test.

video, FPR participants expressed how they developed their botanical pesticide amidst scepticism, which when proven effective and not labour intensive, garnered the trust of the fellow farmers in the pilot villages. Much pride and collective spirit were developed through achieving this self-sustaining solution. Although not impossible, it was difficult to present and explain farmers' collective and innovative 'thinking' and 'doing' during conventional lectures. Captured on video, farmers' vernacular styles of telling their own success stories were more appealing than instructive and informative lectures. As a result, the number of farmers who agreed with the statement that 'farmers have the ability to conduct experiments' increased significantly in video villages.

Stimulating changes in pest management practices

Learning through video has improved the overall knowledge about reasons, procedures and benefits of botanical pesticide use. This approach has also significantly improved an understanding of the principles of botanical pesticide use and changed attitudes favourably. Sound understanding and a favourable attitude are important factors for influencing the decision to use a local pest management practice. However, these might not always be the main triggering factors for changing behaviour. Therefore, it is necessary to know whether and how the changes take place.

Results show that after watching the video, more women and men used the botanical pesticide in the field and seed storage with no change in the control villages and no significant change in the workshop villages (Table 5). While asked for the reasons for not trying the pesticide, a woman in the workshop villages replied,

> I wanted to prepare the pesticide but I forgot the name and amount of the plants to use. I could not write it down, since I am illiterate. I asked one of our group members but did not get satisfactory feedback.

Some other participants in the workshop villages also raised the question of ingredients and their amounts. Participants tried to follow the instructions of the demonstrations and when they could not remember they tried not to reflect or bother about it. Those who wrote down the procedures did not want to share with other members. There was no such challenge in video villages, where participants had the chance to watch the video several times.

Although effective in getting across the message, conventional lectures may have limited effect in changing behaviour, stimulating reflection and understanding principles of sustainable technologies. The video showed the spirit, motivation and creativities of the FPR participants in their vernacular styles of expressions complemented by scientific explanations. How is it possible to include those factors in a conventional lecture? These are key factors to drive people to try new ideas. A participant replied from the village with facilitated video show,

> I was surprised to notice that we also know the plants (. . .) but we never thought of trying out this way. (. . .) discussion also helped me to understand benefits of botanical pesticide. I prepared the pesticide in the next week we watched the video

The capability of an individual farmer and groups of farmers to innovate new ways to solve pest management problems as demonstrated through sequences of moving pictures led people to try new ideas. Video shows followed by facilitation additionally contribute by building their confidence about pest management innovations. More women and men started preparing the pesticide in villages where we conducted the facilitated video show. Women applied the pesticide in the

Table 5. Botanical pest management practices adopted by the respondents, before (November 2009) and after (September 2010) different types of learning sessions.

Botanical pest management practices	Women (%) adopted in different learning groups								Men (%) adopted in different learning groups							
	Video only ($N = 33$)		Video and discussion ($N = 34$)		Workshop ($N = 35$)		Control ($N = 35$)		Video only ($N = 36$)		Video and discussion ($N = 38$)		Workshop ($N = 39$)		Control ($N = 38$)	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. Preparation of botanical pesticide	18.2	33.3	17.6	44.1**	14.3	25.7	14.3	11.4	5.6	13.9	7.9	31.6**	2.6	10.3	5.3	5.3
2. Use of botanical pesticide and plants to deter pests in the field	21.2	54.5**	23.5**	70.6**	17.1	31.4	14.3	14.3	19.4	47.2**	15.8	57.9**	10.3	20.5	13.2	13.2
3. Application of botanicals in the seed storage	15.2**	45.5 **	11.8**	47.1**	5.7	17.1	11.4	14.3	8.3	19.4*	7.9	23.7*	2.6	10.3	7.9	7.9

Note: Values in the same row of the group with '**' are significantly different at $p < .01$, with the McNemar X^2 test.

homestead vegetable cultivation or the field close to their homestead. They also applied plants in the storage of seeds and crops. In general, men used the pesticide in their crop field.

More women in the villages with the facilitated video show compared to the control or workshop villages reported adopting only botanical pesticide (Table 6). There is also a significant change in the overall pest management approach in the video villages with no significant change in the workshop and control villages. Video alone proved effective in bringing out new ideas in people and opening up the possibilities of farmer experimentation. Discussion contributed by clarifying any confusion, doubt or scepticism.

Beyond adoption: impacts on capacity to innovate

The video provided options to work with biological and physical principles of botanical pesticides and elicited the spirit of collective actions but did not provide a 'one size fits all' prescription for the adoption of farmers' ideas.

Will a farmer who depends on synthetic pesticides be convinced by only hearing about the success of his/her fellow farmers' new ideas on botanicals? How is it possible that uneducated people are able to explain the mechanism and their methods of using plants in deterring pests? The video clarified mechanisms of 'why' and 'how' farmers' innovative thinking works and competitive advantages over other ready-made solutions available for pest management. Simple prose, moving images from daily life, coupled with scientific explanation of farmers' innovations were mirrors to reflect on similar skills of theirs that remained in-house. Women and men know from their experience that many other elements such as naphthalene and cattle urine inhibit pests. Only when they were exposed to the innovative experience of others through video did many of their own original capacities sprout up (Table 7). Participants in video villages applied their own ideas of adding naphthalene in order to increase repellent power and avoid the bad smell of the fermented extract. They also used the idea of burying the pot covered with a lid in the soil to facilitate quick fermentation and avoid unpleasant odours. Some farmers added cattle urine, which they knew from their experience to have pest-repellent characteristics and to be a plant nutrient supplier. Some of them used medium-sized clay pots (called *motka*) to produce large amount of pesticide (e.g. 20 litres) in groups. Women and men also started adding more plants, which were different from what had been shown in the video. The plants include *nishinda* leaves (*Vitex negundo*), *kamntigi* or *nakhful* (*Impatiens balsamina*), drumstick (*Moringa oleifera*), black pepper (*Piper nigrum*), papaya (Carica papaya) and touch-me-not (*Mimosa pudica*).

Interview data with the participants indicated that there is continued motivation about botanical pesticide innovation in video villages, compared to workshop villages. In video villages, there was a reciprocal sharing of the pesticide between members who prepared it and those who did not. As a result, more men and women had a chance to apply the pesticide. They also exchanged the video disk (CD) with other non-members in the village. Interviews revealed that a member shared the CD with one of her relatives, who prepared the pesticide after watching the video. Video helps people to reflect and get inspired to try new ideas. Men's groups started using the pesticide in rice – the staple crop grown in three seasons.

In most cases, farmers (both men and women) swap the pesticide with their fellow farmers. On the second or third instance, they charged fellow farmers a small amount of money per litre of the product. Participants reported that most other farmers were willing to pay for their innovations. This created an entrepreneurial potential of the innovations in some video villages. After watching the videos, and observing farmers' interest, local pesticide dealers also became interested about the entrepreneurial aspects of the botanical pesticide. Farmers reported that a local pesticide dealer collected about 200 L of pesticide from three video villages. This implies

Table 6. Changes in pest management approaches, before (November 2009) and after (September 2010) different types of learning sessions.

Pest management approaches	Women (%) adopted in different learning groups								Men (%) adopted in different learning groups							
	Video only ($N = 33$)		Video and discussion ($N = 34$)		Workshop ($N = 35$)		Control ($N = 35$)		Video only ($N = 36$)		Video and discussion ($N = 38$)		Workshop ($N = 39$)		Control ($N = 138$)	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Only chemical pesticide	78.8	45.5**	76.5	32.4**	82.9	74.3	85.7	85.7	77.8	41.7**	81.6	34.2**	89.7	76.9	84.2	84.2
Chemical, botanical pesticide and other alternatives	21.2	39.4 **	23.5	41.2**	17.1	25.7	14.3	14.3	22.2	50**	18.4	44.7**	10.3	23.1	15.8	15.8
Only botanical pesticide and other alternatives	0	15.2**	0	26.5**	0	0	0	0	0	8.3**	0	21.1**	0	0	0	0

Note: Values in the same row of the group with '**' are significantly different at $p < .01$, with the Wilcoxon sign rank test.

Table 7. Adaptation of botanical pesticide innovation in different learning sessions.

Innovative ideas for botanical pesticide	Reported in different learning groups: Video	Video and discussion	Workshop
Adding naphthalene to the pesticide	+	+	−
Adding different plants	+	+	−
Using mud pot (called motka) to prepare large amounts of pesticide	+	+	−
Bury the pots under the ground to facilitate quick fermentation and avoid odour	−	+	−
Using dried fresh plant parts in the storage	+	+	+
Adding fermented cattle urine	+	+	−

Note: (+) sign indicates respondents of the groups reported and (−) sign indicates respondents of the groups did not report.

that video-mediated learning provides a leverage to facilitate communication among a wider set of actors in the system, and draw upon their support.

Discussion and conclusion

The findings suggest that the video-mediated learning session is more effective than conventional lectures to convey new ideas of FPR participants and improve fellow farmers' KAP about complex local agricultural innovations. In contrast, a conventional workshop is less effective in creating a learning environment that mediates changes in perceptions, attitudes and practices of learners. Video creates an environment that generates experiential learning by conveying ideas, motivations and commitment to the subject among peer farmers. This encouragement influences learners' existing perceptions, values and practices.

Earlier studies on local rice seed innovation practices in Bangladesh and Benin indicate that videos developed based on a few well-selected local innovations were able to explain underlying biological and physical principles (Van Mele, 2006). The more the principles resonate with farmers' perceptions, the more video becomes useful as a stand-alone method. The findings of this study correspond with those findings. Also, in Bangladesh, farmers who operate in a highly variable and risky environment often receive contradictory information about chemical pesticide use in crop cultivation, mostly from the actors working in agricultural markets such as pesticide dealers (Mohiuddin et al., 2009; Robinson et al., 2007). Although they perceive little marginal benefit, they use chemical pesticide as insurance to reduce or eliminate risks. This study indicates that farmers may interpret the key principles behind botanical pesticides in different ways even though they understand and agree with the views of other stakeholders such as retailers or scientists. Lee (2005) mentioned different sustainable agricultural practices and found that farmers' decision-making behaviour about pest management innovations is intricate by nature. Farmers who appeared in the video were of similar backgrounds to their peer learning groups in video villages. Nevertheless, their new ideas and motivations might not necessarily correspond with the perceptions and attitudes of the learners. Video, however, proved effective in initiating learning opportunities for an individual outside his/her comfort zone with regard to the cognitive dissonance created by messages that contradict their existing practices (Heong & Escalada, 1997). Visual cues, farmers' words from everyday life, humour and creative thinking helped to mirror the tacit knowledge of other women and men. In this respect, the findings partly correspond with the results of other studies that used videos to stimulate learning of rural development professionals dealing with complex problems such as coastal management and HIV in a classroom situation. These studies highlight potential use of video in initiating learning through critical reflection (Witteveen & Lie, 2009; Witteveen et al., 2010).

Development of an effective farmer learning tool is a significant challenge for sustainable pest management programmes in low-income countries. Message-based extension and communication approaches for sustainable agriculture focus on the end result of farmers' decision-making behaviour (Meir & Williamson, 2005). In contrast, learning-centred approaches affect farmers' decision-making processes. In the former approach, the message is considered as 'heuristic' or 'rule of thumb' to influence a decision about adoption. The latter approach focuses on whether farmers are willing and able to make informed decisions, the ultimate goal being adaptation rather than adoption of a message (Meir & Williamson, 2005; Van de Fliert, 2003). Our findings support that video is useful for both approaches. With respect to adoption, our findings are similar to how multi-media campaigns (leaflet, poster and radio) have been used successfully in changing the rice pest belief system among Vietnamese farmers (Heong, Escalada, Huan, & Mai, 1998). The campaign was based on one simple rule of thumb, 'do not spray insecticides for leaf folder control in first 40 days after sowing'. The programme reached out to about two million farmers. Although the media campaign was successful in modifying farmers' beliefs, the use of media coupled with FFS and radio drama programmes further developed and transformed the message to be more effective (Heong et al., 2008; Huan, Mai, Escalada, & Heong, 1999).

The findings also confirm that video mediates learning that helps men and women in reconciling perceptions of other farmers about problems, and solutions. In the video, we have shown options of how they could be benefitted using innovations of their fellow farmers, who applied the pesticide in vegetables grown in the field and homestead, and in the storage. When they grasped how other men and women facing similar realities were creative in developing solutions they started including their own creative thinking. Respondents in video villages adapted the innovations, as opposed to farmers in workshop villages who tried to adopt the messages. As such, learning in video villages was more effective in building farmers' capacity of innovation – that is their ability to combine and put into use different types of knowledge and be part of facilitating those ideas in their community and networks. Women, as motivated and stimulated by watching others women in the video, started applying the innovations in their small-scale homestead vegetable cultivations and seed storage, which is gender-segregated women's work in Bangladesh. It follows that video is an effective means to create images and ideas born from other farmers' experiential learning. Videos stimulate changes that accommodate to the individual's reality (e.g. women apply pesticide in the field near the homestead). This situation could be related to why the impact of most FPR initiatives remained dormant due to externally driven initiatives that were mismatched between scientific and local knowledge and skills, and lack of suitable communication (Bentley, 1994; Hall & Nahdy, 1999; Van Asten, Kaaria, Fermont, & Delve, 2009). Video proved effective to overcome this limitation and scale out local innovations.

Why is it necessary to support farmer-to-farmer exchange of local innovation using media? For more than five decades, studies have confirmed the inherent weaknesses of farmer-to-farmer extension. Specifically, the quality of the message deteriorates when agro-ecological concepts and principles are too complex for farmers to share with others. Farmers may lose the control of messages when they highlight key benefits and processes. As well, they may be biased in conveying the information, and consider key messages as farm secrets (Aktar, Chowdhury, Zakaria, & Vogl, 2010; Huque, Chowdhury, & Saha, 2008; Kiptot, Franzel, Hebinck, & Richards, 2006). Even innovative face-to-face extension approaches such as going public are effective only for simple messages supported by visual evidence (Bentley, 2009). Face-to-face extension can be of high quality, but it is often costly, and unable to reach those people who may need it (Bentley et al., 2003). For instance, it is a challenge to reach the extensive numbers of disadvantaged people (e.g. resource-poor women and the illiterate) and strengthen their capacity in a country like Bangladesh (Chowdhury, 2010; Chowdhury, Hambly Odame, & Leeuwis, 2014). With respect to reaching more marginalized audiences, the results of this study complement findings of other studies done on rice seed production and post-harvest innovations using video which have focussed specifically on women farmers (Zossou et al., 2009a; Zossou et al., 2009b). Our study included a comparison of video-mediated learning between men and women and found that video-mediated learning is equally effective for strengthening innovation capacity of both men and women. The findings found the gender division of labour to be relevant to farmers' knowledge in some situations such as seed storage, while new knowledge was taken up by both male and female farmers without gender role limitations.

Moreover, the findings support that video can be effectively used to support innovations (e.g. pest management), which are built on complex agro-ecological principles, and require explication of intuitive, normative and biased perception and attitude among farmers. Literacy was not a limiting factor when video could be reviewed and discussed in depth. Since we did not include images of necessary biological and agro-ecological processes, there is still scope to strengthen the learning potential of video by including animation and visuals of agro-ecological interactions (e.g. life cycles, predatory behaviours of beneficial insects). Also, in this study, video alone mediated a substantial degree of reflection and learning, but with facilitation there was an unexpected and additional benefit of uncovering evidence and opening up concerns among farmers and their relationships with other stakeholders (e.g. pesticide businesses).

This study provides substantial evidence in favour of our hypothesis that video complements the participatory and face-to-face extension approach to reach out to disadvantaged farmer groups (smallholder women and men) more rapidly and enhances their capacity to innovate local pest management practices. The video-mediated learning approach is recommended as a continuous process of refining and/or developing the video. This can be done by including relevant innovations (e.g. ideas and messages to clarify confusions and remove doubts) stimulated in villages of both primary and secondary scaling out targets (Figure 1). Furthermore, it is recommended that future research explore the possibilities to scale out local innovations using video, both along local uptake pathways and in combination with other media such as radio, television and mobile technologies (Bentley, 2009; Okry, Van Mele, & Houinsou, 2014; Van Mele, 2011). Throughout South Asia, including Bangladesh, there is a remarkable opportunity opening up due to growth in both 3G and new 4G networks. 'Radio plus' efforts are enabling radio stations to collect, comment on, webcast and archive local content from farmers (Chowdhury & Hambly Odame, 2013). Streaming of video online and posting video discussions stimulates a wide set of interactions with synchronous and asynchronous feedback among stakeholders. In the YouTube channel alone, every minute 100 hours of videos are uploaded and archived making them available for continuing dissemination through social media, commentary and use (YouTube, 2013). In this respect, it is not difficult to imagine that technological innovations (e.g. 3G network, Smartphone for video viewing and social networking services) and institutional innovations will include video-mediated learning to support extension and knowledge mobilization services for sustainable agriculture in Bangladesh and elsewhere.

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