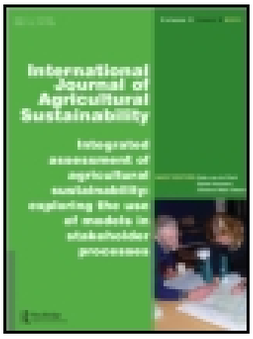

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Towards sustainable vegetable growing with farmer learning videos in Benin

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ABSTRACT

Vegetable production plays an important role in nutrition, food security and poverty reduction in Benin. However, vegetable production is hampered by pests and farmers rely on pesticides to control them. Improving farmers' knowledge is important for the use of sustainable, intensive agricultural practices. This paper assesses the role of learning video in changing vegetable farmers' behaviour towards sustainable agriculture. Drawing mainly on mass distribution of learning videos, DVDs entitled 'Improving vegetable production' were sold through non-conventional dissemination networks from August to December 2015, to strengthen farmers' learning. In June 2016, we interviewed a sample of 120 buyers/viewers in four different areas where the DVDs were sold. The interviews were followed by a field visit to collect evidence of the change of practices reported during the interviews. Farmers who watched the videos enhanced their creativity and adapted the learning to their environment by using more sustainable agriculture practices. About 86% of respondents indicated that they now spend less money for pesticides to manage pests and diseases. Video-mediated learning promotes local innovation, improves farmers' knowledge and triggers agro-ecological practices with little or no input from the conventional extension system.

KEYWORDS

Learning videos; agricultural advisory services; knowledge acquisition and dissemination; behavioural change; sustainable agriculture

Introduction

Vegetables are essential for a healthy and balanced diet. High-value vegetables are, however, highly susceptible to pests and diseases, so these crops are sometimes subjected to the intensive use of pesticides including insecticides, fungicides and herbicides. In Africa, farmers use more pesticides on vegetables than on traditional staple food crops such as cereals, cassava and rice (Martin, Assogba-Komlan, Houndete, Hougard, & Chandre, 2006). Farmers often use agrochemicals with little understanding of their impact on human health and the environment. They also have imperfect knowledge of the safe handling, storage and use of pesticides (Matthews, 2008; Williamson, 2005). In Benin, farmers used larger volumes of pesticides on vegetables than on cotton and the excessive use of synthetic pesticides has negative effects not only for the effective pest control but also for the environment and human health (Williamson, Ball, & Pretty, 2008).

Farmers' health is an important concern for policymakers when looking at the economic efficiency of vegetable production (Ngowi, Mbise, Ijani, London, & Ajayi, 2007). Several policies aimed at reducing the use and dependence of vegetables on synthetic pesticides are encouraged and focused mainly on 'ecological pest management' which is defined as a production system which relies on ecological processes, biodiversity adapted to local conditions and the use of on-farm and local inputs (Martin et al., 2006). Several studies found that this method is less successful than initially hoped because of farmers' limited knowledge and capacity (Pretty & Bharucha, 2014; Toleubayev, Jansen, & Van Huis, 2011).

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Therefore, improving farmers' knowledge and capacity development is key for encouraging sustainable agricultural practices which contribute to environment protection and human health (Pretty & Bharucha, 2014). Furthermore, the global concerns about the impacts of agrochemicals have expanded over time to include others, such as animal welfare, food safety, energy use, landscape, biodiversity and climate change (Oosterveer & Sonnenfeld, 2012). In view of growing challenges of enhancing sustainable food production when faced with climate change, the Food and Agriculture Organization of the United Nations (FAO) noted that agro-ecological conservation agriculture practices can facilitate human adaptation to a warming climate while building more resilient agricultural systems and contributing to the eradication of hunger and poverty (FAO, 2016). However, water is the limiting factor for agricultural adaptation to climate change. Access to irrigation reduces the vulnerability caused by seasonality and allows farmers to diversify their farms (Hussain, Giordano, & Hanjra, 2003). Drip irrigation applies water directly along the crop rows through small drippers: very efficient for water management and to improve vegetable yields (Venot et al., 2014). Thus, disseminating drip irrigation system would be a sustainable solution to adapt to a warmer, dryer climate.

Drawing lessons from traditional extension systems, which are now understaffed and less able to cope with the changing and dynamic demands of modern and sustainable agriculture (Rivera & Zijp, 2002), various agricultural research and development projects use Farmer Field Schools (FFS) as a participatory approach to enhance sustainable agriculture by encouraging farmers' learning and innovations (Nederlof & Odonkor, 2006; Van den Berg & Jiggins, 2007). But several authors have suggested that FFS for pest management have limited success in farmer-to-farmer exchange of learning outcomes and spill-over effects beyond those farmers trained directly by the FFS (Bentley, 2009; Davies, 2006).

The challenge for this research was to find a suitable, alternative agricultural extension and communication method to support farmers' capacity of innovation by dealing with pest, soil and water management, to promote conservation agriculture and reach out to more smallholder farmers. To this end, the farmer-to-farmer training video has been developed as a communication method over the years (Bentley, Chowdhury, & David, 2015; Van Mele, Wanvoeke, & Zossou, 2010). Some videos, available in local languages, were made according to the zooming-in, zooming-out method, which identifies problems that have a broad geographical relevance, then zooms in on solutions which are scientifically sound and which have been used by real farmers who show their innovations and explain them on the video (Van Mele, 2006). The farmer-to-farmer training video has gained importance in agricultural extension services across Africa (Okry, Van Mele, & Houinsou, 2014; Van Mele et al., 2010) and has started to receive attention from donors in the agricultural sector (Zoundji, Okry, Vodouhê, & Bentley, 2016). Despite the success of this communication tool, many still consider this media to be non-interactive and unable to convey the complex agro-ecological knowledge that is required to support farmers' behavioural change towards sustainable agriculture. Chowdhury, Odame, Thompson, and Hauser (2015) wrote that video shows accompanied by facilitation enhance farmers' knowledge about botanical pesticides, yet evidence is still lacking as to whether videos without facilitation can also build farmers' agro-ecological knowledge and enhance farmers' experimentation through their own learning initiative. This paper assesses how videos triggered vegetable farmer behaviour change for using conservation agriculture practices and drip irrigation equipment in Benin, where there are few extension workers and a lack of policy to take advantage of information and communication technologies (ICTs) in the agricultural sector.

Theoretical framework

Many studies have addressed why and how people adopt technologies and new practices (Leeuwis, 2004). A well-known model of technology adoption/diffusion proposed by Rogers (1995) identified the relative advantage, compatibility, complexity, trialability and observability as characteristics which determine the rate of innovation adoption. As an innovation involves new ways of doing things (or doing new things) or the application of all types and sources of knowledge to achieve desired social and/or economic outcomes (Hall, 2005; Leeuwis, 2004), the decision to adopt an innovation is a mental process consisting of five stages: knowledge, persuasion, decision, implementation and confirmation (Rogers, 1983). While Rogers' model is useful in revealing the social, economic and personal characteristics of adopters, its focus on individual characteristics of

farmers rests on the assumption that adoption of innovation is an individual effort and process. However, Leeuwis (2004) argues that the adoption of innovation is not an individual process but results from a coordinated effort and action in a network of interdependent actors.

There has been a shift in thinking from looking at adoption of innovation; Röling (1992) describes the emergence of knowledge systems thinking, in which an articulated set of actors, networks and organizations are expected or managed to work synergistically to support knowledge processes. In this system of knowledge development, farmers are experts on their own farm and take decisions based on knowledgeable interference from observation and analysis through social learning (Röling & Jiggins, 1998). By supporting this knowledge systems thinking, Leeuwis (2004) found that the role of communication and learning is crucial in the development of knowledge, attitudes and perceptions (KAP) about agricultural innovations. Environmental, social and didactic learning which encourage farmers' experiments was also suggested for small-scale farming knowledge development (Stone, 2016). Another way of accessing adoption of innovation was proposed by Kolb (1984) through 'experiential' learning, referred to 'learning by doing' or 'discovery learning': conclusions drawn by farmers on the basis of their own experiences tend to have a greater impact than insights formulated by others.

The theories mentioned above lead to the development of an analytical framework which emphasizes the role of KAP in the decision-making process of technology adoption. We used *ex ante* and *ex post* approach (Tin et al., 2010) to assess vegetable farmers' practices changes in KAP. KAP are key variables to explain behavioural change for innovation (Röling, 2005) in the context of soil fertility decline and pest development because of intensive vegetable growing due to the small land holding and poor management of water. Farmers' decision-making towards alternative pest, soil and water management will be crucial for the adoption of sustainable agriculture technologies because farmers rely mainly on the intensive use of mineral fertilizers, chemical pesticides and water cans for vegetable growing. As video has the power and capacity to stimulate behaviour change (Chowdhury et al., 2015; Zossou, Van Mele, Vodouhe, & Wanvoeke, 2009), promoting sustainable agriculture technologies using video will contribute to innovation which is the application of knowledge to achieve desired social and economic ends (Hall, 2005; Leeuwis, 2004). In this paper, we ask if the video can provide a real enough experience to stimulate farmers to investigate sustainable vegetable-growing practices.

Materials and methods

The study was conducted in four municipalities (Sèmé-Podji, Cotonou, Ouidah and Abomey-Calavi) of south Benin. These are the major zones of vegetable production in urban and peri-urban Benin where soil-borne diseases, nematodes, mining insects, thrips and various aphid species are major pests (Adégbola & Singbo, 2001; Perez et al., 2017). Generally, vegetable farmers used pesticides prophylactically to prevent the occurrence of plant health problems. Pesticide use in vegetables is much more intensive than in other crops.

This study area lies along the Atlantic Coast and stretch between 1°45′ and 2°24′ E and 6°15′ and 7°00′ N to the west and 6°15′ and 7°30′ N to the east (Akoègninou et al., 2006). The DVD used as a research material was a compilation of a comprehensive series of nine farmer-to-farmer videos on vegetable growing, available on the website of the international NGO Access Agriculture and freely downloaded from the website www.accessagriculture.org. With permission and support from Access Agriculture, the selected videos were compiled as a digital video disc (DVD) titled 'Improving vegetable production' with a language menu that allowed the viewer to watch the videos in French, English and in three major West African local languages Fon (spoken in Benin), Yoruba (spoken in Benin, Nigeria and Togo),and Bambara (spoken in Mali).

The videos show all the different steps from nursery management, field operations, harvesting and post-harvest handling and finally processing. The content of these videos is focused on sustainable agriculture practices and drip irrigation techniques. Various underlying scientific principles of technologies and local innovations are explained by a narrator in easy-to-understand language, interspersed with farmer interviews. In each video at least four experienced men and women farmers show and explain the techniques. The videos can be watched in any order, and each one can stand alone. From August to December 2015, copies of 'Improving vegetable production' DVDs were made and sold at a subsidized rate to entertainment DVD vendors, agro-input dealers, a vegetable seller and a taxi-motorcycle

driver. Collaborating vendors were invited to sell the DVDs through their commercial outlets in southern Benin. Locally produced entertainment DVDs cost about $2 or $4 USD, and we suggested selling each farmer learning DVD for a minimum of $1. Each distributor was rewarded at $0.40 per each DVD sold as a motivation to collect the requested data. Any surplus above $1 went to the seller.

In June 2016, a snowball sampling procedure (Vogt, 1999) was used to reach 30 vegetable farmers who viewed the videos, based on their willingness to meet during the field survey period in each municipality where the videos were sold. In each municipality, we started by collecting qualitative data through focus group discussions to get an idea of the level of knowledge of our informants about ecological or organic farming, and their ability and willingness to engage in sustainable agriculture. Based on insights gained from this qualitative learning phase, we formulated a semi-structured questionnaire which allowed for broader discussions on challenges and opportunities for learning through training videos. We interviewed in total 120 vegetable farmers followed by a visit to their fields to collect evidence of the change of practices. Farmers' knowledge towards sustainable agriculture (ecological or organic agriculture) was investigated through simple-dichotomy statements (yes or no) while the practices were measured through frequency-determination statements (never, once, and more than once). The questionnaire was pretested to validate the questions. All collected qualitative data were analysed using thematic trends in respondents' statements, a formal method in ethnography (Sanjek, 2000). We used quotes to bring respondents' views into the analysis either as testimonies or as concluding statements.

Results and discussion

Respondents' socio-demographic characteristics

Table 1 shows the socio-demographic characteristics of the respondents by age, gender, education and experience in vegetable production. Table 1 reveals that most (72.5%) of the respondents were between the ages of 20 and 40, with an average of 28.4 years. Vegetable production is youth dominated and young farmers are comfortable using digital ICTs. Most of the respondents were male (65.84%), in large part because men have more money and more freedom to travel and buy things than women. However, women are highly involved in vegetable production activities, albeit mostly in their husband's field. Table 1 shows also that almost half of the respondent (45%) never attended formal school or only completed primary school (32.2%). This highlights the importance of making training materials in the farmers' own language (Mundy & Sultan, 2001). Most of the respondents had an experience of 3–10 years (55.84%) in vegetable production. The socio-demographic information such as age, gender and education is one of the important demographic factors that can contribute to the knowledge and practices of farmers (Sarker, Itohara, & Hoque, 2010; Seyed, Hosain, Khalil, Yaser, & Abbas, 2010).

Table 1. Respondents' socio-demographic characteristics ($n = 120$).

Characteristics		*n*	Percentage
Age	20–40	87	72.5
	41–50	25	20.84
	51–60	08	6.66
Gender	Male	79	65.84
	Female	41	34.16
Education	No formal schooling	54	45
	Finished primary school (6 years)	39	32.5
	Finished first level of secondary school (4 years)	18	15
	Finished second level of secondary school (3 years)	6	5
	Any level of university	3	2.5
Experience in vegetable production (in years)	3–10	67	55.84
	11–20	39	32.5
	>20	14	11.66

Source: Field data, 2015–2016.

Farmers' sources of agricultural information

As farmers' sources of information shape the kind of decisions they make (Leeuwis, 2004), farmers' sources of agricultural information were assessed for vegetable farmers (Table 2). These sources were evaluated by presenting respondents with a list of sources extracted from the literature and after discussion with resource persons like the Director of Innovations and Agricultural Advisory services from Benin Ministry of Agriculture. We asked informants to indicate which sources they use for accessing information on farming activities.

Informal networking (peers, relatives, other farmers, etc.) is the most important source of information used regularly by 100% of respondents.

Table 2. Sources for agricultural information.

	$n = 120$		
Information sources	Never (%)	Occasionally (%)	Regularly (%)
Research and agricultural extension services	17.5	48.33	34.17
NGOs	10	62.5	27.5
Agro-input dealers	2.5	21.66	75.84
Informal networking (peers, relatives, other farmers) and farmers association	00	00	100
Training videos	95.84	4.16	00
Local radio/television	94.16	5.84	00
Online information (Internet)	95.84	4.16	00

Source: Field data, 2015–2016.

Agro-input dealers, NGOs and research and agricultural extension services were used by farmers either regularly or occasionally as sources of agriculture information. The fact that farmers were not regularly receiving agricultural extension services (37%) and relied heavily on informal networking (100%) and agro-input dealers (76%) could help explain why farmers were motivated to learn through videos. This is supported by Dutta (2009) and Zoundji et al. (2016), who found that people mainly rely upon non-conventional or informal social networks to meet their information needs. Farmers' social network is like a conduit of information which can influence other farmers to change their practices. Less used sources of information by our informants were the internet (4.16%), training videos (4.16%) and radio and television (5.84%). This could reflect the lack of availability of ICT resources or the lack of appropriate training video dissemination mechanisms in the study area.

Even, though small-scale farmers seldom pay for agricultural information in Benin, the entertainment DVD vendors, the agro-input dealers, the vegetable seller and the motorcycle-taxi driver were able to sell 669 learning DVDs within five months, and people were very motivated to watch them (Zoundji et al., 2016). The clients include farmers (58%), officials and private sector (27%), researchers, students and parents of students (11%), farmers' organizations, NGOs and agricultural extension workers (4%). Farmers are eager to obtain training videos and are motivated to pay for them once they realized that the content was relevant (Zoundji et al., 2016). Respondents purchased the videos from vendors of entertainment DVDs (25.83%), agro-input dealers (47.5%), vegetable sellers (7.5%) and a motorcycle-taxi driver (4.16%), while 9.16% received the videos as gifts from friends or relatives and 5.16% did not have their own videos but have watched them with friends. About 11% of respondents (farmers) said they were eager to be involved in selling the training DVDs. This implies that farmers are motivated to engage in entrepreneurship.

Farmers' knowledge, perceptions and attitudes

As access to agricultural information is important in the development of KAP regarding innovation, most of the respondent (96%) found the content of videos extremely useful. After watching the videos, they realized that they were over-spraying agrochemicals to control nematodes. Though the videos did not show spraying, experienced farmers in the videos showed how to control nematodes with alternative techniques. This is in line with Meijer, Catacutan, Ajayi, Sileshi, and Nieuwenhuis (2015) and Zoundji et al. (2016) who found that the information a farmer has about a new technology forms the basis of his perceptions and attitudes towards the technology. Most of the respondents (85%) had a favourable perception towards sustainable agriculture. But all of the respondents often use agrochemicals with little understanding of their impact on human health and the environment as Aristide, a vegetable farmer, at Abomey-Calavi.

> Before the video training, I used to manage nematodes, pests and other diseases by using any agrochemicals I could get hold of. I just needed to see insects and pests in the field to unleash a treatment. But after watching the video, I realised how wasteful and harmful I have been because I did not have the appropriate knowledge. I found how farmers spend money unwisely in the purchase of agrochemicals while endangering their health and the environment.

Emile, another vegetable farmer at Ouidah, emphasized how much he had gained from the training videos:

> We all (my wife, children and me) love your videos and found the videos very useful. Even my children know now how to manage nematodes. From a DVD of nine useful videos bought at 1 USD, I made real benefits in reducing the cost of agrochemicals in the vegetable production and obtained good quality and yield.

The testimonies showed that small-scale farmers applied knowledge acquired from training videos and drew their own conclusions through innovation. These conclusions drawn by farmers on the basis of their own experiences could have a greater impact

on them than insights formulated by extension workers or researchers on the basis of experiences that learners cannot identify with. This confirmed that the training video is an extension tool which promotes emulation and enhances experiential learning where farmers learn in an inductive way from action. As ecological pest management (EPM) is encouraged to reduce the use and dependence of synthetic pesticides (Pretty & Bharucha, 2014; Toleubayev et al., 2011), training videos could be an alternative method to improve farmers' knowledge and capacity development on EPM. Most respondents (89%) believe now that certain plants like papaya, and banana can encourage the development of nematodes in the vegetable fields and found the video-mediated learning approach very persuasive. Furthermore, this method increases farmers' attentiveness and attraction during the learning processes.

This study revealed that farmers usually applied pesticides up to seven times or more per cropping cycle or season depending on the type of crop. This is in line with Ngowi et al. (2007) who showed that vegetable farmers did not receive adequate agricultural extension services and were lacking knowledge in pesticide use. Before watching videos, most of the respondents were aware of the risks that pesticides can pose to health. However, they continued to treat their crops without any form of protection. But after watching training videos and applying knowledge acquired, about 86% of respondents declared that they were now using fewer agrochemicals and spending less money to manage pests and control diseases. During the interview period, farmers were principally harvesting tomatoes, and Mr David, a farmer at Sèmé-Podji, shared with us how he had reduced the use of external inputs on his farm. He said:

> To grow tomatoes on a 400m2 plot, I often used for example 1 kg or 1.5 kg of TOPSIN M (fungicide), 1 to 2 litres of K-Optimal (insecticide), 2 kg of Diafuran 5G (nematicide) and about 30 kg of NPK (fertilizer), but since September 2015 I started applying the knowledge from the videos. I'm progressively reducing the external input. For this season, I used 0.5 kg of TOPSIN M, 0.5 litres of K-Optimal, no Diafuran 5G and 10 kg of NPK and the tomato yield is still the same as before videos, but now they keep longer than before videos. This is the third time I've harvested on this plot after applying knowledge from videos.

This statement showed the concrete and simple way by which farmers evaluate the savings in pesticide expenses and how they realized that they spend less money on the pesticides to manage pests and diseases. External input used decreases progressively with each growing season since farmers have started applying conservation practices. Thus, when farmers use less external inputs, they spend less money. Also, when farmers said 'the tomatoes yield still the same like before videos', we can conclude that the quality of the pest control has not decreased even though the use of external inputs has declined. However, farmers recognized that conservation agricultural technologies application need more time than conventional agriculture.

Another woman farmer at Cotonou, Madam Pauline said:

> This is my third vegetable cropping season with video learning, and I noticed from my own experience a decrease of pesticides, and mineral fertilizers when I applied various land and seed bed preparation techniques on purpose, intercropped (a single bed holds three different vegetable for example), crop rotation, soil fertility based on farmyard manure and compost. Some years ago, I heard from Glégan (an extension agent) that these practices are good for the health and economically more profitable than conventional practices. But I did not care. When I heard same things from farmers like me in the videos and saw their practices, I was more convinced and starting experimenting on about 500 m^2 of land and the results are what you are seeing. This production system takes much more time; they do not need lot money for pesticides and fertilizers than the conventional production system.

This study was carried out three vegetable-growing seasons (less than one year) after farmers starting watched videos. This is enough time for farmers to have tried the innovations several times. Two or three years previously, some of the farmers heard from extension services that agro-ecological practices were good for the health and more profitable than conventional practices. Farmers did not find the information convincing when they heard it from extension agents, but they did believe the videos. Videos stimulate learning and facilitate more experimentation for change than face-to-face extension carried out by extension worker.

Learning videos help farmers to reduce the production costs and grow better vegetables which can be stored and preserved fresh for a longer time than conventionally grown produce. 'Learning by doing' or 'discovery learning' (Kolb 1984) supported the way farmers observed the decrease in pesticide use and evaluated the savings in pesticide cost which influences their decision to adopt sustainable

practices. For example, FFS in Mali provided farmers with training on alternative methods of pest control and enabled cotton to be grown three times more cost-effectively than farms that purchased and used synthetic pesticides (Settle, Soumare, Sarr, Garba, & Poisot, 2014). Learning video persuades farmers to adopt good agricultural practice and to change their behaviour with agrochemicals. Learning videos provide visual evidences of the over use of agrochemicals and show how farmers could save money, and control pests and diseases. When farmer explored new alternatives and became convinced; their perception changed and could lead to the sustainable adoption of innovation. In this study, farmers adapted their pest management practices following knowledge acquired through learning videos. Learning videos can improve farmers' knowledge and trigger agroecological practices. As Bentley et al. (2017) observed in Mali, people watched striga videos and improved their understanding of striga's biology and effects. Video is capable of communicating complex issues such as the biological and physical processes that underlie innovations related to pest management innovations. Farmers who watched the videos enhanced their creativity by making, for example, their own drip irrigation kit using locally available materials hence adapting the learning to their environment. Table 3 shows some EPM practices adopted by farmers after watching the videos.

This study also revealed some organizational and technological innovations triggered by the video on 'drip irrigation for tomato', one of the nine videos on the DVDs. In that video, farmers explained the benefits and challenges of a low-cost drip irrigation system and show how such a system is set up. Since August–September 2016, about 33% of agro-input dealers involved in distributing the DVDs have started selling the drip irrigation kit because of an increased demand for it. This positive and proactive reaction by agro-dealers, to actually sell drip irrigation equipment as seen on the videos shows that dealers will respond to market demand created by learning videos. It is remarkable because in previous experiences with many development projects, most farmers stop using drip irrigation as soon as development projects ended (Wanvoeke, Venot, Zwarteveen, & de Fraiture, 2015). This is because most projects prefer working with groups of farmers, but the groups fall apart when the project is no longer there to hold the group together. Development projects should offer room for farmers to experiment with novel technologies, like drip irrigation, and working in groups may be the easiest way for the project to get a critical mass of farmers together, and to start engaging with the private sector for the project sustainability. Yet there must also be engagement with the private sector, such as equipment suppliers.

Before watching the videos, all respondent used the watering can which provides a simple and accessible irrigation technique and is widely practised by farmers for vegetable production in the study areas. This technology requires low investments, but it is labour intensive and allows irrigation of only a small garden (FAO, 2014). After watching videos, all respondents (Table 4) were willing to invest in drip irrigation and 17.5% of them already bought the kit which costs about $500. About 6% of respondents had made their own drip irrigation kit (Figure 1) using buckets and some old hoses. In many African countries, development actors promote drip irrigation to save water

Table 3. Practices changes ($n = 120$).

Some ecological pest management practices developed in videos	Before watching videos (*ex ante*, %)	After watching videos (*ex post*, %)
Rotate crops to control weed, pest and improve soil fertility	15.8	91.7
Use compost to improve soil fertility	25.0	96.7
Protect the seedlings from pests and animals by putting an insect net over the seedbed	0	55.8
Use resistant plant varieties to reduce damage to plants	39.2	99.2
Use mucuna to cover crop and revive degraded soil	0	4.2
Spend less money in the pesticides to manage pests and diseases	0	85.8

Source: Field data, 2015–2016.

Table 4. Practices towards water management ($n = 120$)

Item	Before watching videos (ex-ante, %)	After watching videos (ex-post, %)
Motivation to buy drip irrigation kit	3.3	100
Farmers bought drip irrigation kit and set up	0	17.5
Farmers made their own drip irrigation kit using local product (see Figure 2)	0	5.8

Source: Field data, 2015–2016.

Figure 1. Farmers' innovation. Source: Field data, 2016.

(Woltering, Pasternak, & Ndjeunga, 2011). In southern Benin where this research was carried out, water is plentiful and available in shallow wells, but farmers like drip irrigation to save time and labour. So even without the handsome drip irrigation kit presented in the video (Figure 2), farmers saw the value of it and made the concept work using their own resources. This is in line with Hall (2005) and Leeuwis (2004) who defined an innovation as new ways of doing things or 'doing new things' or application of all types and sources of knowledge to achieve desired social or economic outcomes. Farmers who could not afford the kit of drip irrigation came up with their own innovations and were proud of them. Thus, the learning video triggered farmers' creativities to adapt basic principles of improved technologies to the local context. Zossou et al. (2009) also emphasized that farmer's innovations are often shaped by capital limitations, and mainly rely on locally available resources, especially knowledge.

Conclusions

Smallholder vegetable farmers lack certain kinds of knowledge of ecological farming before watching the training videos. They often believe that the only solution to pest problems is to spray more frequently and to use different types of pesticides. This could also be attributed to the almost total absence of extension services (34% regularly and 48% occasionally) and training since farmers rely primarily on informal networking and agro-input dealers' network as sources of agriculture information. As ecological farming is not common in the study areas, farmers' existing sources of information could not lead to many new agro-ecology practices. However, farmers were in need of training and found local-language training DVDs relevant. Training videos in farmers' vernacular languages have a tremendous potential to effectively share information and to increase the rates of dissemination and implementation of agricultural innovations in Africa.

After watching videos and applying the knowledge acquired, about 86% of respondents spent less money on agrochemicals. The videos encouraged farmers to learn by doing and to engage in their own discovery learning. Vegetable farmers found the videos convincing and later reconfirmed the ideas based on their own farming experience. This could contribute greatly to the adoption of sustainable technologies. Learning videos have therefore improved farmers' knowledge and positively influenced their perceptions towards sustainable agriculture. It is apparent from this that learning videos can build farmers' agro-ecological knowledge without extension worker facilitation and enhance farmers' experimentation through their own learning initiatives. Learning

Figure 2. Drip irrigation system in the video. Source: Video on 'drip irrigation for tomato'.

videos can be used as an extension tool to encourage farmer-led, bottom-up and local innovation in sustainable agriculture. As improved farmer knowledge and capacity development are important policy considerations for intensification of sustainable agricultural practices (Pretty & Bharucha, 2014), learning videos could be an excellent way to create space for sustainable agricultural development and encourage farmers to come up with their own innovation. This study also reinforces the proposal that videos can play an important role in enabling farmers to implement innovative practices. Video can be used to develop a training programme on pest management, especially on the shift from agrochemicals to ecological practices in vegetable farming. The videos also stimulate agro-dealers to stock new equipment (e.g. for drip irrigation) which is an organizational innovation for the dealers.

To arrive at better farmer practices for the adoption of sustainable agriculture technologies, besides face-to-face extension, extensionists can use learning videos as a crucial communication tool. This is important because videos help farmers to draw on their own experiences and tend to have a greater impact on them than insights formulated by others. However, each extension tool has its own advantages and disadvantages. Quality videos and their successful use have promoted conservation agriculture and water management through drip irrigation in vegetable growing in Benin.

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