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Farmer responses to technical advice offered at plant clinics in Malawi, Costa Rica and Nepal

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ABSTRACT

This study explores how communication and its technical content shape farmers' response to advice delivered at plant clinics. Thirty-six farmers who visited a plant clinic in one of three countries (Malawi, Costa Rica and Nepal) were given at least one diagnosis of a plant health problem and up to six options for managing the problem. Almost all of the farmers were able to use at least some of these management recommendations. Communication was verbal, but reinforced in writing; all of the farmers received a one-page prescription form that summarized the recommendation. Communication per se was rarely the reason farmers failed to adopt technologies. Farmers who opted not to use recommendations often had logical, material reasons for doing so, and they showed a preference for chemical control. Of the 31 farmers who were advised to apply pesticides (including organic ones), 23 people (74%) accepted this advice to spray, but only 14 of 22 farmers (54%) tried advice for cultural or biological control. Farmers' response to an innovation is too complex to always describe as accepted vs rejected, and this decision depends on the fit of the technology itself, and on the quality of how the innovation is communicated.

KEYWORDS

Plant clinics; communication; agricultural extension; adoption of technology

Introduction

Sustainable agricultural intensification depends on farmers acquiring new ideas in three main ways: environmental learning (e.g. observing the natural environment and experimenting), social learning (gathering ideas from other farmers) and didactic learning (being taught, especially by extension agents) (Stone, 2016). Farmers typically bring different styles of learning to bear at once, for example, extensionists in Ghana taught farmers to plant rice in lines, by following a string (didactic learning), while farmers later experimented with easier ways to plant straight, without string, that is, environmental learning (Bentley, Van Mele, & Acheampong, 2010).

As the example from Ghana suggests, adoption of new farm technology is not necessarily a binary, yes-or-no question. For example, farmers may adopt hybrid maize on one plot and not on another (Sumberg, 2016). In addition, adoption of technology may be influenced by both material constraints (e.g. transport problems, or lack of capital) and by access to information (i.e. when literate farmers in Ethiopia are more likely to use mineral fertilizer than their peers who cannot read) (Croppenstedt, Demeke, & Meschi, 2003). Complex innovations require farmers to learn more, for example, it is easier to change the pattern of maize planting than it is to use computerized milking robots in a dairy barn. Maize farmers

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can experiment on their own with planting density, while automated milking requires collaboration between farmers, public-sector researchers and the companies that sell and service the devices. Adoption can be even more difficult if the computer technicians who programme the software lack the farm background needed to use the product in the field (Eastwood, Klerkx, & Nettle, 2017). In sub-Saharan Africa, adoption of agroforestry techniques depends on the knowledge, attitudes and practices of farmers, beside the profitability of the innovations, where proposed techniques are often environmentally beneficial, but not necessarily profitable for the farmers who use them (Meijer et al., 2015).

If complex innovations require more learning than simple ones, then integrated pest management (IPM) practices should require accurate communication of new ideas. IPM often requires detailed knowledge of agro-ecology and pest life cycles, for example. A farmer may need some hands-on teaching (didactic and environmental learning), for example, to make a pheromone trap that baits an insect with the scent of sex and then kills it with a waft of insecticide. In a study in Senegal, researchers and farmers experimented with two new styles of rice farming. They found that the first, pre-season trainings were insufficient and farmers could not remember how to use the new techniques (which included changes in timing of transplanting, herbicide and urea fertilizer rates, for example), so during the growing season, farmer field school (FFS) facilitators regularly visited participants to remind them of the timing of interventions (Krupnik et al., 2012). FFS is an intensive form of extension that often shares non-chemical pesticides and other alternatives to synthetic pesticides, which is crucial for sustainable intensification (Pretty & Bharucha, 2015).

Plant clinics

The plant clinic is a newer extension method than the FFS. The plant clinic, like FFS, is based on respect for farmers' knowledge and on the promotion of IPM. Unlike FFS, the plant clinic offers one-on-one plant health advice in response to the demands of individual farmers (Boa, Franco, Chaudhury, Simbalaya, & Van Der Linde, 2016). The plant clinic is staffed by extension agents, called 'plant doctors', and is located in places frequented by farmers such as markets, cooperatives and extension offices. The plant clinic is identified with a sign or banner. Some basic equipment (e.g. a magnifying glass and illustrated books about pests and diseases) helps the staff to make the diagnoses. The service is held on a regular basis (e.g. the same time every week or fortnightly). Farmers are invited to bring samples of their unhealthy plants and the plant doctor tells the farmer what is wrong with the crop (a diagnosis), and how to manage the problem (a technical recommendation). As a memory aide, the farmer receives a one-page, hand-written prescription form summarizing the diagnosis and recommendation (Boa, 2009; Danielsen & Kelly, 2010). Unlike most forms of extension, in which the interaction is started by an extension agent, at a plant clinic the farmers (usually) take the initiative and approach the clinic to seek help (Boa et al., 2016). The plant doctors face the challenge of dealing with multiple crops and with any plant health problems that farmers may present. The plant doctors often make several recommendations for a single problem, which is consistent with IPM principles (Ehler, 2006). So advice given at plant clinics is inevitably diverse (Danielsen, Boa, et al., 2013).

CABI began supporting plant clinics in 2003 (Bentley et al., 2007). From early experiences in Bolivia (Bentley, Boa, Danielsen, & Zakaria, 2007), Uganda (Alokit et al., 2014; Danielsen & Matsiko, 2016), Bangladesh (Kelly, Bentley, Harun-Ar-Rashid, Zakaria, & Nuruzzamann, 2008), Nicaragua (Danielsen, Centeno, et al., 2013) and Sri Lanka (Bandara & Kulatunga, 2014), the plant clinics have expanded to 34 countries in 2017, under CABI's Plantwise Program. The plant clinics began teaching innovations that did not require economies of scale (see Jirström, 1996) but could be used even on small farms. The clinics sidestepped social learning, which had been problematic for FFS (Bentley, 2009; Winarto, 2004), to teach farmers directly, especially smallholders who would approach the clinic and demand help. Plant clinics provided a one-on-one didactic learning experience where a motivated farmer demanded answers from a plant doctor, who gave advice which the clinic user could try at home; learning and adoption were expected to be high.

The Malawi plant clinics started in 2013 and there are now more than 100 plant clinics in 13 of Malawi's 28 districts. The Costa Rican plant clinics started with 11 plant clinics in 2014, in 2 regions, Central West and Central East. The plant clinics began in Nepal in 2008 and now operate in 45 of Nepal's 75 districts (Adhikari et al., 2013). The plant doctors in Malawi, Costa Rica and Nepal are extensionists from the Ministry of Agriculture and they have been trained by Plantwise, similar to the way that FFS was able to go to scale

Table 1. Summary of study sample.

	Malawi	Costa Rica	Nepal
Study sites, (community, district)	Ndaula, Lilongwe West Kafukule, Mzimba North Mitundu, Lilongwe West	Naranjo, San Ramón, Tucurrique	Arye Bhanjyang, Palpa Gokarna, Kathmandu Hemja, Kaski Bhalwari, Rupandehi,
Plant clinic visits	3	1 extension event held by plant doctors	4
Visits to farmers	12 (11 women, 1 man)	10 (5 women, 5 men)	14 (10 women, 4 men)

by engaging with public-sector extensionists in Côte d'Ivoire (Muilerman & Velema, 2017).

Managing a plant clinic may be overly challenging for some extension agents especially those who are not experts in plant protection. Studies in Iran show that only about half of farmers are satisfied with the quality of the services they receive at the plant clinics (Azimi, Allahyari, Damalas, & Kavoosi-Kalashami, 2017; Ghiasi, Allahyari, Damalas, Azizi, & Abedi, 2017). However, it is unclear from these questionnaire-based studies why Iranian farmers were satisfied (or not) with the plant clinics. Was it because of flawed technical information or faulty communication, a combination of both or some other reason entirely?

In this paper we examine the ways farmers perceive advice from the plant clinics. We explore verbal and written communication between farmers and plant doctors, looking at the content of the message and how effectively it is delivered. The research question was: How do communication and its technical content shape farmers' response to plant clinic advice?

Methods and materials

A qualitative study was carried out in Nepal, Malawi and Costa Rica from September to November 2016. In each country, the study team visited three sites (four in Nepal) (Table 1; Figure 1). The visits included observation of a plant clinic in operation (Malawi and Nepal) to observe the interaction between plant doctors and farmers. The research included semi-structured interviews with plant doctors, and a review of the plant clinic records. Plant clinic data from the Plantwise Online Management System (POMS) were analysed for the frequency of crops and problems presented and the types of recommendations given.

Thirty-six farmers (26 women and 10 men), all former plant clinic visitors, were interviewed on their farms to assess how the recommendations from the plant clinics had been perceived and used. In Nepal and Malawi, these farmers were selected from the clinic register in consultation with the plant doctors; selection of interviewees was purposeful (e.g. to include women and men, to have a mix of plant health problems, to have some insect and some disease problems). In Costa Rica the plant doctors chose from farmers known to them, also seeking a gender balance and a mix of pest types. The study sample is summarized in Table 1.

At the plant clinics, the authors observed if farmers brought samples of unhealthy plants. Bringing a sample is a simple way for farmers to communicate with the plant doctor in the visual channel (to show the plant health problem, not just talk about it). The authors also observed if plant doctors spoke respectfully to farmers, and if plant doctors asked about farm management (e.g. 'What have you applied to this crop?') in order to make an accurate diagnosis. We observed if plant doctors gave a diagnosis, a recommendation and if they explained why the advice would work. The authors asked the plant doctors about the words they used, for example, in Malawi plant doctors called 'manure' by a loan word from English 'manyowa' yet it became clear that this was the word that farmers themselves used (i.e. the term was easy to understand). The interviews with plant doctors were also an opportunity to review some of the plant clinic records and to ask plant doctors how they had explained these ideas during the consultation with farmers, for example, how scientific terms or abbreviations listed in clinic records had been explained verbally at the clinic. The authors also asked about the use of fact sheets and other written communication.

On the research methods

Qualitative, ethnographic methods (including wide-ranging interviews and direct observation on the farm) allow for many more issues to be introduced than by quantitative research (Labov, 1972). The most accurate way to describe communication is by

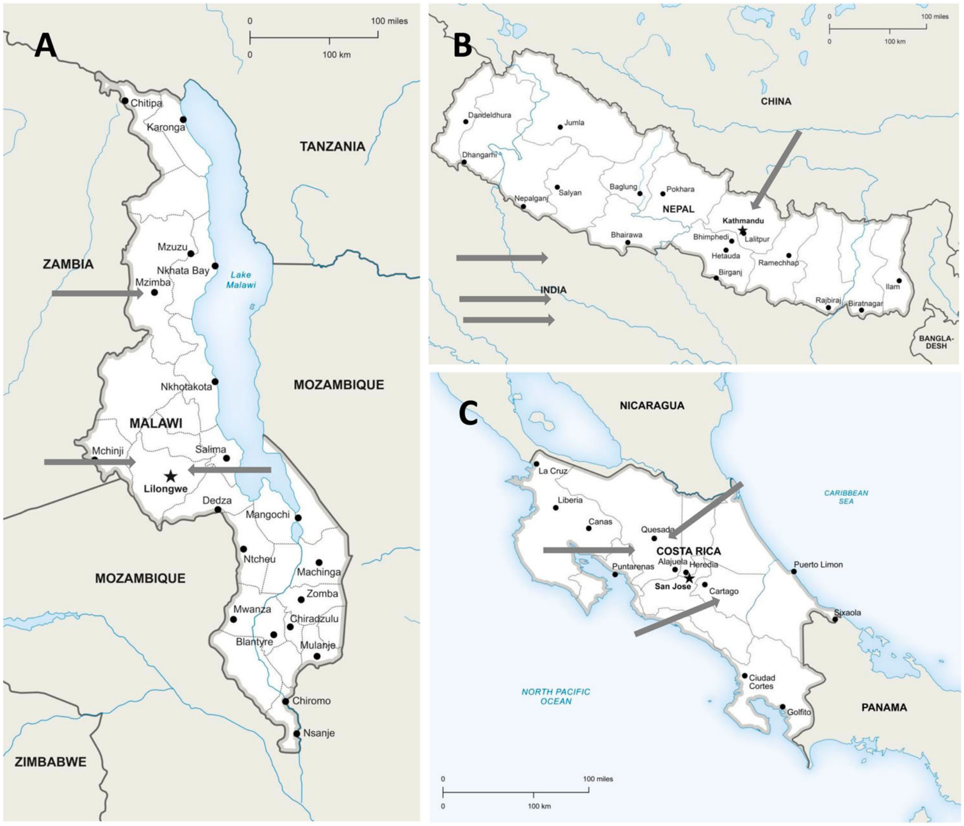

Figure 1. Selected study sites (arrows) in Malawi (A), Nepal (B) and Costa Rica (C).

observing it in the field, in the tradition of sociolinguistics, paying attention not only to what is said, but how it is said (Kumar, 2011; Trudgill, 2000). Most of the authors of this paper are pest management experts, and were in most cases able to make a judgement at the clinic or on the farm about the technical value of the advice given to farmers at the plant clinic.

Results

Brief description of communication at the plant clinics

At the plant clinics, communication is generally clear and open. In Malawi, the plant doctors are fluent in the local languages (e.g. Chichewa and Tumbuka). In Costa Rica, the plant doctors and their clients all speak Spanish. In Nepal, the plant doctors speak Nepali, which the farmers understand well, even the ones who also speak a minority language.

The plant doctors are respectful and attentive with their clients, and good listeners. In all countries they tend to address the farmers with honorific titles (the equivalents of 'Mr' or 'Ms' in English), use an appropriate tone of voice (not yelling, mocking or scolding).

In Malawi and Nepal, the plant clinics operate in public places (e.g. in markets). In Costa Rica the clinics operate during office hours in the Ministry agencies, and plant doctors visit farmers in the field. Almost all farmers in Malawi and Nepal bring samples, possibly reflecting good communication from the plant doctors, and certainly a sign that farmers want to have their problems well understood. In Costa Rica some farmers bring samples. Others telephone or come to the office asking for a visit from the plant doctor, who can then take a sample in the farmer's field. Farmers who bring samples to the plant clinic are better able to communicate their plant health problem to the plant doctor.

Grassroots support is also a sign that rural communities value the communication taking place at the plant clinics. For example, in Nepal, leaders of cooperatives and FFS groups attend the plant clinics and encourage farmers to come. In Malawi, local people care for the tables and chairs from one plant clinic day to the next, and in the small town of Kafukule, farmers built the plant clinic a shade; such local investments suggest that farmers value the plant clinics.

The plant doctors also communicate with peers and experts to help improve their diagnoses. The plant doctors in Costa Rica identified unfamiliar plant health problems with help from a WhatsApp diagnostic support group and from experts in the Ministry. Plant doctors in Malawi sought these identifications through peers, and through experts at CABI's diagnostic service in the UK, through the Malawi Plant Doctors' WhatsApp group. Plant doctors in Nepal have a Facebook group to help make diagnoses.

Prescription forms, making communication last longer

Talk does not last very long, and in all three countries, plant doctors fill out a written prescription form which includes the names of recommended products, to help farmers remember them. Farmers can also show the prescription forms to shopkeepers, so the forms become a device for empowering farmers, a bit. The plant doctors also explain the prescription forms to the farmers, which helps farmers to better understand the written forms.

Plantwise has designed prescription forms with long lists of boxes for ticking off – making it easy to enter the data into a computer, but rendering the forms more difficult for farmers to read. The recommendation for the farmer is reduced to a small box.

In Malawi the plant doctors write their recommendations on the front of the Plantwise prescription form in English and in the local language (e.g. Chichewa or Tumbuka) on the back. This Malawian innovation makes the written material easier for the farmer to understand. The forms are neatly filled out, with clear handwriting. A few plant clinics fail to indicate the dilution rate with the written recommendation; that is, some prescription forms mention the name of a chemical to use, but not how much water to add to a certain amount of product. The prescription form has a space for a diagnosis, but sometimes the plant doctors forget to fill in this line.

In Costa Rica the plant doctors do not use the Plantwise prescription form, preferring the visit forms designed and used by Ministry extension agents. These simpler forms have a large, lined space for writing a fairly long recommendation. Usually the plant doctors write the diagnosis also. The visit forms are clear, and legible.

In Nepal, normally the plant doctors write down the diagnosis and the recommendation. Sometimes the diagnosis and part of the recommendation are written in English (which few farmers can read). This was an unfortunate and unanticipated side effect of the 'clinic' analogy, where bad habits from the human health system were unwittingly borrowed into the plant clinics. Nepali medical doctors tend to write their prescriptions in English, or in a mix of English and Nepali, and may even use Latin abbreviations for the frequency of drug administration (Joshi et al., 2001). Fortunately, most Nepali plant doctors resist such obfuscation, and write prescriptions in Nepali, and in a clear, legible handwriting as well.

Fact sheets

CABI promotes the use of fact sheets and other literature intended for a farmer audience (Bentley & Boa, 2013; Cameron, Somachandra, Curry, Jenner, & Hobbs, 2016). This written material, along with the prescription forms, is intended for the farmers as a memory aide. Yet, few farmers in any of three countries receive fact sheets or other written material, except for the prescription form.

Despite the lack of fact sheets and the occasionally hard-to-read prescription form, plant doctors were usually getting their point across to the farmers (e.g. speaking in terms that were easy to understand). The communication with farmers is usually effective enough to enable them to adopt the technologies recommended by the plant doctors. The following section examines how farmers responded to the information given at the plant clinic.

Farmer responses to advice

Malawi

In Malawi, one female farmer (case 1, Table 2) was given four recommendations to manage rosette virus in her groundnuts: (1) rogue, that is, uproot and destroy diseased plants, (2) rotate crops, (3) plant an improved variety and (4) plant the groundnuts closer together. Her response shows how farmers creatively judge each proposed practice on its own merit. First, like most farmers, she rejects roguing; farmers are reluctant to uproot any plant that may still yield something. Besides, this destructive practice only works when a contagious disease is just starting to gain a foothold in a field, while it is useless if most of the plants already have the disease, or if the problem is vectored by a highly mobile insect. Second, like most farmers in

Table 2. Farmers visited, Malawi.

Farmer, place	Crop, diagnosis, date of query	Recommendation	Farmer's response	Analysis
1. Female Shuga, Phiri La Njuzi, Lilongwe W.	Groundnut, Rosette virus 24 March 2016	Rogue, crop rotation, plant improved variety closer together	She plans to rotate her crop, and sow the plants closer together. Will plant farm-saved seed	Will use two of the recommendations, including rotation, and a new planting density
2. Female Kanyama, Phiri La Njuzi, Lilongwe W.	Tomato[a], Red spider mite 20 May 2015	Botanical insecticide (*Tephrosia*) with onions and laundry detergent	Used botanical pesticide for two seasons. Observed large yield increase	High acceptance of pesticides, including botanical ones
3. Female Shati, Phiri La Njuzi, Lilongwe W.	Mustard[a], Red spider mite April 2014	Botanical insecticide, *Tephrosia* and soap in water	Applied as recommended and was pleased with high yields	High acceptance of botanical insecticides
4. Female Shati, Phiri La Njuzi, Lilongwe W.	Tomato[a], Bacterial wilt April 2014	Rogue (possibly also advised to rotate crops)	Rogued infested plants, and planted potatoes. Applied *Tephrosia* and rotated the crop with maize	Farmer's action goes beyond prescription, possibly based on info from other sources. *Tephrosia* does nothing for wilt
5. Female Kafukule, Mzimba North	Tomato, Fruit worm 9 Sep 2015	Hand pick caterpillars, spray cypermethrin (apply a bottle cap in 10 l water)	She applied the cypermethrin, but in 15 litres of water. Controlled the pest	The farmer ignored the tedious prescription to hand pick insects. Applied a lower dose than recommended
6. Female Kafukule, Mzimba North	Tomato, Spider mite and white fly 28 Dec 2015	Keep field weed-free. Remove old leaves. Apply insecticide. Intercrop with garlic or onion	The garden is weed-free. Applied cypermethrin several times: controlled mites but not whitefly	Farmer and her husband only recall the chemical control. They bought another chemical at the shop to control whitefly
7. Male Kafukule, Mzimba North	Tomato, Fruit worm 9 Sep 2015	Spray cypermethrin. Handpick caterpillars and destroy	Applied cypermethrin. Solved the pest problem, repeated application in 2016	Farmer is satisfied with insecticide, avoids hand-picking
8. Female Matiasi, Mitundu, Lilongwe W.	Beans, Stem maggot 30 Aug 2014	Dimethoate. Apply 3 to 7 days after crop emergence	Did not apply	Did not apply prescription, in 2014 because it was too late and in 2015 because the crop died suddenly
9. Female Chithonje Mitundu, Lilongwe W.	Tomato, Bacterial wilt 30 Aug 2014	Crop rotation (prob. roguing too)	She reluctantly uprooted diseased plants. The rest stayed healthy	She still asked for chemical control
10. Female Mitumba, Mitundu, Lilongwe W.	Beans, Aphids 30 Aug 2014	Cypermethrin	Did not buy the chemical in 2014, and lost the crop. She did use the chemical in 2015	Lacked money to buy the prescription in 2014, but it worked well in 2015 and she used it again in 2016
11. Female Bowa, Mitundu, Lilongwe W.	Maize, Striga 6 Feb 2016	Crop rotation, more manure	The household did apply the prescription, and buried the crop residue as well	Adopted the prescription even though they remembered it poorly
12. Female Zondawako, Mitundu, Lilongwe W.	Maize, Termites 6 Feb 2016	Confidor at the start of flowering. Verbally advised to bury crop residues	She buried the maize stalks and was pleased with her large harvest	A rare case where the farmer followed cultural controls[b] rather than chemical

Source: Prescription forms from the plant clinics (columns 1–3) and farmer visits (column 4).
Note: Queries taken to clinic, diagnoses, recommendations, and farmers' responses.
[a]Diagnosis and recommendation based on farmer's memory. Could not be found in register.
[b]'Cultural controls' are changes in cropping practices, for example, weeding or planting styles.

Malawi, this farmer is already rotating her crops, so she will continue to do this. Third, she will not plant the certified seed of an improved variety, because of the costs involved. But she is determined to use the fourth idea. Rosette virus is transmitted by an aphid which prefers isolated plants. Planting groundnut closer together can help discourage the insect vector (Moses, Brentu, & Nyarko, 2016). The fourth recommendation would be counter-intuitive without background scientific information about how the aphid behaves. The farmer accepted the idea, so the communication at the plant clinic did help her to make an informed decision to test a new idea about plant spacing.

Other farmers (e.g. cases 2–3, Table 2) readily adopted the advice of using a botanical insecticide, because it was affordable and managed their pests. But not all farmers simply adopt an idea. For example, one farmer (case 5) adopted the recommended chemical insecticide, but apparently misunderstood how much water to mix it with. While accepting pesticides, she rejected the idea of hand-picking insects from the crop – which is simply too tedious. Another farmer (case 9) did choose to use roguing (uprooting affected plants to stop the spread of disease), because she had no alternatives, but even she would have preferred a cure for the bacterial wilt on her tomatoes.

Roguing is recommended too frequently. Of 359 queries registered in Malawi for 6 months in 2016 (POMS records, for all crops and all clinics), 155 recommendations (43%) included advice to uproot, destroy, rogue or remove infected plants (data not shown).

Costa Rica

Like the other plant doctors, the Costa Ricans give farmers diagnoses and recommendations for plant health problems, verbally and in writing, and sometimes also teach small groups of farmers. For example, after making the effort to diagnose palm weevils, a new pest, the plant doctors organized a 10-session practical course to teach a group of 20 farmers how to control the insect, where attendees learned in detail the ecological background of the pest and how to control it (Table 3, case 1).

Several of the cases from Costa Rica (1, 2, 3 and 7 – in Table 3) involved difficult diagnoses, which the plant doctors were able to make with the help of experts. This happened less often in Malawi and Nepal, where plant doctors often shrugged off problems they could not diagnose. Plant doctors who work hand-in-hand with farmers, visiting their farms several times a year, are able to communicate well and induce some significant changes, for example, the farmer in case 10, who moved his vegetable

Table 3. Farmers visited, Costa Rica. Queries, diagnoses, recommendations and farmers' responses.

Farmer, place	Crop, diagnosis, date of clinic visit	Recommendation	Farmer's response	Analysis
1. Male Tucurrique, Jiménez, Cartago	Peach palm, Weevils 2015	Clear leaf litter and drench soil with *Beauveria* and *Trichoderma* to kill pupae. Trap adults with pheromones and apply insecticide in palm canopy as the plant flowers	Recommendation fully understood and adopted. Solved the pest problem	He learned the technique and background info in a special course organized by extension in response to the weevil diagnosis
2. Female Tucurrique, Jiménez, Cartago	Coffee, Anthracnose Ca. 2014	Apply a copper-based fungicide	Applied the fungicide. Solved the problem	The diagnosis was difficult, but the plant doctors did not give up easily
3. Male Tucurrique, Jiménez, Cartago	Lettuce, Fusarium 2015	Spray bicarbonate of soda in water, followed in 3 days by Trichoderma	Applied the prescription as advised and problem was solved	Another difficult diagnosis, aided by other experts
4. Female Naranjo, Alajuela	Violet, Thrips 2013	Insecticide	Applied as advised, problem solved	Farmers accept chemical control
5. Female Naranjo, Alajuela	Anthurium, Mealy bugs and mites 5 May 2016 and earlier	Insecticide (unspecified) mixed with oil	Applied 2 insecticides	She also received info from other sources
6. Female Naranjo, Alajuela	Ornamental plants, Fungus September 2016 and earlier	Use less irrigation water in greenhouse, apply fungicide	She tried the fungicide but could not adjust the water flow	Electronic irrigation system was too difficult to use
7. Male Naranjo, Alajuela	Celery, Mites October 2015	Chemical acaricides followed by an organic product to prevent a 2nd attack	He applied the products as recommended and saved his crop	His next celery crop was free of mites, without chemicals
8. Male San Ramón, Alajuela	Beans, Mites ca 2011	Acaricide	Used chemical successfully, then experimented with crop rotation	He adopted the prescription, but also tried crop rotation based on papers he read
9. Female San Ramón, Alajuela	Chayote, Thrips 2015	Pyrethrin (natural insecticide)	She applied the product, which solved the problem	Farmers tend to accept chemical prescription
10. Male San Ramón, Alajuela	Lettuce, Bacterial rot 2013 or 2014	Move vegetables to a cooler place	He moved his vegetables to a higher altitude, built a new greenhouse	Major change in cultural practices, based on sound grasp of the prescription

Source: Information from farmers during field visits.

production to a higher, cooler climate as a result of the plant doctor's advice.

When farmers failed to use advice it was often because they were unable to, even though they understood it perfectly: for example, the farmer in case 6 (Table 3) was advised to reduce the water flowing from her sprinklers. But the irrigation system was purchased as a package, was controlled electronically, and she could not persuade the dealer to return and adjust the equipment. This is like the automated milking technology which farmers in Australia and Western Europe simply cannot adopt on their own without cooperation from the dealers who sell it (Eastwood et al., 2017).

Nepal

In Nepal, there is more evidence that differences in communication play a role in farmers' responses to proposed innovations. The farmer in case 2 (Table 4) was growing tomatoes and other vegetables in a 'tunnel', a kind of greenhouse with open sides. She had a complex problem (an insect and a disease – leaf miner and late blight) and she was given a long list of recommendations. She tried the chemicals, but arguably the most important advice for the control of late blight was to rotate the crops. This is a difficult decision to take with a valuable crop planted in an expensive structure. The farmer would have needed more background information to convince her of the need to substitute tomato for a potentially less profitable crop; she had not understood that the organism that caused late blight was living in the soil, and thriving with each tomato crop she planted. She was applying the new information piecemeal, waiting for the individual tomato plants to die one by one, and replacing them with other species, especially cauliflower. It is not yet clear how successful this experiment was.

Farmer responses to advice by technology and plant health problem

Combining the cases from all 3 countries (Table 5) shows that farmers accepted plant clinic advice to spray pesticides (e.g. insecticides and fungicides) in 23 cases, and only rejected such recommendations 8 times (an acceptance of 74%). Of the 31 farmers who were advised to use pesticides, 8 of these were (entirely or partially) for botanical or biological pesticides, and 6 of the farmers (75%) accepted this advice, suggesting that plant clinics can be a way of promoting non-chemical pesticides (see cases 2 and 3, Table 2; cases 1, 3 and 9, Table 3; and cases 7, 12 and 14, Table 4). Farmers were less likely to accept advice for cultural or biological control (or for pheromone traps). Such advice was accepted on 14 occasions and rejected on 12 (accepted 54% of the time) (see Table 5). The 54% acceptance rate for cultural controls etc. is no doubt an over-estimate, since it includes techniques such as crop rotation and weeding which farmers often performed anyway, with or without advice from the plant clinic.

A second analysis (Table 6) compares the adoption of recommendations by type of plant health problem, for example, diseases vs. arthropod pests (insects and mites). Seventeen of the farmers (47%) used all or most of the advice, while 13 (36%) followed some of it and only 4 (11%) rejected all of the recommendations. That is, almost all of the farmers find something of value at the clinic, advice they can use on their farm. Advice for insect pests vs. diseases is accepted in similar proportions (20 arthropod cases and 13 for disease).

The more the messier

Farmers who receive several recommendations for a plant health problem may be more likely to use at least some of the advice than if they receive just one recommendation. But increasing the number of recommendations also makes it less likely that any one piece of advice will be followed. In practice, the farmers seem to have viewed the multiple recommendations as items on a menu they can choose from freely. As Table 7 shows, farmers received about three recommendations per problem in Malawi and Nepal. Costa Rican farmers received fewer recommendations (average 1.7) per prescription.

A virtue of multiple recommendations for a single problem (as in IPM) is that the plant doctor can give the farmer an alternative to chemical control of plant health problems. Plant clinic data recorded in POMS suggest that plant doctors in Malawi and Nepal favour cultural control, but that chemical control is a close second, and is part of most recommendations (Table 8). Plant doctors in Costa Rica are more likely to recommend chemical pesticides and mineral fertilizers. Of the cultural practices recommended in Costa Rica, 12 (39%) were on 'remove diseased leaves or fruits'. Crop rotation and use of certified seed was only recommended once and resistant varieties not at all (Table 8).

Table 4. Farmers visited, Nepal.

Farmer, place	Crop, diagnosis, date of clinic visit	Recommendation	Farmer's response	Analysis
1. Female Gokarna, Kathmandu	Sponge gourd, Fruit maggots 22 Sep 2016	Spray Malathion. Use pheromone traps	Sprayed Malathion, which she already had. Did not use traps	It was too late in the season to use the traps
2. Female Gokarna, Kathmandu	Tomato, Leaf eaten by insect (and disease as well, pos. late blight) 6 June 2016	Change variety, use fertilizer, test soil pH, keep field clean, use pesticides only as needed. A 2nd prescription was prob. for fungicide, roguing and crop rotation	Applied insecticide and fungicide. Did not rotate crops or test for pH, but as tomato plants in tunnel died she replaced them with cauliflower and spinach	She adapted the prescription, but may not have understood that the disease-causing fungus was soil-borne
3. Male Gokarna, Kathmandu	Cucumber, Fruit fly September, 2015	Pheromone traps when the plants are flowering	Bought a trap, tried it. Then made more traps for a larger area. Left the traps up for longer	Applied prescription creatively. Is in close contact with the plant doctors and the cooperative
4. Female Gokarna, Kathmandu	Tomato, No diagnosis 22 Sep 2016	Cleanliness, change variety. Apply Krilaxyl Gold, Agromin	She applied the fungicides; the crop died	Plant doctors did not recognize this invasive pest (tomato leafminer, an insect)
5. Female Hemja, Kaski	Rice, Foot rot and stem borer 16 June 2016	Foot rot: dip root in Bavistin while transplanting. Stem borer: apply Furadan in sand or ash in whorl	Barely recalled the prescription. Did not apply	The farmer did not think the damage was important
6. Male Hemja, Kaski	Pumpkin, Fruit fly 16 May 2016	Bury the fruit. Make malathion-fruit traps. Wrap setting fruit in newspaper. Pheromone traps	He did not remember the prescription or act on it	He eats the leaves and not the fruit, so he was uninterested in controlling the fruit fly
7. Female Hemja, Kaski	Tomato, Powdery mildew 19 July 2016	Crop rotation. Clean host plant. Apply a mix of sulphur and lime every 10 days for 3 times. Copper sulphite every 10 days	She thought sulphur would damage the tunnel[a] plastic, so did not spray. Used another pesticide which did not work. Uprooted tomato and planted coriander	The only part of the prescription she used was crop rotation, but she did that because of the season of the year, not to manage disease
8. Female Hemja, Kaski	Cucumber, Fruit fly 6 May 2016	Bury damaged fruit. Use pheromone traps. Cleanliness	She used the traps until hail ruined the crop	Learned about pheromone traps in a previous FFS
9. Female Arye Bhanjyang, Palpa	Tomato, Late blight September 2016	Remove affected parts. Mancozeb with Metalaxyl, once every 10 days. Next year treat soil with solarization	She took the prescription form to the shop. Applied fungicide and fertilizer she made from buffalo urine and plants	The liquid fertilizer is the creative use of information from FFS
10. Female Arye Bhanjyang, Palpa	Tomato, Pith rot September 2016	Cleanliness. Copper oxychloride. Treat soil next year with solarization	Also took the prescription to the shop, applied the fungicide and liquid fertilizer	Same as above
11. Female Arye Bhanjyang, Palpa	Chili, Root rot September 2016	Crop rotation. Copper oxychloride. Treat soil next year with Bavistin	She avoided fungicide, but used liquid fertilizer. The crop did well	She planned to eat the fruit herself, and did not want pesticides. FFS graduate
12. Male Bhalwari, Rupandehi	Mustard, Aphids February 2016	Ash, spray soap water. Dimethoate when the problem is bad	He applied the insecticide but it was not effective because of fog	He preferred chemicals to soapy water
13. Male Bhalwari, Rupandehi	Lentils, Blight February 2016	Mancozeb every 7 days, 3 times	Applied, and the plants grew, but never formed pods	Misdiagnosis. Probably wrong variety for the area
14. Female Bhalwari, Rupandehi	Onions, Thrips February 2016	Field monitoring. Cow urine in water and imichloropid	She bought the chemical and applied it, but the onions died	Applied insecticide at 25 times the proper rate, that is, trouble calculating the dilution rate

Note: Queries taken to clinic, diagnoses, recommendations and farmers' responses.

Discussion

In Everett Rogers' influential diffusion model, farmers learn from other people, for example, a researcher or an extensionist tells one farmer about hybrid maize seed or a herbicide. Knowledge of this innovation flows from farmer-to-farmer (Rogers, 2003). However, anthropologists realized early on that farmers were not just copying innovations, but actively

Table 5. Farmers' technical responses by type of technology, all countries.

Farmer response	Cultural and biological controls and pheromone traps	Chemical controls
Used the advice		
Malawi[a]	Crop rotation (cases 1, 4, 11) Roguing (cases 4, 9) Control weeds (case 6) Apply more manure (case 11) Bury maize stalks (12)	Biological insecticide (cases 2, 3, 4) Insecticide (cases 5, 6, 7)
Costa Rica[a]	Entomopathogenic fungi (cases 1, 3) Move vegetables to cooler place (case 10)	Insecticide (cases 1, 4, 5, 7, 8, 9) Fungicide (cases 2, 6)
Nepal	Crop rotation (case 7) Pheromone trap (cases 3, 8)	Insecticide (cases 1, 2, 12,14) Fungicide (cases 2, 4, 9, 10, 13)
Rejected the advice		
Malawi	Roguing (case 1) Seed of improved variety (case 1) Remove old leaves (case 6) Intercrop with garlic or onion (case 6)	Insecticide (cases 8, 10, 12)
Costa Rica	Reduce the amount of irrigation water (case 6)	
Nepal	Pheromone trap (cases 1, 6) Crop rotation (case 2 – partially adopted) Test soil for pH (case 2) Bury diseased pumpkin fruit and wrap growing fruit in newspaper (case 6) Bury damaged fruit (case 8) Field monitoring (case 14)	Insecticide and fungicide (case 5) Chemicals (case 7) Fungicide (case 11) Ash and soapy water (case 12) Biological insecticide, that is, cow urine (case 14)

[a]The case numbers refer to Table 2 (Malawi), Table 3 (Costa Rica) and Table 4 (Nepal).

Table 6. Farmer's technical responses by type of problem, all countries

Farmer response[a]	Disease (fungi, virus and bacteria)	Arthropod (insects, mites …)	Weed	Disease and arthropod (mixed diagnosis)
Malawi				
Used all or most of advice (5)	cases 4, 9	cases 2, 3	case 11	
Used some of advice (6)	case 1	cases 5, 6, 7, 10, 12		
Used none of advice (1)		case 8		
Costa Rica				
Used all or most of advice (9)	cases 2, 3, 10	cases 1, 4, 5, 7, 8, 9		
Used some of advice (1)	case 6			
Nepal				
Used all or most of advice (3)	cases 9, 10	case 3		
Used some of advice (6)	cases 8, 11	cases 1, 12, 14		case 2
Used none of advice (3)	case 7	case 6		case 5
Unhelpful advice[b] (2)	case 13	case 4		

Note: The case numbers refer to Table 2 (Malawi), Table 3 (Costa Rica) and Table 4 (Nepal).
[a]The numbers in brackets are the total number of cases.
[b]Unhelpful recommendation: problem was misdiagnosed and farmer followed advice to no avail.

experimenting with them (Johnson, 1972; Richards, 1986). In practice, experimenting and learning from the neighbours are complementary. Farmers learn in both ways: social learning (e.g. emulating influential community members) and environmental learning, that is, testing novel techniques to see if they work (Henrich, 2001). Contemporary agricultural innovation is also primed by NGO or government extensionists, called 'didactic learning' (Stone, 2016), for example, learning about pheromone traps (to control insect pests) from the plant clinic.

While some earlier studies did show that clinic advice was often adopted by farmers (Bentley et al., 2009; Hussain, Ndengu, Kuntashula, Welamedage, & Nguyen, 2016), other researchers showed that plant clinics did not consistently give accurate diagnoses or recommendations (Danielsen, Boa, et al., 2013; Danielsen & Matsiko, 2016). Many extensionists were not plant protection specialists. As extensionists became plant doctors they suddenly had to diagnose plant health problems on many crop species and provide sensible recommendations on dozens of pests and diseases. In this study, the authors noticed relatively few misdiagnoses (see Table 4, cases 4 and 13) and few gross errors of communication. In

Table 7. Percentage prescriptions with 1–6 recommendations for the 10 most commonly presented crops at plant clinics in Malawi[a] and Nepal[b] and all crops in Costa Rica[c].

Number of recommendations/ prescription	Malawi (n = 359)	Nepal (n = 316)	Costa Rica (n = 92)
1 recommendation	11%	7%	60%
2 recommendations	27%	19%	22%
3 recommendations	38%	32%	13%
4 recommendations	16%	28%	4%
5 recommendations	8%	10%	1%
6 recommendations	1%	3%	–
Av. per prescription	*2.9*	*3.3*	*1.7*

Source: Plant clinic data from Plantwise Online Management Systems. Downloaded 20 February 2017.
[a]Maize, tomato, cassava, mustard, rape, banana, Chinese cabbage, potato, cabbage and orange (data from 6 months).
[b]Tomato, cucumber, bean, gourd, citrus, mango, pumpkin, cauliflower, cabbage and rice (data from one year).
[c]Chili, tomato, citrus, coffee, lettuce, celery, cucumber, pumpkin, basil and 14 minor crops (data from one year).

Table 8. Types of technical recommendations given to farmers (%).

	% of all recommendations			% prescriptions with type of advice		
Type of recommendation	Malawi (*n* = 359)	Nepal (*n* = 316)	Costa Rica (*n* = 92)	Malawi (*n* = 359)	Nepal (*n* = 316)	Costa Rica (*n* = 92)
Cultural	43	34	20	81	83	25
Chemical pesticide	32	29	42	60	70	63
Biological pesticide	18[a]	13[b]	7.2	33	32	9
Physical	3.3	11[c]	0.7	6.1	28	1
Manure	2.4	1.8	1.3	4.5	4.4	2
Monitoring	0.6	3.6	4.6	1.1	8.9	7
Fertilizer	0.6	5.6	19.1	1.1	14	25
Biological[d]	0.1	1.7[d]	4.6	0.3	4.1	8

Source: Plant clinic data from Plantwise Online Management Systems. Downloaded 20 February 2017.
[a]Mostly made from *Tephrosia* or neem.
[b]Mostly made from neem and/or cow urine.
[c]Mostly pheromone or yellow traps.
[d]Mostly *Trichoderma* and *Bt.*

general, the clinics engaged in sound didactic learning. The farmers received a menu of technologies from the clinic and subjected those recommendations to further environmental learning back home.

However, there were cases where the farmer misunderstood the dilution rate, and applied far too much insecticide on a crop. One farmer (case 14, Table 4) was told to apply one gram of product in 5 litres of water, yet it is difficult for a smallholder to measure a gram without a chemist's scale, or to extrapolate from 5 litres to enough water to fill a sprayer (e.g. 20 litres). It is easier for farmers to understand volume measures which can be measured with a spoon or other familiar device, in a large enough dosage for a whole sprayer. In Malawi, plant doctors did make more realistic recommendations (so many millilitres of product per 20 litres of water), but sometimes the written instructions included abbreviations that smallholders find difficult to grasp (e.g. 'ml'). Symbols and abbreviations are difficult for low-literate audiences to read (Badarudeen & Sabharwal, 2010).

Spoken language at the plant clinic was usually appropriate (e.g. respectful) and accurately communicated the plant doctors' diagnoses and recommendations. Sometimes plant doctors communicated the background scientific information to farmers, but not always. Prescription forms at plant clinics conventionally do not include a space for communicating why a recommendation will work. Some plant doctors made useful innovations in communication, such as writing the recommendation on the back of the prescription form in the local language (Malawi). In two cases in Nepal (cases 9 and 10, Table 4), the prescription form helped farmers to buy the recommended product at the shop. Without the advice in writing, many farmers would find it hard to recall some of the chemical names.

The prescription forms could be improved, for example, making them easier to read and printing them in the local language rather than in English. Measurements must always be communicated in volumes that rural people understand (e.g. a spoonful rather than 15 millilitres). But in general, farmers understand the content of the technical messages (such as diagnosis of plant health problems and management advice).

Farmers tend to evaluate each recommendation on its own merits. Farmers may be less likely to adopt a recommendation such as roguing, if it is advised in cases where it will do little good or where the labour requirements make it unfeasible for the famer to implement. Plant doctors usually give three or more recommendations for a single problem, which is consistent with IPM principles. Even if the advice is intended as a to-do list, farmers may treat it more like a menu, choosing the recommendations they prefer. A disadvantage of such lists of options is that it is not clear which management practices are the most important for effective control. The more recommendations a farmer receives, the more likely it is that some of the advice will be ignored. Farmers also follow some advice sequentially, for example, spraying insecticide one year, but managing the pest the following year by crop rotation. This confirms previous studies which have shown that adoption is not simply a binary yes–no question. Farmers can reject a technology, partially adopt it or try it out and then dis-adopt (Sumberg, 2016). Such non-linear adoption is a product of environmental learning as farmers work through the economics and agronomics of an innovation by experimenting with it.

Most of the cultural controls that farmers tried are similar to what farmers are already doing (e.g. rotating and weeding their crops – Table 5). This aligns with the observation by Thurston (1990) who concluded that farmers in many countries rotated their crops without realizing that this and other traditional practices helped manage disease. Sometimes plant doctors helped to refine the concept of crop rotation for farmers, for example, explaining not to follow tomatoes with potatoes because they are of the same family and share some of the same diseases.

Farmers needed little encouraging (or explanation of background information) to try new chemicals. Plant doctors were sympathetic to farmers who did not want to use chemicals, and sometimes recommended biological pesticides as an alternative. Farmers in Malawi readily adopted insecticides, whether made from local plants or from store-bought chemicals. When farmers did avoid chemicals, they did so for clear agronomic reasons, for example, because the crop had already been lost. In Costa Rica, farmers were more likely to adopt advice from their plant doctors than were farmers in Malawi or Nepal (Table 5). This may be because the Costa Rican plant doctors spend more time with fewer clients during their field visits, so they can communicate more complex and subtle information, and because Costa Rican plant doctors make house calls, visiting all the farmers they advise, so they understand each farmer's case better, but it may also be because most of the recommendations in this Central American country are for chemical pesticides (8 of 12 cases), which farmers are usually keen to try.

Total rejection of all recommendations was rare (Table 6). Only 11% rejected all of the recommendations. This compares favourably with a study of potato farmers in Ecuador, where FFS graduates adopted some of technologies offered and not others; adoption ranged from 23% for recommended storage methods to a high of 83% for crop rotation (Mauceri et al., 2007).

Conclusions

Farmers in the three study countries rejected advice from plant clinics based largely on technical considerations, not because of problems with communication. Most farmers tried at least some of the advice they received at the plant clinic, making a creative selection of which advice to try, and may have been satisfied with the partial adoption of advice, as long as the plant health problem was solved. The plant doctors usually give the farmers several recommendations, at least some of which usually appeal to the clinic user. If farmers were already practicing some of the recommendations before visiting the clinic, such as crop rotation, then the use of that practice cannot always be counted as adoption or rejection of advice (depending on how the farmers were rotating crops before). Giving several recommendations enhances the odds that at least some of the advice will be followed, while reducing the probability that farmers will use all of the proposed innovations. It also allows the clinic clients to use their own judgement and creativity to solve their problem. On the other hand, a menu of options may obscure the most important recommendation. This is where effective communication comes in: while advising farmers, plant doctors rarely if ever distinguish between optional and required bits of advice.

For farmers, adopting technology is a means to harvesting a healthy, profitable crop, not a goal in itself. Measuring technology adoption may suggest how well farmers accept an innovation, without telling researchers if the farmers' problems are being solved or not. This qualitative study suggests that adoption of advice from plant clinics is not binary. Future studies should ask more nuanced questions about technology adoption, and establish more categories of response (not just 'accepted' vs. 'rejected'). Rather than measuring crude adoption, researchers should also look at which options farmers accept, and how well such change solves the farmers' problems. Odds are that farmers temper outsiders' advice for technical reasons, not because of mis-communication.

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