Comparing Farmer Field Schools, Community Workshops, and Radio: Teaching Bolivian Farmers about Bacterial Wilt of Potato

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Abstract

Bacterial wilt (Ralstonia solanacearum) is a serious disease of potato. It can be managed with cultural practices, but only if farmers understand the technologies, and the reasons behind them. Face-to-face extension methods, like farmer field school (FFS), can teach these messages to smallholders, but other methods may also be useful. This paper compares FFS with two less-costly methods: "community workshops" and radio, and presents follow up surveys of these three extension methods. Community workshops were almost as effective as FFS for teaching most ideas; radio spots were less effective, especially for ideas that require demonstration, but they reach a much larger audience. The three extension methods gave the most different results for time-consuming technologies, where a more compelling demonstration may convince farmers to adopt a task that adds work to an already busy day. Extension methods should be chosen for the particular context. The more complicated, tedious, and counter-intuitive a new technology is, the more important it may be to use a more intensive intimate extension method and the less likely that a mass media will be successful.

Keywords: Bolivia, Brown Rot, Extension, *Ralstonia solanacearum*, Training

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Introduction

Many extension experts consider farmer field schools (FFS) an effective way to teach integrated pest management (IPM), especially in tropical countries (Carpenter, 2003; Gallagher, 2003; Groeneweg, Versteeg, & ChavezTafur, 2004; Pretty, 2002; Ricker-Gilbert, 2005; Röling & Van de Fliert, 1994; Thiele, Braun, & Gandarillas 2005; Van de Fliert, 2003). FFS teaches farmers in small groups (about 25), who typically meet once a week for several hours to learn about the agro-ecosystem in the field, over a whole season—from seed (planting) to harvest (generally not including storage). FFS uses discovery-based learning; farmers find out for themselves the principles of IPM through observation and simple experiments (Davis, 2006; Pumisacho & Sherwood, 2005). Although FFS was first developed to teach insect pest control, it has since been used for many topics, including plant disease (Braun, Jiggins, Röling, Van den Berg, & Snijders, 2006). Others have adapted FFS to involve farmers in research (Nelson et al., 2001; Onduru, 2003; Ortiz, Garret, Heath, Orrego, & Nelson, 2004).

The earlier, entomological versions of FFS emphasized avoiding insecticides, to conserve natural enemies. Farmers compared sprayed and unsprayed rice plots side-by-side, observing how beneficial insects and spiders controlled insect pests in the insecticide-free "IPM" plot (Winarto, 2004). However, when FFS was adapted to teach disease management, fungicides were often needed (Pumisacho & Sherwood, 2002). Nepalese farmers were taught to manage *Botrytis* in chickpeas using a split plot, where one side had a disease-resistant crop variety, fungicide and a lower plant density (Pande et al., 2005). FFS for managing disease has been shown to help farmers raise yields. A study in Peru where late blight was the main limitation showed that FFS graduates had higher potato yields (mean 15.7 t/ha), than non-FFS farmers (mean 13.7 t/ha) (Zuger, 2004, cited in Ortiz et al., 2004).

Attention is often drawn to the higher quality of FFS. A study in China compared FFS with the T&V (teaching and visit) approach, and found that FFS farmers continued learning well after the training had finished, whereas the others did not (Mangan & Mangan, 1998). A study in Java showed that farmers learned much in FFS and experimented with new technology, but found it difficult to teach the concepts to their neighbors (Winarto, 2004).

An experience with cowpea FFS in Benin suggests that field school is costly and that mass media (e.g. radio) may be more cost-effective (Nathaniels, 2005; Norton, Rajotte, & Gapud, 1999). Other authors (Feder, Murgai, & Quizon, 2004a, 2004b; Rola, Jamias, & Quizon, 2002) compared Indonesian field school graduates with farmers who had not taken FFS. The two groups had similar rice yields, used similar amounts of pesticides, and there was little diffusion of information from trained farmers to others.

Farmers learn in an FFS, but perhaps cheaper methods could reach a larger audience at a lower cost. In Bangladesh, a visit from an extension agent was found to be more cost effective for teaching IPM techniques than a farmer field school (Ricker-Gilbert, 2005). Radio can be used to reach even more people with an IPM message. There is a need to evaluate the cost-effectiveness of FFS, compared with other, less-expensive methods (Anandajayasekeram, Davis, & Workneh, 2007).

Radio's lack of visual information limits its ability to show a new tool, or detailed symptoms of plant diseases. However, topics like planting dates, where to get clean seed, or the virtues of crop rotation can be discussed verbally, without pictures. Studies in Vietnam have shown that messages such as avoiding insecticide on rice for 40 days, to conserve natural enemies, can be transmitted by radio (Heong et al., 1998). But whatever radio's limitations, it may cost 1000 times less than face-to-face extension, per person reached (Chapman, Blench, Kranjac-Berisaljevic', & Zakariah, 2003; Ramírez & Quarry, 2004). A radio program that could share even a few key points with several million farmers might be a wiser use of money than an FFS that reached just 2% of the farming population.

Purpose and Objectives

This study was designed to test the relative effectiveness of three extension methods (FFS, workshops, radio) for teaching disease management to Bolivian smallholder farmers. To do so, the study took advantage of activities of the "Bacterial Wilt Project," led by the International Potato Center (CIP) and implemented with PROINPA (Foundation for the Promotion of and Research on Andean Products).

During 2002-2003, as part of the Bacterial Wilt Project, extensionists from PROINPA trained farmers in over 30 communities in Chuquisaca, central Bolivia, on bacterial wilt (BW) of potato, caused by the bacterium *Ralstonia solanacearum*. BW was reputedly introduced to Bolivia in 1984 with infected seed following widespread loss of the potato crop due to very heavy rainfall resulting from El Niño. BW is a quarantine disease so the government of Bolivia refuses to certify as seed, potatoes from BW-endemic areas. BW causes tuber rot, can kill the whole plant before it even produces tubers and can persist for many seasons in a field after an initial infection.

Estimates of economic losses in Bolivia are up to $1000/ha or more in a single season, depending on yield loss (up to 80%) and potato prices (Barea et al., 2004b; Equise, Barea, & Alvarez, 2004). Because of its persistence over many seasons the cumulative economic loss is potentially very much greater. By 1996, bacterial wilt was present in over half of the potato fields in Chuquisaca and around Vallegrande, in Central Bolivia, affecting about 15,000 ha and 20,000 farm families respectively (Barea et al., 2004b; Equise et al., 2004). Seed production areas in Chuquisaca were quarantined for 12 years after the mid 1980s, and seed producers lost income as they were forced to sell seed as ware potato.

The disease is difficult to control in central Bolivia: much of the infection is latent (e.g. does not show symptoms), so farmers can easily confuse healthy and diseased seed potatoes. When infected seed from lower valleys is planted at high elevations, the low temperatures prevent the bacteria from multiplying enough to produce plant wilt, but the bacteria are still in the plant and hence in progeny tubers. Depending on the district, when seed lots were monitored with detection techniques (developed by CIP) 20 to 60% of symptomless tubers were found to be positive for BW (Priou, 2004).

The survey population is reasonably homogeneous. All are smallholder farmers, in old, stable communities (i.e. none were recently settled or migrants). They are native speakers of Spanish, although they live close to Quechua-speaking communities, and the local Spanish is influenced by Quechua (e.g. with many loanwords). They typically farm two to four hectares of land, divided into various fields. They plow steep hillsides with oxen, and grow many crops in an effort to be self-sufficient in as many food items as possible. All or nearly all households grow potatoes to eat and most also sell potatoes, which is an important cash crop.

BW Project staff trained people in 10 communities using FFS, but taught farmers in 20 others with a less intensive method we call "community workshops," and reached about 70 communities in the project area (and a few others outside it) with radio messages. Before doing the study, the authors hypothesized that farmers would "learn more in an FFS than in a workshop, and more in a workshop than from the radio" (Bentley et al., 2003b, p. 1). We reasoned that FFS is more costly, so if either of the other methods have comparable results, they may be more cost-effective than FFS.

Methods

The authors and other project staff prepared three sets of parallel extension training materials on BW: one set for FFS, one for community workshops, and one for radio. The extension methods were different, but the underlying extension messages were intended to be as similar as possible for all three methods covering the same five key topics:

1. BW diagnosis using the stem vascular flow test (or stem glass test). The test is done by holding vertically a 3-cm potato stem base section in a glass of clean water and observing the smoke-like milky threads exuding from the stem vessels, indicating BW infection (Bentley et al., 2003b).
2. Means of BW spread and sanitation measures to avoid it.
3. Use of healthy seed and where to find it.
4. Crop rotation and incorporation of manure to recover infested soil.
5. Where the BW pathogen lives and survives (including sources of inoculum and ecology).

The messages included bio-ecological principles and background knowledge that farmers must know if they are to adopt a new practice, as shown in Table 1.

Table 1

Outline of BW Topics Taught to Farmers in Three Extension Methods

Topic	Key Ideas	Recommendations
1. BW diagnosis	• When a plant has BW, one or more stems wilt and then the plant dies. • When potato plants have received enough water, and wilt anyway, it can be due to BW or to fungal vascular diseases, insect damage or stem wounding. • Using a vascular flow test to diagnose BW.	• Recognize BW in the field. • Do the vascular flow test to diagnose BW.
2. Means of BW spread	• BW spreads through seed, soil on tools, animals' hooves and farmers' sandals, bags, runoff and irrigation water. • BW is hard to eradicate from infested fields, so various sanitation measures should be applied to prevent contamination of BW-free plots.	• Rogue diseased plants and bury or burn them. Eventually put ashes or lime in the hole. • Wash tools, sandals and bags (preferably with a bleach solution) before entering field. • Dig drainage ditches; do not use irrigation water that crosses infested fields.

Table 1 (continued)

Topic	Key Ideas	Recommendations
3. Use of healthy seed	• Infected seed spreads BW to potato fields. • Recognizing BW symptoms in tubers. • There may be no visible symptoms, even in infected seed. The bacteria can be present in the tubers, but in a latent form.	• Recognize and use healthy seed. • Identify sources of BW-free seed e.g., from BW-free highland areas where farmers do not plant seed brought from lower elevations.
4. Crop rotation	• Crop rotation or a long fallow reduces disease-causing bacteria in the soil. • Some crops are potential hosts and should not be planted after a BW-infested crop. • Rotation or fallow is effective only with the proper sanitation practices to prevent plot recontamination. • Hen manure helps reduce BW pathogen in soil and improves plant growth.	• After a BW-infected potato crop, collect rotten tubers at harvest and keep fields free of weeds and volunteer potato plants. • Rotate crops or fallow for at least two years before planting potatoes again. Rotate with crops that cannot host BW. • Plow hen manure into fields.
5. Where the BW pathogen lives and survives	• BW is caused by bacteria: very small, living things that one cannot see, but which multiply rapidly. • BW develops from infected seed potato seed or the bacteria penetrate the roots from infested soil. • The bacteria that cause BW also live on roots of weeds and volunteer potato plants. The BW pathogen needs heat and moisture to multiply so BW develops less at higher, cooler altitudes leading to latent infection.	• Use healthy seed grown in the highlands. • Plow in the dry season to expose soil to sun or frost. • Keep fields free of weeds and volunteer potato plants.

Farmer Field School

The participants included local leaders and other farmers, selected with the help of locally-elected, community leaders (*dirigentes*). Each FFS had a learning field: a potato field already infested with BW. So participants could see how healthy seed manages bacterial wilt, “a local farmer planted certified seed in half of the plot and local seed in the rest (the same rates of fertilizer and fungicides were used)” (Bentley et al., 2003b, p. 2). Every FFS session included an “agro-ecosystem analysis,” which is a structured comparison of the two halves of the plot, usually considered a central feature of FFS, involving field observation, drawing sketches, and discussion. The participants drew potato plants in the stage of growth they had seen in both halves of the plot and included their observations (e.g. diseases, insects, and weather) and then discussed how the environment and clean seed influenced plant health. Activities in the learning field were complemented by simple experiments where farmers infected seed in pots, and by talks and demonstrations. Farmers attended 10 sessions with about 25 participants in each field school (about 40% were women). The field schools were given by PROINPA staff who received intensive, on-the-job training and close supervision from a staff member (agronomist H. Equise) who had taken a three month practical course on FFS in Ecuador in 1999, organized by the FAO and CIP.

Workshops

The workshops shared some features with the FFS. They included an IPM focus, bio-ecological information, and a learning plot to show the importance of healthy seed. There were three main differences. First, the workshops were open to the whole community, not to a group of 25, and often 50 or 60 people attended. Second, workshops met less often only “three times per crop cycle, while the FFS met about ten times” (Bentley et al., 2003b, p. 2). Third, the workshops did not include an agroecosystem analysis. Partly this was to save time, which was one of the goals of the workshop; also the workshops were seen more as straightforward ways of disseminating technology, with less emphasis on class participation.

Radio Programs

The staff wrote six scripts of three minutes each, to convey the same agro-ecological information that was given in the FFS and workshops. As in the workshops and FFS, the radio programs emphasized cultural control (healthy seed, crop rotation, and sanitation practices). The short programs were written in vernacular Spanish by the same agronomists who carried out the FFS and workshops. Each message was read on the air three to four times a day by professional journalists at Radio Mauro Núñez, a community, non-profit station. After a month the next message was introduced (Bentley et al., 2003b, p. 4).

Costs and Audience

Because there were 10 FFS sessions but only three workshop sessions, and workshops had class sizes double or triple those of FFS, the per capita cost of a workshop was much less than that of a farmer field school. We conservatively estimate 2000 listeners to the radio program, based on the population of the villages (but not the towns) of the areas where the Radio Mauro Núñez broadcasts can be regularly received (Table 2).

Table 2

Costs of Different Extension Methods (including staff costs)

Methods	Number of farmers reached	Total cost (in US dollars)	Cost per farmer (in US dollars)
FFS	318	24,170	76
Workshops	746	19,400	26
Radio	2000	840	0.42

Survey Methods

The research design had three treatments (i.e. FFS and radio vs. workshop and radio vs. only radio). These three extension methods were the categories for sampling interviewees. It is often difficult to interview a random sample of smallholder farmers in a developing country as there may not be a list of the population to construct a sampling frame; even if there is a list, many villagers are away from home on any given day. In Chuquisaca, the rugged, semi-arid topography meant that many houses were a kilometer apart over steep terrain—which added to the time and cost of reaching people. This forced us to take a quota sample (the people we could find, either at home or in their fields). In 2003, the authors administered a short questionnaire to 55 farmers in nine communities (19 had attended an FFS, 18 had gone to a Workshop, and 18 had listened to the radio programs) (Bentley et al., 2003a).

The results of the 2003 questionnaire suggested that there were differences between the treatments, but that farmers in all three groups learned something (Bentley et al., 2003a). In 2004 the authors and other colleagues conducted a survey of a larger sample of 173 farmers (59 from FFS, 79 from workshop, and 35 from radio) (Barea, Salinas, Rioja, Equise, & Quiruchi, 2004a). The 2003 study emphasized knowledge (what people had learned about BW), while the 2004 questionnaire stressed behavior (how people controlled BW). The timing of the surveys made sense, because by 2004 farmers had had more time to try the new practices. All of the data presented in Tables 3-10 is from the 2004 survey. Data were analyzed using a chi-square test of homogeneity of proportions.

Communities were chosen that had had little previous extension contact with PROINPA (e.g. no previous FFS had been done there). Communities were purposively chosen to include contrasting agroecological zones, and there was a tendency for the FFS communities to be in higher-altitude, seed-producing areas, with more concern about BW and possibly more contact with extension, but not necessarily from PROINPA. Because many agencies in Bolivia perceived bacterial wilt as a national emergency, from the mid 1980s on, several NGOs, government agencies, and a prominent seed project (PROSEMPA) taught about BW in the area. The seed-producing communities were more motivated to pay attention to these messages. Our samples may have been biased, with "progressive" farmers over-represented in the FFS compared to the other groups (see Feder et al., 2004a). If anything, this would be expected to lead to an upward bias in the impact of FFS compared to other extension methods but we do not believe that this effect was very large. As far as we can judge there are no systematic biases, which would have produced the pattern of differences between the three survey groups, except the possible over-sampling of more progressive farmers in the FFS group.

This study does not have an absolute control group, i.e. we have no group of interviewees without exposure to any media. This is an inherent problem with studies of radio, which blankets a large area. During the first survey, all but one person (in all groups) said they had heard the messages over the radio, and many of them repeated the messages for the interviewers. So all (or almost all) of the farmers learned something from the radio and extension programs, but people (in all three treatments) probably also learned something from other sources.

Results

Topic 1: Diagnosing BW

During the first survey, most interviewees "could describe at least some of the symptoms of diseased plants and tubers and explain the symptoms of bacterial wilt in their own words" (Bentley et al., 2003b, p. 6). This was not surprising, since they had had serious problems with the disease for over ten years. Our training taught them to use the flow test to diagnose BW. Among the FFS graduates and workshop attendees, many farmers did not use the vascular flow test, although most of those who did not were familiar with the test (Table 3). Similar results were found during the 2003 study (Bentley et al., 2003a). FFS graduates were not more likely to do the flow test than those who attended the workshops, but FFS and workshops attendees used it more than people who only listened to the radio (χ^2 [2, N = 49 for FFS, 65 for Workshop, and 35 for Radio] = 20.462, p < .001; Table 3).

The reasons people gave for using the flow test were significantly different among all three training methods. Most of the workshop attendees (and significantly more FFS graduates) knew the test, even if they had not used it (χ^2 [2, N = 25 for FFS, 44 for Workshop, and 34 for Radio] = 47.577, p < .001; Table 3).

Table 3

Farmers Who Did Stem Vascular Flow Test at Least Once to Diagnose Bacterial Wilt

Tried the Flow Test at Least Once	FFS	Workshop	Radio
Yes[a]	24 (41%)$_a$	21 (27%)$_a$	1 (3%)$_b$
No, even though they saw wilted plants in their field[a]	25 (42%)$_a$	44 (55%)$_a$	34 (97%)$_b$
Because they do not know it[b]	4 (16%)$_a$	17 (39%)$_b$	34 (100%)$_c$
Because of other reasons[b] (lack of interest, time or did not have a clear drinking glass)	21 (84%)$_a$	27 (61%)$_b$	0 (0%)$_c$
No, because they did not see wilted plants in their field	10 (17%)	14 (18%)	0 (0%)

Note. Percentages in the same row that do not share same sub-scripts differ at p < .05 in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 49 for FFS, 65 for Workshop, and 35 for Radio) = 20.462, p < .001.
[b]χ^2 (2, N = 25 for FFS, 44 for Workshop, and 34 for Radio) = 47.577, p < .001.

Topic 2: Crop Sanitation Practices

FFS graduates were no more likely than workshop graduates to pull up (rogue) diseased plants, and remove them from the field. But radio listeners were much less likely to do so (χ^2 [2, N = 45 for FFS, 67 for Workshop, and 30 for Radio] = 11.887, p = .003; Table 4). However, FFS was more likely to convince farmers to adopt a more complex behavioral change: not just culling diseased plants, but also adding a soil amendment to the hole. Differences were highly significant between all groups, with FFS graduates the most likely and radio listeners the least likely to put lime, ash or manure in the hole after uprooting the potato plant (χ^2 [2, N = 42 for FFS, 57 for Workshop, and 19 for Radio] = 14.301, p = .001; Table 4).

Table 4

Farmers' Practices for Wilting Potato Plants

Rogued (culled) Diseased Plants	FFS	Workshop	Radio
Yes[a]	42 (71%)$_a$	57 (72%)$_a$	19 (54%)$_b$
Without soil spot treatment[b]	22 (52%)$_a$	41 (72%)$_b$	19 (100%)$_c$
With soil spot treatment[bc]	20 (48%)$_a$	16 (28%)$_b$	0 (0%)$_c$
No although they saw wilted plants in their field[a]	3 (5%)$_a$	10 (12%)$_a$	11 (31%)$_b$
No because they did not see wilted plants in their field	14 (24%)	12 (15%)	5 (14%)

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 45 for FFS, 67 for Workshop, and 30 for Radio) = 11.887, $p = .003$.
[b]χ^2 (2, N = 42 for FFS, 57 for Workshop, and 19 for Radio) = 14.301, $p = .001$.
[c]Applied ashes, manure, lime in the hole left after plant removal or burned soil.

Farmers who took field schools were more likely than workshops attendees to wash their tools (with water, soapy water, a bleach solution, boiling water, or water and ashes or lime) to avoid carrying bacteria from one field to another. The radio listeners were by far the least likely to wash their implements (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 44.758, $p < .001$; Table 5).

Table 5

Farmers Who Washed Tools before Entering the Field to Avoid Transmitting BW

Washed Tools before Entering the Field	FFS	Workshop	Radio
Yes[a]	45 (76%)$_a$	34 (43%)$_b$	2 (6%)$_c$
Only with water	14 (31%)	16 (47%)	2 (100%)
With water and other product (soap, bleach, stove ashes or lime)	31 (69%)	18 (53%)	0 (0%)
No[a]	14 (24%)$_a$	45 (57%)$_b$	33 (94%)$_c$

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 59 for FFS, 79 for Workshop, and 35 for Radio) = 44.758, $p < .001$.

Topic 3: Use of Healthy Seed

Most farmers "understood that infected seed is the main source of BW, even those who had only listened to the radio" (2003 survey, Bentley et al., 2003b, p. 5). FFS graduates and workshop farmers were both more likely to actually use healthy seed than radio listeners. As Table 6 shows, most farmers claimed to use healthy seed, which for them included first and second generation certified seed, and other seed known to be disease-free (e.g. seed they brought from highland fields which they knew to be healthy). The differences were only slightly significant between radio and the other treatments, but not between FFS and workshops (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 6.32, $p = .042$; Table 6).

Table 6

Farmers Who Planted Healthy Seed

Planted Healthy Seed	FFS	Workshop	Radio
Yes[a]	51 (86%)$_a$	65 (82%)$_a$	23 (66%)$_b$
No[a]	8 (14%)$_a$	14 (18%)$_a$	12 (34%)$_b$

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 59 for FFS, 79 for Workshop, and 35 for Radio) = 6.32, p = .042.

Topic 4: Crop Rotation and Incorporation of Manure

Almost all farmers rotate for at least one season after a potato crop, so the training method had no influence on this practice (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 0.735, p = .692; Table 7). However, FFS graduates were significantly more likely than workshop attendees or radio listeners to know that crop rotation would also reduce disease, differences between workshop and radio were not significant (χ^2 [2, N = 57 for FFS, 77 for Workshop, and 33 for Radio] = 11.702, p = .003; Table 7).

Table 7

Farmers Who Applied Crop Rotation to Manage Diseases and Pests

Rotated Crops	FFS	Workshop	Radio
Yes	57 (97%)	77 (97%)	33 (94%)
Knew that it would reduce diseases and pests in soil[a]	53 (93%)$_a$	53 (69%)$_b$	24 (73%)$_b$
Did not know it would reduce diseases and pests in soil[a]	4 (7%)$_a$	24 (31%)$_b$	9 (27%)$_b$
No	2 (3%)	2 (3%)	2 (6%)

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 57 for FFS, 77 for Workshop, and 33 for Radio) = 11.702, p = .003.

Method of training had little influence on the use of hen manure, and the differences were not significant (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 0.844, p = .656; Table 8). A few farmers from FFS and workshop said they used manure to control BW, although most used it to fertilize the soil (for which it is well suited, of course).

Table 8

Farmers Who Used Hen Manure

Used Hen Manure	FFS	Workshop	Radio
Yes[a]	16 (27%)$_a$	26 (33%)$_a$	9 (26%)$_a$
Used manure to increase yields, or to fertilize the soil	13 (81%)	24 (92%)	9 (100%)
Used manure to control BW	3 (19%)	2 (8%)	0 (0%)
No[a]	43 (73%)$_a$	53 (67%)$_a$	26 (74%)$_a$

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 59 for FFS, 79 for Workshop, and 35 for Radio) = 0.844, p = .656.

Topic 5: Where the Pathogen Lives and Survives

Farmers who took the FFS were significantly more likely than the workshop attendees or radio audience to plow in the cold season in order to turn over the soil and expose the bacteria to frost (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 10.573, p = .005; Table 9).

Table 9

Farmers Who Plowed Soil During the Dry Season to Expose it to Frost

Plowed in the Dry Season	FFS	Workshop	Radio
Yes to manage BW and/or pests[a]	46 (78%)$_a$	47 (60%)$_b$	16 (46%)$_b$
Did not do it or did not know it[a]	13 (22%)$_a$	32 (40%)$_b$	19 (54%)$_b$

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 59 for FFS, 79 for Workshop, and 35 for Radio) = 10.573, p = .005.

Sharing Information with Other Farmers

FFS graduates were not more likely than workshop attendees to share information with friends and neighbors, and radio listeners were significantly less likely than the others to share new ideas about BW with other farmers (χ^2 [2, N = 59 for FFS, 79 for Workshop, and 35 for Radio] = 18.427, p < 0.001; Table 10).

Table 10

Farmers Who Shared Knowledge with Other Community Members

Shared Knowledge	FFS	Workshop	Radio
Yes[a]	34 (58%)$_a$	52 (66%)$_a$	8 (23%)$_b$
No[a]	25 (42%)$_a$	27 (34%)$_a$	27 (77%)$_b$

Note. Percentages in the same row that do not share same sub-scripts differ at $p < .05$ in the chi-square test of homogeneity of proportions.
[a]χ^2 (2, N = 59 for FFS, 79 for Workshop, and 35 for Radio) = 18.427, p < 0.001.

Conclusion and Implications

Conclusions

The general tendency was for FFS graduates to have learned more than workshop attendees, and much more than radio listeners. But results varied among different practices, and the difference was greatest for time-consuming technologies, where a more compelling demonstration may convince farmers to adopt a task that adds work to an already busy day. Adoption of new behavior was also uneven, and was influenced in part by confounding variables not in the research design (e.g. the cost of the technology).

Topic 1: diagnosing BW. The flow test was used by only 30-40% farmers for the two more intensive training methods. The test requires a clear drinking-glass and crystal clean water, both of which are in short supply in rural Chuquisaca. During open ended questioning in the interviews, some farmers explained that they did not need to do the test to distinguish drought from BW, because if they had irrigated, they knew their potatoes were not dying from drought. They also knew that BW infects individual plants, while drought affects whole fields. They also said that they uprooted diseased plants and examined the roots, to see if they were eaten by insects or rotted by other soil-borne diseases.

Topic 2: crop sanitation practices. Pulling up diseased plants reduces the spread of bacterial wilt, and also reduces inoculum in the soil; this practice was recommended for small field area (e.g. below 0.5 ha or even smaller) prevalent in the project area and with BW incidence less than 5%. However, most farmers are only willing to rogue 100 to 150 plants per plot (eight hours of work). When many plants are infected, farmers become discouraged from uprooting them all (Salinas, Villavicencio, & Barea, 2004). Still, FFS and the workshop participants did uproot plants, and FFS graduates were more likely to apply a soil amendment to the hole to kill the pathogen in soil. The bactericide effect of lime and stove ashes in soil had been demonstrated in greenhouse experiments at CIP (Priou, 2004).

Radio listeners had heard of washing implements, and mentioned it as one of the things they had heard on the radio during the survey. The idea impressed them (and a few even thought it was funny, i.e. counter-intuitive), but hardly any adopted the practice, while people who took FFS or workshops reported some adoption. The training allowed that cleaning tools helped to avoid spreading soil-borne diseases.

Topic 3: use of healthy seed. Method of training had little effect on this behavior. Even if farmers understand the importance of healthy seed, purchase is constrained by high costs. Potato seed can cost about 40% of the crop budget. About 30% of the farmers in the study area say they cannot afford healthy potato seed (Salinas et al., 2004).

Topic 4: crop rotation and incorporation of manure. Using crop rotation for IPM depends on having land available. A BW Project survey in 2003 found that farmers with less than 1.9 hectares rotate for just two years, while those with two to 2.9 hectares of cropland (27% of the sample) rotate for an average of three years; 64% of farmers with over three hectares rotate for four years (Salinas et al., 2004). Crop rotation is a conventional practice in the area, and most farmers use it, depending on how much land they have, so well over 90% of farmers rotate crops, regardless of extension method.

Applying manure has consistently shown the suppression of various soil-borne diseases. Sterilized manure generally does not suppress disease, so the mechanism may be biological, although the exact antagonistic micro-organisms that suppress disease are poorly known (Noble & Coventry, 2005). Studies, as part of this project, also showed significant suppression of BW and yields were dramatically increased (double that of the control group), with 20 t/ha of hen manure (Barea, Equise, Montenegro, & Sardán, 2004c; Priou, 2004). However, small and medium farmers can rarely afford to buy much manure. Farmers may be more likely to use manure to increase yields than to manage disease. Therefore, there was little effect of training on whether or not farmers applied manure. They seem to have done so if they could afford to buy manure, in order to fertilize their soil, rather than to manage disease.

Topic 5: where the pathogen lives and survives. The more intensive the training, the more likely farmers were to make the extra effort to plow the hard, winter ground, to expose the pathogen to frost and UV light, thus reducing soil populations. Plowing with oxen is strenuous work (especially when the soil is hard and dry) and the ox team often has to be rented. Those who did not plow in the cold, dry season argued that the soil was too hard then, or that they had no time.

Implications

Sharing information. FFS graduates were not more likely to pass on new ideas about managing disease than workshop attendees, a result that is consistent with earlier studies cited above (Anandajayasekeram et al., 2007; Feder et al., 2004a, 2004b; Rola et al., 2002; Winarto, 2004).

Change in behavior. The hypothesis guiding this research was that the FFS treatment should lead to the most learning and adoption of new technology. This hypothesis was broadly confirmed, although the degree of change varied with each practice. The biggest differences in adoption rates between extension methods were for washing tools and for time-consuming behaviors (dry season plowing, applying a soil amendment after rouging diseased plants), where a more compelling demonstration may convince farmers to adopt a task that adds work to an already busy day. But the 10 sessions of FFS were little better than three sessions of community workshop for encouraging people to adopt other technologies (e.g., using the flow test, rouging diseased plants or buying healthy seed) and workshop can reach more farmers at a lower cost.

All of the BW-management technologies demand that farmers spend money or labor, or both, so some people may decide that the expense is not worth the savings in disease reduction, even if they understand the technology and its rationale. This study did show that face-to-face extension (either FFS or workshop) is more convincing than radio. But the effect of radio on its own may have been underestimated in this study, because all of the farmers heard the radio spots, including the people in field schools and workshops. Hearing the radio spots may have reinforced some messages, or given them added credibility, giving the face-to-face methods a slight advantage in this study. But even the radio listeners adopted at least some of the recommended practices. Recall that it cost three times as much per capita to deliver a field school as to give a workshop. Radio is at least 100 times cheaper per person than an FFS.

Care should be taken in generalizing our findings. We compared three extension methods for only one problem (BW) and for adoption of a few technologies. Future research could compare themes such as long-term learning (retention), permanent technical change and empowerment. Future studies should also compare yields of FFS and non-FFS farmers (as in Ortiz et al., 2004).

Because it costs orders of magnitude less to reach a person by radio than by FFS, future studies should determine which messages can be conveyed by radio (or videos, newspaper etc.). The more complicated, tedious, and counter-intuitive a new technology is, the more important it probably will be to use a more intimate extension method, and the less likely a mass media will be successful.

Taking a broader perspective, however, FFS, radio and workshops should be seen as complements, not as alternatives in a broader integrated extension program. FFS could be useful for starting collegial research to improve management of a target crop or problem (see Biggs, 1989), developing key extension messages with farmers' involvement and understanding how to communicate these messages most appropriately. This could be followed up with use of radio and workshops to disseminate key extension messages more widely. FFS and radio could be combined, using FFS communities as "radio studios" where farmers discuss what they learned in field school, with their words broadcast to thousands of their peers (Bentley & Van Mele, 2005).

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