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Folk experiments

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Abstract. Folk experiments in agriculture are often inspired by new ideas blended with old ones, motivated by economic and environmental change. They tend to save labor or capital. These notions are illustrated with nine short case studies from Nicaragua and El Salvador. The new ideas that catalyze folk experiments may be provided by development agencies, but paradoxically, the folk experiments are so common that the agencies that inspire them usually pay little attention to them. Some folk experiments are original, but others simply copy innovations that farmers have seen somewhere else. Unlike formal scientific research, in which results are consistently written, folk experiments are rarely "inscribed," because the results are for use by individual farmers and need not be shared with an audience.

Key words: Central America, Farmer inventions, Folk experiments, IPM (Integrated pest management), Technical change in agriculture

Abbreviations: FFS – Farmer field school; IPM – Integrated pest management; Promipac[1] – Programa de Manejo Integrado de Plagas en América Central (Integrated Pest Management Program in Central America); SDC[2] – Swiss Agency for Humanitarian Aid and Development Cooperation; Zamorano – Also known as the EAP (Escuela Agrícola Panamericana, or the Pan American School of Agriculture).

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Introduction

Nearly all smallholder farmers tinker with new techniques. Even "traditional" technology is routinely subjected to small, incremental changes to retain its viability (Stone, 2004). Smallholders experiment on their own, with or without encouragement. Folk experiments blend new ideas and old ones, are motivated by changes in the environment and the economy, and seek to resolve labor and capital constraints, among other reasons.

Farmer participatory research, the notion that scientists and farmers can collaborate on research, is based on the observation that farmers experiment, but also on a social agenda (e.g., mistrust of government research). Accounts of folk experiments often mention the farmers' research topics (e.g., they try new crop varieties, experimenting with fertilizers and planting dates), but there have been few detailed accounts of how farmers actually experiment (Sumberg and Okali, 1997). For example, Mak (2001) tells us that farmers in Cambodia have adopted modern high yielding rice varieties. They have also used manure and chemical fertilizer at different times and at various rates of application and tried various ways to irrigate or plant on river floodplains so they can get enough soil moisture early in the rainy season. But we are spared the details of how the farmers experimented (Mak, 2001).

Sumberg and Okali (1997) surveyed 189 farmers in Ghana, Kenya, and Zimbabwe and concluded that most farmers experiment, often with some type of control group and experimental treatments, and that these experiments are essential for adapting techniques in constantly evolving farming systems. Yet each individual experiment is not very novel or useful. It is their aggregate effect over the long run that gives them value. Sumberg and Okali (1997) suggest that farmer experiments have little to offer formal research and that there is little room for synergy between researchers and scientists. On the other hand, Critchley and Mutunga's (2003) survey of farmers in Kenya, Tanzania, and Uganda from 1997 to 2001 yields 18 promising technologies for soil and water conservation, including turning gullies into gardens, digging planting pits for millet and sorghum, and harvesting water from roads. In this paper I argue that a few folk experiments will be of interest to scientists. Even small changes help make technologies more appropriate and do so in ways that scientists will not have thought of. The best folk experiments do not simply copy an innovation but combine new ideas creatively with local knowledge.

Motivations

Smallholders experiment to adapt to changes in their economic environment. Examples include increased demand for blemish-free fruits and vegetables in supermarkets (Reardon et al., 2002) or improved roads (which lower transportation costs), changes in fertilizer and commodity prices, currency exchange rates, and tax and subsidy structures. Unrelated changes also may interact with each other to demand new solutions. For example, during the "coca boom" of the 1980s in Bolivia, Quechua-speaking colonist farmers cleared tracts of rainforest to plant coca for the rapidly expanding (and illegal) international cocaine market. Coca leaves must be dried soon after harvest or they will spoil. During heavy rains, some farmers took advantage of newly improved roads to truck their green, wet coca leaves up to their home villages in the dry Andean valleys, where they could spread the leaves in the sun to dry (Sanabria, 1993). Similarly, in one area of China with access to better roads and markets, over three quarters of the farm households in the valley were high innovators, while in more isolated communities only 30–40% of households were high innovators (Wu and Pretty, 2004).

Anthropologist Orlove (2002) describes how environmental change in Lake Titicaca led to dramatic changes in techniques used by small-scale fishers, who were also smallholder farmers. Trout were introduced into the lake in the 1960s by a misguided development project, and the silverside (another fish) was introduced from lowland South America by a sports fishing club in the 1970s. While local people were not consulted about the silverside, they created a new system for fishing. For the first time, they began fishing in the middle of the lake and built small, wooden boats, scaled-down versions of the ferries used to cross the straits between the big lake and the small lake. They made new nets reworked from sea-fishing nets that a few locals had seen on the Peruvian coast (Orlove, 2002).

Another example are the Zande of Sudan, who suffered disastrous environmental change during colonial times. They were relocated from the valleys to poorer soils on ridges. Villages were broken up and families were scattered over the land on rectangular plots with no regard for soil type. All were forced to grow cotton. They responded by experimenting, notably with new crop associations (e.g., peanuts and eleusine). Many of these crops and varieties had themselves been introduced only a few decades earlier (de Schlippe, 1956).

The idea that environmental change leads to technical change is an old one. Danish economist Boserup (1965) writes that population increase drives the change to a more intensive agriculture. The model has been attacked and modified over the years (e.g., Wiegers et al., 1999; Hunt, 2000; Sheridan, 2002; Walker, 2004), but its underlying assumptions – that a community either has knowledge of new technology (e.g., intercropping, perennial crops, and irrigation) or else that inventing it will not be a problem – remains relatively uncontested. (Although Stone and Downum, 1999 suggest that more agricultural intensification was not always possible in the pre-Columbian Southwestern US).

New and old ideas

Folk experiments may be quite simple, especially when local people learn of a new idea that is more or less functional "as is," and can simply be tried and adopted. For example, Zapotec farmers in Mexico adopted ox plows and sugar-cane mills (*trapiches*) in colonial times. More recently they adopted coffee-growing, chemical fertilizer, and hybrid maize, apparently with little modification of the technologies (González, 2001). Farmers chat and share ideas when they meet to pool labor or machinery. Families that regularly help each other form networks and call each other "friends" (Bentley, 1992a; Harper, 2001). Wu and Pretty (2004) have dubbed these networks "farmer innovation circles." The circles are especially good at moving ideas if there is a friendly outsider in the province to suggest attractive ideas to local innovators.

New ideas can even be exchanged without any verbal explanation. The Ka'apor Indians in Pará State, Brazil, acquired lime trees and sugar cane while raiding the settlements of Portuguese-speaking Brazilians to get steel for making arrows and tools. During these brief attacks, some men took the time to collect new crops to take home. The actual Ka'apor experiments with these new crops were, and still are, fairly simple. They plant them in dooryard gardens where the plant can be observed. If the people like the plant, and if it thrives, they will try to transplant it when they move their village. The experiment reaches a successful conclusion if the plant survives the move or if it continues to live in old fallow after people have moved to a new site (Balée, 1994). New ideas from development projects may also encourage creativity. Sumberg and Okali (1997) note that farmers who had been involved with development projects were somewhat more likely to experiment than others.

Perhaps it is obvious that new ideas will spark creativity. It is less obvious that folk creativity also depends on old ideas. For example, Indonesian farmers who took farmer field schools (FFS), which teach background ecological knowledge, made several inventions such as early plowing to control white rice stem borer. Early plowing is based on farmers' old knowledge of plowing (e.g., the tools to do it). When this old knowledge is combined with a newly acquired ability to recognize the adult and egg stages of the stem borer, farmers realized that early plowing would kill the eggs they had begun to notice in their rice stubble (Winarto, 2004a).

Resolving constraints

Modern agricultural technology from the formal sector tends to be either mechanical (labor-saving) or biochemical (increased returns to land). Scientific inventions for agriculture tend not to be capital-saving. On the other hand, folk experiments are often designed to save cash expenses. For example, British farmers systematically try agrochemicals at lower doses. Farmers know that manufacturers set doses conservatively (i.e., high) and that with a little trial and error a grower can find a lower and cheaper dosage yielding acceptable results (Lyon, 1996).

Another constraint to innovation is the need for consistent results (Stone, 2004). There also may be conformist adoption, where people adopt innovations because many other people are adopting them (Henrich, 2001). In an example from Nicaragua, local people experimented with boiling a black toad and using the water to control leaf-cutter ants. The innovation was probably not effective, but it spread anyway, encouraged by serious pressure from leaf-cutter ants and by the belief that toads are poisonous and evil (Julio López, personal communication).

Research method

In Honduras in the 1990s my students, colleagues, and I created a course that we thought stimulated farmers to experiment (Bentley, 1992b, c; González, 1993; Rodríguez, 1993; Bentley et al., 1994) We taught them that insects were living animals that laid eggs, and that most of them were killed by natural enemies before they reached adulthood. The course consisted of field exercises and slide shows, anecdotes, and even little games. It lasted for three days and was designed to be fun, as we thought that playfulness nudged the mind into creativity. The smallholder farmers who took our course (eventually several thousand people) certainly did invent some useful, non-chemical, pest control techniques (see Bentley et al., 1994; Bentley, 2000; Meir, 2000a, b).

In 1994 the SDC (Swiss Agency for Humanitarian Aid and Development Cooperation), the agency of the Swiss government that funds development in other countries, started funding a project called Promipac (Integrated Pest Management in Central America). Promipac worked in Nicaragua and El Salvador, and was led by Zamorano, a vocational agricultural college in Honduras.

While Swiss officials visited Promipac regularly, it was (and is) standard practice for donor agencies to hire consultants to evaluate their projects (usually at mid-term and at the end of projects). The agency and the local institution usually collaborate on writing a set of research questions (i.e., the "terms of reference") and then take the consultants around to field sites. In 2003 I was asked to join Peter Trutmann to do a mid-term evaluation of the third phase (a three-year cycle of funding) for Promipac (Trutmann and Bentley, 2003). Many evaluations are fairly superficial, a sort of project continuation ritual (Tripp, 2001). This particular evaluation was more sincere. The SDC and Promipac both thought the project was successful, but they encouraged us to be critical. Trutmann and I were both genuinely interested in the project. I had helped to write one of the early proposals for it nine years before and wanted to know how the work had evolved.

Promipac's training method was the farmer field school (FFS), a kind of school without walls, but a version highly adapted for Latin America (López et al., 2003; Cáceres et al., 2003; Rueda et al., 2003). The Central American FFS included many exercises for direct participatory learning (e.g., raising a slug in a cup of earth and counting the eggs it lays) (Pilarte et al., 2004). It also included a small farm plot where field school students were encouraged to experiment with some local ideas for pest control (Julio López, personal communication). I visited nine field schools. If they were not in session, I interviewed farmers who had "graduated" from earlier ones. Trutmann and I also read project literature, heard two days of presentations by project staff, and visited universities and other agencies involved with the project.

When I asked farmers about what they learned from the project and how their work changed as a result, I realized that many of the changes were not due to simply adopting new technology, but to farmers' own experiments, which had been stimulated by new ideas. Before leaving Central America, Trutmann and I gave presentations on our report, once in Nicaragua and again in El Salvador, to Promipac and to others involved in the project.

Folk experiments and inventions

In La Ermita, San Martín, central El Salvador, a group of FFS graduates were thinking in new ways about tomato disease. For example, Freddy Guzmán noticed that his *güisquil* plants[3] had mosaic virus and wondered out-loud if the disease could spread from his squash to his tomatoes. This sense of wonder, of questioning, seemed enhanced in many people who had taken field schools. His neighbor, Manuel Enríquez, learned from the FFS (and from previous extension work) that the mosaic virus is transmitted by whitefly, but he added his own observation (i.e., old ideas) that the virus was worse in the lowlands. Thus he recognized that the development of the disease involved more than simply being inoculated by the whitefly. As he put it:

> There's one thing, mosaic is not just that the whitefly pierces [the plant]. In poor, dry soil, the [disease] gets to it faster. In the high [country the disease] doesn't bother it and in the flat land along the river [the disease] is never missing.[4]

The project training seems to have helped smallholders think of disease not just as a symptom but as a problem with a causal agent and an environmental context. Jesús Granados hypothesized that a tomato disease called *culo negro* (literally "black butt") and possibly caused by *Alternaria*, was not the same as *tizón* (blight). He had observed that fungicides controlled the blight, and even though he applied a broad-spectrum fungicide, his tomatoes rotted anyway.

As Mr. Guzmán, Mr. Enríquez, Mr. Granados, and two other neighbors talked about disease, they ran through a list of subtle, trial-and-error type tests they were doing with different kinds of chemical and organic fertilizers (e.g., chicken manure, cattle manure, kitchen ash) besides lime. Here is the creative interaction between new and old ideas. They noted the effects of disease and yield. Now that they knew that organic matter had bacteria in it, they wondered if applying chicken manure to soil could cause plant disease. They concluded that the organic matter should be composted, not fresh. New ideas from the project, combined with their own farming experience, helped them to form these hypotheses. The cases presented below are all examples of innovations where the farmers' own, local knowledge contributed as much as new ideas.

Case 1: Long lived tomatoes

In the FFS in La Ermita, Jesús Granados and his neighbor Pedro Erroa learned that diseases are caused by living organisms and that disease can be transmitted by soil, seed, or whitefly. They are planning on planting five rows of a tomato variety (i.e., Santa Cruz), which they have noticed is especially long lived. They want to see if they can take good care of it and make each plant live for a year. Their hypothesis is that older plants will be tougher and have fewer diseases. People seem to form hypotheses unselfconsciously, intuitively.

Case 2: Botanical insecticide, every other time

In Cristalina, near Candelaria de la Frontera, western El Salvador, Esteban Martínez and Carmen Alvarez are alternating botanical sprays (mostly garlic and chile) with synthetic pesticides. They spray every four days, one time with botanicals, the next with chemicals. They think that this gives them acceptable control of whitefly in tomato and mites in chili, while reducing the amount of commercial pesticides. The strategy allows them to use chemical pesticides less frequently. They don't think the botanicals work as well as the synthetics, which is why they use both kinds of insecticides. The extensionists in participating institutions are teaching people to use botanical insecticides[5] and the farmer innovation has been to use them every other time (instead of all or nothing). This is a qualitative experiment, without a control group and without numbers. Yet the farmers know what level of pest control they need to achieve if they are to sell their chili and other produce. Reaching this goal by using some botanical insecticide saves capital.

Case 3: Redesigned screen-house

In El Porvenir, Texistepeque, western El Salvador, one of the participating farmers, Ezequiel Gómez, was given four meters of screen and shown how to build a screen-house to keep whiteflies out of vegetable seedlings. While the extensionist built his screen-house on a table of sticks, Mr. Gómez redesigned the screen-house by using only half the screen (deciding that he only needed a smaller screen-house) and by building it directly on the ground. This allowed the seedbed to preserve moisture and keep the plants moist in this arid area. The farmer's small design modification helped adapt the screen-house to its environment. In this case, the farmer adopted the principle of the screen-house, because he understood the role of the whitefly as a vector of mosaic virus, something he learned from the extension program. But Mr. Gómez made original contributions with regard to the screen-house size and soil and water management, based on his own understanding of his needs and environment. His experiment clearly mixed old and new ideas. It was stimulated by new market demand for vegetables and by (economic and environmental change) and it saved both labor and capital.

Case 4: Sacks and molluscicide

As mentioned above, Zamorano is the college that runs Promipac. I was the anthropologist in Zamorano's Crop Protection Department from 1987 to 1994. In the 1980s, Zamorano invented an early season method to control slugs. One of the methods was the "trash trap" (i.e., piling mounds of cut weeds in the field and turning them over every few days to kill slugs hiding from the sun). It was inspired by farmer observations that slugs gather under stacks of maize stalks left to dry in the field. But, I noticed in the late 1980s that although the technology worked in theory, and even though farmers understood it, they refused to adopt it. It was labor-intensive and counter-intuitive, since the technique was not applied in the bean field when slugs attacked, but had to be used in the maize fields, months before planting the beans. In addition, large, mature maize leaves are sharp. They can cut a person's face, and so it was painful to apply slug bait or tend slug traps in a maize field (Bentley and Andrews, 1991). For nearly 20 years, farmers continued to complain about slugs, and extensionists continued to recommend the baits and traps. Gradually they improved. By the 1990s, a version had emerged that involved leaving cans of beer, or *chicha*, under the piles of trash to drown the slugs (López, 1997). Since the beer traps do not have to be checked as frequently, it makes them easier to use. Additional modifications helped the traps kill more slugs. They could be used directly in the bean fields and not just as a preventative before planting, which further appealed to farmers.

By 2003 farmers were using new slug control technology and modifying it in useful ways. Ildefonso Flores, in Hoyos, Cabañas, central El Salvador, said he uses old sacks as slug traps. The sack is a functional modification of the trash trap because it provides the same lethal refuge, but the scrap of sack is easier to move about than a pile of weeds. Mr. Flores combined the trap with commercial molluscicide (i.e., snail pellets laced with Metaldehyde). Snail pellets were not available in the 1980s when the trash trap was invented. Putting snail pellets under the sack traps does cost some money, but it saves a lot of time since the farmer can go at least a week between visits. Campesinos are often willing to spend a little money to save time.

Case 5: Green grass slug trap

Farmers in Santa Teresa in Condega, northern Nicaragua learned about ecological slug control through a project course. They mentioned that snails are "all females" (actually they are hermaphrodites), that they lay 70 eggs, and however counter-intuitive, that they must be controlled in the dry season (i.e., July) before they lay their eggs (i.e., September). This knowledge inspired Genaro Ruiz to make a slug trap with cut, green plants. "One makes a trap with cut green plants (*guate*). Ten or 15 slugs come to it and they are skewered on a stake."[6] The green plants form a close bundle, so they are easier to turn over than loose piles of old cut weeds. Like the previous example, this experiment also saves on labor as it is easier to make than earlier technologies. The technology is also an adaptation to change in the environment, since the bean slug became a problem in Central America only in the early 1980s.

Case 6: Tortillas for the ants

Ediberto Cruz, in Santa Lucía, San Vicente, central El Salvador, places a tortilla in an ant nest when hoeing nearby. The ants eat the tortilla instead of stinging him and are fed at the same time. The invention is based on new ideas from the Promipac (e.g., that ants are beneficial insects because they eat insect pests) blended with the old idea that fire ants will eat tortillas.[7] In the 1980s Central American farmers routinely killed ants and tried to destroy their colonies. Feeding these beneficial insects is an example of how campesinos can easily invent new ways of manipulating and conserving the larger, native natural enemies (Bentley and Andrews, 1996).

Case 7: Picking dead leaves

Farmers in a field school in Volcancillos, Morazán, northeastern El Salvador were growing cucumbers when an unidentified fungal disease suddenly turned the leaves black. The people pulled off as many leaves as they could, removing them from the field in the hope that this would help the plants recover.

They had arranged their FFS plot to include an IPM side and a "traditional" (chemical-control) side. Essentially, this division was modeled after a formal experiment, with two treatments, although each treatment was actually comprised of several technologies. In the FFS the people learned how to recognize fungus and that it is a living thing. They dumped the dead leaves away from the plants because they knew that the leaves could have inoculum on them. They tried to remove the leaves from the diseased plants in both sides of the plot. They also planned to spray both sides with a fungicide – a chemical one on the traditional side and the antagonistic fungus

Trichoderma on the IPM side. They were using more than one independent variable in each treatment. While the analysis will be qualitative, it should give them an idea of whether they can keep the disease to a tolerable level by pruning diseased leaves and spraying fungicide. They said they wanted to see if the plucked leaves would grow back. In other words, they are operating with two hypotheses: (1) plucking leaves and spraying fungicide will control the disease, and (2) new leaves will later grow back. They are testing several ideas simultaneously in the same plot, unlike formal experimentation (Saad, 2002).

Case 8: Living, natural insecticide?

In Cinco Pinos, Chinandega, northern Nicaragua, Azucena Soriano took an FFS on tomatoes. Ms. Soriano had never grown tomatoes before and learned that they needed to be staked. The extensionist recommended *Gliricidia* leaves as a botanical insecticide. Combining both of these new ideas (i.e., stakes and *Gliricidia* insecticide), Ms. Soriano made tomato stakes of live, freshly cut *Gliricidia* branches. Central American smallholders use *Gliricidia* as living fence posts because the posts take root easily. Ms. Soriano happily recalled how the *Gliricidia* stakes also took root in her tomato patch. Now she is observing them to see if the leafy stakes will help keep insect pests away from her tomatoes. Her experiment is still underway, but it is worth following up, to see if the tomatoes staked to living *Gliricidia* do have fewer insect pests. Unlike most of the technologies we have discussed so far, this one is actually more than an adjustment. It is a whole new technique. Whether it works or not remains to be seen, but it is a novel invention by Ms. Soriano, a smallholder farmer.

Case 9: Qualitative sampling

In El Cacao, Jinotega, northern Nicaragua, Luis Martínez used a kind of qualitative sampling.[8] He had *Plutella* (i.e., cabbage worms, the larvae of diamond-back moths), which he controlled with only three applications of insecticide. In the 1990s, farmers were applying pesticide weekly for *Plutella* in Central America. Mr. Martínez's dramatic reduction in insecticide use was possible because he learned to sample for pests during project training. He went up to 25 days between applications. Before taking the FFS, he used to spray insecticide *every four days*. He was pleased that less spraying saved him time and money. Mr. Martínez went to the field to look at his crop every two or three days, looking at ten or twenty plants in one place, then looking at some more in several other parts of the field. It took him an hour at the most because the small, but glossy, green worms were easy to see in the cabbage whorl.

This is an important lesson that should encourage entomologists not to insist on quantitative sampling (see Baker, 1999). Farmers often lack the math skills and the time to count a random sample of insects and calculate a percentage. However, as this example shows, they may reduce pesticide applications if they are free to improvise qualitative sampling techniques.

Discussion

Unlike conventional agricultural research, which tends to use capital to save labor, smallholder farmers are more interested in cutting cash expenses. Hardware stores that cater to tropical smallholders frequently sell most tools (e.g., axes, hoes) without handles, since the shopkeepers know full well that their customers would rather save money by making the handles themselves at home, from local wood. Table 1 shows that the experiments discussed above save on either labor or capital, and most of them save on both.

As Table 2 illustrates, all but two of the folk experiments discussed here were a response to environmental or resource change.

Folk experiments blend new ideas and old

While adapting to change and saving costs may motivate experiments, in Table 3, we see that the source of each folk experiment was a mix of new and old information. Some of the introduced ideas are techniques, but others are merely background, bio-ecological information. None of the farmers were simply copying or replicating techniques they had seen others do. All made an original, intellectual contribution to their folk experiments.

It is clear that the farmers' folk experiments drew on ideas they had learned from extension agents, in this case, in field schools convened by Promipac. It seems intuitively obvious that new ideas stimulate change, as Fernández-Armesto (2000) stresses in his ambitious history of the world. Ancient civilizations that lacked contact with others experienced less technical and cultural change. If fresh ideas breed change for societies, the same should be true for individuals. The rate of folk experiments should increase as people learn new things. The idea seems so self-evident that it has been subjected to little empirical testing. Some of the pioneer studies have been surprising.

Wyckhuys (2005) recently tested the hypothesis that new ideas stimulate smallholders to invent pest control alternatives. Wyckhuys surveyed Honduran farmers as part of a two-year study. Unlike many earlier studies, he included a kind of control group. He interviewed farmers who had taken a course on the natural history and control of the fall armyworm, a common maize

Table 1. Saving labor and capital through folk experiments.

Case	Saving labor	Saving capital
1. Long-lived tomatoes	Planting tasks (e.g., making seedbeds) can be done less frequently	Saves on costs for seed
2. Botanical insecticide	It takes some time to make the botanical insecticide, though this is probably offset by the savings in travel time to buy a chemical pesticide	Saves on the cost of buying commercial pesticides
3. Redesigned screen-houses	Smaller screen houses are easier, quicker to build	Saves money on screen, but also on other materials (nails, etc.)
4. Sacks and molluscicide	Easier to turn over than the cumbersome "trash traps"	Does cost some cash, although that is no doubt compensated by the saving in labor
5. Green grass slug trap	Saves a lot of labor, since the traps can be turned over less frequently	
6. Tortillas for the ants	It may save the labor of destroying the ant hill[a]. It helps people avoid the pain of being stung, which may improve labor efficiency	May save the expense of poisoning the anthill with insecticide
7. Picking dead leaves	No. It actually takes labor, which is why the people are following the results to see that the practice actually does control the disease	If it works, it may save capital (for fungicides)[b]
8. Living, natural insecticide	If it works she will not need to look for the *Gliricidia* leaves and prepare the insecticide, although she will need to prune the stakes	The trees are abundant locally and stakes can generally be cut at no cash expense
9. Qualitative sampling	Can save time compared with quantitative sampling, and requires less arithmetic	Allows lower use of chemical pesticides

[a]Before taking a course on insects, Central American smallholders tended to think of ants as pests, and many people went out of their way to disturb the ant colonies.[b]The fact that the people are trying fungicides and picking leaves seems to confound the experiment. Of course, if the combination does not work, the farmers will know that they can either abandon cucumbers or try a new control technique. If the combination does work they will probably start trying each tactic on its own.

pest in Central America. Of 25 farmers who took the course, only one (4%) invented something, and (unfortunately for the claim that "new ideas spark inventions"), even more of the interviewees who had not received training had invented something – 11 out of 95 (12%). Inventions included dropping salt or granulated fertilizer down the maize whorl to kill the armyworms living and feeding there and using solutions to wash the insects off the plants or to drown them in the whorls (Wyckhuys, 2005).

Table 2. Adapting to environmental and economic change through folk experiments.

Case	Environmental change	Economic change
1. Long-lived tomatoes		Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars
2. Botanical insecticide		Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars
3. Redesigned screen-house	Whitefly is a new and difficult pest to control	Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars
4. Sacks and molluscicide	Bean slugs are a new pest	
5. Green grass slug trap	Bean slugs are a new pest	
6. Tortillas for the ants		
7. Picking dead leaves	Cucumber growing was new to this community	Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars
8. Living, natural insecticide	Tomato growing was new (to this particular farmer)	Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars
9. Qualitative sampling		Expanded opportunities for commercial vegetable growing by smallholders after the end of the wars

Table 3. Blending old and new ideas in folk experiments.

Case	New idea (from the project)	Farmers' intellectual contributions
1. Long-lived tomatoes	Diseases are caused by living organisms	They knew of a long-lived tomato variety
2. Botanical insecticide	Botanical insecticides	Alternated every other time with chemical insecticides
3. Redesigned screen-house	Screen protects plants from whitefly (virus vector)	Made the house smaller and put it on the ground
4. Sacks and molluscicide	Trash trap (Also commercial molluscicide is a new option, although it comes from chemical companies)	Added commercial slug pellets. Used a sack instead of trash
5. Green grass slug trap	Trash trap	Fresh green plants are easier to move around than loose, dry weeds
6. Tortillas for the ants	Ants are beneficial insects	Ants eat tortillas (and they may sting, unless they are distracted with food)
7. Picking dead leaves	Fungus is a living thing The inoculum is on the leaves	Plucked leaves may grow back
8. Living, natural insecticide	Tomato stakes; *Gliricidia* as insecticide	*Gliricidia* grows from stakes
9. Qualitative sampling	Quantitative sampling	Observing the crop and the pests but not using math

Fall armyworm populations rise and fall from one year to the next and were low when Wyckhuys did his research. This may help explain why farmers who took the course were not motivated to experiment. Or the "untrained" farmers may have learned new ideas from somewhere else (e.g., the radio, a fertilizer salesman, earlier extension efforts). Wyckhuys (2005) does show that the farmers who had taken pest management training were more likely to use alternative technologies (e.g., spraying sugar water to attract beneficial insects or using botanical insecticides). Perhaps these techniques controlled pests successfully enough so that the farmers felt little urge to experiment on their own. Or perhaps, counter-intuitively, learning scientific ideas actually does nothing after all to encourage farmer experiments.

Maybe people experiment "naturally" with or without new ideas to exercise their imagination. If this is true, folk experiments would be a bit like Chomsky's idea of the novel utterance (i.e., most of what people say has never been said before), an idea traced to Wilhelm von Humboldt's notion of the mind and its "infinite use of finite means" (Chomsky, 1988, 2005). Aside from clichés, like "I thought you were watching the kids," people churn out novel statements one after the next. While little of that talk is particularly memorable or poetic, it is new. Perhaps everyone experiments in the same way as they make novel statements – compulsively, effortlessly, without achieving dramatic results, at least not every time. If a person has heard some extension messages, parts of them end up in her experiments, and if she has not been visited by extensionists, she simply bases her experiments on other ideas.

Everyone experiments

As the cases in this article show, it is not necessary to teach farmers scientific methods (e.g., control groups, numerical data, and formal treatments) for them to experiment.[9] Saad (2002) suggests that stressing scientific method may actually sidetrack farmers into doing pseudo-scientific trials that do not take advantage of farmers' own knowledge. That may be slightly overstated, but the cases above show that smallholders mix new bio-ecological ideas and new techniques into their experiments, without training in scientific method, even if researchers are not overly interested in folk experiments and make no special effort to encourage them.

For smallholder farmers, every year, every field is an experiment (Stone, 2004). Some of those experiments are pretty simple, much like the manure and well-water trials mentioned by Mak (2001). Still, high-yielding rice could not have been adapted to Cambodia without these little experiments.

The more mundane folk experiments modify a physical tool to make it simpler or cheaper or more practical (e.g., the smaller screen houses or the slug control devices). But sometimes people do create something new, based on a bio-ecological idea (using *Gliricidia* for tomato stakes or tortillas for ant food). These are technologies that can be profitable and practical for thousands of households.

An agricultural researcher could be excused for dismissing farmer experiments as part of the background noise of farming. Whether researchers pay attention to them or not, farmer experiments are still essential. Twenty years of little experiments are finally making the trash trap workable, while the original researcher's prototype was impractical. Little experiments like cases 1, 3, 7 and 8 can help bring small-scale, commercial vegetable production to Central America. And an innovation that allows insecticide use to be reduced (cases 2 and 9) is of value to the economy and the health of growers and consumers.

The farmer inventions mentioned in this paper are not spreading as quickly as they could. In part this is because extensionists do not have a tradition of documenting and extending folk experiments. Few institutions, Promipac included, have the time and money to validate farmer inventions. Validating the inventions takes more time than documenting them. For example, in the early 1990s, Zamorano staff learned that various farmers independently used sugar water to attract beneficial insects (Meir, 2000a). Luis Cañas validated this invention (Cañas and O'Neil, 1998). An invention that took a few moments to create and a few field visits to document ultimately took a whole PhD thesis to validate. The resources to scientifically validate every promising folk experiment simply do not exist.[10] Even without scientific validation, however, farmers could be encouraged to try the most interesting inventions of other farmers.

Science and writing

Latour and Woolgar (1986) describe a scientific laboratory and, by implication, all science as a literary effort. Besides publishing, scientists write labels on vials, produce sheets of figures, and write field notes. The scientific entering, cataloguing, and writing up of data is called "inscription." Folk experiments, on the other hand, are not inscribed.[11] As Balée (1994) points out, one of the main differences between folk knowledge and science is that science is written. Folk knowledge is just talked about, and talk does not last very long.

Science is unnatural, a historically late human development (Wolpert, 2000). So is writing. It was invented around 3000 BC in Sumer (perhaps two hundred thousand years after humans began speaking) and was so unnatural that it was only invented independently two other times (i.e., China and Mesoamerica). Writing is not instinctive; it has to be taught to people in school. Unlike writing, speaking is so instinctive that children do not learn it so much as "acquire" it. Their minds pick up language effortlessly by listening to the fragmented talk around them (Chomsky, 1985).

Folk experiments really are experiments, but they are not science. An experiment is "a test made to demonstrate a known truth, to examine the validity of a hypothesis, or to determine the efficacy of something previously untried" (Morris, 1970). Putting Brazil nuts in cookies to see if you like them is an experiment, but it is not science. Experiments come naturally to all people, the way speaking does. Experiments are to science as speaking is to writing.

The fact that farmers experiment suggests that agricultural researchers can collaborate with them. But this is an old idea. Until the late 19th and early 20th centuries, agronomic research was routinely done on farms (Sumberg and Okali, 1997). In 1887 plant pathologists at the USDA first studied Bordeaux mix for controlling grape disease by sending out questionnaires to farmers. By 1888 farmers in four states were designated special agents to test Bordeaux mix. In 1889–1990 there were grower agents in ten states doing experiments. Many other examples can be given throughout the early twentieth century – studying peach yellows in Minnesota, cotton disease in the South, and grape disease in California. Agricultural scientists gradually stopped working with growers and moved experiments on-station because farmers often were not careful enough with experimental protocols or deliberate enough about writing down their results. That is, the scientists wanted their experiments inscribed; the farmers just wanted to cure their crop diseases (Campbell et al., 1999).

Folk experiments go un-inscribed and casually disregard scientific method. But that does not matter. Folk experiments do not have to be scientific, in the same way that an artist, an engineer, or a chef may be knowledgeable and creative but not strictly scientific. Because scientists and farmers are so different, they have something to teach each other. At the same time their differences make it difficult for them to collaborate (Sumberg and Okali, 1997).

Some will argue that farmers' experiments are simply too common to pay attention to individually and that the farmers' role is to make demands on the research agenda, evaluating proto-type technologies, and adopting them to their own fields. This is how plant breeders work with farmers. Plant breeders now routinely find participatory plant breeding useful. New crop varieties developed or selected with farmers often have the characteristics that the farmers demand (Witcombe et al., 1996; Thiele et al., 1997; Bellon and Reeves, 2002; Lançon et al., 2004). Farmers' biggest role in participatory plant breeding is to say what they want in new crop varieties (not do the actual crosses) and then to judge the more promising lines.

Finally, there is no need to hold farmers to a higher standard than we hold agricultural scientists. Formal agronomic research itself advances by small steps; it takes years to come up with what are, after all, often small improvements (Sumberg and Okali, 1997). Formal experiments are often on tedious topics like crop response to fertilizer or disease incidence under different doses of fungicides.

Agricultural scientists who create new technologies can gain useful ideas from farmers. If nothing else, scientists need to know farmers' demands. But whether smallholders have contact with formal research or not, agriculture will continue to evolve, thanks to millions of unheralded folk experiments.[12]

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Notes

1. Promipac is an SDC project, carried out by Zamorano (Honduras) with collaborating institutions in Nicaragua and El Salvador.
2. A private agricultural university in Honduras.
3. *Güisquil* (*Cnidoscolus chayamansa*) is a small, light green squash with a large single seed that grows on a climbing vine. It is called *pataste* in Honduras, *chayote* in Mexico, *chaya* in Nicaragua, and it has other local names.
4. "*Hay una cosa, el mosaico no es simplemente que la mosca blanca pica. En suelo pobre y seco, más rápido le pega. En lo alto no molesta, y en vega no le falta.*"
5. Although some of its partners (i.e., institutions that teach farmer field schools with Promipac's support) do like botanical insecticides, Zamorano itself has never favored them. This is because they may not work and, even if they do, botanicals may kill beneficial insects and create pest resistance. It is possible that the botanicals act like a placebo, giving farmers the confidence to avoid a chemical spray, meanwhile allowing natural enemies to control the pests.
6. "*Se pone una trampa con guate verde. Llegan 10 a 15 babosas y se ensartan con estaca.*" *Guate* is a local term for various kinds of hay, fodder, and plant residues.
7. These are *Solenopsis geminata*, the native, black fire ant. They are an unusual species with a "miller caste" of workers that have large mandibles for grinding seeds into flour for the rest of the colony. They also are generalist predators, preying on soft-bodied insects (Hölldobler and Wilson, 1990). These beneficial insects are not to be confused with the imported, red fire ant, *Solenopsis invicta*, that is making a nuisance of itself in North American pastures.
8. Sampling is the key to IPM. It involves counting pests at random places in a field, calculating the percentage of pests in the field, and comparing this number to an "economic threshold." For example, Zamorano used to advise cabbage growers only to spray insecticide if there were *Plutella* larvae on 40% of the cabbage plants. Although it sounds simple, sampling can take several hours and involve math skills and a calculator. Smallholders have been loathe to sample, which is why a streamlined, qualitative sampling method that respects the philosophy of "look before you spray" and helps reduce pesticide applications would be beneficial (see Baker, 1999).
9. Of course, it is still necessary to teach scientific method to agronomy students.
10. Some of the reviewers asked for more evidence that these folk experiments worked (e.g., that the experimenters themselves continued to use them and that the ideas spread to their neighbors). I admit that I do not have that kind of information now. This is partly due to the fact that I was mostly interested in invention and experimentation and less in diffusion.
11. There are some self-conscious exceptions. The journal *Honey Bee* publishes farmer experiments in India. The Indonesian journal *Media Jaringan Petani Indonesia* also devotes space in each issue for farmer experiments (Winarto, 2004b). And ethnographers jot down some farmer experiments. These and other exceptions aside, farmer experiments do not have to be written, and the vast majority are not. Scientific experiments are written as part of their protocol. At the very least the data is entered into the researcher's notebook.
12. In 2005, I learned that Promipac had stopped using the farmer field school method, in part because it is more time-consuming than many other extension methods. The field school is a high quality method, but it is probably too expensive and cumbersome for mass extension programs. As this paper suggests, the field school may be more useful for doing research with farmers than for extension.

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