The Mothers, Fathers and Midwives of Invention:

5.2

Zamorano's natural pest control course

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Background and context

Maize and beans are the main food crops of Honduras and the rest of Central America. Beginning in 1980, Zamorano (Escuela Agricola Panamericana) provided scientific, IPM (integrated pest management) research for smallholder maize & bean farmers. Early efforts were led by Keith Andrews, a US entomologist, who founded the Department of Crop Protection at Zamorano. Although the Department's focus was IPM, it had a broad enough philosophy to allow for participatory research in natural crop protection.

Project history

From 1983 to 1991, the centrepiece of the Department of Crop Protection was its Maize-Bean Section, which was Zamorano's first experience working on-farm with smallholders. The Maize-Bean's work was influenced by FSR (Farming Systems Research) and by anthropologists. The agronomists did formal on-farm trials, and were influenced by farmers, who helped manage the trials. The Maize-Bean Section invented several useful technologies (e.g. trash traps to control *BEAN SLUGS*, *Sarasinula plebeia)*, and conducted some formal experiments with extension, which showed that visual aids were expensive, but did not necessarily aid in teaching. Perhaps the Section's most important contribution was the notion that IPM research/extension programmes should teach farmers basic biological information, e.g. life cycles of key pests, to give farmers the concepts that underlie IPM technologies.

Between 1988 and 1989, Project members tried to induce 14 farmers in a village near Zamorano to invent new technologies for managing *MAIZE EAR ROTS* (a disease complex caused by the fungi *Stenocarpella* spp. and *Fusarium maydis*). We gave a scientific seminar on ear rots to farmers, emphasizing the causal agents (fungi) of MAIZE EAR ROTS, the one topic about the disease which farmers understood poorly. We gave samples of seed to farmers to test for resistance (an improved, open-pollinated variety, and a local variety from another province). Farmers also looked through stereoscopes to observe the fungus better. Of 14 farmers who received plant pathology training, 13 planted varietal trials, but only one of them conducted a more novel experiment. He planted a maize field where the irrigation water flowed from the west and the wind blew from the north, so he could use the pattern of ear rots in his field to determine whether the inoculum was transported by water or air.

That experience taught us that farmers could invent things, by blending scientific and local knowledge, but that we would need to work with many more farmers to get a large enough sample of really good farmer experimenters to invent many useful techniques. We formed the Hillsides IPM Section team in 1991 to do that.

Organizational structure and stakeholders

At first, we taught short courses at Zamorano (described below), to NGO extensionists, para-technicals and farmers associated with the NGOs. Team members drove hundreds of kilometres every week to visit remote NGO personnel and farmers who had taken the short course. There were eventually 10 people in the Section, including 2 Honduran farmers. In 1993, 2 of the Salvadoran agronomists began teaching courses to NGOs in El Salvador. In 1994, we opened a Hillsides IPM Programme in Nicaragua with Swiss support.

Motivations and expectations of the farmers

The farmers who took our training were largely motivated by a desire to find alternatives to chemical pesticides. However, many of the farmers we worked with had strong ties to NGOs. Just a few years earlier, in the 1980s, these same farmers were more interested in pest control *per se*, especially chemical control. By the early 1990s, farmers had been shocked by reports of poisonings of banana plantation workers, and the NGOs had become more eager to find alternatives to pesticides. By the early 1990s, many Central American smallholder farmers were interested in alternatives to chemical pesticides for at least the 3 following reasons:

- media coverage of poisonings of banana workers,
- information from NGOs on pesticides (e.g. the "Dirty Dozen"),
- farmers' own experiences with pesticides, as they and neighbours became ill or, in a few cases, died as a result of exposure to chemical pesticides.

Research

Approach

We reasoned that, ***if necessity is the mother of invention, then the fathers are new ideas.*** We still need more studies of farmer knowledge, but by 1991 we knew that:

Honduran smallholders know little about:

- Insect reproduction
- Parasitism
- Entomopathogens

Smallholders know a fair amount about large, colourful, diurnal insects, especially if the insects are useful or harmful. They tend to know a great deal about economically useful insects, e.g. honey bees, edible insects.

Folk knowledge about pests is mixed. Smallholders frequently have high interest in pests and know much about them, while still being confused on some topics, e.g. how the insect reproduces. Folk knowledge has 4 different sets of properties, *depending on how important the topic is to farmers and how easy it is for them to observe* (643).

These 4 sets of properties can be compared to textures. Knowledge of things that farmers find

thick	⇒ important and easy to observe
thin	⇒ unimportant, but easy to observe
empty	⇒ unimportant and difficult to observerve
gritty	⇒ important, but difficult to observe

(for details see table 9)

Based on the ideas about local knowledge, the IPM Hillsides Section coined the following

Hypothesis

If we fill in key gaps in farmer knowledge, the farmers will invent useful technology, based on a synthesis of folk knowledge and scientific ideas.

Methodology

We taught the new information as a 3-day short course, which we called 'Natural Pest Control', instead of, e.g. as a 'farmer field school' (FFS) which is held over a whole cropping cycle. The main reason for this was logistics, not philosophy. Honduran farmers are often a whole day's travel through the mountains. We wanted to get a group together at a convenient place (Zamorano or a local settlement) and impress them with new ideas, and then visit them later, to see what they invented. In contrast, farmers in Southeast Asia, where the FAO and collaborators pioneered FFS methodologies, were often easier to reach by car.

There were 5 main sections or topics to the training (insect life cycles, predators, parasitoids, entomopathogens, and pest control techniques - especially the manipulation and conservation of natural enemies.) We used lectures & slides, games, jokes, skits, field demonstrations. This mix of method allowed us to teach the same thing several times, without teaching it the same way: we called it ***'redundancy with charm'.*** Our number one rule was that ***no one was allowed to be boring.*** Other mistakes were acceptable.

Examples of activities

We used butterfly nets to capture social wasps returning to their nests, to show farmers the wasps' prey items. The farmers identified the prey as agricultural pests. We counted the number of wasps with prey for 15-20 minutes and extrapolated that to hundreds of thousands of prey items in a single

Table 9: Four textures of folk knowledge

Description	Example	The ideal IPM specialist's response
Thick: local people may know more about the topic than scientists do. The local knowledge can be empirically verified by the scientific method.	Honduran farmers know more about wasp honey and how to harvest it than do entomologists. Farmers know various techniques for controlling bird pests without killing them, e.g. stringing tape from old cassettes, like ribbons in the field.	Learn from farmers. Validate their knowledge and techniques.
Thin: local people know the topic in a way that scientists can understand, although local knowledge is less complete than scientists'.	Honduran farmers know many predatory insects by folk names, but do not realize that they are beneficial (natural enemies of Herbivorous insects).	After learning the local system, teach local people the missing ideas. Add to their folk knowledge.
Empty: local people know nothing about the topic.	Honduran farmers are unaware that parasitic wasps exist.	Fill in the gap in local knowledge. Teach them about the existence of parasitic hymenoptera etc.
Gritty: local people have beliefs and perceptions which are at odds with scientific notions. The local ideas seem strange, premodern, wrong etc. to scientists. These ideas cannot be verified with the scientific method.	The belief that insect pests are spontaneously generated by insecticides or chemical fertilizer is fairly widespread among smallholder farmers.	Be careful. Avoid contradicting people unless it matters to the IPM programme. Carefully learn the local perception and its reasoning, which often is logical, but is based on incomplete facts, and then use local rhetoric to explain the scientific perspective (e.g. insect pest outbreaks following insecticide use are the result of genetic resistance and the death of beneficial organisms—not spontaneous generation). Teach these ideas with respect for the local people.

year. We taught farmers to collect and to observe insects, in the daytime and at night, when insects are especially active. These and other activities convinced farmers that many insects are important natural enemies of pests.

We gave course participants an 80 page manual (which was perhaps too long), with black & white technical drawings and plain prose. People took the manual home, to use as a reminder of what they had learned.

We used before and after tests to determine that farmers were learning the course material. We visited 52 farmers in 1992, a few months after their Natural Pest Control Course; and found that they had invented 33 new techniques as a result of the training (665). In November, 1992, we held the first farmer-experimenter workshop, in which farmers who had taken the Natural Pest Control Course reported their inventions to each other (666, 667). This became an annual event and is still held.

We left farmers to experiment on their own. We made little effort to teach them experimental methods. They tried new things on their own (see Box 3-5). The farmers did not use control groups, repetitions or other formal methods.

Their usual method was to

- notice a problem
- think of a possible solution, based in part on information about insect ecology, which they learned in the Natural Pest Control Course
- try the solution, usually first in a small area

During the farmer-experimenter workshops, farmers describe their inventions to each other, telling which problem they wanted to control, and why they thought the new idea would work. We went to the field, where the farmer-inventors demonstrated the inventions. During their talks and demonstrations, other farmers voiced opinions and questions in a relaxed, collegial manner.

Outputs

Farmers and extensionists were happy to learn about insect life cycles and insect natural enemies, but they did not want a whole course on nothing but sex and violence in the insect world. The farmers wanted to learn specific pest control techniques. We included as many as possible in the Natural Pest Control Course.

Box 3: Sugar water to control fall armyworm

Hubalda Castro, a leader and farmer from El Sitio, Comayagua, told us about the control of fall armyworm (*Spodoptera frugiperda*, Lepidoptera: Noctuidae): ***sprinkling sugar water on her maize crop to attract ants and wasps which eat the armyworms***. Mrs Castro had always known that the ants were attracted to sugar, but during the Natural Pest Control Course, she learned that ants also kill caterpillars. She said that in a parcel where she had planted about two pounds of maize (about 400 m^2), she used four pounds of sugar. She mixed the sugar with a bucket of water, as though she were making a soft drink, and 'sprayed' it with a whisk made of dry corn husks. She taught the practice to a friend. He was unconvinced, but was exasperated by the pest attack in his two manzanas (1400 m^2) of land. He bought 25 pounds of sugar, mixed it with water and spread it on his maize plants. According to Mrs Castro, neighbours told him that he was crazy, that it would be better to give them that sugar so they could put it in their coffee. The farmer applied the sugar anyway and it controlled the armyworms. When we visited him, he was halfway through with his harvest. He had harvested over five wagon loads of maize. Now the people who ridiculed him saw what happened and they too used sugar to control armyworms.

Many other farmers independently invented the sugar water idea. Some used rotting mangoes instead of sugar, reducing their costs. Luis Cañas, a Salvadoran entomologist working at Purdue University, has reconfirmed the value of this practice in his PhD dissertation (652).

Box 4: Conserving natural enemies

Several entomologists taught us the importance of native, natural enemies of crop pests. Some of the key predators of pests in Honduras are the fire ant (*Solenopsis geminata)*, social wasps (Vespidae, especially *Polybia* spp., *Polistes* spp.), and earwigs (*Doru* spp.). We confirmed this by reading (658, 664, 669) and we asked entomologists Lastres, Cáceres and López to join our team. We supported research by the Mexican agronomist, Eloy González, on the ecology of fire ants and social wasps (654).

We knew farmers often went out of their way to spray insecticide on earwigs, to dig up ant nests and to burn wasp nests, because farmers thought of native predators as nuisances; many of them can be induced to bite or sting people. In our short course we taught farmers about beneficial insects, and the importance of not killing them. In response, 55 of the 100 farmers who MEIR interviewed stopped killing beneficial insects after taking the Natural Pest Control Course. Another 30 farmers discussed the importance of conserving beneficial insects with MEIR, but did not tell her a specific example of having done so.

One reason for the success of this behavioural change, other than the fact that our course had convincing lectures and demonstrations, is that the new behaviour (not killing beneficials) involves no labour and no cost. It replaces behaviour that does have costs.

Box 5: Rice grains in vegetable seed beds to prevent ant damage

For years, I had wondered about how to develop an alternative to the high use of insecticides in vegetable seedbeds, where fire ants (*Solenopsis geminata*) often collected all of the expensive, imported seeds, unless insecticide was used. The best alternative was to make a seedbed on a table, and keep the table feet in cans of water. But this was labour-intensive and involved cutting down many saplings to make the table.

In July, 1991, Eloy González was doing field work for his thesis on fire ants and social wasps. Every day he would place 100 fall armyworm larvae on maize plants and observe them to see how many were killed by predators. Most were killed by fire ants, who often took the armyworms so quickly that González did not have time to actually observe the ants carrying the caterpillar away. Lorena Lastres suggested putting a ring of white flour around each maize plant. She said that we would be able to see the ants' footprints in the flour.

González ringed his maize plants with flour, and on July 6 he reported that he had collected no data for a whole day, because ***the ants had spent the day carrying flour back to their nests, and had not foraged for worms***. This observation suggested that flour could be used to prevent fire ants from removing vegetable seeds. On July 13, we conducted an experiment planting 6 1m x 1m seedbeds, with red onion and bell pepper seed. The treatments were:

1. 0,5 kg of raw rice grains around the edge of the seedbed, covered with dry grass.
2. About 1 kg of white flour around the edge of the seedbed, covered with dry grass.
3. About 1 kg of maize flour around the edge of the seedbed, covered with dry grass.
4. Some limestone powder around the edge of the seedbed, covered with dry grass.
5. Control. Seedbed only covered with dry grass, but with no rice, flour etc.
6. Absolute control. Seedbed uncovered, with no rice, flour etc.

The rice grains were especially effective. With some further experience, we learned that the technique works as well with much less rice, which is more effective when sprinkled over the surface of the whole seedbed, instead in a ring around the edge. A handful or 2 of raw rice grains protects a seedbed as large as several square meters.

Fire ants will not bother to dig up vegetable seeds, if there are larger seeds on the surface. The ants become accustomed to foraging for rice in the seedbed, and after the vegetables germinate, the ants hunt the herbivorous insects that attack the seedlings. As we taught farmers to sprinkle rice grains on the surface of seedbeds, the farmers refined the technique by using cheaper, handier alternatives, like stale tortilla scraps. (The tortilla is a traditional, unleavened maize bread, popular in Mexico and Central America).

S. geminata is an unusual species; it has a miller caste of workers with large mandibles. Millers tend to stay in the nest, to grind up the seeds that foragers bring in. The species is extremely omnivorous, and eats insects as well as seeds (658).

Adoption has been high. 22 of 100 farmers have adopted this technique (662).

The examples in the boxes above show that of the technologies we taught to farmers, some were invented by farmers themselves, after we helped them fill in their gaps in bio-ecological knowledge of insects. This confirmed our hypothesis.

However, many of our technologies (e.g. conserving native predators) were actually from traditional, formal science, and were not developed with participatory methods. One of our most successful technologies, rice to control ants in vegetable seedbeds, was invented by the project anthropologist, with inspiration from entomologists and others. For years we taught this technology to farmers, and it rapidly spread throughout Central America, but we played down the way in which the technique was invented. It was a counter-example to the participatory approaches that we wanted to develop.

Table 10: 10 Farmer inventions in response to natural pest control training

1. Sugar water to control fall armyworm in maize.
2. Caterpillar soup for spreading entomopathogens to caterpillars in beans.
3. *Gliricidia sepium* leaves to reduce white grub (*Phyllophaga* spp., Coleoptera: Scarabaeidae) damage to crop roots.
4. Neem leaf slurry to deter fire ants from seeds.
5. Crushed June beetles (adult *Phyllophaga* spp.) to discourage females from laying eggs in soil.
6. Bell pepper and onion to deter chilli weevils (*Anthonomus eugenii*, Coleoptera: Curculionidae).
7. Cabbage planted under maize to deter diamondback moths, (*Plutella xylostella*, Lepidoptera: Plutellidae) with maize as a habitat for earwigs, natural enemies of *Plutella xylostella*.
8. Sacks as barriers against whiteflies (*Bemisia tabaci*, Homoptera: Aleyrodidae).
9. Gourd fruit to distract leaf cutter ants (Hymenoptera: Formicidae: Attini).
10. Chilli, marigold & alcohol applied on slugs in trash traps.

Source: 662

Of 100 farmers interviewed, MEIR documented a total of 25 techniques invented and used by farmers as a result of taking the Natural Pest Control Course (MEIR, personal communication). A rate of invention this high is consistent with our original hypothesis that farmers will use new bio-ecological information to invent novel pest control strategies.

Linkages

For a time, we had UNDP funding for our work in Honduras, and SDC (Swiss Development Cooperation) funding for our work in Nicaragua. We were able to add a programme in El Salvador simply by selling courses one at a time to NGOs. We also sold courses in Honduras, especially after some funding there ended. Some Section members worked almost exclusively selling and teaching short courses to NGOs (especially in Honduras and El Salvador). Other team members taught some courses, but mainly did follow-up with NGOs (especially in Honduras and Nicaragua): reviewing course content with extension agents and para-technicals, helping them teach farmers, introducing timely crop protection techniques according to the annual cropping cycle. Many of these technologies came from the old Maize-Bean Section - in which some of us had participated. We taught other practises we had learned from another disbanded Section: Cabbage. We met weekly and in other ways tried to keep the 2 parts of our Section together, but we also encouraged independent thought, which may have pulled the 2 apart. The follow-up work with NGOs obliged some team members to spend most of their time away from Zamorano (and their families) on long road trips. These Section members were more interested in extension than in R&D. They were masters of the art of extension and became emotionally involved with the NGOs they visited. They used the course more as an extension tool than for technology generation.

Some NGOs joined Zamorano to form the 'IPM Consortium.' It still continues, and as of 1997, members included:

- Zamorano
- Catholic Relief Service
- World Neighbours
- International Clearinghouse for Information, Documentation and Research on Cover Crops (CIDICCO)
- The Loma Linda Farm (Elias Sánchez)

This cooperation was a learning process during which at times:

The Zamorano team complained that some NGOs:

- didn't take us seriously
- didn't teach the new information consistently well to farmers

Some NGO staff complained that Zamorano:

- didn't co-ordinate enough with the leadership in Tegucigalpa
- took too much of their time
- and that the NGOs couldn't teach the concepts they learned from Zamorano, unless the NGOs had visual aids, like the slides we used in the Natural Pest Control Course. Eventually we printed photographs for them to use.

With time, these differences with some NGOs were largely solved, but it was almost always easier to teach a course to an NGO than to collaborate with an NGO over a long time. When researchers and NGOs form a consortium, they have to allocate funds, cars, prestige (i.e. the credit for success), while making demands on each other's time. This leads to tensions which may or may not be resolved.

Economics

We do not really know the economic returns to this research. We suspect that returns were positive and high. The Section cost a little over US$ 100,000 a year, taking into account a PhD salary, 4 MS salaries, some student scholarships, fuel for 3 used pick-ups inherited from the Maize-Bean Section, bills from cheap hotels & fried bean restaurants, production of visual aids, and some office space etc.

The benefit is much harder to calculate than the cost. A few of the more successful of the Hillside IPM Section's technologies (see Boxes 3-5) are being extended by NGOs and GOs throughout Central America, with or without formal ties to Zamorano. Perhaps 10,000 people have received Zamorano's Natural Pest Control training. MEIR's sample of 100 farmers adopted 365 innovations as a result of the course. She estimates that individual innovations could give farmers an average of over $25 in economic benefits (662).

The following cost:benefit analysis is based on several assumptions and is meant only as an illustration, but assuming an average benefit of only $5 per innovation, and assuming that each farmer adopted only 2 innovations, and that 10,000 farmers were trained, a rough calculation of benefit would be US$ 100,000 per year. This is about equal to the Project's costs. However, project costs may run for about 6 years, while the benefits will last for many years afterwards.

There is great potential for these benefits to reach a wider audience. Of 27 million people in Central America, assuming that half (13.5 million) are rural people, with household sizes of an average of 5 people, then there are 2.7 million farm households in Central America which could potentially benefit by these technologies. Reaching these households would require extension costs, which would have to be paid by other agencies. Still, it is probable that the Natural Pest Control technologies discussed in this chapter (and MEIR's) will continue to yield returns for years.

Sustainability of the approach

Some of us left the Section in 1993-94. Others continue. Some still work in Honduras, based at Zamorano, teaching the Natural Pest Control Course to NGOs, and continuing to hold a farmer-experimenter workshop, and publish the results. Zamorano still has a Hillsides IPM Project in Nicaragua, with funding from Swiss Development Cooperation and partner organizations. This Project works with a large consortium of institutions to offer courses based on the Natural Pest Control Course, and the Project also teaches IPM technologies developed by the old Maize-Beans Section.

The approach we developed in the early 1990's continues to be used in Central America, by Central American agronomists, NGOs etc. It is 'sustainable' in the sense that local people have adopted the approach. It is beyond the scope of this paper to judge whether the work of teaching and extending the ideas can continue without donor funding.

As in our earlier experience with maize ear rots, the Zamorano Method had applications for plant diseases, not just for insect pests. The approach was useful enough to use a somewhat similar teaching method for a plant pathology course. Nicaraguan and Honduran farmers used ideas on basic plant pathology to think of 273 crop disease control measures (670, 671). At least one participating NGO, Campesino a Campesino, and several farmer training centres in Honduras developed their own disease courses, based on these ideas.

Assessment

Although the rate of invention was high (an average of one invention per 4 farmers), it could have been higher. In the Spring of 1998, Zamorano held a week-long seminar to review the Hillsides IPM work. During that meeting several old colleagues said that they hadn't realised that one goal of the Hillsides IPM Section was to stimulate farmer experiments by means of bio-ecological training. It was my mistake not to emphasize this enough in 1991-92. All of my students and colleagues did not appreciate that the training was designed to help farmers invent; the Section did not stress this to the farmers, and did not emphasize it enough in the follow-up with farmers. I thought that the new bio-ecological information would be so powerful, that some farmers would naturally use it to invent new techniques, and that it did not matter much if we consciously stressed the idea of farmer experiments.

Nevertheless, we have reconfirmed the idea that farmers will invent things, if the farmers are taught new bio-ecological information. The next step, for this and for other projects, is to be more proactive in supporting farmers invent. ***We should tell farmers that one goal of the training is to enable their own research***. We should follow farmers more closely to document what they invent, and we should reward the best experiments (e.g. with trips to farmer-experimenter workshops; with simple but prestigious prizes).

Even with our modest follow-up farmers invented enough new techniques to reconfirm the value of farmer creativity, and the notion that scientists and farmers can collaborate. Asian farmers who have taken the Farmer Field Schools have also invented new, natural pest control techniques, based on the synthesis of new and traditional information (672, 663). This suggests that filling the key gaps in farmers' bio-ecological knowledge can help them to be more creative.

Farmers who have taken the Natural Pest Control Course, and who maintain ties with the IPM Consortium, continue to experiment. In November, 1996, farmers in the fourth annual farmer-experimenter workshop at Zamorano presented 7 pest control inventions and 6 other practices. The workshop lasted for 4 days, giving the farmers ample time to demonstrate their technologies, which are described in LÓPEZ (659).

Conclusions and recommendations for others

Necessity is the mother of invention, but new ideas are the fathers. Zamorano's Natural Pest Control Course fills in the key gaps of farmer knowledge and so helps farmers to invent. But their inventions may die young unless they are nurtured. Project agronomists can be midwives to farmers' ideas, encouraging farmers, acknowledging, respecting and rewarding their efforts. Project personnel can also nurture new ideas by documenting them and teaching them to other farmers, who will refine and adapt them further.

Tell the farmers that the training is supposed to stimulate invention. Use brainstorming during the course to help farmers see how many new ideas they can think. Have systematic feedback links for eliciting farmer inventions.

Give prizes for good inventions (perhaps cash, but especially tools, trips to seminars, plaques, their name in a newsletter etc.). This is analogous with public-sector formal scientists, who are motivated by prestige. The nice thing about prestige: it is inexpensive to make and no one ever gets enough of it.

Farmer-experimenter seminars are helpful. Use multiple R&D styles. Use participatory research methods ***and*** traditional scientific research when appropriate. Focus more on the technology you want to develop than on a particular research method. BIGGS & SMITH (649) suggest that ***the success of participatory methods depends less on the method itself, and more on the skill of the researchers and on their institutional context.***