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A comparison of two IPM training strategies in China: The importance of concepts of the rice ecosystem for sustainable insect pest management

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Abstract. Our study in China of two Integrated Pest Management (IPM) training programs for farmers shows that one is more effective than the other in reducing pesticide applications as well as in imparting to farmers an understanding of the rice ecosystem. The two training programs are based upon two different *paradigms* of IPM. This article uses a *triangulated* method of measuring concept attainment among farmer trainees in China as one measure of the effectiveness of training. Concepts of insect ecology brought about by training, as well as persistence of concepts one year after training, are measured. This information is compared to farmer data on pesticide applications and yields in order to determine the comparative effectiveness of two models of IPM farmer training in Sichuan Province. Results indicate that the Farmer Field School (FFS) model of training, based upon a new Ecology-Based IPM paradigm, is more effective than the 3 Pests 3 Diseases (3P3D) model based upon an older Economic Threshold IPM paradigm. Crop yield results and pesticide applications by farmers after training are also used to indicate which of these paradigms of insect pest control is more effective, hence scientifically accurate.

Key words: China, Concept formation, Crop protection, Ecosystem, Farmer field school, Farmer knowledge, Insect pest management, IPM, Pesticide reduction, Training

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Introduction

Farmers' practices are based on what they understand. A well-formed concept of a crop ecosystem provides a far better understanding for insect pest management than does a set of formulas or instructions. The purpose of this article is to compare understanding of the rice agro-ecosystem, and insect pest management practices, of Chinese farmers resulting from two different models of training for Integrated Pest Management (IPM) in rice. These two models are linked to different paradigms of IPM and are furthermore characterized by different roles taken up during and after training by the farmer-trainees. Comparison of effectiveness in terms of change of farmer concepts, change of spraying behavior, and yield results will be presented and analyzed.

Data presented in this article were gathered during a cooperative effort between the FAO Inter-country Programme in Integrated Pest Control in Rice and the Sichuan Province Plant Protection and Quarantine Station, China. Two groups of farmers, enrolled in two different IPM training programs, are compared. Farmer trainees were interviewed before and after training. They were interviewed again a year later after growing a post-training rice crop to determine their level of understanding of the rice ecosystem, and how that understanding affected their pesticide practices. Results are presented and analyzed.

Emergence of a new ecology-based IPM paradigm

The understanding of agricultural insect ecology is presently undergoing rapid change. There are several paradigms of IPM that agriculturists presently adhere to. The most up-to-date paradigm for rice IPM is that put forward by Kenmore (1980), further developed in a review article by Way and Heong (1994) and empirically substantiated by five years of detailed field work by Settle and others (Settle et al., 1996). This Ecology-Based view can be summarized as follows:

1. Beneficial insects/spiders comprise the majority of species in healthy ecosystems. For example, in Indonesian tropical wet rice ecosystem, 64% of all species identified were predators (306 species) and parasitoids (187 species); neutrals (insect detritivores, plankton feeders) comprise 19% (Settle et al., 1996: 1980). Rice pests constitute only 17% of species.
2. Beneficials are extremely effective in controlling major rice pests; very substantial reduction of pesticide applications does not threaten rice yield.
3. Contrary to previous understanding, beneficials typically enter the tropical wet rice ecosystem *before* pests, and feed on detritivores and other "neutral"[1] insects, e.g., Springtails (*Collembola*) and Midge larvae (*Chironomidae*) already present in the rice paddy. Beneficials are therefore present from the start of the crop season and effective in pest control from an earlier stage than had previously been assumed (Settle et al., 1996; Wu et al., 1994).[2]
4. Chemical pesticides seriously disrupt the balance of the wet rice ecosystem, in ways that are mostly destructive. Pesticides often induce pest outbreaks by killing beneficial insects/spiders, reducing natural pest control, and resulting in sometimes explosive outbreaks of pest species that are either (a) resistant to, or (b) physically invulnerable to, pesticides. E.g., Brown Planthopper eggs are laid within the rice stalk and shielded from spray; after spraying, they hatch into a field free of their natural enemies and reproduce explosively without predation (Kenmore, 1980). Systemic pesticides can kill the early "neutral" insects that lure the first generation of beneficials, and kill the beneficials as well.

It is therefore important for farmers to be able to identify beneficials, to know how they function in the crop ecosystem, and to reduce pesticides that destroy them.

The Farmer Field School (FFS) model of training was designed to train farmers how to apply this Ecology-Based model of IPM (Kenmore et al., 1995). In the FFS, a method called "agro-ecosystem analysis" is used to assess all beneficials, pests, neutral insects, and disease, and then determine if any intervention like a pesticide spray is needed. Economic Threshold Levels (see next paragraph) are discussed in the FFS,[3] but crop protection decisions are based on conserving beneficial insects/spiders.

The previous model of IPM, referred to here as Economic Threshold IPM, is one that primarily relies on pesticides rather than beneficial insects/spiders for pest control. In Economic Threshold[4] IPM, the dominant pests are counted by a method called scouting. The "Economic Threshold Level" (ETL) is a formula for determining when economic loss of a crop's value exceeds the cost of a pesticide application. When the number of pests per hundred plants (or some representative number) goes above a certain predetermined quantity, economic loss will occur. In practice, the ETL in China becomes a "prevention index," a pest average per plant beyond which Chinese farmers are told to spray. Economic Threshold IPM does not take account of the whole agro-ecosystem, but only looks at the pest–plant relationship. The Three Pests Three Diseases (3P3D) training is based upon this earlier Economic Threshold IPM paradigm.

The wet rice ecology

The work of Settle et al. (1996) that provides the chief empirical basis for Ecology-Based IPM was carried out in Indonesia, within the tropics. The climate of Meishan County, Sichuan Province, where this study was carried out, is temperate, experiencing mild winters during which the insect fauna either dies off or become dormant. Despite this climatic difference, Chinese researchers have begun to document the same fundamental ecological interrelationships in temperate rice growing China (Wu et al., 1994). It has been found that temperate wet rice ecosystems in Sichuan respond to Ecology-Based IPM practices in much the same way as tropical systems (Luo et al., 1995).

In this article, the research results of Settle et al. (1996) will serve as the standard for scientific correctness regarding workings of the wet rice ecosystem. This will serve as the criterion against which ecosystem concepts of farmers will be determined to be correct, consistent, or complete. This represents a conscious choice to gauge farmers' understanding before and after two different models of training against one scientific view of rice field ecology, which we believe to be the most thoroughly researched, most accurate, and most comprehensive. While there are differing standards of "correctness" relative to different paradigms, it is also true that Economic Threshold IPM does not deal with the entire crop ecosystem, but only pests and plants. Also, older paradigms are inevitably replaced by newer, more powerful, and more comprehensive ones.

While it is true that the FFS training is founded upon this Ecology-Based IPM view of Settle et al. (1996) and that Economic Threshold IPM training is not, it is nevertheless necessary to compare farmer responses from both training programs against the best, most current understanding of the rice ecosystem in order to draw conclusions about the importance for farmers of ecosystem concepts in reducing insecticides – an important measure of effective IPM.

The importance of farmers' concepts about the ecosystem

Sustainable agriculture has to be based upon an integrated understanding of the agro-ecosystem. This understanding should be held by every farmer who uses the land. Yet it has been found, through many years of experience among farmers in many countries, that rice farmers in general know little about their rice field insect ecologies. Only one article we have been able to find mentions anything about levels of farmer understanding of the wet rice ecosystem in China. This article, which is an analysis of the economic benefits of IPM, contains one short statement that untrained farmers "displayed a sound understanding of the potential of the natural enemies [i.e., beneficial insects/spiders] and what condition needed to be satisfied before pesticides were necessary for application" (Li, 1992: 3). No mention is made of any methodology to establish this assertion, however, and our experience and that of approximately 100 trained crop protection technicians and hundreds of farmers we have talked with over three years in China does not seem to corroborate this statement. Instead, we have found that while farmers may indeed be able to name and identify four or five major rice pests, it is the exceptional farmer who can provide the local name for even two insect/spider predators or parasitoids that kill those pests.

Possible reasons for this lack of indigenous understanding about beneficial insects/spiders are numerous. Perhaps there was less need to be aware of the role of beneficials in pest control before the increased demand for food resulting from the population press of this century made any threat to the food supply more critical. While use of biological control in China dates from before AD 340, when the use of weaver ants for control of citrus pests is first described (James and Thorpe, 1994: 396), there is little evidence for this technique being used in grain crops. Another reason for this lack of awareness may be that the recent introduction of modern chemical pesticides plus agricultural extension services to promote their use may have replaced and even eliminated any traditional knowledge there may have been about beneficial insects/spiders.

Yet this lack of awareness of insect/spider predators and parasitoids among farmers should come as no surprise. While scientific naming and systematics of insect species is two centuries old, serious ecological studies of the functioning of beneficial insects/spiders as a natural pest control agent in wet rice can be said to have begun with the work of Kenmore (1980).

Major agricultural research institutions have only recently begun to seriously explore the intricacies of rice insect ecology. There are several reasons for this. First, our understanding of ecology in general is relatively recent. There is also a history of reductionism and specialization in science (e.g., entomologists often know insects very well and spiders very poorly because of an artificial division of disciplines; or entomologists may specialize in effects of insecticides upon only a few pest species, and know little about crop ecology). In addition, the ways research must be conceived and planned in order to get funding tend to require demonstrable results; it is far easier to clarify the relation between a pest and the rice plant than to research the extreme complexity of all the animals interacting in the wet rice ecosystem. A 1990 bibliographic review of 1,356 articles on rice pest management published over the previous thirty years in professional journals found that only seven (7) entries contained research on the "third trophic level" in the rice ecosystem, that is, beneficial insect/spider predators and parasitoids. The remaining 1,349 articles dealt with only the rice plant (the first trophic level), and the herbivorous pests that ate that plant (the second trophic level) (Whitten et al., 1996: 577). Understanding among scientists (not to mention farmers) of the functioning of beneficial insects/spiders in rice pest control is very recent.

What is a concept and what makes it correct or scientific?

There is a considerable literature on the nature of concepts and concept formation. Usually, a concept is regarded as a correct idea (according to current understanding), and an incorrect idea is called a "misconception" (Pines and West, 1986: 583). Rather than review this literature, suffice it to point out that all measures of cognitive structures are in some manner behavioral; a concept is something whose existence is inferred from responses or other behavioral outcomes. The fundamental theories of learning upon which our notion of "concept" rests are Piaget's, which emphasizes that concepts are constructed by learner interaction with the environment (Piaget, 1970) and Vygotsky's, which elaborates the importance of the social and linguistic environment in guiding learning (Vygotsky, 1992).

For purposes of this article, a *concept* will be defined as the understanding indicated by farmer responses to interview questions (e.g., farmer descriptions of the ecological functions of insects/spiders in the rice field). These responses will be evaluated in accordance with three criteria: (a) correctness according to the paradigm of rice field ecology described by Settle et al. (1996); (b) consistency; (c) completeness.

These responses will then be compared to crop protection decisions made during the year after training. That is, corroborating evidence for robust concepts is also sought from responses not only about understanding (e.g., farmer descriptions of the ecological functions of insects in the rice field) but also about behavior (amount of pesticides applied after training). The result is a scale for measuring concept strength or robustness through comparison of different types of responses and reported after-training behaviors. Correct, consistent, and relatively complete responses will be considered to indicate concepts that are more ***robust*** than concepts that lack these qualities.

We will attempt here to demonstrate that farmers who base their crop protection measures on a robust overall concept of the ecosystem get yields that are as good as farmers who do not, but use less pesticide. We will attempt to point out that an accurate conceptual understanding of the rice ecosystem has a direct effect upon pest protection practices. We will attempt to show that for wet rice, Ecology-Based IPM is more effective than Economic Threshold IPM.

Two models of IPM training compared

This study compares development of farmers' concepts of the rice ecosystem across two different models of IPM farmer training: the Farmers' Field School (FFS)[5] entailing, in this case, six sessions in the field spread over eight weeks of a rice season (mid tillering to pre-harvest); and the Three Pests Three Diseases[6] (3P3D) model, consisting of four sessions at critical pest control times during the same crop season.[7]

The comparison of these two training models builds upon the work of one of us (M. S. Mangan, 1996) in which the use of the criteria for concept measurement by comparison of internal consistency, completeness, and appropriateness of triangulated responses, was first carried out. A brief comparison of the main features of these two models of IPM training is found in Table 1.

These contrasts are sufficient to show that the two models of farmer training were different not only in terms of method and emphasis, but also were motivated by different philosophies regarding the role of the farmer.

The methodology

Interview instrument and method

Information presented here was gathered in two farmer training programs in Sichuan Province, Meishan County. Interviews were carried out in two villages located about ten kilometers apart as the crow flies. Farmer culture is the same, with no significant difference in spoken dialect. The geographic proximity of the two training sites served as a control for a range of natural conditions that may otherwise have influenced results, such as differences in rainfall, temperature, wind, or soil type; no general differences in yields could be attributed to these factors. The proximity of the two villages also served as a control for social factors that might affect results. Wet rice cultural practices[9] were virtually the same in both localities. Also, local dialect of the farmers, a factor affecting interviewing outcomes, was virtually the same. Because of this similarity of background in the two sample populations, differences in responses as well as in behavioral outcomes between the two groups could indeed be attributed to the respective models of training that are here compared, and not to other intervening social factors.

A standard interview schedule was developed in which several questions were asked that probed the same understanding. For example, farmers were asked at three points in the interview schedule if there were animals in their fields that were beneficial, and to mention and/or draw them and explain how they were beneficial. Another 11 questions indirectly asked about the farmer's understanding of beneficials. For example, farmers were asked if they ever decided not to spray because there were other insects in the field which would kill the pests. By using "triangulation" (Patton, 1990: 187), that is, looking at farmer's responses to not just one, but several questions, and comparing these responses with each other, it was possible to get a picture of the internal consistency and completeness of the thinking of each respondent about the rice ecosystem and the use of pesticides.

All interviewers asking questions in this study were Chinese Crop Protection Technicians who were taking part in IPM training. The interview schedule was used as a question guide rather than a questionnaire form. The purpose was to get a picture of the farmer's own knowledge, so if farmers did not understand the question the first time, interviewers could reword the same question until the farmer did understand it. All answers to all questions given by farmers were regarded by the interviewers as correct; there was no sense of the interview being an "examination." In all cases, indication of understanding was regarded as more important

Table 1. Comparison of the farmers' field school (FFS) and three pests three diseases (3P3D) training models

FFS (Ecology-Based IPM)	3P3D (Economic Threshold IPM)
First rule is conservation of beneficial insects/spiders.	First rule is control and elimination of pests and diseases.
Takes place in rice field each week allowing farmer trainees to watch the development of beneficials, pests, neutrals, and disease throughout the season.	Takes place in classroom four times as determined by agricultural technicians, with some field time to identify important pests and diseases.
Bases crop protection decisions on "Agro-Ecosystem Analysis;" farmers look each week at beneficial insects/spiders pests, neutrals, crop health, and weather. Weekly change in ratio of beneficials to pests is used to determine whether to use pesticides (Li, 1996: 3). ETLs are discussed but are not a primary decision tool. Diseases are controlled with biological and chemical agents.[8]	Bases crop protection decisions on "Scouting" of pests at the four most critical stages. If pests reach the "Economic Threshold" (ETL), farmers then spray. Beneficials are discussed but crop control decisions are not based on their ecological function. Emphasis is on identifying and controlling the three (or four) major pests with the "right" chemicals. Diseases are treated like FFS.
The farmer's role is to learn to manage fields by making decisions based on his or her own observations of each field's ecosystem, assessing pests, beneficials, neutrals, disease, water, and nutrition. He or she is empowered to be come "expert" of his or her fields, using appropriate cultural practices or control agents with the purpose of conserving beneficials and growing a healthy crop.	The farmer's role is to learn how to identify and count the most important pests, to know "Economic Thresholds" for each pest, and to know which is the "correct" pesticide for each pest and the correct biological or chemical agent, or proper cultural practice, for the three or four worst diseases. Farmers learn that there are "correct" formulas and chemicals devised by experts, and are taught to follow these.
Training is based on a Nonformal Education approach where Facilitators empower farmers to make their own decisions based on their own observation.	Training is based on an Instructional approach in which Instructors tell farmers the correct way they should protect their rice crop.

than the form in which the answer was given. Both the method of interviewing and the analysis of the answers took this into account.

Farmers were interviewed in early July, 1995, before training began for the Farmer Field School (FFS) farmers, and after the first session of the Three Pests Three Diseases (3P3D) training.[10] Interviews of the same farmers were carried out after training in late August, 1995. Four of the technicians who had participated in the original interviewing then returned more than a year later, October, 1996, to conduct a final interview with as many farmers as we could find in order to find out how they applied their training. Owing to very high levels of migration in the Chinese countryside (Croll, 1996), it was not possible to find all farmers a year later, and only 23 FFS farmers and 22 3P3D farmers from the original sample were interviewed.

Results presented here represent a longitudinal qualitative study based on three interviews of farmers carried out by native speakers of Chinese working with the Crop Protection Service.

The findings

Consistency and correctness of responses

One way to measure the formation or development of a concept is to look for consistency and correctness. According to this approach, a set of consistent and correct responses at different points in the interview shows there is a coherent, robust concept. An inconsistent set of responses displays a weaker (or perhaps non-existent) concept. Consistently Incorrect responses are assumed in this scheme to display a lack of a concept.

In order to measure this, farmers were asked questions at different stages in the interview schedule which related to the ecosystem. The questions whose responses are compared here were:

Q. 75 "Are any animals or insects that you have observed good for your crop? Yes_ No_. (If yes) Name, describe or draw those insects or animals which are beneficial."

Q. 86 "Do you think it is beneficial to have insects in your fields?"

Q. 89 "If you could, would you eradicate all insects and animals from your fields?"

Examples of responses

If a farmer answered as follows, he or she would be ***Consistently Incorrect (A)***:

A. 75 "No insects are good for the crop. They are all dangerous."

A. 86 "No, its bad to have insects in the field. None of them are good."

A. 89 "Yes, I would kill them all."

In contrast, a set of responses such as the following would be ***Consistently Correct (C)***:

A. 75 "Yes, spiders are good, and dragonflies. And parasite wasps kill caterpillars."

A. 86 "Yes, many insects help control pests, like spiders."

A. 89 "No. I want to keep the good ones so they control the pests, and so I don't want to eliminate all insects."

An example of a ***Inconsistent (B)*** response would be one in which a farmer may correctly understand the role of beneficials but would still eradicate everything in his or her field.

Table 2, below, summarizes responses of the two groups of farmer trainees.

These results indicate that, during the intervening year after training, FFS trained farmers seem to have moved forward on their own toward development of more robust concepts of the rice ecosystem. This is consistent with the FFS training approach, which was designed to empower farmers to become experts in their own fields. Training was based not upon prescriptions and "right answers" but on developing fundamental concepts of how nature functions and how best to (and not to) deal with crop protection situations. The reason for this approach was the belief – based upon previous FAO training experience – that a firm concept of how the field ecosystem works is better than any set of discrete (and often disjointed) instructions.

Such a concept is based upon analysis of many accumulated observations. Much time was spent by FFS farmers doing field activities like the insect zoo in which they could witness how beneficials could eat pests, or upon compensation trials where farmers could see for themselves how pest damage is often overcome by the plant – rice plants from which a proportion of leaves or tillers were experimentally cut off to simulate pest damage would grow new leaves or tillers to compensate. The reporting of findings after each weekly Agro-Ecosystem Analysis gave FFS farmers the opportunity to draw and analyze their own observations, then report and present them for discussion to the others present. Their objective when making a decision was to conserve beneficials, rather than wipe out pests. All these features of FFS training doubtless contributed to the post training growth of concepts among FFS farmers.

3P3D training, on the other hand, had no experimentation, but only explanation with questions and answers. Furthermore, field time was limited to looking for examples of the particular pests and diseases that were to be treated at that critical time, not on looking at any of the numerous other animals in the ecosystem. Emphasis was upon identification of relevant pests and diseases in the field; beneficials were mentioned in the classroom as being important, but ignored in making decisions about whether or not to spray. In classroom sessions, 3P3D farmers were taught use of the "right" pesticide to combat pests and diseases. Learning about the ecosystem was at best incidental; there was no intention to assist trainees to construct a coherent concept of the ecosystem.

This training emphasis in the FFS upon fundamental concepts rather than prescriptions, and upon farmers making decisions based upon their own observation rather than following a formula or instruction, seems to have paid off. Understandings actually grew in the intervening year, presumably as a result of FFS farmers observing their ecosystems for themselves and drawing their own conclusions.

However, these results show a slide backward for the 3P3D trainees one year later. Since the training was based upon prescriptions for action, the memorizing of ETLs (but not necessarily understanding the ecological logic for using them) and using the "right" pesticide, there is little retention of a really scientific understanding. Activities were designed to prove the validity of a pesticide-based approach to control and to encourage farmer trainees to follow "correct" instructions,[11] rather than to empower farmers to make their own decisions.

Completeness of responses

In the interview schedule, there were seven questions at different times in the interview that directly asked the farmer to mention predators and parasites (beneficials). For example,

Q. 75 "Are any animals or insects that you have observed good for your crop? Name, describe or draw those insects[12] or animals which are beneficial."

Another 11 questions asked indirectly in some way about beneficials. For example,

Q. 98 "Some people, such as scientists, say it is important to have some insects, spiders and other animals (like snakes) in the fields. What do you think of that?"

Table 3 compares responses of the two groups of farmer trainees based on aggregated results of exam-

Table 2. Consistency/correctness. Farmers' responses regarding their understanding of the function of beneficial insects/spiders in their fields (FFS = Farmer Field School; 3P3D = 3 Pests 3 Diseases)

	(A) Consistently Incorrect (No Concept)	(B) Inconsistent (Intermediate)	(C) Consistently Correct (Robust Concept)
PRE FFS (N=27)	14	11	2
POST FFS (N=26)	0	17	9
FFS ONE YEAR LATER (N=230)	0	9	14
2nd SESSION* OF 3P3D (N=25)	2	20	4
POST 3P3D (N=25)	0	17	8
3P3D ONE YEAR LATER (N=22)	0	19	3

*By the time we arrived to begin interviewing, the 3 Pests 3 Diseases training in Long Ting Village had already completed the first session of training. Our preliminary interviews for 3P3D training are therefore not a true "*pre*" test, and farmer responses reflect the results of a session of training already undergone.

ples of beneficial insect/spiders in the wet rice ecosystem given during the interview. This comparison of both training outcomes against one view of the rice ecosystem – the most current and best researched – is done to assist in determining which elements make for effective IPM training, and will contribute later in this article to an overall assessment of which of the two types of IPM training is more effective.[13]

A "G" Test (Sokal and Rohlf, 1981: 744, 859), a sensitive non-parametric statistical measure to compare different data series, was performed on the above series of numbers of beneficials named or described.

The FFS farmer Pre-Test data give a fairly representative picture of farmers' understanding of beneficial insect/spiders before any training. Differences between the Second Session 3P3D farmers and Pre-test FFS farmers can be attributed to the one training session that 3P3D farmers had already undergone. Thereafter, differences between the two samples can be attributed to differences in the two training programs.

Of particular interest is the significant increase in number of beneficials mentioned a year after training by FFS farmers. This finding indicates that these farmers were stimulated enough by the FFS training model to carry on with their own learning during the intervening year. There is no such indication from the 3P3D results. Since both samples were interviewed by the same four technicians within the same week, no difference in this result could reasonably be attributed to any interviewer effect. No further training programs were undergone by either group in the intervening year.

An additional "G" Test comparison shows that FFS farmer responses one year after training for naming beneficials are significantly more complete than Post FFS responses. But 3P3D farmer responses one year after training have not significantly increased over Post 3P3D responses. For 3P3D farmers there has been no gain in completeness. The training they received about beneficials seems to have had little influence. These results are shown in Table 4.

This difference is consistent with the different emphasis of the two training programs, as shown by the following sample responses one year after training:

Q. 122 "What have you learned in this training that is important to you as a farmer?"

Fairly typical 3P3D farmer responses were,

> "The technique of applying pesticides," or, "I know more about how to use pesticides."

By contrast, a fairly typical FFS farmer response was,

> "I learned how to investigate the field. When there are many beneficials, it isn't necessary to spray pesticides. I learned how to prevent pests and disease myself."

We and others have found that knowledge of natural enemies of rice pests is very important to farmers, once they understand their function in the rice ecosystem. In fact, FFS farmers often express dismay that they had been killing these beneficials prior to training, and may even voice their irritation that the Crop Protection Technician hadn't told them about this earlier. The results in Table 4 confirm this anecdotal experience.

Use of pesticide after training

The final measure of training differences has to do with application of pesticides during the year after training. It is clear from farmer responses that the FFS model is better at getting farmers to reduce pesticide applications, the single most significant indicator for applying the lessons learned. Table 5 shows a comparison of the amount of pesticides that were applied

Table 3. Completeness. Numbers of beneficial insect/spider types named by farmers based on aggregated responses to three different interview questions about the wet rice ecosystem

	Number of beneficial insects/spiders mentioned							
	0	1	2	3	4	5	>5	
PRE FFS (N=27)	16	6	2	2	1	0*	0*	($G_{df=4}$, $p < 0.05$):
2nd SESSION OF 3P3D (N=26)	8	12	6	0	0	0*	0*	2nd session 3P3D farmers know more beneficials than untrained FFS farmers
POST FFS (N=26)	0*	1	2	11	7	5	1	($G_{df=5}$, $p < 0.005$):
POST 3P3D (N=25)	0*	7	9	3	3	2	1	FFS farmers know more beneficials than 3P3D farmers
FFS ONE YEAR LATER (N=23)	0	0*	5	5	3	1	9	($G_{df=5}$, $p < 0.005$):
3P3D ONE YEAR LATER (N=22)	1	0*	9	3	5	4	0	FFS farmers have gained further knowledge of beneficials in the intervening year

*These data cells were not entered into "G" test calculations.

Table 4. Growth in completeness of understanding during year after training for each training model: Comparison of numbers of beneficial insects/spiders identified

	0&1	2	3	4	5	>5	
POST FFS (N=26)	1	11	11	7	5	1	($G_{df=5}$, $p < 0.005$):
FFS ONE YEAR LATER (N=23)	0	5	5	3	1	9	Indicates learner "take off" during the year following FFS training
POST 3P3D (N=25)	7	9	3	3	2	1	($G_{df=5}$, $p < 0.25$):
3P3D ONE YEAR LATER (N=22)	1	9	3	5	4	0	Indicates learning is at a standstill; no progress in year following training

to their rice crop during the 1996 rice season for both FFS with 3P3D trained farmers. It is evident that FFS farmers sprayed their crop significantly fewer times than 3P3D farmers. Most farmers mix fungicides and insecticides, and occasionally even herbicides, when spraying. Table 5 covers all spray events for all types of chemical agent (insecticide, herbicide, fungicide[14]), and also tabulates total generic chemical insecticides applied during the season, for the two different farmer trainee groups.

"G" Test results on frequency of spray applications shown in Table 5 indicate that spray practices of FFS and 3P3D farmers are statistically indistinguishable prior to training. While the post-training samples are small, it is clear that FFS farmers present a different case than 3P3D farmers, and that the FFS training resulted in reduced application of pesticides as compared with 3P3D training.

The FFS farmers that we studied in Meishan County, Sichuan, in 1996 sprayed 1.4 times fewer (38.78% less) than they did in 1994. The 3P3D farmers sprayed 0.67 times fewer (17.82% less) than they did in 1994.

In order to give the reader a broader perspective on these results, other unpublished studies carried out by the Chinese General Station for Plant Protection for 1995 show that a sample of 1,506 FFS trained farmers in 22 counties, eight provinces, in general spray only 58% (42% less) pesticide measured in grams per Mu than did a sample of 738 untrained farmers. Another 1994 study involving 1,373 FFS trained farmers in 32 counties, 10 provinces, revealed that FFS farmers sprayed an average of 2.8 times per season while untrained farmers sprayed an average of 4.1 times per season.

As described in Table 1, FFS training emphasized the danger to beneficial spiders/insects resulting from pesticide use, and placed primary emphasis upon conservation of beneficials as the best approach to crop protection. 3P3D training emphasized use of the "cor-

Table 5. Comparison of spray applications between FFS and 3P3D: Comparison of total reported sprays for rice seasons before and after IPM training (1994 and 1996 crop seasons)

Total no. of sprays (all agents)	FFS PRE TRAINING CROP ′94 (n = 26)*	3P3D PRE TRAINING CROP ′94 (n = 25)*	FFS POST TRAINING CROP ′96 (n = 23)	3P3D POST TRAINING CROP ′96 (n = 22)
5 times or more	6	7	0	2
4 times	3	4	1	5
3 times	12	11	6	7
2 times	4	3	13	7
1 time	1	0	3	1
TOTAL SPRAY EVENTS:	94	94	51	68
AVERAGE NO. OF SPRAYS:	3.61	3.76	2.21	3.09
"G" TEST SIGNIFICANCE:	$G_{df=4}$, $p > 0.50$ (no difference)		$G_{df=4}$, $p < 0.10$ (significance at 90th percentile)	
TOTAL GENERIC INSECTICIDES USED, ALL FARMERS+	11 kinds	10 kinds	5 kinds	9 kinds

*One farmer from initial samples of both FFS and 3P3D could not remember how many times pesticides were used in the 1994 pre-training rice crop.

+This particular tabulation does not include fungicides, herbicides or biological agents.

rect" insecticides – that is, the most effective for killing each type of insect pest – and when best to apply it. While 3P3D training mentioned that there were several types of beneficials in the field, the procedures in 3P3D for deciding to spray insecticides took no account of the role of beneficials. Any message to either reduce pesticide applications or conserve beneficials was overridden by the emphasis on pesticides as the primary method of crop protection.

The difference in spray applications cited in Table 5 is consistent with the differences in content and emphasis between the two types of IPM training. Farmers who know there are natural enemies to their rice pests helping them in their fields are far more reluctant to spray. Not only do the figures in Table 5 indicate this, but FFS trained farmers will readily state this.

Yield comparisons

Yields, however, showed no significant difference between the two villages. All farmers planted a single crop of hybrid rice. Yields recorded here are from farmer estimates. FFS yields averaged 535.2 kg per Mu; 3P3D yields averaged 560.5 kg per Mu. This absolute comparison of yield figures of itself tells us little. But comparison of relative increase or decrease against the previous year's yield for the same group of farmers is useful. These results are shown in Table 6, below.

A "G" Test performed on these yield figures showed no significant yield difference to reflect any advantage from the higher levels of pesticide used by 3P3D farmers. Keep in mind that these villages were approximately 10 kilometers apart, and experienced virtually the same general weather and pest conditions for the 1996 crop year.

Outcomes: Triangulated evidence for persistence of concepts

FFS Farmers show a growth of internal consistency in the intervening year; 3P3D farmers show regression to more inconsistent responses, as is shown in Table 2. FFS farmers also show growth in the completeness of responses about beneficial insects/spiders in the wet rice environment, while 3P3D farmers remain about the same. Finally, as the third leg of this evaluation triangle, pesticide applications among FFS farmers are substantially lower than those of 3P3D farmers (Table 5, above) indicating that FFS farmers make serious attempts – sometimes in circumstances where there is little institutional support (discussed below) – to apply their new techniques and understanding.

Table 6. Yield comparison between FFS and 3P3D for rice harvest (One Mu = 1/15 (0.0666) hectare) based on farmer recall

Kg per MU	FFS Farmers (n = 23)	3P3D Farmers (n = 21)*
>600/MU	0	0
575–599/MU	5	8
550–574/MU	6	8
525—549/MU	2	1
500—524/MU	10	3
<499/MU	0	1
AVERAGE YIELD/MU	535.2 Kg	560.5 Kg
AVERAGE INCREASE/DECREASE COMPARED TO 1995	+7.4 KG/MU	–4.3 KG/MU
"G" TEST DIFFERENCE:	$G_{df=4}$, $p < 0.25$ (no difference)	

*One 3P3D farmer (not entered in this comparison) failed to recall his yield levels for each year.

These findings constitute evidence for a correlation between more robust concepts of the wet rice ecosystem and farmer ability to apply more sustainable, less pesticide intensive IPM methods. They also suggest a better understanding of sustainable, low spray IPM methods among FFS farmers.

More work needs to be done, however. For example, our data also show that FFS farmers do not adequately comprehend the role of neutrals in the rice ecosystem even after training. While predator-pest relationships are easy to observe and appreciate, the role of neutrals (e.g., detritus feeding Springtails, certain midges, etc.) as early season prey for beneficials, remained less well understood. Generalist predators like spiders do not just feed upon rice pests; they feed on a range of prey, and FFS farmers even after training still have difficulty visualizing how neutrals are important as a food source for beneficial insects/spiders in the rice field *before* the onset of pests.

Implications for IPM farmer training

The problem of institutional support

It should be pointed out that farmers trained in the FFS model had very little support for their new IPM techniques from the Chinese extension system when compared with 3P3D farmers. The Chinese crop protection system is based upon tracking pest trends at Plant Protection Service sample fields, which are then used for county level pest forecasts. Pest warnings are broadcast to farmers via an electrical loudspeaker system present in virtually every village. These announcements convey warnings from the forecast station about pest danger, and announce to farmers the ETLs or spray indexes; they do not contain any advice to take note of the presence of beneficials or to conserve beneficials. Farmers generally interpret such announcements as instructions to spray their crop.

This crop protection approach is more consistent with the 3P3D training approach, but conflicts in several ways with the FFS approach. In fact, FFS farmers have to deliberately ignore extension messages containing information inconsistent with their training in order to make their own decisions based upon presence of beneficials as well as pests. 3P3D farmers found no such conflict with what they had learned.

The social and technical support provided by the Chinese extension system is very influential among farmers. We suspect that even greater reductions in pesticide applications with no threat to yield, as well as more concept growth among FFS farmers, could have been achieved in the intervening crop year had the extension system and crop protection messages been altered to support Ecology-Based IPM (J. Mangan, 1996: 204–5).

The FFS empowered farmers with the confidence to make decisions based upon their own observations, and promoted the development of consistent scientific concepts. FFS farmers added to their own knowledge during the intervening year. This shows that the FFS clearly triggered a kind of learning "take off." FFS farmers' concepts grew in strength – probably as a result of continued field observation

– despite their receiving incongruous extension messages throughout the intervening crop season. Learning based upon internally consistent scientific concepts achieved through trainee experiences and reinforced by group discussion is far more powerful than learning based upon memorized instructions or inconsistent explanations.

On the other hand, if supports such as farmer groups for Ecology-Based IPM are not instituted, we suspect FFS farmers will eventually revert to conventional practice and spray more. Interviews of farmers in Indonesia two years after FFS training showed that understanding acquired in the FFS had regressed because there was no effort by the extension system to maintain or augment it, and also because pesticide salesmen – a potent influence in rural communities – derided IPM or threatened unforeseen danger. Also, other extension messages, such as the instruction to treat all pest problems with pesticides, were in conflict with FFS training (Vayda and Setyawati, 1994). We cannot expect farmers to resist contrary trends forever. Even Galileo recanted under pressure. Social pressure and less sustainable pest control practices will eventually overcome the new understanding if crop protection messages that conflict with Ecology-Based IPM continue to be broadcast to farmers by the extension system. This is exacerbated by the fact that the crop protection service in China makes money by selling pesticides to farmers, and this activity conflicts with any general lowering of pesticide use. At the most fundamental level, Vygotsky's theory of learning would indicate that social supports are a fundamental requirement for learning (Vygotsky, 1992).

Overall costs and effectiveness of training models

Which training model is more effective? The answer to this question depends upon the objectives and purposes of the training and upon how long the training result is supposed to last. If farmer dependence upon and compliance with pest control instructions is a primary objective, then 3P3D is more desirable. If significant reduction of pesticide applications plus independence of decision making by farmers is a primary objective, then FFS is more desirable.

We believe pesticide reduction, ability of farmers to carry on with learned practices after training, and informed, independent decision making by farmers, are important outcomes of IPM training. FFS-trained farmers not only retain the desired knowledge longer and apply it more seriously, but also seem to have been given confidence and curiosity enough to continue learning about the rice ecosystem after the end of training. It is evident that the FFS model is more effective.

Economic benefits to farmers

The average 1995 cost of an FFS in Sichuan was approximately RMB ¥4,500 while the cost for a 3P3D training was approximately ¥4,000.[15] While no information was gathered on economic benefits to the farmers in this study, previous studies in China (unpublished data from ten Provinces, 1994) have shown that, for 1,373 FFS trained farmers, net income from rice land before training average ¥300.8 per mu; after training averaged ¥370.6 per mu (an increase of 18.83%); while 992 untrained farmers averaged ¥297.8 per mu. FFS training and reduced use of pesticides saves farmers money. Indeed, all farmers seemed pleased that they had learned how to reduce costs and increase income. While we likewise did no cost-benefit analysis of 3P3SD training, that model of IPM training also saves farmers money. A 1993 analysis of farmers in Jiangxi Province trained with Economic Threshold IPM in a way similar to the Meishan County 3P3D, showed a net income increase for farmers of ¥22.17, or 7.06%, per mu (Cheng and Liang, 1993: 36).

While this comparison is only suggestive, it would appear that economic benefits to the farmer are higher for the FFS model than for the 3P3D model, though further studies would seem to be in order. Studies after 334 FFS carried out in China from 1994 through 1996 show no yield loss, and indeed slight yield gains among trained farmers.[16] These findings have been corroborated by economic studies of FFS training undertaken in other countries (Pincus, 1991). If collateral changes in the extension system were also undertaken in China in order to better support Ecology-Based IPM, it would be possible to achieve very significant reductions in pesticide application with no loss of yield. And there would be additional benefits from a farm population more aware of the dangers of agro-chemicals, as well as the need to achieve sustainability.

Specific changes might deal with the content of village broadcasts and the nature of crop protection advice. These could be altered to support Ecology-Based IPM. Broadcasts could encourage farmers to conserve beneficials and observe crops weekly for the presence of both beneficials and pests. Furthermore, policies that allow (and indirectly encourage) Crop Protection Services at the County level to make an increasing proportion of their operating costs from the sale of pesticides could (and should) be abolished (J. Mangan, 1996).

Conclusions

Using the criteria presented here, it is clear that the FFS training model is more effective than the 3P3D model at achieving an understanding of the rice ecosystem. There is much better retention of the concepts learned in the FFS as compared with the 3P3D training model. Furthermore, the FFS model of training clearly triggers a self-learning process that carries on after training, and the 3P3D model does not.

Insect populations vary dramatically on a micro-geographic level. Also, pesticides are presenting an increasing threat to a balanced rice agro-ecosystem (not to mention wildlife, livestock, and human health). For both these reasons, sustainable crop protection should be carried out on a field-by-field basis by each individual farmer in order to reduce the use of unneeded pesticides. The extension of Ecology-Based IPM will empower farmers to make more environmentally responsible crop protection decisions.

Finally, we feel the FFS model of farmer training is one that might be adapted wherever sustainable practices at the community level are needed. This model of training involves community members in both analysis of the environment and decision making. Other forms of integrated agriculture might use FFS training. Other needs for understanding complex natural systems might be met by FFS training. Sustainable community resource use, or even wildlife conservation at the community level, might employ similar training. Sustainable management of our resources requires understanding of complex interactions not restricted to any single discipline. The FFS has proven an effective model to meet this type of training need at the grass roots level in the developing world.

Notes

1. The term “neutral” is a rough designation referring to an insect that neither eats the crop (i.e., pests) nor feeds upon crop pests (i.e., predators and parasites).
2. It had previously been assumed that any increase in beneficials merely followed an increase in pests. While this may be true for any specific pest/predator pair, it is not true for an ecosystem in which so many alternative neutral prey species are available for any predator species prior to the arrival of pests attracted by the crop.
3. It should be pointed out that Ecology-Based FFS training also dealt with ETLs. However, primary emphasis was placed upon conserving beneficial insects/spiders. Farmers learned, for example, that a field condition in which there are 30 Brown Planthoppers (BPH) per rice plant but no Wolf Spiders is very different indeed from a field situation in which there are 30 BPH but also one Wolf Spider per plant. The former might pose danger of an outbreak; the latter is quite safe. Level of threat from other pests – Skipper butterfly, Armyworm, Locusts, Stemborers, Rice bugs – is similarly affected by the number of beneficial predators and parasites present.
4. ETLs are based upon field trials where level of a particular pest, stage of the rice crop, price of insecticide treatment, and market price for the crop, are the variables. Trials for establishing ETLs in China (or elsewhere) take no account of the crop ecosystem, such as other insects/spiders present in the field.
5. The Farmer Field School (FFS) is the name of the training promoted by the FAO Inter-country Programmme for Integrated Pest Control in Rice in South and Southeast Asia, of which China is a member country. The FFS training model was first developed in Indonesia and then adapted to other countries.
6. The 3P3D Program was supported with World Bank funding, and was actually called “World Bank Training” (Shi Hang Peixun). We have chosen to label this program “Three Pests, Three Diseases,” because Chinese Plant Protection Station data showed that those 3 pests and 3 diseases caused a major proportion of crop loss, and major emphasis in the training was given to these. In fact more than that number of pests and diseases were dealt with in training. The major pests and diseases treated in the 3P3D training were Stemborers, Skipper butterfly, and Grasshoppers. Army worm, Thrips and other leaf-eaters also received attention. Major diseases are Blast, Sheath blight, and Bacterial leaf blight.
7. The times during which 3P3D training sessions were convened were determined by the Crop Protection Service, and took place during the seedbed, tillering, panicle initiation, and booting stages.
8. Other aspects such as weed control, fertilizer application, use of fungicides, etc., were largely the same for both programs, and were not the object of our comparative research.
9. In agriculture, the term “cultural practices” refers to the specific local farming techniques and practices, from plowing and planting to harvesting and post-harvest treatment.
10. It proved impossible to arrange for a true “pre-test” of the 3P3D farmers because their first training session dealt with the rice seedbed and had already taken place by the time interviewing could be arranged. An accurate impression of untrained farmers can therefore only be gained from the FFS pre-test responses.
11. The final session of the 3P3D training was a final exam where farmers were asked, e.g., “What is the best pesticides to use against Stemborers in the seedbed?” “What is the best pesticide and correct concentration for Skipper butterfly?,” etc.
12. It should be noted that in colloquial Chinese, spiders, insects and even worms are all “chongzi.”
13. While we fully understand that the FFS was more purposefully designed to teach farmers about beneficials, we feel this comparison against the best current scientific understanding is essential in order to get an idea of more fundamental requirements for IPM training. On the other hand, we make no attempt to evaluate the respective training programs against their respective specific training objectives, which would tell us nothing about the more fundamental

requirements for IPM training which this article attempts to delineate.

14. It is fairly typical for Chinese rice farmers to mix insecticides, as well as to add fungicides and/or herbicides to the concoctions. The following count of spray applications therefore includes all three.
15. Rate of exchange at the time of these estimates was approximately ¥8.30 per USD. There was no rigorous accounting for all costs of these programs; these figures are based upon estimates conveyed orally to one of us (James).
16. Unpublished National Station for Plant Protection data.

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