IMPACT OF EDUCATING FARMERS ABOUT BIOLOGICAL CONTROL IN FARMER FIELD SCHOOLS

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ABSTRACT

An Integrated Pest Management (IPM) Farmer Field School (FFS) is a field-based activity that lasts a full cropping season. A typical FFS meets once a week and 25-30 farmers participate in an FFS. In addition to group dynamics activity and a special topic session, an FFS emphasizes scientific learning through experimentation. Biological control is discussed and confirmed by carrying out insect zoo studies. A common insect zoo in rice IPM FFS involves placing a lycosid spider among field collected Brown Plant Hopper (BPH) in a clear bottle. Seeing is believing and perhaps for the first time, the concept of biological control is understood by resource-poor farmers. This process of educating farmers about biological control can be further enhanced by simple “exclusion cage” experiments.

Learning about biological control was also achieved in Dalat, Vietnam, leading to an understanding of the selective action of the microbial insecticide Bacillus thuringiensis in managing the diamondback moth on cabbage. With the information from experiments and pilot studies, farmers were able to organize village-wide activities to conserve the population of Diadegma semiclauseum (Hellen), a key larval parasitoid of Plutella xylostella (L.).

Similar impacts were observed in cotton fields in China, India and Pakistan where populations of pests were kept in check when FFS graduates did not carry out early sprays. Preliminary studies indicated that the species diversity was higher in IPM plots as compared with plots regularly treated with insecticides. In India, the number of species was 48 in IPM plots and 31 in non-IPM plots. For Bangladesh, the study showed 49 species in IPM plots compared with 36 species in non-IPM plots. Combined with an increase in biological control knowledge (FFS farmers scoring 16.9 points for recognizing natural enemies as compared to 2.3 for non-IPM), there is a concomitant reduction in use of insecticides (43% for IPM farmers versus 34% for non-IPM). With the skills acquired at FFS, farmers have increased incomes, as farmer education activities help consolidate the impact of biological control in farmers’ pest management decision making (34% increase in FFS farmers as compared to 10% for non-FFS farmers).
From experiences in implementing IPM FFS in rice, vegetables and cotton in Asia, it was evident that educating farmers about biological control result in farmers using less chemical insecticides and becoming more efficient in their production activities. Even in a crop that is not subjected to regular use of insecticides, such as coconut, teaching biological control is just as critical to farmers to keep pests in check. For example, teaching farmers about how baculovirus and *Metarrhizium anisopliae* kill the rhinoceros beetle, *Oryctes rhinoceros* (L.), help them better comprehend the nature of rhinoceros beetle damage and encourage them to reduce breeding sites for the pest. Outbreaks of invasive pest species, such as *Brontispa longissima* (Gestro) on coconut, provide additional opportunities to use the Farmer Field School to educate coconut farmers about biological control.

**INTRODUCTION**

Biological control usually refers to “the action of parasitoids (parasites in the original definition), predators and pathogens in maintaining another organism’s density at a lower average than would occur in their absence” (DeBach 1964). Implicit in this definition is the desire to understand how these parasitoids, predators and pathogens act on their prey. However, in the last century, this empirical approach was replaced with a desire to discover effective parasitoids and predators for possible introduction into a new area where a pest has been transported. This approach is called classical biological control. It drew much support from successes with the cottony cushion scale in California (DeBach 1974) and control of the coconut leaf moth in Fiji (Tothill *et al.* 1930). Another field of interest in biological control is the rearing of millions of natural enemies for release into the field, often at regular intervals. This inundative biological control has been viewed as too expensive and probably unnecessary in a tropical setting.

Besides classical and inundative biological control, there is a rich and dynamic array of natural enemies that help keep pests in check under most agro-ecosystems in Asia. These have been reported by Kenmore *et al.* (1984), Ooi (1986), and Wood (1973). This paper will examine the education of farmers using the Integrated Pest Management (IPM) Farmer Field School (FFS) approach (Dilts and Hate 1996; Pontius *et al.* 2002). Lessons learnt in programmes involving rice, vegetables, cotton and coconut will be analysed to identify the impact of biological control education on implementation of IPM by farmers.

**REVISITING FARMER FIELD SCHOOL**

Over the last decade, the IPM Farmer Field School (FFS) has emerged as a robust approach to educate poor farmers to manage their crops more efficiently, not just in Asia but also in Africa and South America. The defining principles of an FFS have been clearly described by ter Weel and van der Wulp (1999) and Pontius *et al.* (2002). The FFS is the primary learning approach piloted in Indonesia (Dilts and Pontius 2000). An IPM Farmer Field School (FFS) is a field-based activity that lasts a full cropping season. A typical FFS meets once a week and 25-30 farmers participate in an FFS. In addition to group dynamics activity and a special topic session, an FFS emphasizes scientific learning through experimentation. In each FFS, field plots would be set up to compare an ecological approach versus an existing practice. Each
week, farmers would observe both plots and collect data on plant development and population trends of insect pests and their natural enemies. The data collected enable farmers to learn and practice agro-ecosystem analysis and farmers will acquire the skills to make a “science-informed” decision. The process of agro-ecosystem analysis involves stepping into the field to collect data on crop growth and population of pests and natural enemies (Fig. 1). Upon returning to the meeting room, farmers learn to sort out the insects collected (Fig. 2).

Following discussion farmers present their results in an agro-ecosystem drawing (Fig. 3). The decisions made by the group are presented to the class and actively discussed and opportunities for follow up activities identified (Fig. 4). In this way, male and female farmers are introduced to the complex concept of biological control.

Discussions of conditions of the field plots are based upon farmers’ analysis of field collected data. The Field School uses a participatory learning process. The process emphasises taking decisions and actions based on an open discussion of ideas which is free from the domination of any individual. These decisions are tested in the field laboratory. The FFS process, besides its emphasis on field ecology, provides participants with an opportunity to examine human social dynamics. As a result, FFS participants not only learn about the cause and effect relationships that exist in the field, they also acquire a greater understanding of human relationships.

The analytical processes employed in the FFS enhance farmers’ capacities to examine the conditions, in which they live and work. Participants, having completed their FFS, are able to take decisions and take actions that would improve those conditions. The increased understanding of participants regarding human social dynamics enables them to develop collaborative efforts to ensure that planned actions are implemented.

Even after the FFS, farmers continued to experiment and in some cases worked in groups. For example, farmers in the village of Kalensari in Indonesia continued to study a non-pesticide method to control the white stemborer (Warsiyah et al. 1999). Examples of follow-up studies by farmers are reflected in Ooi (1998), Ooi (2000), Ooi et al. (2001) and van den Berg et al. (2004). This confirms that farmers are able to carry out experiments and develop innovative IPM (Chambers et al. 1989).

Figure 1. Collecting field data from a sub-plot in a rice field in Thailand.
Figure 2. Sorting out insects collected from the rice field.

Figure 3. Making an agro-ecosystem drawing.

Figure 4. Using the agro-ecosystem drawing to explain the decisions arrived by the farmer group.
ROLE OF BIOLOGICAL CONTROL IN IPM

When severe outbreaks of leaf-eating caterpillars were reported in the late 1960s at the time when oil palm was encouraged in a diversification to rubber planting in Malaysia, Wood (1973) determined that these outbreaks followed the use of broad-spectrum insecticides. This was proven using an insecticide check technique in large blocks sprayed recurrently with dieldrin. Wood (1973) thus concluded that the bagworm, *Metisa plana* Walker (Lepidoptera: Psychidae) was made to increase by the destruction of its natural enemies. The successful identification of biological control as the main factor in keeping insect pests in check in oil palm led to management practices in most estates which avoided use of insecticides.

Field studies in the late 1970s and early 1980s showed that biological control is the core of IPM in an annual crop such as rice (Kenmore *et al.* 1984; Ooi, 1986). That biological control is central to the development of IPM in rice was shown from insecticide check experiments similar to the one conducted in oil palm. This suggested that regular use of insecticides can lead to pest outbreaks in rice in the tropics.

Recent literature reviews further confirmed the importance of indigenous natural enemies in rice in the tropics (Ooi and Shepard 1994; Shepard *et al.* 1987; Way and Heong 1994), but ironically, farmers did not know about the role of these natural enemies, particularly of predators in rice fields. Farmer education was important to help farmers understand the need to conserve these natural enemies (Kenmore 1996; Matteson *et al.* 1994).

Arguably, the introduction of *Diadegma semiclausum* (Hellen) (Hymenoptera: Ichneumonidae) and its successful establishment on cabbage with diamondback moth had demonstrated a positive impact in the cooler highlands of Indonesia (Sastrosiswojo and Sastrodihardjo 1986), Malaysia (Ooi 1992), Philippines (Poelking 1992; Ventura 1997), Vietnam (Ooi *et al.* 2001) and Taiwan (Talekar *et al.* 1992). In Dalat, Vietnam, in order to enhance the establishment of *D. semiclausum*, farmers in two communities carried out studies to better understand the role of Bt (Fig. 5) in conserving this parasitoid. Through this effort, the impact of *D. semiclausum* was realized within six months when it was not possible for the parasitoid to establish despite two years of continuous releases before the study (Ooi *et al.* 2001).

In cotton, as in rice, biological control has been shown to be fundamental in the development of IPM (Ooi *et al.* 2004). All the key pests in cotton in Asia are native and indeed have a wide range of parasitoids, predators and pathogens that help keep pest populations in check. Similarly, the focus of coconut IPM has been on the role of biological control in keeping key pests such as *Oryctes rhinoceros* (L.) (Coleoptera: Scarabaeidae) in check (APCC 2005). While the baculovirus and *Metarhizium anisopliae* occur naturally in its centre of origin in Southeast Asia, the rhinoceros beetle occasionally escape from natural biological control. This is often attributed to poor sanitation where organic materials that serve as breeding grounds for the beetle are carelessly left in the open. In this particular case, farmer education about the diseases that kill *O. rhinoceros* larvae, will convince coconut farmers to remove potential breeding materials of the beetle. Recent outbreaks of the coconut leaf beetle, *Brontispa longissima* (Gestro) (Coleoptera: Chrysomelidae) in Asia and the successful biological control with *Asecodes hispinarum* Boucek (Hymenoptera: Eulophidae) offers yet another opportunity to educate farmers about biological control (FAO 2004).
HOW TO TEACH FARMERS BIOLOGICAL CONTROL

Biological control, whether classical or conservation, relies on the recognition, understanding and appreciation of the action of natural enemies. Implicit in this statement is the necessity to educate farmers. The IPM-FFS has emerged as a means to educate farmers about the complex ecological principles in their agro-ecosystems. As biological control is the key component of IPM, it is natural that farmers are introduced to ecology through an understanding of biological control.

It has been argued that in classical biological control, there is no need to involve farmers. This may be true in the case of the coconut moth in Fiji (Tothill et al. 1930) where interventions by coconut farmers were not common. However, lessons learned in the biological control of the diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), suggest that cabbage farmers should be made aware of and participate actively to enhance establishment and maintenance of the key parasitoid, *D. semiclausum*. (Ooi 1992).

That farmers can understand ecological concepts in general and biological control in particular have been reported (Bentley 1992; Ooi 1998). It is not surprising that using the FFS approach, farmers are introduced to biological control using the insect zoo approach. Often, the insect zoo is used to help farmers discover the predatory behaviour of natural enemies found in the field, thus helping them increase their understanding of ecological principles in their agro-ecosystem (Pontius et al. 2002). Questions about biological control events are discussed and confirmed by carrying out insect zoo studies. For example, in rice, the biological control of the brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae), is convincingly demonstrated by placing a lycosid spider among field collected BPH in a clear bottle (Fig. 6). Seeing is believing and perhaps for the first time, the concept of biological control is understood by resource-poor farmers.

**Figure 5.** Farmers carrying out bioassay of *Bt* using DBM larvae in Vietnam.

**Figure 6.** *Lycosa pseudoannulata* feeding on brown plant hopper. UGA1390042
To prove that generalist predators are important, exclusion cage experiments are usually set up to demonstrate the importance of these predators in keeping the brown planthopper (BPH) population in check. In this experiment, several large cages are placed over young rice seedlings and over the week, the seedlings are cleaned of any arthropods. BPH adults are introduced and when the population of BPH are established, half of the cages are opened to allow general predators in. Both types of cages are monitored weekly and the results are usually astounding, hence confirming the learning of biological control (Kenmore et al. 1984; Ooi 1996).

Armed with the skills to discover biological control, farmer graduates have been able to discover the impact of nuclear polyhedrosis virus (NPV) of Spodoptera exigua (Hübner) (Lepidoptera: Noctuidae) (van den Berg et al. 2004). Similarly, farmers in Dalat, Vietnam have been able to carry out studies to better understand the action of Bt to replace the use of chemical insecticides and hence give an opportunity for D. semiclausum a chance to impact on the populations of DBM (Ooi et al. 2001).

In all FFS, insect zoos form part of the farmer education process and through this, many farmers come to appreciate the role of biological control in keeping pest populations in check. Some exercises to teach rice farmers about biological control are suggested by Ooi et al. (1991) and Shepard and Ooi (1991).

To facilitate learning of biological control, IPM Facilitators are themselves educated first in season long Training of Facilitators programme. IPM Facilitators are taught in a way that will enable them to use a similar way to teach farmers in FFS.

**RESULTS OF TEACHING FARMERS BIOLOGICAL CONTROL**

In discussing the impact of IPM in general and the teaching of farmers in biological control, the outputs from the FAO-EU IPM Programme for Cotton in Asia are used. The impact studies evaluated pre- and post-FFS data from FFS graduates, from non-FFS farmers (exposed) in the same village and a separate control group. It compared farmer practices in the year before farmer field school training with those in the year after. As soon as FFS groups were formed in the selected study sites, a sample of participating farmers was interviewed about their previous season’s cotton cultivation and other related background information. The survey was repeated in the year after the FFS when the participants were by themselves again and were no longer guided by an FFS facilitator. The post-training data collection was conducted several times over the entire crop cultivation season in order to minimize errors from recalling information. In China and India the studies covered the years 2000 and 2002, while in other countries the years 2001 and 2003. Selected results from the studies are presented to reflect the result of farmer education.

In a study of 287 farmers in India and Pakistan, it was shown that cotton farmers who graduated from FFS had 16.9 point scores for recognition of natural enemies as compared to 2.3 points for non-FFS (exposed) farmers (Fig. 7).

This enhanced knowledge and skill can be translated to incomes in a concomitant study to evaluate average gross margins. A comparison of 1,060 farmers across five countries in Asia...
where the EU funded and FAO implemented Cotton IPM project was implemented showed that the average gross margins increased by $228 per hectare (+34% relative to control) for FFS farmers and $67 (+10%) for exposed farmers (Fig. 8); thus demonstrating the potential of educating farmers in biological control for reducing rural poverty.

The gains made could be attributed in part to savings in reducing use of insecticides by the farmers as illustrated in Fig. 9 based on the same farmers studied above. Insecticide use was reduced by 6.0 kg per hectare (-43%) for FFS farmers and 5.0 kg (-34%) for exposed farmers. The results suggest diffusion of knowledge from FFS farmers to non-FFS farmers.

This again may be translated into a healthier agro-ecosystem in a separate study of the species found in IPM and non-IPM fields. This study was undertaken as part of a study to encourage IPM Facilitators to teach farmers about agro-biodiversity in cotton fields. In both sites in India and Bangladesh, there was a higher number of species in IPM fields (48 and 49 for India and Bangladesh respectively) as compared to non-IPM fields (31 and 36 respectively) (Fig. 10). Predators and parasitoids contributed to the higher biodiversity recorded in IPM fields.

Lessons learnt from the implementation of IPM in rice, vegetables and cotton suggest that farmers need to be educated in the science of biological control if they are to benefit from the impact of this renewable resource (Ooi 1996; Ooi et al. 2001; 2004).

Recognition of Natural Enemies

(Test score increases relative to control (average of 287 farmers in India and Pakistan)

Figure 7. Recognition of natural enemies. Test scores increase relative to control (average of 287 farmers in India and Pakistan).
Impact of IPM-FFS on Farmer Income
(Gross margin increase relative to control (average of 1,060 farmers in 5 countries)

Figure 8. Impact of IPM-FFS on farmer income. Gross margin increase relative to control (average of 1,060 farmers in five countries – Bangladesh, China, India, Pakistan and Vietnam).

Figure 9. Impact of IPM-FFS on pesticide reduction. Gross margin increase relative to control (average of 1,060 farmers in five countries – Bangladesh, China, India, Pakistan and Vietnam).
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