

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 semiclausum* (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.



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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 South-east 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).



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

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 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))

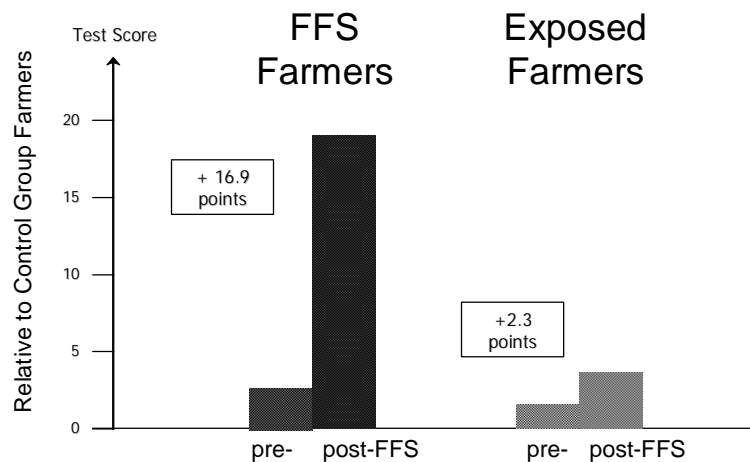


Figure 7. Recognition of natural enemies. Test scores increase relative to control (average of 287 farmers in India and Pakistan).

Impact of IPM-FFS on Farmer Income

(Gross margin increase relative to control (average of 1,060 farmers in 5 countries))

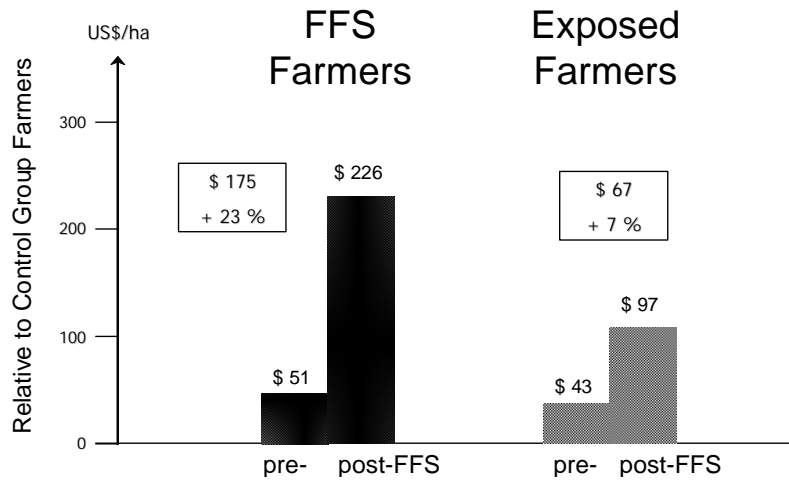


Figure 8. Impact of IPM-FFS on farmer income. Gross margin increase relative to control (average of 1,060 farmers in five countries – Bangladesh, China, India, Pakistan and Vietnam).

Impact of IPM-FFS on Farmer Income

(Gross margin increase relative to control (average of 1,060 farmers in 5 countries))

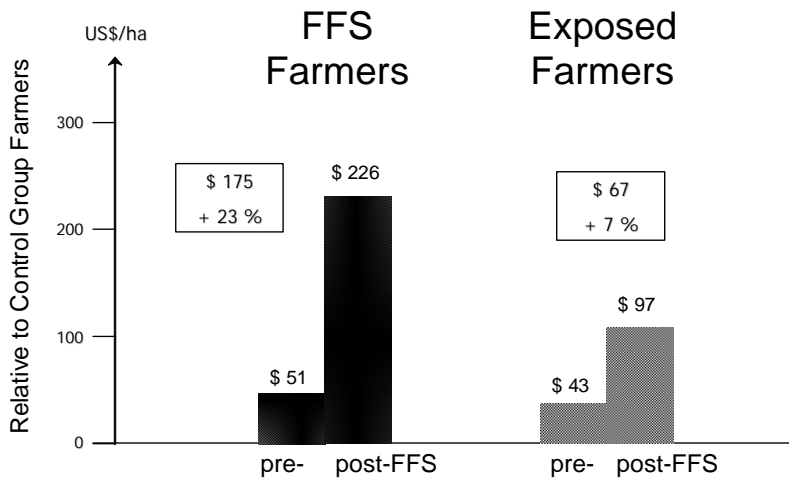


Figure 9. Impact of IPM-FFS on pesticide reduction. Gross margin increase relative to control (average of 1,060 farmers in five countries – Bangladesh, China, India, Pakistan and Vietnam).

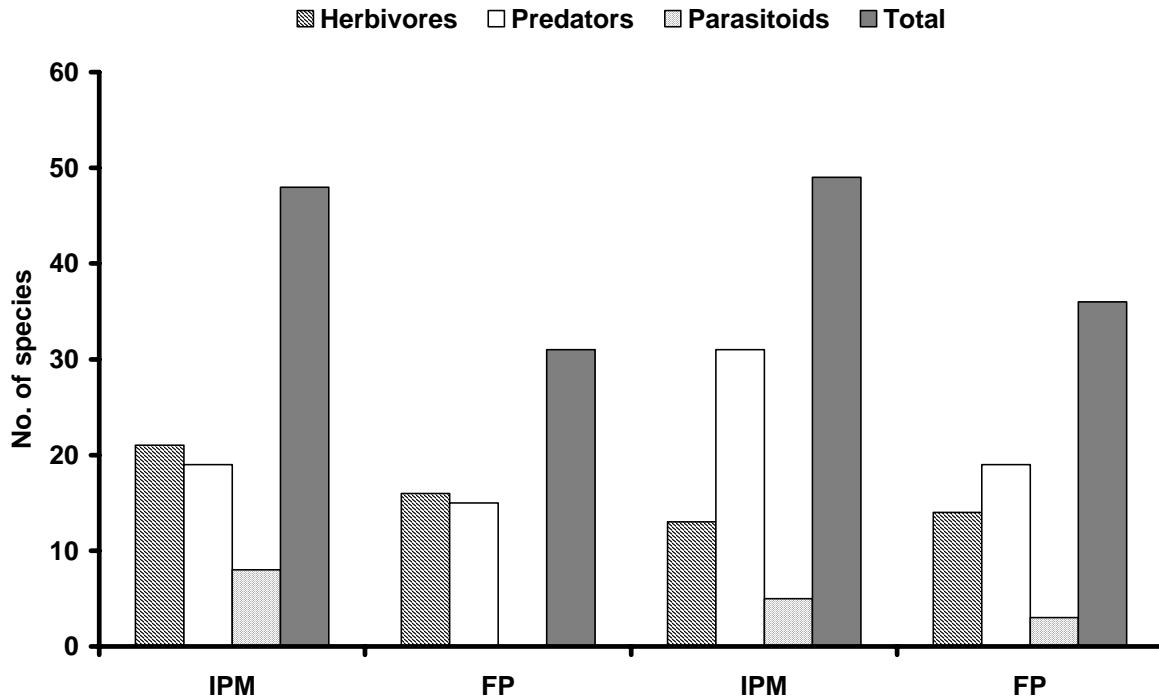


Figure 10. Comparison of number of species sampled from IPM and non-IPM cotton fields in Andhra Pradesh, India and Jessore, Bangladesh, 2003.

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THE ROLE AND SIGNIFICANCE OF FARMER PARTICIPATION IN BIOCONTROL-BASED IPM FOR BRASSICA CROPS IN EAST AFRICA

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ABSTRACT

Few attempts on biological control of arthropod pests on annual crops in sub-Saharan Africa have been successful. This is because of (1) inadequate taxonomic information on potential biocontrol agent(s), target pest and preferred host plants; (2) insufficient adaptation of potential agent(s) to bio-ecological conditions; (3) lack of consideration of the total pest complex of the target crop and farming systems; and (4) poor involvement of farming communities and extension personnel in information dissemination. The ICIPE-led diamondback moth (DBM) biocontrol project for East and Southern Africa has been addressing these issues since its inception in 2000.

Diadegma semiclausum, an exotic DBM parasitoid, was released in Ilkiding'a-Arusha/Tanzania pilot area in October 2002. Hands-on farmer training was conducted before the release. The establishment, spread and impact of the parasitoid was monitored through surveys. Parasitism rates increased from 10% before release to 36.2% and 66% (10 months and two years after release, respectively). Farmers reduced spraying frequency and changed increasingly to Bt-based products, many stopped spraying for DBM control completely. Aphid control measures changed from area to spot application. In consequence, DBM population and damage was significantly reduced. Evidence from neighbouring areas, where the parasitoid had spread to but where farmers were not trained, indicated that farmers were unaware about the presence of the parasitoid. They continued routine spraying with broad-spectrum insecticides. Consequently, the level of parasitism was much lower and damage very high.

The lessons from this experience and their implications for wider use are discussed in this presentation.

INTRODUCTION

Crucifers, particularly cabbage, *Brassica oleracea* L. var. *capitata*, kale, *B. oleracea* L. var. *acephala*, cauliflower, *B. oleracea* L. var. *botrytis*, Ethiopian mustard, *B. carinata*, Chinese

cabbage, *B. campestris* L. var. *pekinensis/chinensis* and broccoli, *B. oleracea* L. var. *italica*, are among the major crucifer vegetables grown for home consumption and for cash in many parts of East Africa, notably in the highlands. They are a valuable source of vitamins and minerals. About 90% of the crop is produced by small holders on ¼ to one-acre land holdings. The bulk of the produce is sold in urban centers where it has high demand as a relish.

In East Africa, crucifers are grown in a wide range of agro-ecological conditions, and therefore, the pest complex and intensity, and management strategies practiced by farmers vary within and between farmers and locations.

A wide range of pests (insects and diseases) attacks the crop (Varela *et al.* 2003). The diamondback moth, *Plutella xylostella* (L.), aphids, *Brevicoryne brassicae* L., *Lipaphis erysimi* (Kaltenbach) and *Myzus persicae* (Sulzer), the webworm, *Crociodolomia binotalis* Zeller, the sawfly, *Athalia* sp. and cutworms, *Agrotis* spp, are the major insect pests. Although DBM was identified as the key pest of brassica crops in Eastern and Southern Africa in a workshop conducted in 1995 (Nyambo and Pekke 1995), the pest status of the cabbage aphid, *B. brassicae*, is becoming increasingly a major threat to brassica crops in East Africa. Its attack is associated with the transmission of the tulip mosaic virus (TuMV) disease, which can be devastating to the crop. Black rot, *Xanthomonas campestris* pv *campestris* (Pammell) Dawson, downy mildew, *Peronospora parasitica* (Pers.) Fr., and the tulip mosaic virus, TuMV, are the key diseases limiting production. Thus, any pest control strategy recommended to growers must consider its implications to the total pest complex within the prevailing production system. In East Africa, mixed cropping is common and pesticides recommended for one crop are used on a number of crops in the production system (Macharia *et al.*, 2005; Nyambo, pers. obs.).

Until recently, application of synthetic pesticides was the preferred method of controlling pests of crucifers in East Africa, and testing of pesticides remained the major research activity (Löhr *et al.* 1998). In Kenya, the tests conducted in 1995/96 showed that organophosphates, carbamates and pyrethroids were no longer giving effective control of DBM compared to new products such as growth regulators, phenyl pyrazole and Bt-aizawai-based products (Kibata 1996). More recent studies confirmed that Karate, the most commonly used insecticide, is not only ineffective against the DBM; its use had negative economic returns in four separate trials (Macharia *et al.* 2005). There has also been an increase in complaints from farmers and extension workers about the loss of effectiveness by the majority of commonly used insecticides against crucifer pests, particularly the DBM, in Kenya and Tanzania in recent years (Macharia *et al.* 2005).

Due to the existing pest complex in crucifer crops and the status of DBM as indicated above, effective pest control approaches that emphasize integrated pest management at farmer level, are imperative in the East African production systems. Thus, recent studies have emphasized biocontrol-based IPM for crucifer crops in the region. The main objective has been to identify and develop IPM compatible components that can be used by the majority of the small-scale farmers in the region and a delivery vehicle that can ensure sustainable uptake. This involved a two-pronged approach (1) development of biocontrol-based IPM approaches and (2) participatory dissemination of new knowledge generated.

DEVELOPMENT OF BIOCONTROL-BASED IPM APPROACHES IN EAST AFRICA BIOCONTROL OF DIAMONDBACK MOTH

Since it was becoming increasingly difficult to control DBM with the commonly used synthetic pesticides, it became necessary to investigate use of natural enemies, a practice successfully used in Asia. The identification of suitable DBM natural enemies for integration in pest management strategies for East Africa has been a process that started with (1) inventory of indigenous natural enemies (2) assessment of the effectiveness of local natural enemies, (3) proper taxonomic studies through molecular techniques of local natural enemies, and (4) search for more effective natural enemies for introduction into the region.

EFFECT OF INDIGENOUS NATURAL ENEMIES ON DBM

In surveys conducted in Kenya, Tanzania, and Uganda in 2000/2001, parasitism rates were shown to be below 15% (Löhr and Kfir 2002). In this study, the most frequent parasitoids were *Diadegma mollipla* (Holmgren) (Hymenoptera: Ichneumonidae) and *Oomyzus sokolowskii* (Kurdjumov) (Hymenoptera: Eulophidae). Entomopathogens, notably *Zoophthora* sp., *granulosis* virus (PlxyGV) and an unidentified bacterial diseases were also recorded in Kenya and Tanzania but their impact on DBM was well below 2% (Cherry et al. 2004; Nyambo pers. obs.; Oduor et al. 1997).

PROBLEMS OF PROMOTING BIOLOGICAL CONTROL OF DBM IN EAST AFRICA

Taxonomic confusion. Before publication of the review of *Diadegma* parasitoids of diamondback moth (Azidah et al. 2000), all *Diadegma* spp collected from DBM in African countries were considered as *D. semiclausum* and/or simply *Diadegma* spp. Biocontrol practitioners challenged this as *D. semiclausum* has been successfully used for the control of DBM in Asia (Amend and Basedow 1997; Singh et al. 1993; Talekar et al. 1989) and there was no obvious reason why it should not perform in the East African highlands where conditions are very similar. Azidah et al. (2000) grouped all African *Diadegma* parasitoids of DBM under *D. mollipla*. This was confirmed by Wagner et al. (2002), using molecular taxonomy techniques in the ICIPE led DBM project. Henceforth, the indigenous *Diadegma* spp attacking DBM in East and Southern Africa is now commonly known as *D. mollipla* (Wagner et al. 2002), a parasitoid that is more effective on the potato tuber moth, *Phthorimaea operculella* (Zeller). This scientific revelation on the true taxonomic status of the African *Diadegma* species provided the justification to import and introduce *D. semiclausum* from Asia to the East Africa highlands. The parasitoid was introduced to Kenya, Tanzania and Uganda following the existing national biocontrol regulations all of which are based on the FAO code of conduct.

Insufficient adaptation of potential agent(s) to bio-ecological conditions. Ecological adaptation and efficiency of biotypes is yet another constraint that had to be addressed to ensure optimization of identified agents. Some populations of *Cotesia plutellae* are recognized as efficient control agents for DBM, while others are very poor (Amend and Basedow 1997; Talekar, pers. comm.). The *C. plutellae* biotype of South Africa is a highly efficient parasitoid as compared to the very rare ecological homologue *Apanteles* sp. (misnamed *C. plutellae*) in East Africa (Löhr and Kfir 2002). Therefore, the South Africa strain was chosen for mass rearing and introduction in semi-arid areas of East Africa.

Lack of consideration of the total pest complex of the target crop and farming systems.

There have been few successful attempts to control arthropod pests of annual crops using biocontrol agents. This is partly due to the fact that perennial crops offer a more stable environment where both the pest and its natural enemy can co-exist for a long time. In annual crops, success has been achieved in systems where continuous cropping and harvesting is practiced, e.g. the cassava mealybug (Neuenschwander 2003; Nyambo pers. obs.) and/or where alternative host plants provides refugia for the pest and its natural enemy. This could be the real reason for the success of the cereal stem borer biocontrol programme in Eastern and Southern Africa and the successful suppression of bean fly maggot in some parts of Ethiopia by *Opius phaseoli* Fischer and *Sphegigaster brunneicornis* Ferrière (Abate 1995; Nyambo pers. obs.).

The single pest approach, which ignores other important and/or potential pests, and is adopted in many situations, has contributed to the failure of many other biocontrol attempts (Abate 1995). This is because farmers will continue to apply pesticides to control the other major crop pests for which no alternative control measures are known. This not only threatens the survival and effectiveness of biocontrol agents, but also brings into question the rationality of attempting biocontrol on a single pest within a crop pest complex (Nyambo 1995). The attempted biological control of the potato tuber moth, *Phthorimaea operculella* Zell in Zambia 1979-82 using two introduced parasitoids, *Copidosoma koehleri* Blanchard and *Bracon greeni* Ashmead failed in some areas because farmers continued to apply broad spectrum insecticides to control aphids and the spread of viral disease in the crop. However, where farmers stopped spraying, the parasitoids were well established and brought the pest under control (Mingochi *et al.* 1995). The same fate applied to the attempt to control *Helicoverpa armigera* Hübner in tomato, eggplants, okra and tobacco in 1980 using *Trichogrammatoidea armigera* Nagaraja and *Apanteles ruficrus* Haliday (Mingochi *et al.* 1995). This must have happened because farmers were neither informed nor knowledgeable about their role in enhancing effective biocontrol of arthropod pests. A single method approach to pest control will also not be efficient and sufficient for the brassica production systems of East Africa due to the existing pest complex. Based on this background, it became necessary to investigate the possibility of combining biocontrol with other compatible options that will facilitate optimization of introduced biocontrol agents.

Lack of biocontrol compatible alternatives. The situation reported in Zambia (Mingochi *et al.* 1995) is not unique and could be repeated in many other production systems if not well addressed. To optimize the benefits of the biocontrol-based IPM programme in East Africa, it was deliberately planned in the ICIPE led DBM project to investigate and integrate all possible strategies that would reduce over-dependency on synthetic pesticides.

BOTANICAL PESTICIDES

In recent years, many farmers in East Africa started to use plant extracts, often home extractions from a wide range of plants, for pest control in a wide range of crops. This has partly been because synthetic pesticides are costly, and, as indicated above, they are ineffective in controlling key pests. However, not all plant extracts are compatible with biocontrol agents. Some could also have negative effects on non-target organisms, human and the environment,

and this has to be avoided. Fortunately, the use of neem-based pesticides has been greatly researched worldwide including at ICIPE (Schmutterer and Ascher 1984; 1987), and commercial formulations are available in local shops.

The use of botanicals to control major insect pests of crucifers and their compatibility with arthropod natural enemies was studied in Kenya (Akol *et al.* 2002; 2003; Okoth 1998) and South Africa (Charleston *et al.* 2003). In the work done in East Africa, extracts from the neem tree, *Azadirachta indica* A. Juss, were found effective against the DBM and had low negative effects on *D. mollipa*, the indigenous DBM parasitoid, and therefore, could be used as alternatives to synthetic pesticides where they are available. Neem-based pesticides were also tested elsewhere and found to be compatible with arthropod natural enemies of DBM (Haseeb *et al.* 2004; Leeson 2001). As a result, neem-based products are being promoted as alternatives to the commonly used synthetic pesticides among crucifer growers in the region.

BIOPESTICIDES

Microbial control agents with potential against DBM have been recorded in East Africa as indicated above. However, their contribution in regulating DBM populations is low. Some of these, e.g. the granulosis virus, PxlyGV, is a potential agent that could be produced, formulated and applied (Cherry *et al.* 2004; Grzywacz *et al.* 2002). Dudutech, a private company based in Kenya, has taken up this challenge and the work is on going. Moreover, some strains of *Bacillus thuringiensis* (Bt) have been shown to give effective control of DBM and other lepidopteran pests, and, with low negative effects on potential arthropod natural enemies of DBM (Amend and Basedow 1997; Haseeb *et al.* 2004; Kibata 1996; Kok and Acosta-Martinez 2001; Krishnamoorthy 2002; Ng *et al.* 2002). Based on these findings, Bt.-based products, such as dipel, thuricide, xenthari, all available from local pesticide dealers, are suggested as an option where spraying lepidopteran pests becomes necessary.

AGRONOMIC PRACTICES

This is the basis for sound IPM development and promotion (Varela *et al.* 2003). It encompasses selection of varieties with some tolerance to key pest problems when and where available, e.g. the Danish types of cabbages are known to be tolerant to mosaic virus. Use of certified disease free seeds are highly recommended as a strategy for controlling black rot. Mulching the crop with dry grass in the nursery and field has been shown to (1) minimize attack by aphids and therefore the build up of tulip mosaic viruses (Achieng *et al.* 2003) (2) provide attractive environment for ground dwelling natural enemies and (3) conserve ground moisture for better plant growth, and (4) reduces splash and hence early black rot infestation. Other measures include plant nutrition, water management, e.g. when and how to use overhead or furrow irrigation, field sanitation and time of planting, proper selection and application of pesticides based on frequent (at least once a week) crop scouting and making use of the observations for decision making.

Many growers still have to spray against the cabbage aphid, and so guidance on which insecticide to choose and how to spray for effective control of aphids have to be made clear to the end users. The current best practice is spot application on infested plants only. This has given satisfactory results in smallholder cabbage production.

PARTICIPATORY DISSEMINATION OF RESEARCH OUTPUTS

Good research results are useful if they are properly disseminated to end-users. Many biological control attempts in sub-Saharan Africa ignored the role and contribution of national extension services and farmers, which contributed to failures and lack of sustainability (Mingochi *et al.* 1995; Nyambo 1995). The ICIPE-led DBM project attempted to address this issue by involving and engaging the national research and extension programme of the collaborating countries in project formulation (Nyambo and Pekke 1995; Seif and Löhr 1998), research and dissemination of results. Workers of the national research and extension departments in each respective country conducted the surveys on indigenous natural enemies. National programmes largely handled parasitoid release and monitoring activities (Fig. 1).

DISSEMINATION OF THE RESEARCH OUTPUTS TO FARMERS

To ensure sustainable uptake and dissemination to farmers, it was deemed necessary to capacitate the national extension workers in each respective country (Fig.1). This was done through an intensive one-week hands-on training course in biocontrol-based IPM for master trainers in each collaborating country. The course targeted the district subject matter specialists (horticulture and crop protection). These course participants would be responsible for down streaming the information through their national extension systems until it reaches the farmers. The national biocontrol units were given a two-week training course on how to rear the natural enemies and carryout field releases. The two national units were to collaborate in terms of planning effective field releases in major crucifer growing areas.

CASE STUDY: ILKIDING'A, ARUMERU DISTRICT, TANZANIA

The multi-practice approach was field tested at Ilkiding'a, Arumeru District Tanzania in October 2002, a coffee-vegetable based production system. Two of the master trainers from the Tanzanian Ministry of Agriculture and Food Security (MAFS) identified the release site in an area where cabbage growing is taking off as a cash crop among small-scale farmers. Baseline data were collected for a year before the planned field releases. The level of parasitism in northern Tanzania was about 10% before releases. Farmers were already spraying twice a week from transplanting to harvest using either selegon, endosulfan, decis or karate (alone or in mixtures), all recommended for use on coffee, and yet the cabbage produce was of extremely poor quality. The DBM pressure on the cabbage crop in the area was causing a crisis situation. This being a highland area, *D. semiclausum* was the preferred agent. A release permit was obtained from the Plant Health Service, MAFS. On the day of the release, a hands-on farmer training was conducted. It involved a demonstration of the parasitoid and a question and answer session to educate the farmers about *D. semiclausum* (what it is, how it works) and the role of farmers in its preservation. About 20 farmers and the village extension worker from the locality participated in the training. Farmers were shown how to release the agents and participated actively in the release exercise. Approximately 700 female and a similar number of male parasitoids were released. Thereafter, the farmers were left alone. It was anticipated that the agent would get established and propagate itself in the area while the know-how would be spread by word of mouth between farmers. The event was captured on the local TV and radio stations and broadcast during the week of field release.

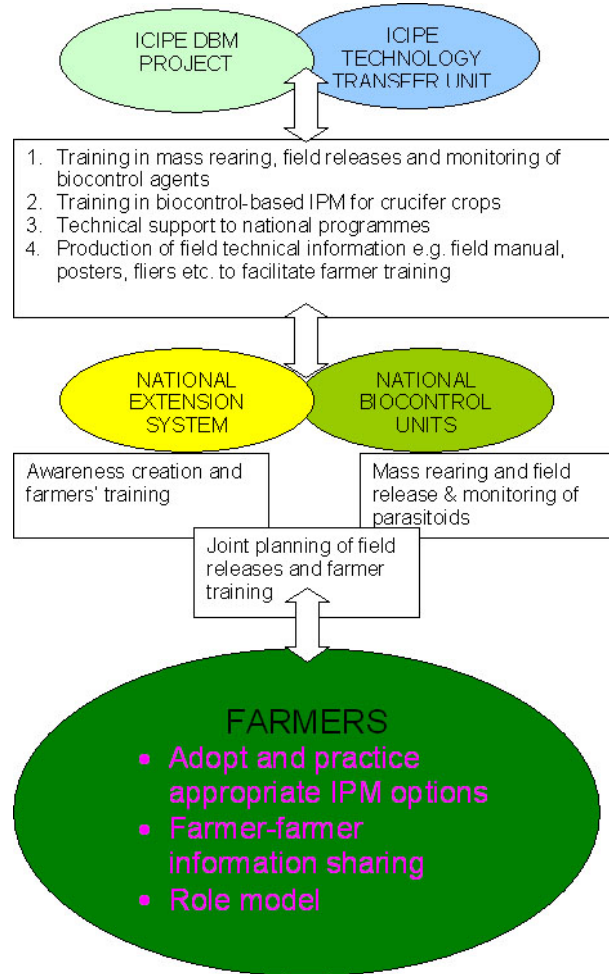


Figure 1. Capacity building for dissemination of biocontrol-based IPM program.

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RESULTS

Ten months after first releases, the level of DBM parasitism had increased to 36.2%, this increasing to 66% after two years at the release site (Fig. 2). At the release site, farmers reduced spraying frequency and changed increasingly to Bt-based products and many stopped spraying for DBM control completely. Aphid control measures changed from area to spot application. In consequence, DBM population and damage was significantly reduced from 32 DBM/plant pre-release period to 4.0 DBM/plant in two years. This is a very significant improvement considering the fact that spraying has been reduced to a maximum of two per season and the crop quality improved. Evidence from neighbouring areas, where the parasitoid had spread to but farmers were not trained, indicated that farmers were unaware about the presence of the parasitoid. They continued routine spraying with broad-spectrum insecticides. Consequently, the level of parasitism was much lower, with an average of 51% and 1.8 damage score per plant (Fig. 2).

Following these results, a refresher course for the Tanzania master trainers was organized in collaboration with Ilkiding'a farmers. The Ilkiding'a cabbage growing area became a classroom for the extension workers and the course facilitators in February 2005.

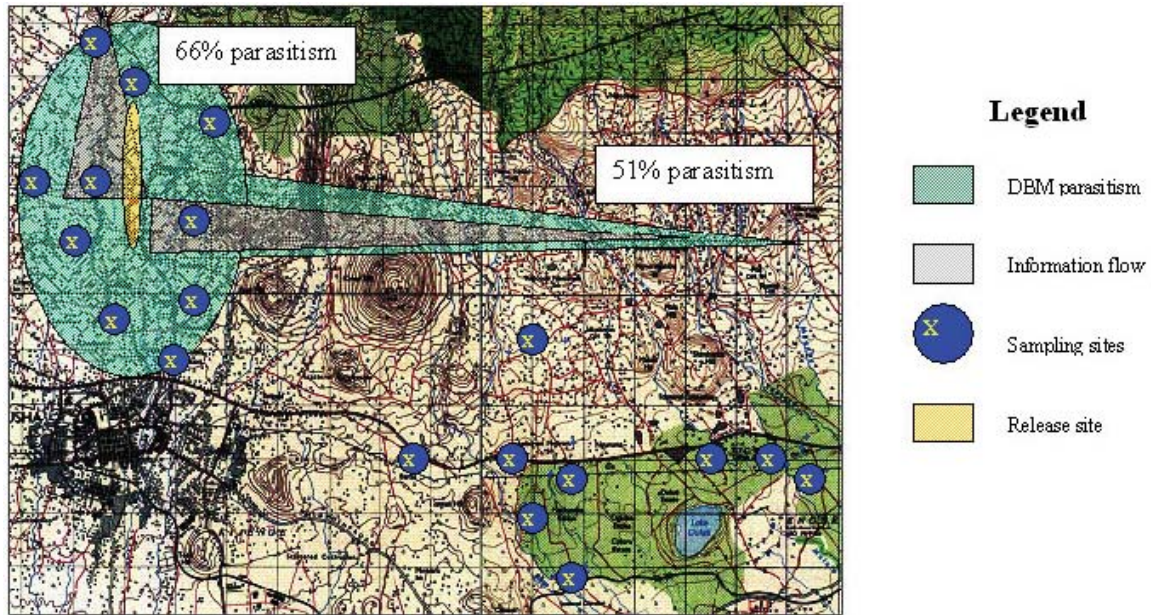


Figure 2. Ilkiding'a release site: Level of parasitism, parasitoid spread and information flow from release site after two years: October 2002 to October 2004.

LESSONS FROM THE ILKINDING'A RELEASE SITE

1. Participatory research and extension, that emphasizes production systems and pest complex, should be the way forward to enhance and facilitate sustainable uptake and effectiveness of identified arthropod biocontrol agents
2. Capacitating farmers to take active participation in biological control initiatives is of utmost importance to ensure successful establishment of the agent, its propagation and effective control of target pest.
3. Field releases of biocontrol agents and farmer training has to be planned in such a way that they occur simultaneously.
 - a. I see I remember
 - b. I touch I remember
 - c. I hear, I see, I touch, I remember more

It is important to emphasize to farmers the fact that, unlike pesticide sprays, which give results within a short time, biocontrol takes time and the results may not be immediate. The Ilkiding'a group realized the effects of the agent in the September-October 2003 cabbage crop, a year after the first release. To them, this was the real convincing point, which marked the start of the success of the initiative. They learned by doing it themselves.

4. Farmer training should be supported with other forms of ICT to reinforce the message and also to raise awareness among other growers in similar growing zones. It should not be a one-off activity.
 - a. Although *D. semiclausum* spread to over 10 km from the release point in two years, the knowledge about it and how to enhance its effectiveness remained concentrated

at the release point (Fig. 2). As a result, crucifer growers in other villages continued to use the broad-spectrum pesticides and damage on the crop persisted despite the presence of the parasitoid.

- b. The radio and TV programmes were a motivation to the farmers at the release point to practice what they learned. It also served to raise some awareness at the district level, and as a result, other growers made some enquiries wanting to learn from the farmers at Ilkiding'a.
- c. The TOT course participants need to visit successful release sites to learn from growers for them to conceptualize and internalize the value of biocontrol-based IPM practice.

CONCLUSIONS AND THE WAY FORWARD

Thoroughly researched and carefully implemented classical biological control is an important tool for integrated pest management. Equally important are the consideration of the whole pest complex of the crop and the participation of farmers and extensionists in research and implementation. This ensures full understanding of the introduced changes and allows the natural control factors to play their role. The ICIPE-led DBM biocontrol-based IPM for brassica crops could become a role model for other biocontrol attempts in Africa.

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CASE STUDY ON ORGANIC VERSUS CONVENTIONAL COTTON IN KARIMNAGAR, ANDHIRA PRADESH, INDIA

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ABSTRACT

Cotton (*Gossypium hirsutum* Linn.) yields, profits and pest incidence at fields of farmers partaking in an export oriented organic cotton production program are compared with yields of conventional cotton production in the same village during a bad cotton season (2004). Late season drought reduced actual yield by 42% compared to the estimated yield in October 2004 and usual average yields. Organic cotton yielded on par at 232 Kg seed cotton /acre against conventional cotton at 105 Kg/acre. Organic cotton was more profitable at plus Rs 559/acre (approx. US \$ 13) (1 US\$ = Rs. 44) versus minus Rs 1307/acre (minus US\$ 30) in conventional cotton and had significantly less problems with *Helicoverpa armigera* (Hubner) Lepidoptera, Noctuidae and *Pectinophora gossypiella* (Lepidoptera: Gelechiidae). Pest control in organic cotton was about Rs. 220 (US \$ 5) per acre (5% of total production costs of organic cultivation) as against Rs. 1624 (US \$ 37) per acre (30% of total production costs of conventional cultivation) in conventional cotton. Pest management in organic cotton was based on prevention: balanced nutrient management, intercrops and early spray of HaNPV.

Thirty-four farmers, part of a large organized group (over 200 farmers), volunteered to test organic cotton on part of their farm, allotting 79 acres for organic farming though owning about 296 acres. For certification purposes a contiguous area of about 40 acre should go organic. The 34 farmers were organized in two groups for training, credit and savings, maintenance of certification administration and marketing purposes. Farmer Field School sessions (FFS) were conducted on weekly basis during the season but also after the season to deal with

post harvest handling and marketing. As a result of this year's experience all participating farmers will bring their total cotton under organic management, another 70 farmers will join and 10 neighboring villages are interested, but have been asked to wait because of lack of training manpower. Farmers of the old and new groups will be trained to become farmer trainers.

Packages used for training are based on the FAO IPM- FFS and long term experience of ETC India and its staff in cotton cultivation in Southern India. Linkages are maintained with CIPMC, national cotton research programme and universities. The latter mainly for the selection of varieties. Inputs are purchased from the private sector. Yearly a meeting will be organized in which representatives of farmers from the whole organic cotton program (240 in 2004) will interact with researchers, input suppliers, banks, ginners and spinners. This is meant to create synergy in the whole chain.

INTRODUCTION

Profitability of cotton production systems under rainfed conditions in Andhra Pradesh in India has drastically come down due to loss of soil and soil fertility, imbalanced nutrient application, lack of soil organic matter, and finally, indiscriminate pesticide application. Cotton production in India involves about 9 million hectares (5.5% of arable land) and 4 million marginal, small and large farmers. The production level is about 13 million bales (lint, 170 Kg/bale) per year (GOI) or about 20% of global production. The major problems in cotton production in India are low productivity, mixing of varieties, low profitability, lack of adequate knowledge at farm level, indebtedness of farmers due to high interest rates at the hands of private moneylenders (up to 85% per annum) and finally contamination of cotton with non-cotton materials both at the field level and off the field. According to the Central Institute of Cotton Research (CICR, Nagpur, India), cotton productivity in Andhra Pradesh (AP) has been declining steadily from about 265 kg seed cotton per acre in 1995 to about 162 kg seed cotton per acre in the year 2003.

FAO and ETC implemented IPM, Non Pesticidal Management (NPM) and organic cotton programmes from 1997 onwards. Then it was observed that these methods of cotton production are usually more profitable for farmers growing rain-fed cotton with seed cotton yields up to about 1.2 tonnes/hectare. Organic cotton production entails the use of cultural preventative methods (like intercropping, border cropping, drainage, variety selection), use of natural fertilizers (Farm Yard Manure (FYM), compost, bio-fertilizers, poultry manure, etc..) and biological controls (NPV, Trichogramma, Trichoderma, etc...) rather than synthetic fertilizers and pesticides/fungicides.

When ETC was asked by Solidaridad (that promotes the Made-by fashion label in the Netherlands: guaranteeing fair trade and organic products), to implement an organic cotton programme it accepted the challenge and decided that detailed data collection should be done at organic and conventional farms. The main objective of data collection was (1) To be able to compare the yield, income and profitability of organic and conventionally grown cotton and judge whether organic cotton production is a viable proposition. (2) To find out about the effectiveness of organic nutrient and pest management methods, among others the use of

NPV for managing *Helicoverpa armigera*. (3) To compare the quality parameters of cotton lint with management regimes of individual organic farmers. (4) To identify issues for further detailed studies needed.

MATERIALS AND METHODS

The study comprises of 34 farms/farmers, from 2 villages (Arapally and Repaka) in the district of Karimnagar in the state of Andhra Pradesh in India, who form a part of the larger group of 239 farmers involved in cotton cultivation in an export oriented organic cotton production programme. The local NGO (KRUSHI) was working in these villages for quite some years prior to the introduction of the organic cotton programme. This made the selection of farmers within the village easier. Farmers volunteered after a series of introductory meetings in the concerned villages. In these meetings the concept of organic farming was explained, risks and advantages as well as conditions (contiguous area of 40 acres organic farming, certification, data collection and recording, group sales of cotton...). Farmers feared most loss of production due to complete elimination of chemical fertilizers. The elimination of pesticides was considered less of a problem by the farmers, partially due to the fact that they had been exposed to IPM technologies to a certain extent. Project staff provided an alternative cropping system and a comprehensive outline of crop management, which showed that the same levels of nutrient application could be achieved through organic means and that various tested organic options for disease and pest management existed. This convinced farmers that they would not end up in loss.

Land for cotton production was from a contiguous area of approximately 40 acres in each of the two villages. Cotton was grown on 79 acres of land out of a total of 273 acres of land allotted for organic cultivation. Within the contiguous area 49.5 acres land came out of a long-term fallow (> 3 years) and 28.5 out of a short-term fallow (<1 year). Soils were very light black cotton soils

Farmers were organised in groups of about 20 farmers along the lines of Self Help Groups (credit and saving groups). These groups received an interest free revolving fund equal to Rs 4,000 per member either in kind or cash. This had to be repaid by individual farmers to the group with an interest of 17% as decided by the group (compared with 86% when obtained from money lenders). They mobilized inputs as a group based on the nutrient management package worked out by ETC. The groups would also receive FFS training on a weekly basis. After harvesting, they would store harvested cotton in a common facility and market their cotton produce as a group.

Seeds were procured locally by farmers from their regular commercial seed sources. Cotton seeds were treated and pelleted with nitrogen fixing bacteria *Azospirillum*, *Azotobacter* and Phosphorus Solubilizing Bacteria and an antagonistic fungus - *Trichoderma viride* mixed in fresh cow dung slurry before sowing. A comprehensive intercropping package was proposed to control pests. One of them was intercropping with pulses. All farmers chose to grow soybean but only a few farmers agreed to let it grow till maturity (soybean was not

proposed as the preferred intercrop by the ETC team). The main reason that they decided not to let the soybean mature was that they had never intercropped cotton and feared a negative influence of the intercrop on the yield of cotton, also they felt that inter-cultivation, which they consider important for enhancing cotton yield, was impeded by the intercrop of soybean. Nutrient management practices were worked out for a yield level of 6 quintals of seed cotton per acre and adjusted later on during the season based on weather conditions. Farmers generally decided not to apply the recommended nutrient management package, due to lack of availability but also due to costs involved, particularly with regard to the topdressing with poultry manure. Table 1 gives the nutrient management practices that were suggested to farmers during the year, while Table 2 gives the actual quantity of different nutrient sources applied based on actual field conditions. Fig. 1 shows mixing of bio-fertilizers with seed.

Table 1. Manure requirement for a yield projection of 6 quintals of cotton per acre.

Organic Manure*	N**	P	K	Ca	Mg	S	Zn	Fe
Requirement	48	6	24	18	5	9	0.2	0.9
FYM 4 MT	4	4	14.4	22	16	2.8	0.02	0.06
Enriched FYM (300 kg)	0.36	2.23	1.3	1.6	1.17	0.74	0.001	0.003
Bio-fertilizers (Azotobacter, Azospirillum, each 1 Kg/acre)	10	0	0	0	0	0	0	0
Poultry Manure 2 MT	24	5	18	44	Traces	10	0.1	0
Wood Ash (100 kg/ac)	0.15	0.53	6.5	20	1.25	1	0.0233	0.85
Inter crops	10	0	0	0	0	0	0	0
Total Applications	48.51	11.76	40.2	87.6	18.42	14.54	0.14	0.91

*Data out of compiled database owned by ETC. From various sources: Internet, books, own chemical analysis.

**All nutrients in kilograms

Figure 1. Mixing bio-fertilizers with cotton seeds.



Table 2. Actual quantity of manures applied by all farmers for 79 acres.

Manures	Suggested (kg)	Actually Applied (kg)	% of Suggested
Farm Yard Manure, 4 MT per acre	316,000	14,525	5
Enriched Farm Yard Manure, 300 kg per acre	23,700	7,200	30
Azospirillum	79	86	108
Azotobacter	79	83	105
PSM	79	83	105
Trichoderma viride	39.5	42	106
Poultry Manure, 2 MT per acre	158,000	47,905	30
Wood Ash	7,900	7,650	97

From Table 2, it can be concluded that organic manure was applied at a far lower rate than advised. It was agreed by the farmers that they would take part in the weekly Farmer Field School (FFS) during the cropping season. FFS was conducted for 20 sessions from pre sowing till the commencement of harvesting. Crop management decisions (pest and nutrient) were based on weekly Cotton Eco System Analysis (CESA), which includes monitoring of plant growth parameters, pest predator ratio and local weather conditions. Fig. 2 shows the setting within which the FFS took place.

**Figure 2.** The setting of a Farmer Field School (FFS).

Table 3 provides the generalized pest management options provided to farmers prior to sowing. Individual pest management practices were modified based on Cotton Ecosystem Analysis (CESA) and farmers' capabilities. Fig. 3 provides a view of how the border crop was actually planted in organic cotton fields.

Table 3. Pest and disease management strategies in organically grown cotton fields.

S. No.	Activities
1.	Seed treatment with <i>Trichoderma viride</i> , for root rot and wilt
2.	Intercropping of short duration pulses - cotton : pulses 1:2
3.	Border crop of Maize or Sorghum 5 - 6 rows
4.	Trap crop of Bhendi 50 plants per acre against <i>Earias vitella</i>
5.	Trap crop of Marigold sown randomly against <i>Helicoverpa armigera</i>
6.	Trap crop of Castor sown randomly against <i>Spodoptera litura</i>
7.	Delta pheromone sticky trap against <i>Pectinophora gossypiella</i>
8.	Bird perches within the fields
9.	250 LE of HaNPV (UV stabilized) applied after noticing egg laying
10.	Yellow Sticky traps smeared with castor oil against white fly
11.	Blue sticky traps smeared with castor oil against thrips
12.	Hand picking wherever possible
13.	Detopping after 15 - 17 sympodial nodes

Figure 3. A border crop of maize in organic farmer's field.



The internal control system (ICS) required for organic certification demands that all operations by farmers are documented: the type and quantity of inputs used, the sources, the costs, the labour required, cotton harvested per picking, quality of the cotton, etc.. These data were documented by the farmers under close supervision of ETC and NGO staff, cross checked by an independent internal inspector and shared with the certifier (SKAL). In addition data collected during CESA were documented. These two sources, ICS and CESA, were used for making the analysis we present in this paper.

Farmers were encouraged to compare cotton grown organically in their fields with cotton grown conventionally within their village at every stage during the entire crop growth period. Their impressions were recorded. However, no systematic CESA was implemented in conventional fields.

The 2004 monsoon in Karimnagar was abnormal (total of about 60% of long term average rainfall): heavy rains end of May and early June, a drought from 10 June till early July and cessation of the rains end of October. Sowings commenced from the first week of June 2004 with the earliest sowing done on 6th June 2004. Sowings continued till the end of July 2004 as and when local rainfall and soil moisture permitted. Bulk of planting was done during the month of July, almost a month later than the normal date of sowing. Temperatures were normal during the growing season especially the early and the mid season. Delayed planting combined with late season drought made 2004 a trying year for cotton cultivation in Karimnagar district.

Some farmers (3 out of 34 cotton growers) had a ratoon crop of cotton. The data of these farmers have been excluded from the analysis, as their yields were substantially lower. One organic farmer used critical sprinkler irrigation and obtained significantly higher yields than average. This farmer too was excluded from the analysis. Then there is one farmer who grew a relatively unknown variety and who had very low yields. We attributed that to the variety and excluded the farm from the analysis. So in all a data set of 29 organic farmers is compared with a data set of 11 conventional farmers. The conventional cotton plots were selected near the organic cotton plots based on similarities in soil conditions and varieties grown.

RESULTS AND DISCUSSION

VARIETIES AND YIELD

Farmers used many different, mostly hybrid, varieties. We checked whether any indication existed that varieties were yielding differently. There are insufficient data to test the hypothesis that there is no difference. The fact that yields of different varieties planted at the same day are similar suggests that yields did not differ because of variety issues. Between organic and conventional farmers, similar varieties were used. Thulsi, Bunny and Dyna are most frequently used varieties by both groups of farmers. Thulsi is planted by 30% organic farmers and 40% of the conventional farmers. The other 2 varieties make up another 20 to 30%. The rest of farmers grow a bouquet of varieties, of which Sundeeep (grown only by organic farmers) appears to be promising due to high yields that are observed at organic farms.

DATE OF SOWING AND YIELD

Organic cotton plots were on average sown three weeks later (12-07-2004) than the plots of conventional cotton (25-06-2004). One would expect yield to be affected by date of sowing, especially under rainfed conditions, resulting in lower yields due to late planting. We tested this for organic plots and found an insignificant correlation. We also tested the effect on date of sowing on yields of conventional cotton and found again a weak correlation. Thus we concluded that we could use the whole population of organic and conventional cotton fields for analysis.

ORGANIC COTTON YIELDS ON FIELDS AFTER LONG TERM FALLOW (> 3 YEARS) COMPARED WITH SHORT TERM FALLOW (< 1 YEAR)

Analyzing the data we noticed that a number of farmers, especially in Arapally, seemed to have lower than average yield. When checking the background data, we observed that these farmers had decided to try out organic cotton on fields they had not used for quite some time: from 3 to 15 years. When we tested whether the difference in yield was significant, we found that to be not the case. We also tested the hypothesis that yields of ST fallows were significantly different from the yields of conventional fields and found that yields are not significantly different.

However, we concluded that income of organic cotton on short term and long term fallow fields are significantly higher ($p=0.05$) than the income of conventionally grown cotton (Table 4). The reduction in cost of cultivation of organic farms is the main factor contributing to the higher net-income.

Table 4. Comparative table of yield, income and profitability of short and long term fallow (within organic farms) with conventional farms.

Particulars	Organic fields			Remarks
	L.T. fallow (n=12)	S.T. fallow (n=17)	Conventional (n=11)	
Seed cotton Yield, Kg/acre	224**	240 **	205	Thus income from cotton alone not significant different
Total income per acre, Rs/acre	4617**	5233**	4105	Income of cotton and intercrop
Total costs, Rs/acre	4212 * ($p < 0.005$)	4517 * ($p < 0.04$)	5412	
Net income, Rs/acre	402* ($p < 0.035$)	716* ($p < 0.008$)	-1307	

* Significant; ** Not Significant

This leads to the next question as to which aspect of cotton cultivation takes up the major chunk of cost. Table 5 provides the break up of costs of cultivation.

Table 5. Cost of cultivation per acre (Rs/ac) for organic and conventional cotton cultivation.

Parameters	Organic LT (n=12)	Organic ST (n=17)	Conventional (n=11)
Yields	225	240	205
Seeds	626**	581* (p < 0.014)	720
Fertilizer/manure	1204* (p < 0,04)	1285**	1566
Ploughing	972* (p < 0.0001)	917* (p < 0.0002)	482
Weeding	526**	704* (p < 0.04)	360
Inter-cultivation	293	391	290
Pest Management	203* (p < 2.16E-07)	237* (p < 3.54E-09)	1624
Harvesting cost	390	403	371
Total costs	4214* (p < 0.005)	4518* (p < 0.04)	5413

* Significant; **Not Significant

There is no significant difference between the costs of fertilizers between organic and conventional farms, though conventional farmers spent more than those organic farmers who used land that came out of a long term rotation. On the other hand, cost of ploughing (primary and secondary) is significantly higher in organic farms. The cost of weeding shows a mixed picture. One would have expected the fields that come out of a long term fallow to have the higher costs, but they are significantly higher in plots that have not been under long fallow. There is no significant difference between the cost of intercultivation between organic and conventional farms. The cost of pest management is significantly higher in conventional farms. While in organic farms, the cost of pest management was an average of Rs. 220 per acre, the cost of pest management in conventional farms has been as high as Rs. 1624/ acre.

EFFECT OF RATE OF NITROGEN APPLICATION ON YIELD

We assumed that yields would increase with higher levels of nitrogen application. This hypothesis was tested within organic cotton data set but also between organic and conventional farming. Within the organic cotton data set, only a very weak positive correlation could be established. In conventional farms the nitrogen application level is 2.5 times higher than in organic farms (52 against 20 Kg N/acre, Table 6). Even then, we do not find any significant

difference in seed cotton yield between organic and conventional farms. The fact that rains stopped so early, could have caused that the higher nitrogen availability could not be expressed in the final yield. Water was apparently a more serious constraint than nitrogen.

NUTRIENT MANAGEMENT AND YIELD

For high productivity of cotton good nutrient management is necessary. We were worried that organic cotton would under perform due the very low doses of Farm Yard Manure applied. Thus nutrient management regimes were compared between organic and conventional farms. Nutrient management was calculated purely based on applied nutrients. Soil testing was not done for the first year. Table 6 gives the nutrient management regimes for organic as well as conventional farms. Nutrients have been calculated based on the source of nutrients actually applied as indicated in Table 2 on a per acre basis.

Table 6. Applied nutrients (kg per acre) at organic and conventional farms.

Nutrients	Organic kg/acre	Conventional kg/acre	Remarks
Nitrogen	19.82	52.11*	P < 0.0001
Phosphorus	9.11	40.76*	P < 0.001
Potassium	18.12	23.47**	
Calcium	52.48	0	
Magnesium	5.24	0	
Sulphur	6.65	0	
Zinc	0.25	0	

* Significant; **Not Significant

Nitrogen and Phosphorus application was significantly higher in conventional farms than in organic farms ($p < 0.001$ and $p < 0.001$ respectively). There was no significant difference in potassium application between organic and conventional farms.

A simple calculation of nutrient balance (theoretical removal by full crop compared with total nutrients applied, not measuring anything and not taking into account mineralization, fixation, leaching or vaporization) was done comparing conventional and organic farms. Table 7 provides the average estimated nutrient balance of all the farms in conventional and organic.

Conventional farms appear to have a positive nutrient balance of Nitrogen, Phosphorus and Potassium, while there is a negative balance of secondary and micronutrients. (Ca, Mg, S and Zn). Organic farms have a negative balance on Nitrogen only. Interpretation of these figures is hazardous, but it can be safely assumed that in organic farming more attention needs to be given to nitrogen application and in conventional farming to secondary and micro-nutrients. We can also conclude that the application levels by the organic farmers have been sufficient for the yields realized mainly because water availability was a problem.

Table 7. Comparison of nutrient balance between organic and conventional fields (kg/ac).

Nutrients	Conventional Balance left in soil (kg/acre)	Organic Balance left in soil (kg/acre)
Nitrogen	35	-2.5
Phosphorus	39	4.62
Potassium	14	7.84
Calcium	-7	39
Magnesium	-2	1.56
Sulphur	-3	3.11
Zinc	-0.07	0.11

* Significant; **Not Significant

INTERCROP EFFECT

Soybean was sown (at various dates after sowing cotton) as an intercrop by most of the farmers in both villages involved in the programme. Some farmers have gone in for 2 rows of soybean and some farmers for a single row of soybean. Fig. 4 shows how intercropping was done.



Figure 4. Intercropping with soybean.

A superficial analysis suggests no influence of growing a soybean crop. However, on closer analysis, it appears that those organic farmers in Repaka who harvested soybean have a significant lower yield than the farmers who plowed their soybean into the soil after some time of growth. (119 kg seed cotton/acre as against 356 kg seed cotton per acre, $p=0.017$). Other factors are similar (plant density, N applied, varieties, date of sowing). In Arapally such effect could however not be established because only two farmers harvested the soybean and date of planting of the cotton varied much with the other farmers (one early July, the other end of July).

PEST MANAGEMENT

The major pest problems faced during the season were the boll worms, *Pectinophora gossypiella* and *Helicoverpa armigera*. For pink boll worms, delta sticky pheromone traps were used. In the villages of organic cotton, some farmers had gone in for ratoon cotton. It was expected that pink boll worm infestation would be higher in ratoon crop than other fields. Accordingly enumeration was done randomly to find out the severity of pink boll worm vis a vis the distance from the ratoon crop (Table 8). These observations weren't done systematically and therefore the data presented should be looked at as indicative only.

Pink Boll Worm infestation was about 30% in ratoon cotton, in the organic cotton field used for FFS no Pink Boll Worm infestation was noticed.

Table 8. Enumeration of Pink Boll Worm (PBW).

Date of installation	Date of observation	Period (days)	Counting of PBW adult moths (Nos.)		
			Ratoon crop	Near and adjacent fields	Far away from ratoon crop
12 - 18 Sept., 2004	First week of October	15 days	138	84	68

USE OF HANPV AND NEEM SEED KERNEL EXTRACT (NSKE) FOR MANAGEMENT OF *HELICOVERPA ARMIGERA*

During the season, infestation of *H. armigera* commenced by the first week of September. Based on the Farmers Field School's (FFS) CESA, farmers decided to go in for spraying of HaNPV. Table 9 provides the details of Ha NPV application as soon as the eggs and first instar larvae were noticed in cotton. Fig. 5 shows the preparations towards HaNPV application.

During the season, farmers were encouraged to visit conventional farms also in order to assess the comparative advantage of organic methods especially the use of Ha NPV over synthetic chemicals for managing pests in particular *H. armigera*. Conventional farmers were using costly chemicals, including synthetic pyrethroids, for the control of *H. armigera*. Common beneficial (predatory) insects observed in organic cotton plots by farmers during FFS are presented in Table 10. Fig. 6 shows that also birds liked to have their nests in the organic cotton fields.

Organic farmers who visited conventional fields observed very low levels of natural predators in those fields.

Table 9. Management of *Helicoverpa armigera* using HaNPV and NSKE.

Distribution of Ha. N.P.V to the farmers	10.09.2004
Farmers started HaNPV spray	11.09.2004 (approximately 63 days after sowing)
Farmers completed the spray	30.09.2004
Dose	50 m.l/ acre (5 tanks x 10 lit.) (10 ml HaNPV/ tank)
Time of application	Early morning: 5.00 a.m and Late evening: After 5.00 p.m
Weather condition	On the whole weather conditions were highly favorable after Ha NPV application for epizootic conditions
5% NSKE application	5% NSKE was applied after 6-15 days gap after Ha. N.P.V spray
Ha. N.P.V. Incidences	Observed Ha. N.P.V affected larvae on 21.09.2004 onwards. (i.e., 5th day after spraying)
Mortality rate	High percentage of mortality observed

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Figure 5. Preparations towards HaNPV applications.

Table 10. Common beneficial (predatory) insects observed by farmers in organic plots.

Date(s)	Predator Insects on Organic Plots
10.08.2004 to 21.08.2004 (45 - 50 DAS)	<i>Geocoris</i> spp (Lygaeidae. Hemiptera) <i>Coccinella novemnotata</i> (Coccinellidae. Coleoptera): Lady beetle adults, pupae, grubs and eggs <i>Syrphus</i> spp (Syrphidae. Diptera)
14.09.2004 to 28.09.2004 (75 - 80 DAS)	<i>Cicindela</i> spp (Cicindellidae. Coleoptera): Tiger beetle adults <i>Zelus bilobus</i> (Say) Reduviidae. Hemiptera: Reduviid bug, <i>Orius</i> spp. (Anthocoridae. Hemiptera) <i>Chrysoperla</i> sp. (Chrysopidae, Neuroptera): Chrsoperla adults, <i>Pantala flavescens</i> (Fabricius) (Libellulidae, Odonata): Dragonfly, <i>Lestes</i> sp. (Lestidae, Odonata): Damselfly
07.10.2004 to 14.10.2004 (> 85 - 90 DAS)	<i>Podosus maculiventris</i> (Pentatomidae. Hemiptera): Spined soldier bug

**Figure 6.** A birds' nest in an organic cotton plot.

QUALITY OF LINT

Of organic cotton was tested by CIRCOT (Central Institute for Research on Cotton Technology) in Nagpur. The average lint length of the samples was 29.1 mm, micronaire 3.1 and tenacity 22 (3.2 mm (g/tex)). No clear correlation can be found between the varieties grown by the farmers and lint quality. It can be concluded that the cotton quality is satisfactory, though the micronaire clearly shows the effect of emergency ripening (we would have preferred between micronaire 3.5 and 4.5).

CONCLUSIONS AND RECOMMENDATIONS

These conclusions are based on one, bad cotton season. All conclusions are thus to be considered with caution. Different rainfall patterns and quantities can lead to very different results. It must be recommended to compare organic and conventional production for a number of years.

In the year 2004 organic cotton yielded generally at par with conventional cotton. In the case of organic cotton grown on fields that came out of a short term fallow, yields were higher than yields of conventional cotton. Profitability of organic cotton was significantly higher than conventional cotton. The main contributing factor to higher profitability was the reduced expenditure on pest management.

We did not ask farmers how much money they borrowed from money lenders. Assuming them borrowing about Rs 4,000 per acre, their additional costs would have been Rs 180-200 per acre (assuming 87% interest rate against 17% interest in the SHG and 9 months of borrowing). When a premium will be paid for organic cotton, farmers will earn an additional Rs 400 per acre over conventionally produced cotton. It can thus be concluded that organic cotton production appears to be financially feasible and attractive.

Quality parameters of organic cotton are good and appear to be similar between the different Hybrids used by the farmers. It would be required however to compare the quality parameters with conventionally grown cotton. This year that was not done because conventional farmers sold their cotton before samples could be taken. More detailed sampling on a larger scale would be required to arrive at final conclusions regarding the influence of varieties on lint quality parameters.

Organic farming requires high doses of organic manure. Farmers did not apply the required levels. Still they performed better than farmers who used only mineral fertilizers. The recommended nutrient management package was based on a yield projection of 6 quintals per acre whilst the average yield was only 2.5 quintals. It is quite possible that if the rains would not have stopped early, the lack of nitrogen (under present yield levels on average already short with 2.5Kg per acre) would have expressed itself in poor maturation of bolls and thus low yields. More work is needed to improve the availability of organic manures, particularly on manures with high nitrogen content like poultry, pig or sheep manure.

Intercropping with soybean and harvesting the produce seems to have a negative influence on yield of cotton. This effect could be caused by simultaneous high demand for nitrogen by both cotton and soybean (even when properly inoculated) or (in this case, 2004) it could be caused by competition for water. Farmers might conclude from the results that weeding and inter-cultivation are important to boost yields. Systematic testing of intercrop versus mono-crop, various intercrops and intercropping methods (1 row or more) and inter-cultivation should be undertaken to arrive at definite conclusions.

Pest load in 2004 was relatively low, due to the prevailing climatic conditions. Conventional farmers were facing more severe infestation of cotton bollworm than organic farmers according to their own, organic farmers' and our staff observations. Two factors might have saved the organic farmers. One, the predator population in organic fields was high. Second,

early (when few first instar larvae were spotted) and proper spraying of HaNPV (early morning or evening, conditions of high humidity) on a large scale (all organic farmers did it) created an epizootic condition in the fields which controlled the development of the pest. These factors that controlled development of cotton bollworm could only be established because of the FFS approach, which educated farmers properly.

Ratoon crops of cotton are a source of pink bollworm as became evident from our limited study. Further study into the effect of ratoon crops on establishment of a pink bollworm population should be undertaken.

CASE STUDY: KNOWLEDGE TRANSFER IN CABBAGE IPM THROUGH FARMER PARTICIPATORY TRAINING IN DPR KOREA

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ABSTRACT

Yield losses in DPR Korean cabbage production are serious due to the main brassica insect pests, diamondback moth (*Plutella xylostella* L.) and small white butterfly (*Pieris rapae* L.). Traditional chemical pesticides have a limited impact on these pests because the diamondback moth has developed pesticide resistance. A new Integrated Pest Management (IPM) approach was therefore implemented in 2003. A preliminary IPM trial on five Cooperative Farms (Co-Farms) proved to be very successful and the feedback from participating farm managers was so positive that project partners decided to expand the area of IPM implementation. However, preparing for a large-scale shift in agricultural practices requires effective capacity building at each level of organization in the DPR Korean agricultural structure as well as a sustainable system for knowledge transfer within and between these levels. In 2004, a knowledge transfer concept was developed for the organization of training activities based on the experience from previous years. The scheme is adapted to the DPR Korean agricultural system and meets the requirements of an increased IPM implementation area. The thorough training of the Cabbage IPM Focus Group, a core group of scientists at the Plant Protection Institute, was continued. The knowledge about developing, implementing and monitoring IPM systems is thereby anchored in a scientific DPR Korean Institution, encouraging further independent initiatives for sustainable agriculture. At the same time these scientists were trained to become Master Trainers for the IPM implementation through the national extension service. Training material for the dissemination of IPM ideas was jointly developed by the project partners. A set of farmer participatory exercises was adapted to the DPR Korean context and evaluated at several Co-Farms. From the experiences gained with the training at the Co-Farm level and with the input of the Focus Group members, "A Farmer's Manual for Cabbage IPM in DPR Korea" was developed. This comprehensive information compilation on cabbage IPM will support the knowledge transfer to the practitioner in the cabbage field.

With these measures the stage is set for a successful large-scale implementation of cabbage IPM leading towards strengthening food security in DPR Korea through sustainable production of healthy food.

INTRODUCTION

Cabbage crops are of high importance in the traditional diet and local economy of DPR Korea. The amount of cabbage distributed yearly within DPRK varies between counties and ranges from 60 to 400 kg per family. Cabbage is particularly important as a food source during winter, as it is made into kimchi, a long lasting pickle. The high nutritional value is not the result of a high caloric level but rather the content of vitamins and trace elements. Cabbage is a good source of vitamin C and B as well as iron. Processing cabbage into kimchi by lactic acid bacterial fermentation is very effective in preserving vitamin C and increasing levels of vitamin B. In DPRK, regular kimchi consumption is indispensable for a balanced diet, especially in winter. It is therefore not surprising that the demand for kimchi raw material, cruciferous vegetables, is consistently high. Particularly in urban centres of DPRK, this represents a real challenge for the vegetable farms. One of the consequences of this is that large areas in close proximity to cities are used for continuous brassica cultivation. As a result, problems arise such as decreasing soil fertility, the build-up of soil borne diseases, insect pest outbreaks, and a general negative impact on bio-diversity in the agro-ecosystem.

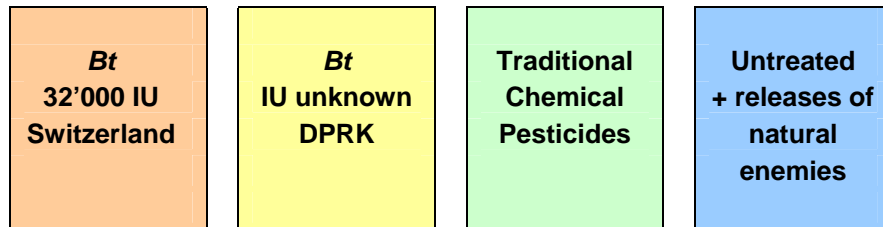
Surveys during the past years showed that in DPRK, extensive problems arise because of the damage from agricultural insect pests, particularly from the diamondback moth, *Plutella xylostella* Linnaeus (Lepidoptera: Yponomeutidae), and the small white butterfly, *Pieris rapae* L. (Lepidoptera: Pieridae). This is exacerbated by the occurrence of insecticide resistance in the former species. The acquisition of pesticide resistance by diamondback moth is a wellknown phenomenon and leads to pest control failures in cabbage crops throughout the world (Talekar and Shelton 1993; Waterhouse 1992). In some areas, economic production of cabbage has become impossible (Talekar 1992).

Integrated Pest Management (IPM) is one of the remaining strategies available to achieve sustainable and profitable cabbage production. Over several years, applied research, capacity building, and knowledge transfer for the development and implementation of cabbage IPM were conducted in close collaboration with Cooperative Farm (Co-Farm) managers, executives and workers. Different methods, tools and techniques were tested in the field and a strategy was developed (Fig. 1.) that met with general approval. The core components of the strategy are 1) transplanting clean seedlings to delay insect pest population build-up, 2) replacing chemical pesticides with bio-pesticides and thereby enhancing the impact of the natural enemy community, 3) releasing natural enemies, and 4) following the recommendations of a monitoring and damage threshold model for pesticide applications. The area of implementation of this strategy was gradually increased and the results achieved on the five Co-Farms involved have proven to be very promising compared to the traditional chemical pest management approach.

Capacity building through knowledge transfer plays a major role within this strategy for the implementation of cabbage IPM. During the first project years, training activities were aimed at forming a core group of scientists, called the "Cabbage IPM Focus Group", at the Plant Protection Institute (PPI) Pyongyang.

1. **Seedlings** are **covered** with a synthetic fleece to prevent early pest damage; a **selective insecticide** is applied
 → the transplanting of clean seedlings delays the population build-up of pest insects
2. Application of the Swiss **monitoring and damage threshold model** to decide whether the field needs spraying or not
 → unnecessary sprays are eliminated, the impact of native natural enemies is strengthened on both target pest species
3. A **selective bio-pesticide** will be used (*Bt* product) to replace chemicals
 → pest populations are suppressed without killing natural enemies of the diamondback moth and the small white butterfly
4. **Release** of the **parasitic wasp** *Diadegma semiclausum* (natural enemy augmentation)
 → to enhance the suppression of the diamondback moth

Testing of the Pest Management strategy at five Co-Farms in DPRK



	Bt Switzerland	Bt DPRK	Chemical	Untreated + NE
Seedbed	<ul style="list-style-type: none"> • Seedbeds are covered with a layer of synthetic fleece to suppress flea beetle and aphid attack and additional two layers for protection against cold temperatures • If there are still insect pest problems, seedlings must be treated with the product <i>Audienz</i> 0.03% prior to transplanting • Treatment of seedlings must be similar to make sure that plant quality at the transplanting date is comparable; seedlings must be free of pests 			
Transplanting and Cultivation Period	<ul style="list-style-type: none"> • The pest density in the field is assessed weekly with the damage threshold model • The <i>Bt</i> product Delfin is applied following the recommendations of the model • Formulation: 500g in 300 litres per ha (max. 4-5 treatments) 	<ul style="list-style-type: none"> • The pest density in the field is assessed weekly with the damage threshold model • The local <i>Bt</i> product is applied following the recommendations of the model • Formulation: According to the producer (PPI) 	<ul style="list-style-type: none"> • The monitoring strategy applied is defined at the beginning of the growing season • A chemical product (e.g. <i>Deltamethrin</i>) is applied following the recommendations of the Ministry of Agriculture 	<ul style="list-style-type: none"> • The pest density in the field is assessed weekly with the damage threshold model • No pest management action by the farmer • Formulation: 500 to 1000 natural enemies per ha (min. 2 releases)
	<ul style="list-style-type: none"> • Standardized farming practises (weeding, irrigation, fertiliser applications) are carried out in all the field plots throughout the growing season 			
	<ul style="list-style-type: none"> • PPI Focus Group will carry out studies about pest density levels on a per plant basis and will determine the incidence of natural enemies 			
At Harvest	<ul style="list-style-type: none"> • Yield per area will be estimated for each field plot individually (several replicates within each field plot). Care has to be taken to make sure that results from differently managed plots are not mixed up. 			

Figure 1. Integrated pest management strategy for cabbage in DPRK.

Knowledge transfer for the Focus Group included various aspects of developing and implementing IPM in the model crop cabbage. Scientific aspects were covered during this time like the development of monitoring and damage threshold models, experimental design and analysis of IPM related field studies as well as technical aspects like the rearing of a diamondback moth parasitoid. At the same time, pilot farmer training activities started at five Co-Farms. Since the field testing of the newly developed IPM strategy was conducted at these farms, the cooperating farmers had to be trained in order to implement IPM in the test fields. The first on-farm training sessions focused on rather technical aspects like using the monitoring and damage threshold model and the application of a Bt bio-pesticide.

The overall aim for the training remained the same during the entire project activities: to build up a sustainable system for the knowledge transfer in DPRK with competent trainers transferring knowledge at the Co-Farm level. In this paper we describe the four prerequisites identified by the project partners for a successful, scaled up implementation of IPM in DPRK: 1) the development of a *knowledge transfer concept* on an institutional level in order to meet the requirements of an increased implementation area; 2) the continuation of *capacity building for trainers*; 3) the development and evaluation of *training exercises* for the transfer of basic ideas behind IPM in *Farmer Participatory Training (FPT)* and 4) the preparation of *didactic materials for knowledge transfer*, like e.g. tailor-made information in an adapted language and illustrations such as high quality pictures, for the on-farm implementation.

MATERIALS AND METHODS

COLLABORATION AND IMPLEMENTATION AREA

A joint initiative from the Plant Protection Institute (PPI) of the Academy for Agricultural Sciences (AAS) Pyongyang together with CABI Bioscience Switzerland and the Swiss Agency for Development and Cooperation (SDC) addressed the above mentioned problems in DPRK, with the aim of achieving a sustainable improvement of brassica production through the biological control of key pests in an Integrated Pest Management approach. The work concentrated on three different regions of DPRK: Pyongyang City, the Miru Hills area, and the South Hamgyong Province in the northern highlands (see Fig. 2.)

KNOWLEDGE TRANSFER CONCEPT

For the development of a knowledge transfer concept, the organizational and socio-political structure of DPRK agriculture had to be considered. In DPRK, a cooperative farming system is established where 1000 to 2000 people are living and working together on a farm covering an area of approximately 500 hectares (in the case of vegetable production). Crops that have to be grown are defined by the governmental planned quota, and usually more than 90% of the yield is fed into the public distribution system. Co-Farms, led by a manager and a chief engineer, are partitioned into work teams and sub-work teams with their respective leaders and engineers. Each work team specializes in the cultivation of a certain crop (a vegetable in the case of vegetable farms). Access to Co-Farms is limited and subject to permissions issued by the Ministry of Agriculture (MoA) for each farm and visit, respectively. The main project partner, the Plant Protection Institute, is one of the research institutes of the Academy of



Figure 2. Collaborating Cooperative Farms for the farm-wide implementation of the cabbage IPM strategy.

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Agricultural Sciences (AAS), the latter being active in various fields of agricultural sciences. The traditional pathway for knowledge transfer in this system is a top down approach via the extension service of the MoA. Extension officers (one per Co-Farm) act as intermediaries of MoA and the farm. PPI traditionally is the advisory body for the MoA. It was necessary to develop a knowledge transfer structure that was adapted to these conditions.

CAPACITY BUILDING FOR TRAINERS

The capacity building for the Cabbage IPM Focus Group had to be continued during the 2004 project phase. Members of the Focus Group must, on the one hand, become experts in IPM, understanding the complex interactions in the agro-ecosystem and being able to cover scientific requirements for IPM implementation. On the other hand, they have to acquire didactic concepts and the pedagogic background to transfer their knowledge in an appropriate way, based on principles of adult education. The training in 2004 for the cabbage IPM Focus Group reflected these two parts. During the more scientific part, further training was provided to the Cabbage IPM Focus Group for the rearing of natural enemies of the diamondback moth. The Focus Group attended a one week training course “Statistics and Threshold Models” covering important aspects of experimental design and data analysis in the context of IPM implementation. As in previous years, the experimental design of the field testing, the monitoring program during the field season and the data analysis were jointly planned and carried out. Training of Trainers (TOT) for the Focus Group included the transfer of previously consolidated knowledge about crop rotation and, as a main activity, the planning, preparation, implementation and analysis of the “Introductory Training for the Implementa-

tion of Cabbage IPM” at the Co-Farm level. The IPM Focus Group implemented this training course in collaboration with a facilitator from CABI Switzerland on the four Co-Farms close to Pyongyang and independently on the highland Co-Farm.

FARMER PARTICIPATORY TRAINING (FPT)

The first steps of Farmer Participatory Training (FPT) during the first project phase focused on the transfer of basic project ideas about IPM and technical skills for the implementation of the strategy such as the introduction of the “Monitoring and Damage Threshold Model”. Since the area managed for IPM in 2004 was extended and more farmers were involved in its implementation, the basic training was repeated for new participants and further training sessions were created. The first new session, carried out in spring, concentrated on crop rotation. The focus of these participatory learning sessions was on the importance of soil-borne diseases and their impact on cabbage production. In summer 2004, the FPT field exercises were planned and evaluated at the five project Co-Farms. FPT focused first on the recognition of cabbage insect pests and the natural enemy complex controlling them. In a next step, the impact of using a broad-spectrum chemical insecticide compared to a specific *Bt* biopesticide was investigated. This knowledge is required for a better understanding of the IPM concept that is to be implemented. Courses were based on the following principle of adult education (see also Pontius *et al.* 2002): adults learn best from direct experience. Learning by doing adds to farmers’ knowledge and experience, and improves their capacity as farm managers in a way that passive experience, like listening to extension messages, can not. Therefore, the most important components in the training were the exercises, where a logical sequence of small experiments, carried out by the farmers, supported the knowledge acquisition.

DIDACTIC MATERIAL FOR KNOWLEDGE TRANSFER

With respect to a broader dissemination and implementation of the cabbage IPM strategy, a manual was developed to provide a concise information compilation on cabbage IPM for the DPRK context in order to support the knowledge transfer. Step by step, inputs from all sides, farmers and scientists, and material adapted from already existing sources (Praasterink 2000; Van Mele *et al.* 2002; Vos 1998) were put together with the aim of developing a booklet that meets the needs of the practitioner in the cabbage field. The intended final product was a portable, weather-resistant booklet with all information necessary for cabbage IPM implementation to make sure that the knowledge can be transferred to where it is needed

RESULTS

KNOWLEDGE TRANSFER CONCEPT

The plan developed for knowledge transfer in DPRK (Fig. 3.) includes a pilot phase, which focuses on the thorough training of a core group of scientists at the PPI. The main aim is to anchor the capacity of developing, implementing and monitoring IPM systems in a scientific DPRK institution, thereby making sure that further IPM activities in other crops could be developed and implemented independently in the future. Parallel to the scientific capacity

building, a TOT is run and subsequently PPI scientists gain their first experience in facilitating FPT at the Co-Farms. Over the course of the first phase and with the appropriate training, these scientists become IPM specialists and Master Trainers.

For large-scale dissemination of the IPM approach in cabbage, the farm extension officers are involved and will be responsible for the knowledge transfer on their farms. At the same time, county extension officers from the MoA join as trainers. Each county extension officer will later become a Master Trainer transferring knowledge to the farm extension officers in the respective county. In the beginning, the TOT is carried out by the core group of PPI scientists together with a CABI extension specialist with the aim that the latter makes her-/himself redundant.

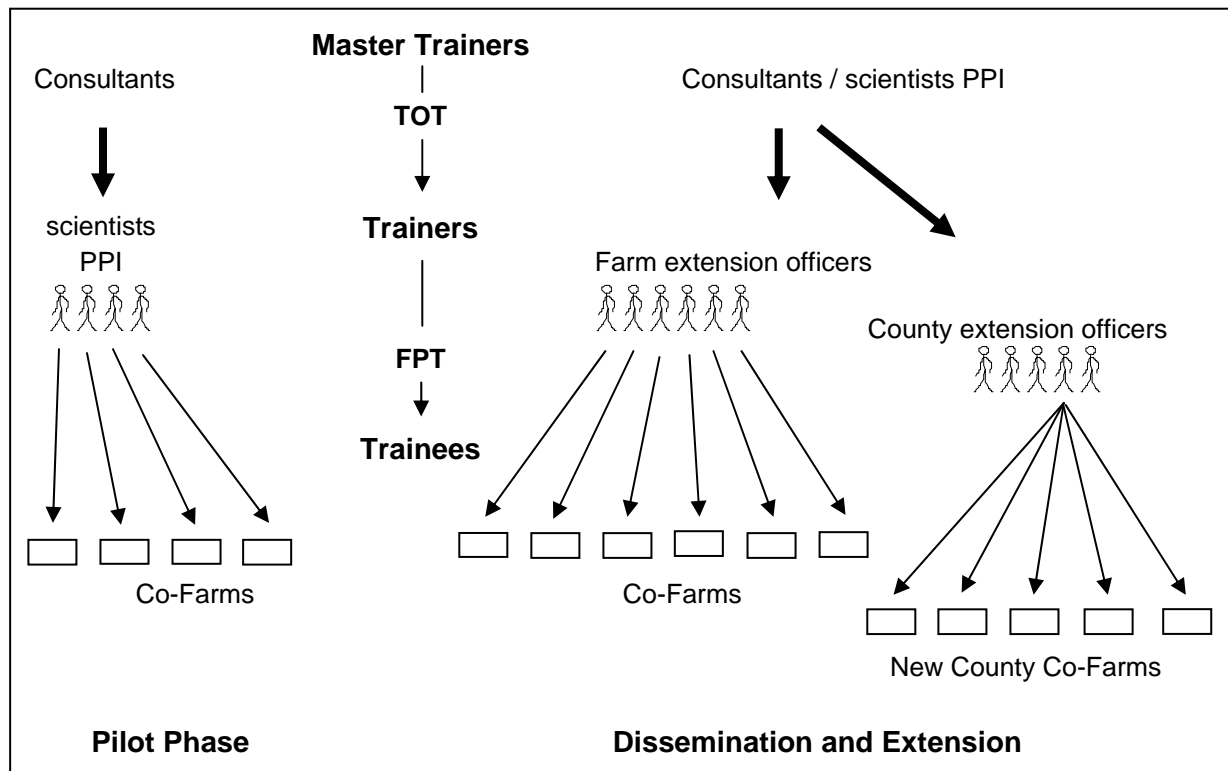


Figure 3. IPM knowledge transfer concept for DPR Korea.

CAPACITY BUILDING FOR TRAINERS

To assure that the Cabbage IPM Focus Group meets the requirements in this knowledge transfer concept, capacity building was continued on two levels: concerning scientific contents and FPT. The main training units, which were in the context of IPM implementation in 2004, are summarized in Table 1.

Extended CABI visits to DPRK in 2004 set the foundation for continuous knowledge transfer to the Cabbage IPM Focus Group and made it possible to discuss problems and IPM-specific questions. In addition to this continuous process, specified training activities were planned. The topic “Crop Rotation” was subject of discussion and dealt with in depth. Further training was provided for the important IPM component of rearing natural enemies.

Table 1. Topics and methods of the main training units in 2004 for the capacity building of the IPM Focus Group in chronological order. SCI = scientific topics; FPT = Farmer Participatory Training topics.

	Topic	Methods
SCI	Crop rotation: theoretical background.	Lectures and discussions as a preparation of FPT
FPT	Crop rotation: On-Farm Information sessions based on current Farm practices	Theoretical sessions with a participatory approach at all participating Co-Farms
SCI	"Statistics and Threshold Models"	One week training course in Pyongyang
SCI	Rearing of natural enemies	Practical work in greenhouse and rearing lab; working out guidelines and management practices during a one month consultancy
SCI	Design of the experimental set-up 2004 for the Co-Farm areas of IPM implementation	Discussion and deduction of the program, monitoring plan
FPT	Basic training for the cabbage IPM implementation at Co-Farms, training for the threshold model and technical training	Participatory training sessions at all Co-Farms carried out by the Focus Group
FPT	Implementation of the experimental set-up on at Co-Farm level	On-site support and backstopping, weekly at all Co-Farms
SCI	International Plant Protection Conference Beijing	Poster presentation at an International Congress, international contacts and exchange of experiences
FPT	Monitoring, the application of bio-pesticides and yield measurements	On-site support and backstopping, weekly at all Co-Farms
FPT	"Introductory Training for the Implementation of Cabbage IPM" on the 4 lowland Co-Farms	Training unit with participatory exercises; hands-on training, discovery learning
FPT	Introduction of the strategy, technical backstopping and FPT unit at the highland Co-Farm	Methods as above, carried out by the Focus Group
SCI	Data compilation, analysis and interpretation	Preparation of the data set 2004 for the presentation at the National Information Day

During a 10 day training course “Statistics and Threshold Models”, the Focus Group together with 16 other participants were able to improve their statistics skills. Other topics covered were an introduction to hypothesis testing and experimental design, and the knowledge gained could be applied to the IPM program by the Focus Group. Finally, attending the International Plant Protection Congress in Beijing facilitated international contacts with researchers world-wide. Moreover, four future Master Trainers from DPRK had the opportunity to exchange experiences in the field of IPM.

The main FPT activities for the Focus Group were directed towards the “Introductory Training for the Implementation of Cabbage IPM” to be carried out at the Co-Farms. The

main steps of knowledge transfer were discussed and the didactics and pedagogical concepts behind the exercises were clarified. Together with the Focus Group, the training was prepared in terms of logistics and material. After the implementation in the Pyongyang area together with the consultant, the Focus Group had the opportunity to consolidate the acquired skills by implementing the training themselves at the highland Co-Farm.

FARMER PARTICIPATORY TRAINING (FPT)

The first new unit of FPT in 2004 concentrated on crop rotation at four Co-Farms (Hwasong, Changchon, Dangsang, and Mangyongdae). All the crops grown at the Co-Farms in one season were compiled with their respective areas and yields. Farmers identified soil-born diseases causing problems on their farms. Adverse effects like yield losses due to these diseases and due to the degradation of soil fertility associated with continuous cabbage cultivation were explained. The method of crop rotation was presented as a means to solve production problems. It became clear that, at the present time, the implementation of a three or four year crop rotation on a large scale is not feasible. Especially in autumn, the production of cabbage and turnip occupies almost the total surface area available for crop rotation in order to respond to the high cabbage demand for kimchi production. Nonetheless, Co-Farms are highly interested in the basic principles of crop rotation. As an important first step for further activities in Integrated Crop Management (ICM), all the Co-Farms will implement and test a small-scale, three-year rotation of vegetable crops.

The main FPT activity in 2004 was the “Introductory Training Unit for the Implementation of Cabbage IPM”, compiled and implemented with the trainers from the IPM Focus Group at the five project Co-Farms. At each Co-Farm, 15-30 participants, both farmers and work-team leaders, attended the training sessions. Training focused first on the recognition of cabbage insect pests and the natural enemy complex controlling them (Table 2). This was done with activities around a so-called “insect zoo”: insects collected in the field were identified and in a discovery learning approach (Fig. 4.) were dealt with to improve the farmers’ understanding of the cabbage arthropod community. Important steps of this part of the training were:

- The identification of “good” and “bad” insects (farmers’ friends and foes)
- The direct observation of predators killing pests
- The direct observation of parasitoids attacking their host

In a next step, the impact of using a broad-spectrum chemical insecticide compared to a specific bio-pesticide, *Bacillus thuringiensis kurstaki*, was shown. Important steps of this part of the training were:

- The effect of a chemical on the pest/natural enemy
- The effect of a Bt product on the pest/natural enemy
- Implications of the findings on the use of a damage threshold model

Table 2. Activities and objectives of the FPT, implemented at partner Co-Farms in 2004.

Introductory Training for the Implementation of Cabbage IPM	
Activities	Objectives
DAY 1	
Exercise 1: Insect zoo: collection and identification of insects	
Different insects are collected in the cabbage field. They are sorted and identified.	Curiosity about the arthropod community in the cabbage ecosystem is stimulated. Participants acquire basic skills in handling and identifying pests and beneficial insects.
Exercise 2: Insect zoo: studying predators	
Experiments are set up in order to find out about qualitative (who is eating whom?) and quantitative aspects (how much do they eat?) of predation.	Participants recognize predators and discover the importance of these beneficial insects in the cabbage field.
Exercise 3: Insect zoo: studying life cycles of pests	
Experiments are set up in order to observe the entire life cycles of lepidopteran pests. They are discussed after having reared different field collected instars.	Participants observe egg laying and subsequent development of pest instars in order to understand life cycles and phenology of these insects. This is an important prerequisite to anticipating pest problems.
Exercise 4: Insect zoo: studying life cycles of parasitoids	
Parasitoids are directly observed when laying eggs. The possible impact of this behavior is assessed in experimental caging.	Participants gradually become acquainted with different aspects of parasitism, starting with a general life cycle of a model parasitoid (<i>Diadegma</i>).
DAY 2	
Theory part 1: Discussion of the results from Ex2 / 3	
Results from the experiments are reported to the group. Examples of pest insect life cycles and pest - predator interactions are summarized. Additional theoretical background information is provided.	With short presentations by the participants and the subsequent discussion including theoretical inputs by the facilitator, new findings about pests and predators are structured and consolidated.
Exercise 5: Comparison of biological and chemical pesticides used in caterpillar control	
The action of chemical broad - spectrum pesticides on pest insects is compared with the action of a specific Bt product. In cage experiments, <i>Plutella</i> and <i>Pieris</i> larvae feed on leaves treated with a) Bt, b) a chemical insecticide, or c) nothing.	Based on the previously acquired knowledge about pest - natural enemy interactions, participants can imagine to what extent "natural" control is decreased, if broad-spectrum chemical insecticides are used. They are motivated to conserve natural enemies.
Exercise 6: Effects of pesticides on natural enemies	
The set-up from Ex 5 is used to assist the discovery of the survival of different natural enemies when Bt is used.	As above (Ex 5).
Exercise 7: Parasitoids on the small white butterfly and the diamondback moth	
Pest pupae (and mature <i>Pieris</i> larvae) and parasitoid cocoons are collected and identified. Parasitoid life cycles are repeated. The parasitism level in the field is assessed for both pests, and its impact is analyzed.	Participants become more familiar with the most prevalent parasitoid species of <i>Plutella</i> and <i>Pieris</i> . They learn more about parasitism and its effect on the two main pest species in cabbage.
Theory part 2: Brief analysis of Ex 5 / 6	
First results are discussed and experiments are assigned to participants for further observations.	

Table 2. Activities and objectives of the FPT, implemented at partner Co-Farms in 2004 (continued).

Introductory Training for the Implementation of Cabbage IPM	
Activities	Objectives
DAY 3	
Theory part 3: Discussion of the results from Ex 5 / 6	
The outcome of the experiments is reported to the group and discussed.	The initiated dialogue amongst participants creates awareness about pesticide associated problems.
Exercise 4: Evaluation of the caging experiment	
Parasitized and unparasitized diamondback moth pupae are counted and the influence of parasitism on the <i>Plutella</i> population is discussed.	Participants discover the efficacy of a parasitoid and find out about possibilities to conserve adult parasitoids in the cabbage field
Theory 4: Implications on the use of the damage and threshold model	
Based on the new knowledge acquired during the previous training days, factors which influence the extent of damage done in the field by a certain number of pests are listed. Theoretical examples are given on how to consider these factors (parasitism, predation, crop stage, pest stage) and the weather situation into a model-based decision making process.	Participants consolidate their knowledge by its application in the new context of threshold model implementation. They are motivated to translate a refined threshold model approach into practice



Figure 4. Distinguishing between “good” and “bad” insects through discovery learning at the Co-Farm level.

The Cabbage IPM Focus Group facilitated the training unit helped to successfully implement this training component. It became obvious that the Focus Group does not only have a broad knowledge about IPM and its principles, but is also capable of transferring the acquired knowledge in IPM to other people. The participants showed high interest and commitment during the courses. From the remarks and questions made by the participants it became clear, that with this training, a vital support for IPM was induced.

DIDACTIC MATERIAL FOR KNOWLEDGE TRANSFER

During the cabbage IPM implementation, the project partners realized that, despite the wealth of information available for IPM and cabbage, there was a need for a manual that provides concise information on cabbage IPM, is written in the Korean language and adapted to the local context. Descriptions and illustrations of major cabbage insect pests and diseases had to be included, as did ideas on how knowledge in IPM needs to be transferred. The first step in the manual's development was a joint decision about its contents. Considering that IPM as a plant protection strategy is new for most cabbage producers in DPRK, an introduction into this approach and its tools was seen to be essential. Farmers should recognize major cabbage insect pests, natural enemies and diseases in the field. Therefore, a section of fact sheets was considered to be indispensable for the manual. It was also decided that a segment covering the discovery-learning exercises should be included in order to facilitate knowledge transfer. When the first draft of the English version of the manual was written, the Cabbage IPM Focus Group reviewed it and adapted it to the local context. Pictures of cabbage pests and diseases, as well as pictures from participatory training, were taken during the whole season. In order to illustrate the IPM component, an artist from the AAS made the drawings. After reviewing the English text version once more, it was translated into Korean while the layout for the English version of the manual was completed.

The English version of "A Farmer's Manual for Cabbage IPM in DPRK" is now available. It consists of 120 pages in a loose leaves system in a ring binder. It has a handy C6 format and the water-repellent paper and print allow farmers to take it to the field (some extracts are printed above).

Part one (Figs. 5a + b.) gives a rather general overview of the IPM approach and its methods and tools. Specific advice is included for the cultivation of cruciferous vegetable crops in DPRK. These different ideas can be implemented and tested in the cabbage field according to the prevailing situation.

The successful implementation of IPM requires fundamental skills and understanding of the relatively complex interactions of organisms in the agro-ecosystem. This in turn demands knowledge about the components of the interactions. Part two (Fig. 5c.) is therefore dedicated to the identification and understanding of pests, diseases and natural enemies in the cabbage field.

Part three (Fig. 5d.) takes into account that the knowledge transfer of a complex matter like IPM is challenging, but nevertheless essential for its implementation. The manual provides a training curriculum based on discovery learning exercises for the introduction of cabbage IPM at the Co-Farm level. The unit was carried out and evaluated on five Co-Farms in 2004 and proved to be very successful. As with the IPM approach itself, the knowledge transfer of its contents has to be flexible and adaptable to specific situations. Therefore some additional exercises were compiled for trainers and farmers covering topics such as the spread and effects of pathogens, plant compensation studies and cage exclusion of natural enemies.

Within the framework of the National Information Day for Cabbage IPM Implementation in DPRK, the English version of the manual was presented to the audience. Options are currently being explored to print the Korean version in Pyongyang and joint efforts will ensure that a high-quality manual in the Korean language will be available in the future for the dissemination of cabbage IPM on a large scale in DPRK.

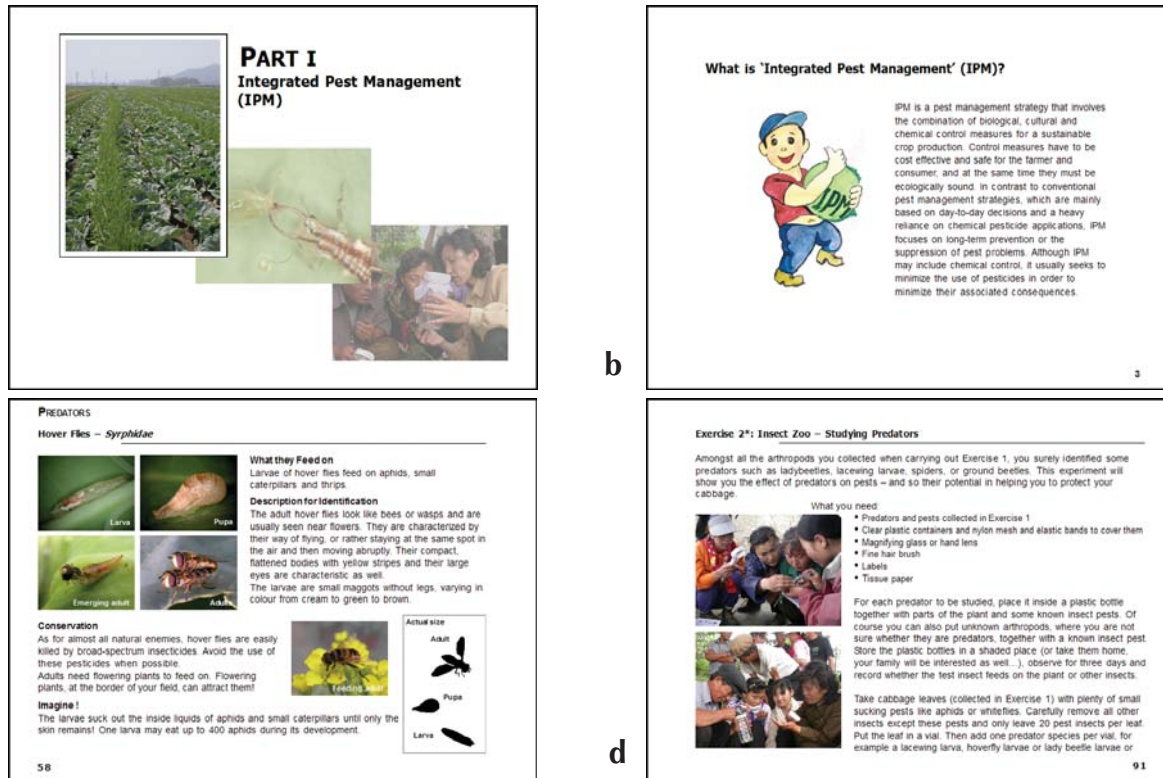


Figure 5. Extracts from “A Farmer’s Manual for Cabbage IPM in DPRK”.

CONCLUSIONS

The experimental implementation of the cabbage IPM strategy in DPRK showed promising results. White cabbage yield has been increased by up to 40% compared to the traditional chemical pest management approach. Unnecessary chemical treatments were avoided in Chinese cabbage since IPM was adopted. In 2004 the IPM strategy was extended to nearly 150 ha representing the majority of the white cabbage cultivation at the five Co-Farms. For the transition from an experimental to a field-testing scale and ultimately to common agricultural practice, capacity building through knowledge transfer is of highly important.

- A *knowledge transfer concept* was developed and adapted to the local agricultural system. A core group of PPI scientists will become Master Trainers through appropriate training and will then facilitate the central TOT involving farm and county extension officers as trainees. The option will also be available for county extension officers to become Master Trainers for county-based TOTs.

- To assure that the core group of PPI scientists meets the requirements in this knowledge transfer concept, *capacity building* was intensified. Through the planning and implementation of training units at Co-Farms, this group acquired the necessary background for FPT and subsequently acting as Master Trainers in the national extension service. Training continued at the same time for scientific aspects of developing, implementing and monitoring IPM systems, encouraging further independent initiatives for sustainable agriculture.
- Training material for the dissemination of IPM ideas through *FPT* was jointly developed by the project partners. A set of FPT exercises has been designed, adapted to the DPRK context and evaluated at several Co-Farms. The participants showed high interest and commitment during the courses. From the remarks made and questions asked by the participants it became clear that this training stimulated awareness and support for IPM.
- Based on training experience at the Co-Farm level and with additional input from the Focus Group and consultants, “A Farmer’s Manual for Cabbage IPM in DPRK” was developed. This didactic material will be used to support knowledge transfer to field-level personnel.

These measures have created the framework for a successful large-scale implementation of cabbage IPM leading towards strengthening food security in DPRK through sustainable production of healthy food.

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IMPLEMENTATION OF BIOLOGICAL CONTROL IN GLASSHOUSE HORTICULTURE IN THE NETHERLANDS

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INTRODUCTION

The use of biological control in Dutch glasshouses has increased tremendously in the second half of last century. Integrated pest management (IPM) is practiced on a large scale in all main vegetable crops. In glasshouse ornamentals IPM is more complicated, but at the end of last century biocontrol was applied in more than 10% of the area with ornamental crops (LTO Nederland, vakgroep Glastuinbouw 2003; van Lenteren 2000). The expansion of the glasshouse area subjected to biocontrol has, however, now come to a halt. In some crops, like gerbera, the number of biocontrol species released is even declining seriously. In general growers mention the following reasons for discontinuing biocontrol: disappointing results with natural enemies, new pesticides which made biocontrol 'unnecessary', the lack of selective pesticides against new pests and the restriction of other selective pesticides.

There are many different factors determining the degree of success of biocontrol measures and the composition of an IPM strategy. Implementation of IPM is complex not only in technical, but also in socio-economic sense (for an overview of motives for growers whether or not changeover to IPM, see de Buck and Beerling, in press). Hence, custom-made IPM strategies are required.

The traditional co-operation between Research, Extension and Education took care of the development and implementation of (new) knowledge, but this so-called triptych fell apart in the nineties due to changes in the market (see de Buck and Beerling, in press). Stakeholders are now following their own strategies and there is a lot of disagreement between for instance growers, environmental organizations and supply chains. This hampers the transition to a sustainable production system.

The traditional 'trend-setter model' is not helpful in the diffusion of complicated innovations without a clear value to growers, such as biocontrol and IPM. A new system of knowledge transfer is needed that meets the interests, visions and strategies of the stakeholders.

Recently in the Netherlands two types of networks have been developed based on the principle of collaboration of all parties: 'growers' networks' and 'socio-technical networks' (STNs). Both types of networks aim to generate interactive knowledge and are formed in order to speed up the innovation process. These networks are discussed hereafter, but first the role of the Dutch government in the transition to sustainable horticulture is described.

LEGISLATION

The Dutch government aims to make crop protection more sustainable: by 2010 the environmental 'burden' should be reduced by 95% when compared to 1998. The government regards IPM as the approach to achieve this reduction and proposes that all growers have switched to IPM by 2010. She has taken on the responsibility to promote knowledge on and implementation of IPM (Dutch Ministry of Agriculture, Nature and Food Quality 2004).

By funding a research program the government facilitates the development and implementation of IPM. This program comprises fundamental and applied research, in which not only solutions to single pest problems are sought, but also interactions of control measures and the integration into complete control strategies are taken into account (see e.g., Dik *et al.* 2004; Pijnakker *et al.* in press). Furthermore, much attention is given to the implementation of (new) knowledge and to the process of transition to sustainable agriculture, for which growers' networks and socio-technical networks have been developed (see hereafter).

GOOD CROP-PROTECTION PRACTICE

In 2003 the government, the growers' organization (LTO), the association of crop protection suppliers (Agrodis), the association of the Dutch agrochemical industry (Nefyto), and organizations for drinking water (VEWIN) and water boards (UvW), reached an agreement whereby they all will be working on reducing the environmental pollution caused by pesticides with at least 95 per cent by 2010 (Agreement on Crop Protection). As a consequence, a Royal Ordinance on the principles of IPM was drafted, which determines that all growers should work according to the principles of 'good crop-protection practice' and that the use of pesticides is reduced to the very minimum necessary to control pest populations below the economic-damage threshold (Besluit beginselen geïntegreerde gewasbescherming 2004). The definition of good crop-protection practice depends on the feasibility of crop-protection measures for 80-90% of the growers of a particular crop, and may change in time. Growers working according to EUREP-GAP guidelines of the European retailers and their suppliers will meet the demands of the Ordinance without difficulty.

Insight into measures of good crop-protection practice must be given in a crop-protection plan and a logbook. The crop-protection plan should address measures with respect to prevention, establishment of the necessity of control, non-chemical control measures, and chemical control measures. Deviations to the plan should be written down in a crop-protection logbook. The plan and logbook are mandatory from 2005 onwards, but at present growers are not yet forced to comply with the crop-protection plan or implement specific crop-protection measures. The aim of a crop-protection plan is to raise consciousness and induce behavioral change in growers.

BEST CROP-PROTECTION PRACTICE

Due to new knowledge and understanding the transition into an even more sustainable crop protection should be a continuous process. To stimulate this process, the government requested researchers to draw up so-called 'best practices' of crop-protection (for glasshouse horticulture: Dik and De Haan 2004). 'Best practices' are the most important crop protection measures that will potentially contribute to a reduction in the environmental burden. Examples are the use of natural enemies for pest control, more efficient pesticide application techniques and screening windows to keep pests out. 'Best practices' are not yet generally implemented and practical experience is often lacking. Almost all 'best practices' face obstacles that need to be removed before implementation is possible, or need further study. Therefore, 'best practices' are not mandatory for the growers, but this set of potential measures is a guide for research funding organizations (like the government) and growers' organizations. Both 'good practices' and 'best practices' will change over time due to advancing possibilities and understanding, thus accomplishing a stepwise improvement of IPM.

IMPLEMENTATION OF IPM BY NETWORK FORMATION

Recently in the Netherlands two types of networks have been developed based on the principle of collaboration of all parties: 'growers' networks' and 'socio-technical networks' (STNs). Both networks mobilize all decisive stakeholders for the implementation of sustainable horticulture. These parties include growers themselves, suppliers and buyers, knowledge workers (from Wageningen University and Research) and advisors (private extension service and crop protection suppliers), sector organizations, producers' organizations and government. Growers' networks have a practical approach and are focused on the changeover to IPM and the awareness of the necessity to implement the latest feasible 'best practices'. The socio-technical networks aim at a practical implementation of an innovation agenda for sustainable development. This agenda is fully decided on by growers and other stakeholders, without a specific focus beforehand.

GROWERS' NETWORKS (FARMING WITH FUTURE)

The heart of the network. The heart of the growers' network (project 'Farming with future') is formed by a group of 6 to 8 growers who meet several times a year (Fig. 1). These groups are lead by researchers (crop protection specialists), trained in managing processes of change. At the moment there are five crop-related networks: for cucumber, for tomato, for rose, for chrysanthemum and for potted-plants. Each group consists of different types of entrepreneurs, *i.e.* growers with different attitudes towards biocontrol and choice of crop protection strategy, but with a common awareness of the need to change to IPM. The growers are from different regions of the country and are an authority within their crop, although not only trend-setters are chosen. The choice of growers is made in consultation with the growers' organization LTO. Within the group discussions about 'best practices', (new) control measures and strategies are stimulated, giving special attention to biocontrol and natural pesticides. In this way growers learn from each other and also get acquainted with new strategies. The flow of information is not directed in one way, *i.e.* to the grower, only. The growers'-networks project ('Farming with Future') is embedded within the governmental research pro-

gram mentioned before, which facilitates feedback to research. Questions and information on obstacles for 'best practices' for example, flow back to research institutions, thus stimulating new research and demonstration projects.

Before the start of the crop (or a year) the grower, assisted by his regular crop protection advisor (private extension service or crop protection supplier) and using input of the latest knowledge from the researcher, designs a crop protection plan. The crop-protection strategy and corresponding plan remain the choice of the grower and will therefore differ between growers. At the end of the cropping season (or a year) the plans are evaluated individually and within the group. To help the evaluation of the chosen strategy, growers register the input of chemical and natural pesticides, natural enemies, and also costs involved (in time and money), as well as output, *i.e.* yield. Using these figures the researcher calculates the environmental impact and the economic results. For the following year, a new plan is made, based on the experiences of the previous year and with new input from research and consultants, thus accomplishing a stepwise implementation of 'best practices'.

Other growers. Next to coaching the individual growers and the networks, much effort is put into the dissemination of results to other growers and convincing them to also implement the strategies that prove to be feasible. For this purpose co-operation (in communication) is sought with stakeholders surrounding the growers (see Fig. 1), thus creating a solid basis for the implementation of new knowledge. Focus is on distribution of technical information as well as on increasing acceptance.

Communication with growers outside the networks occurs in numerous ways and often in co-operation with the extension division of the National Sector Organization 'LTO', which started a communication project called 'Strategist' for IPM in glasshouse ornamental crops. Communication involves leaflets with information about the major pests and diseases for each crop, publications and interviews in growers' magazines, an internet site, presentations at national and regional meetings organized by growers' association, and excursions to participating growers.

As stated before, the implementation of IPM is complex. Straightforward facts, like the efficacy of a (microbial) pesticide, are picked up easily by growers and find their way quickly via study groups and other contacts with and between growers. Knowledge about natural enemies, and more particularly IPM strategies, are never straightforward and require guidance when implemented. In the first place, this means that stakeholders surrounding the growers, in particular the advisors should acquire knowledge. For the large group of 'followers' amongst the growers, crop advisors are even the main knowledge providers in crop protection and play an important role in the crop-protection strategy the grower chooses. The advisors may be independent (e.g., the privatized extension service 'DLV'), but more often they represent a crop-protection supplier. These companies vary in state of knowledge and have their own - more or less sophisticated - IPM strategies. A complicating factor is that the natural aim of these companies is to sell as many products (biological or chemical) as possible to as many customers as possible.

Participation of crop-protection suppliers in this innovation process is sought in several ways (Fig. 1). Advisors from different companies advice the growers within the network. These advisors are directly involved in the compilation and evaluation of the crop-protection

plan of ‘their’ grower. Also, bilateral meetings of research and crop-protection suppliers and other companies involved in advising growers are organized to discuss strategies and research results. The advantage of this one-to-one approach is that the companies then discuss their strategy with the researchers more openly than when competitive companies are present. Awareness of these important stakeholders of the necessity and feasibility of IPM enhances the adoption of biocontrol and a custom-made IPM strategy.

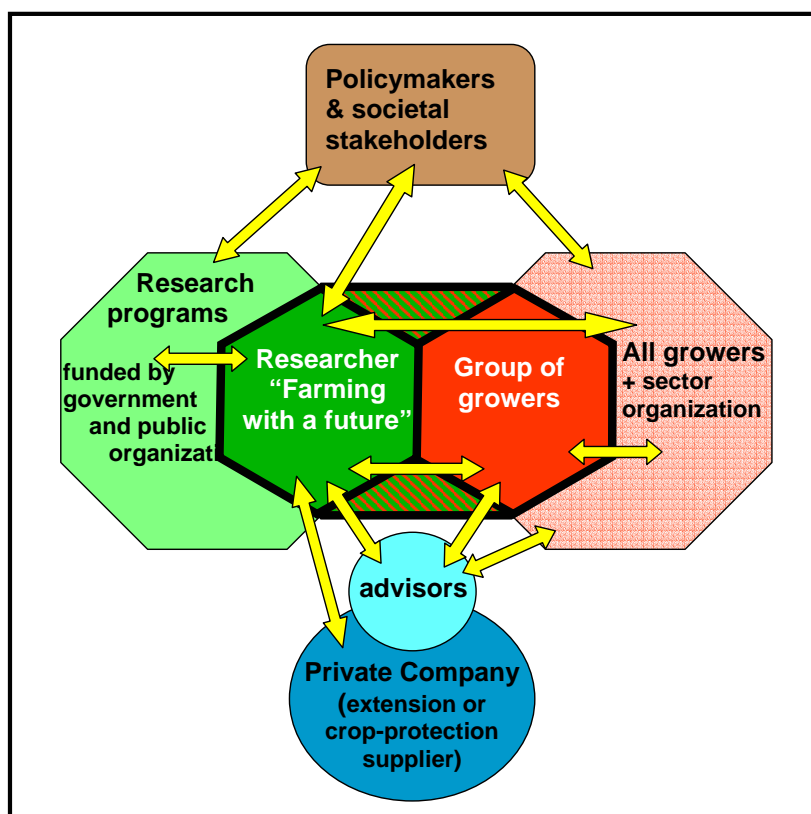


Figure 1. Schematic presentation of a growers' network in glasshouse horticulture and the direct and indirect interactions between the project 'Farming with Future' and stakeholders.

Policymakers and societal stakeholders. Policymakers and societal stakeholders also play an important role in the changeover to a more sustainable crop protection because they can stimulate the changeover, set the goals and determine the framework in which it should take place. In a low-lying country full of waterways and lakes like The Netherlands, regional water boards, drinking water companies and environmental organizations highly influence the present regional and national policy on crop protection. Policy officials and politicians are also influenced by discussions with growers' organizations and organizations of biocontrol producers, chemical industries and suppliers, for instance as in the Agreement on Crop Protection.

The project 'Farming with future' aims to provide policymakers and societal stakeholders a realistic view of the present and future (im) possibilities of biocontrol and IPM and to stimulate discussion among the stakeholders. For this purpose policymakers and societal stake-

holders regularly receive a newsletter and also bilateral meetings as well as round-table discussions are organized.

SOCIO-TECHNICAL NETWORKS

A socio-technical network (STN) is another method to speed up an innovation process by collaboration of stakeholders. The aim of an STN is 1) to intelligently use the forces of sustainability (also called 'People, Planet and Profit') for speeding-up the innovation process to sustainable plant production, and 2) better utilize 'surrounding partners' to induce entrepreneurship. The 'technical part' of a STN consists of one or more specific innovations in the field of technical, knowledge, (consumer-) product or sector development. In addition to Profit, the innovations should improve the aspects of Planet and People.

A STN is primarily based on the capacity of growers to innovate. Growers and stakeholders can be activated by meeting their interests, strategies and visions. The participants formulate a common vision on sustainable development of the sector and the problems that they want to work on themselves. They decide on an innovation agenda for sustainable development, without a specific focus beforehand. Hence, in a STN, the development (for instance of knowledge) is driven by demand.

Secondly, a STN aims at a consensus within the intermediate groups, such as producers' organizations, NGO's and government. Without consensus of intermediates from the start, there is an evident risk that the development and the dissemination of the innovation will become frustrated.

A methodology has been developed to create a STN (Buurma *et al.* 2003; De Buck and Buurma 2004). It comprises three consecutive steps: 1) interviewing stakeholders, 2) identifying potential coalitions between stakeholders, and 3) composing a collaboration agreement. These steps are explained hereafter and illustrated with the case of formation of a STN in the second largest cut-flower sector in the Netherlands: the cut-chrysanthemum sector.

Interviewing stakeholders. A STN requires participation of supporters of values that are related 1) with market (to generate Profit), 2) with society (to care for People and Planet) and 3) with human resource (to induce entrepreneurship and innovative power). A value triangle (Fig. 2) is a tool to identify the mutual positions of the stakeholders. Firstly, stakeholders professionally involved in the innovation are identified for each of these values. These stakeholders are interviewed in-depth, focusing on four items: 1) the values of the respondents, 2) their position in the professional environment, 3) their vision on strategic development and the relevance for themselves and 4) the barriers that hamper its implementation. The interviews do not just focus on a specific theme, *i.e.* IPM, but address the inter-relationships with other important issues as well.

From the interviews of stakeholders within the cut-chrysanthemum sector and during a workshop (see later) four developmental pathways for transition towards sustainable production were apparent, which were visualized in a mind landscape (Fig. 3). Adherents of development 1 urged on the transition from chemical pest control to biocontrol and IPM.

Further knowledge has to be developed on IPM strategies suitable for cut-chrysanthemum. Pest control practices need to be revised, as organisms increasingly become resistant. The decrease in the number of registered pesticides is a result of severe government regulations with respect to environmental protection, combined with the relatively small market demand for pesticides in Dutch glasshouse horticulture as a whole.

Another group believed that cropping systems on mobile benches in artificial substrate are indispensable for a sustainable chrysanthemum sector (development 2). Firstly, the new system increases production efficiency and secondly the use of artificial substrate would eliminate problems with soil-borne pests and diseases. The use of mobile benches offers possibilities for pest management and product development (small, separately manageable units). Results (a better productivity) should be available on the short term, as economic continuity of the chrysanthemum sector is at stake.

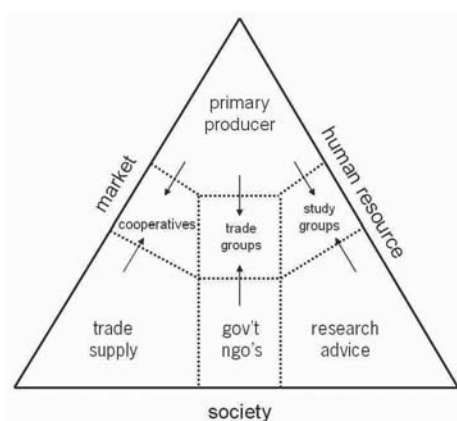


Figure 2. Value triangle: the position of stakeholder groups in the agricultural sector between values that are related with market, human resource and society.

Some stakeholders urge the necessity of more collaboration in the knowledge system: the private companies, research and extension organizations and sector organizations need each other to develop and disseminate IPM in the chrysanthemum sector. This point of view can be considered as network development (development 3).

Adherents of development 4 believe that the market position of the product (the chrysanthemum flower) needs to be improved. The negative image of chrysanthemum as a 'poisonous flower' and its character of cheap mass produce hamper this.

Identifying potential coalitions. Based on the interviews, the next step is the identification of potential coalitions in the mind landscape. Some conditions for a successful coalition are: compatibility of individual strategic solutions, innovative power and a balanced set of individuals' values. The coalition is formed around a central person (like the formation of a cabinet, headed by a Prime Minister) with authority, goodwill, having the willingness and the ability to co-operate. This central person has the mandate of intermediate groups.

In the cut-chrysanthemum sector, changing over to a cropping system in artificial substrate on mobile benches looked promising for development towards profitability and ecological sustainability. Representatives of this developmental pathway operated with confidence, had innovative power and found a link with IPM knowledge development (1 in Fig. 3) evident. Moreover, there were already serious research efforts on development of an IPM strategy for Dutch cut-chrysanthemum production, with involvement of several stakeholders. Therefore, a STN around system development (2 in Fig. 3) and not directly around IPM knowledge development was initiated (De Buck and Buurma 2004).

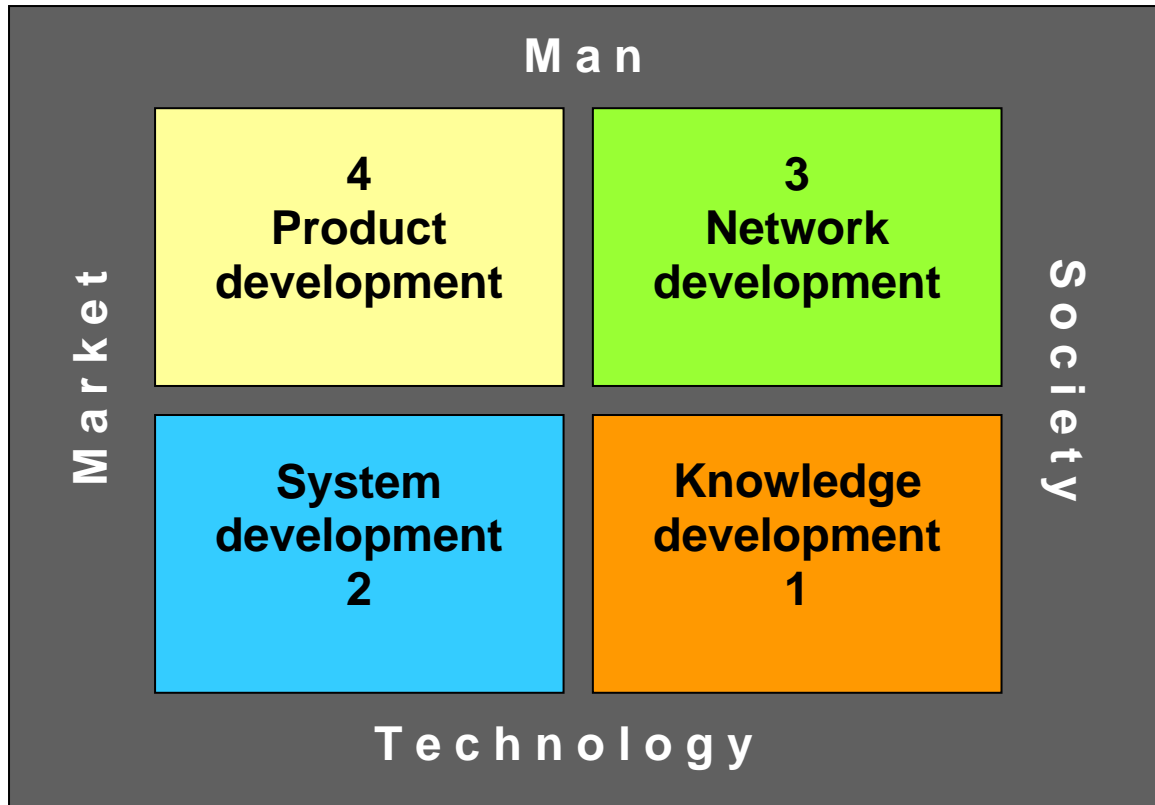


Figure 3. Mind landscape: the four developmental pathways for system innovation in chrysanthemum.

The chairman of the National Crop Committee (in Dutch: Landelijke Gewascommissie Chrysant, an NGO), a chrysanthemum grower himself, was appointed as the central person of STN. Through his position as chairman and grower, he was able to create support for the innovation throughout the sector. As a first activity of the STN a meeting was organized with all leaders of IPM initiatives in cut-chrysanthemum, including ‘Farming with future’ (chrysanthemum growers’ network), ‘Strategist’ (communication project), a crop-protection producer and its supplier (carrying out a trend-setting IPM project), and a researcher involved in fundamental and applied aspects of IPM in chrysanthemum. This meeting has contributed to a close collaboration between all current projects on IPM in the chrysanthemum sector. In fact, this initiative can be considered as a first step in network development (3 in Fig. 3).

Composing a collaboration agreement. In the final step a collaboration agreement is composed, reflecting the intentions and commitment of the participants in this STN to implement a specific innovation development. An appropriate action for this is a workshop with all interviewed stakeholders in which future images are outlined and a plan is designed, necessary to reach one or more of these desired future images.

Concerning the STN in the chrysanthemum sector, a strategic document on sector development on behalf of the National Sector Organization for Horticulture was drafted (De Buck and Buurma 2004). This document elaborates sustainable development as a combination of the four developmental pathways. For the approval and funding of RandD proposals in a specific sector in horticulture the National Crop Committee (representing the sector; LTO) advises the National Sector Organization for Horticulture (in Dutch: Productschap Tuinbouw, an NGO). Both organizations require support from the sector for their decisions. The sector will support those decisions that lead to sustainable sector development in terms of Profit as well as People and Planet.

As a conclusive step, a workshop was held for the stakeholders who had been interviewed. In this workshop, the participants agreed upon the four developmental pathways required for sustainable horticulture (Fig. 3). There was full support for the fact that IPM should be incorporated in the development of the new production system as soon as possible. The participants were aware of the need for support from the whole sector for such extensive changes (system innovation) in cut-chrysanthemum production. Furthermore, the participants concluded that better expertise in pest control is necessary, but acknowledged that this was covered by recent initiatives, *i.e.* the projects ‘Strategist’ and ‘Farming with future’. Finally, the transition to a new production system and IPM should be used to enhance product and market development of chrysanthemum (development 4 in Fig. 3).

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CONCLUSIONS

The growers’ network – for example those of the project ‘Farming with future’ - is an appropriate method for participative and stepwise learning, and enables the implementation of complicated knowledge about IPM and biocontrol. A Socio-technical network (STN) appears to be a useful tool and an appropriate method for stakeholders to decide on an innovation agenda for system innovation, such as the implementation of biocontrol and IPM. It is activated by the innovative capacity and common interests, strategies and visions of growers.

Socio-technical networks and growers’ networks mobilize all decisive stakeholders for the implementation of sustainable horticulture. The interrelationship between the two types of networks on a specific crop is evident. In the case of the cut-chrysanthemum sector, the Growers’ network on IPM stands for the dimension of knowledge development of the STN on sustainable sector development. The Growers’ network enhances the STN as it is driven by stakeholders rather than by researchers. Hence, these networks contribute to a new knowledge system as a successor for the traditional triptych of Research, Extension and Education in the Dutch agricultural sector. Briefly, in a modern knowledge system based on these networks, the focus has shifted from critical success factors to critical success actors. The chal-

lence for the coming years is to spread biological control and new IPM strategies that are developed and applied in the networks, towards the rest of the growers in the sector.

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