UNEP/CABI CRITICAL ISSUES CASE STUDIES

Series Editors: D. R. Dent and H. N. B. Gopalan

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CABI Bioscience

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Contents

Background

Over the past two decades, integrated pest management has become a preferred and widely implemented methodology in crop production. Various factors have caused this growth in IPM, including national and international responses to pesticide-induced pest outbreaks in crops like rice, vegetables, cotton and fruit trees, and public pressure for pesticide reduction in produce, articulated by the food industry. Whereas in the 1970s and 1980s, the IPM concept was very much one of research-driven technology packages, where farmers were the intended beneficiaries but not involved in the process. Today, as IPM spreads, farmers are developing their own local solutions and looking increasingly to researchers for technologies to test and incorporate. As farmer-participatory IPM methods spread, this demand is likely to increase. But can it be met?

The development of practical and economical biocontrol technologies (biopesticides, macrobiological control agents) for pest management has progressed more slowly than anticipated. Even in North America, concern has been raised that methods to support IPM are simply not currently available (Biologically Based Technologies for Crop Protection, Office of Technology Assessment, US Congress). The multinational crop protection industry, to whom many looked for new biocontrol technologies, has not found these economical to develop. Small to medium enterprises specialising in biocontrol technologies (both public and private), that tend to be more local, have received virtually no incentives, and are generally assumed to face a number of problems including:

1. failing to develop products meeting high performance standards;
2. poor product quality and hence safety;

3. failing to achieve adequate market penetration and product distribution;
4. failing to effectively compete with agrochemicals; and
5. operating within an unfavourable regulatory environment.

There is a need to:

1. determine the extent to which the above problems and difficulties are limiting delivery of biocontrol technologies in developing countries;
2. identify the full range of limiting factors experienced by such enterprises; and
3. consider ways in which these constraints and barriers to successful delivery to IPM farmers can be removed.

A number of attempts have been made to evaluate different aspects of the constraints to successful development and use of biocontrol technologies, particularly biopesticides through consultants reports (e.g. Socioeconomic aspects of microbial pesticide use in developing countries, Warburton, NRI, 1995; Microbial Pest Control, Johnsen, FAO, 1997), conferences (e.g. Microbial Insecticides: Novelty or Necessity, University of Warwick, UK, BCPC, 1997) and surveys (e.g. CABI Bioscience: Priorities in Biopesticide R&D in Developing Countries, CABI, 2000). These efforts, tend to provide either an overview of general issues or detailed analysis of only one aspect of the problem (e.g. constraints to R&D). They consistently fail to take a multidisciplinary and a delivery focussed approach that addresses technical, economic, education and farmer related perspectives at one time and in any detail. There is clearly a need to more fully evaluate, utilising such a multidisciplinary approach, the constraints to delivery of high performance and good quality biocontrol technologies to farmers in developing countries. In order to gain sufficient understanding of the constraints and problems facing biocontrol enterprises it will be necessary to undertake a number of case studies.

The biocontrol technologies that are currently available for insect control include various biopesticides based on bacteria (e.g. *Bacillus thuringiensis*), fungi (e.g. *Beauveria bassiana*), nematodes (e.g. *Steinernema* species) and viruses (nuclear polyhedrosis viruses — NPV's) and macrobiological products based on insect predators (e.g. *Chrysoperla carnea*) or parasitoids (e.g. *Trichogramma* species). A number of biocontrol agents are also available as products for control of plant pathogens (e.g. the fungi *Trichoderma* spp.) and nematodes (e.g. the fungus *Paecilomyces lilacinus*). Development, manufacture and use of such biocontrol technologies and the opportunities and constraints associated with each product varies between farming/cropping systems for different countries and regions of the world.

UNEP and CABI have initiated a series of case studies to consider critical issues in the delivery of biocontrol technology to the IPM Farmers. The following case study undertaken in Vietnam highlights the constraints to the delivery of the biocontrol agent *Trichoderma*, a fungal antagonist of a number of soilborne pathogens that attack field crops. Other case studies in the series include:

Delivery of Biocontrol Technologies to IPM Farmers: Nicaragua
Delivery of Biocontrol Technologies to IPM Farmers: India

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Mrs Tran Thi Thuan	*Trichoderma* Production
Dr Pham Thi Thuy	Head of Insect Fungi Laboratory

Some of the people interviewed at Ha Tai

Mr Do Danh Kiem	IPM trainer
Mr Bui Chi Hung	IPM trainer
Mr Pham Hung Luong	'Non-IPM' farmer
Mr Nguyen Huy Ky	PAR-farmer
Mrs Li Thi Hang	PAR-farmer

Some of the people interviewed at Hai Phong

Mr Tho	IPM trainer
Pham Thi Phong	IPM farmer
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The Use of Fungal Antagonists of the Genus *Trichoderma* for the Biological Control of Plant Diseases in Vietnam

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Introduction

Trichoderma spp. is a fungal antagonist of a wide range of fungal plant diseases. The potential use of *Trichoderma* and the closely related genus *Gliocladium* as biological control agents has been studied in many countries around the World and some registered commercial products based on these organisms are now available. This study reviews the development and use of *Trichoderma* spp. in Vietnam and aims to identify where constraints to its commercial development and uptake by small holder farmers exist. It should be highlighted that *Trichoderma* is still an experimental product in Vietnam and although it has been incorporated into the farmer participatory IPM programme in some regions, it is not a registered commercial product and its efficacy remains to be proven. Farmers and extension workers therefore preferred not to talk about *Trichoderma* as a product but they were familiar with the use of *Bacillus thuringiensis* (Bt), and the responses from these groups were based on their experiences with Bt as a commercially available biological control agent rather than *Trichoderma*.

Government Policy

The Vietnamese Government is a strong supporter of IPM and since 1992, it has been running a very successful National IPM programme. Programme activities include Training of Trainers (TOT), Farmer Field Schools (FFS) and Participatory Action Research (PAR) and since 1998, the National IPM programme has been formally supporting local IPM movements to build a community IPM network that can provide a framework for nation-wide IPM implementation. The use of biological control agents such as Bt, Nuclear polyhedrosis virus (NPV), *Metarhizium*, *Beauveria* and *Trichoderma* are seen as potentially important components of IPM.

The National IPM programme was set up in response to the widespread misuse of chemical pesticides, for which no formal regulatory procedures existed. In 1993, the Ministry of Agriculture and Rural Development's (MARD) Plant Protection Department (PPD), Pesticide Management and Registration Division introduced a regulatory procedure for the registration of pesticide products in Vietnam. Between 1995 and 1997, a total of 45 pesticides were banned from use and a further 30 were restricted. Changes were also made in the structure of the MARD so that the Plant Protection Sub Departments (PPSD) are no longer responsible for pesticide sales and distribution, which has allowed the PPSDs to expand IPM programmes more effectively. PPD had observed that pesticide use had decreased since the implementation of the National IPM programme and that a reduction in the percentage of insecticides relative to total pesticide sales had decreased from >83% before 1992 to approximately 52% in 1997.

The PPD Pesticide Management and Registration Division has two centres (Hanoi and Ho Chi Min) which conduct quality control testing to check pesticides before importation as well as random samples from shops. There are no quality control procedures for biopesticides as yet. Registration dossiers are reviewed by the pesticides committee, which meets twice annually. New products

take approximately 2 years to register during which time, PPD carries out efficacy testing of all new products at one or both of its 2 quality control centres. Once granted, registration is valid for 5 years. Information on banned, restricted and permitted pesticides in Vietnam is published in a booklet and up-dated annually. The most recent booklet (published in 1999) lists over 800 permitted pesticide trade names, including 12 Bt *kurstaki*, two Bt *aizawai*, one Bt + NPV virus mix and two *Beauveria bassiana* products. PPD have not established a unique set of regulatory requirements for the registration of biopesticide products, but they do follow the FAO published guidelines on the registration of biological pest control agents. The registration committee makes use of mammalian toxicity and ecotoxicological data supplied by the applicant. Mammalian and ecotoxicological tests are not carried out for biopesticides in Vietnam. There was a perception that *Trichoderma* would not be seen as a biopesticide from a regulatory point of view and no registration procedure for *Trichoderma* has yet been formulated.

Tax is applied to chemical pesticides at a rate of up to 10%, but the rate varies according to product. No tax is currently applied to the importation or sale of biopesticides. PPD felt that biopesticides are widely available, but their slow action was considered to be the most important constraint to uptake and use.

Industry structure

We were unable to find any commercial producers of biopesticides in north Vietnam, although we were informed that in the south of Vietnam biopesticides are more widely used on cotton and there may be some Vietnamese products on the market. We found one commercial Bt plus NPV mix (V-BT) which was distributed by a Vietnamese seed company called Trang Nong Seeds Ltd., but the product is produced in China. All other biopesticide products listed in the PPD booklet are imported. The availability of these registered products appears to be limited. In the one pesticide store that we visited only two Bt based products were available.

Research and Production

There are a number of institutions involved in research on biological pest control agents in Vietnam. We visited Hanoi Agricultural University No 1 (HAU) and the National Institute of Plant Protection (NIPP) as both have research programmes on *Trichoderma*. We were also informed of a number of other research establishments who are working on biological control. These included the Research Institute for Ecology and Biological Research and Environment, the Food Stuff Engineering Institute and The Vietnam Cotton Company, but we were unable to visit these within the time permitted.

HAU is the only agricultural university in Vietnam and offers BSc, MSc and PhD courses. The mandate of the university is three-fold: Teaching, Research and Extension. There are 7000 full-time and 3000 part-time ('in-service training') students and 10 faculties among which there is the Faculty of Agronomy with a Crop Science and a Plant Protection department. The Plant Protection department is divided into Entomology and Plant Pathology. *Trichoderma* research is carried out in the department of Plant Pathology.

HAU has been working on *Trichoderma* since 1996; they have just one isolate, which has been identified as *T. viride*. This was obtained from soil in Ba Vi district, Ha Tay province (North Vietnam). HAU scientists have tested the isolate using *in vitro* bioassays against a range of fungal soil diseases and have performed pot and semi-field trials using tomato plants at the university, but no details were given on the results of these trials. The laboratories are reasonably equipped for general plant pathology but they do not have good facilities for long-term storage of fungal isolates, identification, mass production or quality control, all of which are essential for commercial product development. The researchers did not seem to have good links

with extension workers or farmers although HAU is part of the IPM steering committee.

Funding is a problem at the university and there is a heavy reliance on international collaborative projects for the purchase of new equipment. Access to information is also fairly limited and collaboration with international scientists would be of great value in the areas of identification, long-term isolate maintenance, isolate selection (including field trial evaluation), mass production, quality control, product storage, formulation, application, registration and commercialisation.

NIPP researchers have been working on the development of biological pest control products for over 10 years with the aim of production and implementation of NPV, *Beauveria, Metarhizium, Trichoderma* and *Trichogramma chilonis*. This work has been funded by the State under projects named KC08-14 (1990 – 1995) and KC02-07 (1996 – 2000) and in part by a German NGO called 'Bread for the World' under a project named 'Improvement of Plant Protection Services in Vietnam' (phase one, 1990 – 1995 and phase 2, 1996 – 1998).

NIPP scientists have been working on *Trichoderma* since 1991, they hold 11 isolates of *Trichoderma* spp. which have been isolated from soil in various places in Vietnam. They also have an isolate (*T. harzianum*) from Hungary which they have selected for further development. Isolate selection was by means of *in vitro* bioassays against a range of fungal plant pathogens. Field trials have been carried out through work with IPM trainers and IPM farmer groups to test their *Trichoderma* product on vegetables. Mrs Ly has been involved in the National IPM programme as a disease management resource person for Training-of-Trainers courses. Since early 1999, she participated in the disease management participatory action research (PAR) activities in the Northern provinces, Hai Phong and Ha Tai, and the Southern province Lam Dong during which she introduced *Trichoderma* to farmers. Mrs Ly has supplied PAR groups in three provinces with between 6 and 12 kg of the *Trichoderma* product. *Trichoderma* is also supplied by NIPP

to the Forestry Institute, which pays VND 25,000/kg product for use in its nurseries.

The laboratories at NIPP are well maintained and equipped for research and development of biopesticide products, although the scale of mass production is rather limited. International collaboration (and funding) is required in the areas of identification, isolate selection (including field trial evaluation), scale-up of production, quality control, health and safety, formulation, application, registration and commercialisation. NIPP would see itself as the commercial producer of *Trichoderma*, but it would also consider technology transfer to capable private producers.

The NIPP researchers felt that constraints to the uptake of *Trichoderma* exist at all levels of development. At the farmer level, these included tradition, cost, availability, training and efficacy (variable performance). Researchers have concerns over scale-up of production, formulation, efficacy and shelf life. At the ministerial level, subsidies should be considered for biological pest control products. *Trichoderma* also faces a potential economic barrier in that for best effect, it should be used as a preventative treatment prior to the appearance of disease symptoms in the crop, whereas purchase of chemical fungicides is only required if and when disease symptoms occur.

Samples of *Trichoderma* taken from HAU and NIPP were assessed using standard quality control techniques at CABI Bioscience (UK centre, Ascot). Results (Table 1.) indicated that the product from NIPP was uncontaminated and reasonably viable considering the conditions and duration of storage prior to sampling. The HAU product was found to have lost viability, but the sample received was 10 months old and would be expected to have low viability according to the estimated shelf-life given by the scientists. There was also a high level of bacterial contamination in the sample; this may have been incidental or originated from the formulation materials, but in the absence of a quality monitoring procedure

during production it is not possible to identify the source of this contamination.

Table 1. Results of the CABI Bioscience product quality assessment on *Trichoderma* product samples from NIPP and HAU, December 1999.

Sample	Conidial count/g	Viability	Moisture Content	Contamination
NIPP *T. harzianum* (July 1999) Conidiated rice	7.9×10^9	78%	12.3%	* $<5 \times 10^3$ contaminants/g
HAU *T. viride* (Feb 1999) Conidia powder formulation	1.4×10^9	0%	6.6%	1.27×10^6 contaminants/g

** No contaminants detectable within the accuracy of the CABI standard contamination monitoring procedure (level of contamination detectable = >5 x 10^3/g product).*

Extension and Distribution

The National IPM Programme in Vietnam has been running since 1992. The programme started on rice production but now includes vegetables, soybeans, peanuts, tea and cotton. PPD does plant protection and IPM training. PPSD is the provincial office of PPD from where FFS and PAR are conducted in the province. Extension works from provincial extension centres and their role is to change farmers practices through for example, introduction of new varieties, fertilisers and pesticides, etc..

Within the IPM programme, farmers groups in three provinces, Ha Tay, Hai Phong and Lam Dong are doing participatory action research (PAR) on vegetable disease management. The farmers groups meet weekly to observe the crop and discuss general management practices needed, specifically disease management

practices. It is into these groups that the use of *Trichoderma* has been introduced through NIPP, and trials have been set up to test the effect of *Trichoderma* in controlling soil-borne diseases. Mrs Ly (NIPP) was invited to participate in the PARs and inform the trainers and farmers how to use *Trichoderma*.

We visited two sites where *Trichoderma* was being evaluated as part of the PAR programme on disease management. In preparation for the trials, seedlings were raised in banana-leaf-pots filled with soil from the canal (assumed free from soil borne diseases) mixed with compost. The field treatments were: 1. Compost (properly composted plant waste) plus *Trichoderma*, 2. Compost alone, 3. Fresh manure (partially composted waste and manure — traditional farmer practice). The *Trichoderma* was obtained through the facilitators (PPD staff, trained in IPM) from NIPP and mixed with compost 15 days prior to application. The first group that we visited (Ha Tay — Lhuong Duong village) had only recently set up their trial, the tomato plants had not started fruiting and there was no observable difference between any of the treatments. The group in Hai Phong had a more advanced crop having transplanted their tomatoes in October 1999. They both had selected an area where tomato wilts (fungal and bacterial) were important. The observations of farmers during our visit to this group showed that in all replications, the plant height in the treatments 1 and 2 was higher than in treatment 3 (approx. 78 cm vs. 75 cm). Another clear and consistent difference was found in the number of fruits per plant: approx. 14 for treatments 1 and 2 vs. 8 for treatment 3. One replication showed that blossom end rot occurred only in treatment 3 and not in the treatments 1 and 2. The general conclusion was that the plant development was slower in treatment 3 than in treatments 1 and 2, but no differences were apparent between the *Trichoderma* plus compost and the compost alone at that point in time.

In addition to the National IPM programme, a number of NGOs are active in the promotion of IPM. One such organisation is Agricultural Development Denmark Asia (ADDA). The ADDA IPM programme started in March 1999 and is funded for 3 years by

Danida. ADDA works with the farmers union in Hanoi province. They have started conducting a Training Of Trainers (TOT) mainly with farmers after which it is expected that through farmer training, 240 Farmer Field Schools (FFS) will be conducted on vegetables. ADDA feel that biopesticides should play a very important role in their programme. They hope to include NPV and Bt in their TOT curriculum but they have not done so as yet. ADDA train farmers in biocontrol in general, including the benefits of indigenous natural enemies. They are debating follow-up studies on biocontrol through farmers research groups. There is good potential for a direct link through this NGO for biopesticide distribution and sales particularly as NGOs can be directly involved whereas PPD and PPSD cannot. Furthermore, ADDA works together with the Hanoi Horticultural Technology Centre (HHTC) and the Hanoi farmers union. HHTC have training and lab facilities that could be used or upgraded for local biopesticide production.

In general, all IPM trainers were well informed about Bt and its use, but felt that they would need further training in the use and application of other biopesticide products.

Pesticide suppliers throughout Vietnam are trained by PPSD staff and require a certificate before they can operate their business. As part of their training, they are informed about Bt. Pesticide suppliers also receive information through workshops organised by chemical companies to promote their chemical products. In addition to the pesticide stores, co-operatives also operate in some villages. In Ha Tay, the co-operative supplied Bt to the farmers (at the farmers' request).

During a visit to a pesticide shop in Hai Phong province, we found two biopesticides (see Appendix 1 for labels):

Delfin (3,600 VND/10 g sufficient for1 tank = ½ sao)
V-Bt (8,500 VND / 50 g sufficient for 2 tanks = 1 sao)

(Note 1 VND ≈1/14,000 US$ and 1 sao ≈360m²)

The shop used to carry a stock of BtB (from Russia) but the lot has now past its expiry date. We were also shown a number of chemical products in addition to the two Bt products as if these were also considered biopesticides, indicating some confusion over what was considered a biopesticide. All pesticides, including biopesticides, were stored at room temperature. There were no cold storage facilities.

The retailer was familiar with the application of Bt and the target pests and recommended Bt as she was aware of the health problems caused by chemical pesticides. Demand for Bt was considered to be fairly high, this particular shop sold approximately 300 to 400 packets of Delfin per week in peak growing seasons.

Price comparison between Bt and chemical pesticides was dependent on the product. Cyperin or Cymerin (both cypermethrin) cost VND 6000 for 5 to 6 tanks, considerably less than either of the Bt products. However, the newer chemicals such as Pegasus (diafenthiuron) and Regent (a.i. fipronil) cost more than Bt products (Pegasus VND 10,000/tank, Regent VND 5000/tank).

Current constraints to the use of biopesticides, bearing in mind that Bt is the only biopesticide widely available, were considered to be price, variable quality and subsequent performance and speed of action, which is linked with a general lack of awareness/understanding of how biopesticides work.

Farmers Views

IPM-trained farmers

IPM trained farmers in both Ha Tay and Hai Phong were familiar with and used Bt. They were aware of its relatively slow action and happy to accept this knowing that the product was not harmful to human health either during spraying or after harvest (some

reported getting sick after spraying chemicals). They define a biopesticide as not harmful to the environment and as non-chemical. As participants of the PAR groups all farmers interviewed were also keen to discover if *Trichoderma* would be effective in protecting their crops against plant diseases. There was a general enthusiasm for biological control solutions and chemical pesticides were considered harmful to health and in the case of diamond back moth and cabbage white butterfly ineffective due to resistance. Farmers were able to obtain Bt easily either through pesticide shops or their cooperative, but stressed that there was rarely a choice of brands, while small shops and kiosks only stock chemicals. They were also aware of the variability in quality of Bt products; Chinese and Russian products were considered to be of poor quality, whilst American products were thought to be highly effective but rather expensive.

Most farmers only became aware of Bt through FFS training, but one farmer had been recommended Bt at the pesticide store after reporting resistance to the commonly used pesticides. Bt application is not different from application of chemical pesticides so farmers found it easy to use.

Farmers do not store Bt but buy it as and when required. Cooperatives keep stocks in a store room. Farmers check the expiry date before buying and were aware of the likely loss in efficacy if products were used after expiry.

The IPM farmers were keen to have biopesticide alternatives to all their major pest problems. In particular they listed stemborers in rice, fruit borers and leafminers on tomato and fruit (pomelo, orange, longam) and cabbage white butterfly, *Spodoptera*, *Helicoverpa* and aphids on vegetables (they are concerned that the lepidopterous pests may also become resistant to Bt).

In Hai Phong, the farmers were also keen to explore the possibilities of producing biological pest control products for themselves. One reason they gave was that they have experienced ineffective biocontrol of rats due to badly prepared and stored

Salmonella product in the local pesticide shops. They would trust the product more if they made it themselves. Even if making the biopesticide meant that they had to invest their own time and effort, they would prefer to do it themselves than buy it from a supplier. They also considered the possibility of selling to other farmers.

Non-IPM farmers

Neither of the non-IPM farmers interviewed were familiar with biopesticides although one had heard of Bt when asked specifically, although he said it was not generally available and he had never used it. He said he would be interested in trying Bt if he could be properly trained in its use and application. He was also aware that Bt was used against 'leaf eaters'.

Non-IPM farmers use chemical pesticides when pests are observed in the field and information on spray practices seems to come from relatives (grandparents and parents). New pesticide products are advertised on TV and radio.

NB. The non-IPM farmer that we interviewed in Ha Tay sat in on the interview with the IPM farmers, and having heard more about biopesticides, he became very enthused about their potential, especially in fruit trees.

Conclusions

1. The Vietnam National IPM programme provides a strong base for the uptake of biopesticide products. Besides Bt, farmer-participatory training in the testing and use of biopesticides has been limited due to the lack of availability of products, although links with NIPP have permitted the introduction of NPV and *Trichoderma* in some areas.

2. Regulatory procedures for registration of biological products have not been formally established, but biological products have been registered for use in Vietnam.

3. Biopesticides are not taxed under the current pesticide taxation system.

4. Twelve Bt products and two fungal biopesticides are currently registered in Vietnam, but very few appear to be actually available on the market.

5. A number of institutions in Vietnam are working on the development of biological control agents, but funding is limited and international collaboration is required in many areas to assist these institutes in bringing their agents to the point of commercialisation.

6. Mass production and formulation are key areas where assistance is required.

7. Research institutes do not have links with commercial collaborators.

8. *Trichoderma* is still an experimental product and its general efficacy is still to be proven at the farmer field level.

9. Availability of biopesticides other than Bt is severely limited. Shops that stock Bt rarely have more than two brands available.

10. Non-IPM trained farmers are not aware of biopesticide products and are unlikely to use them unless they are fully informed about their use.

Recommendations

1. Assistance should be offered to the Regulatory authorities on setting appropriate guidelines/data requirements in line with the harmonised OECD data requirements.

2. Links should be set up with the PPD quality control centres to keep them informed on progress with standardisation of quality control of biological products.

3. Funding for international collaboration with Vietnamese Research Institutes should be sought. Areas of particular importance are scale-up of mass production, quality control, shelf-life, formulation, application, registration and commercialisation of biological products.

4. An economic feasibility analysis should be carried out to establish which experimental products are most likely to become competitive commercial products.

5. Close links between Research Institutes and the National IPM programme should be further encouraged to introduce more farmers to various biological control products.

6. Training of retailers as carried out by PPSD should be broadened to include biopesticide products as they become commercially available.

7. The National IPM programme proves an excellent avenue to expose farmers to the concepts of biological control. However, the curriculum will need to be broadened beyond Bt.

8. Farmer-participatory research on new biopesticides should be supported following the PAR model initiated in Vietnam in 1999.

Summary of the Three Case Studies

This summary and following set of overall recommendations represents a collation of the key points and recommendations generated by the three case studies carried out in this series looking at the delivery of biocontrol technologies to IPM farmers in India, Nicaragua and Vietnam.

The findings of the three case studies are summarised below under the headings of policy issues, research and production, distribution and training and farmers views.

Policy Issues

Country	Policy and Economic environment	Regulatory framework and institutions
Nicaragua	• Growing organic sector, especially coffee, offers significant market opportunity • Min. of Ag. in theory supportive of biocontrol promotion but no differentiated or fast-track registration procedures • Donor policy has supported free/subsidised delivery of BCAs to date to convince smallholder farmers of benefits and generate demand	• WTO regulations could be too stringent for local initiatives • Regulatory institutions under-resourced and lack experience in biocontrol
Vietnam	• Incentives such as specialised credit schemes, tax exemption to encourage private sector entry	• Prior to 1993 no regulatory procedures existed in Vietnam for the importation or use of pesticide products. Currently the Vietnamese Plant Protection Department PPD pesticides committee is charge of registration. In addition, 2 centres of PPD (in Hanoi and Ho Chi Minh) conduct random checks on samples from shops and imported pesticides for quality control. There are no quality control procedures for biopesticides yet. • In the list of permitted pesticides there are 12 Bt. *kurstaki*, 2 Bt. *aizawai* and 2 *Beauveria bassiana* and 1 Bt.-virus mix to control insects.

India	• National Government have been promoting the use of Trichogramma through demonstration trials at 26 "Central IPM Centres" distributed throughout the country for the last 5–6 years. • Trichogramma has been widely used in sugarcane for borer control for many years and is actively promoted by sugar mills using parasitoids produced by private industry and State Government labs. • State Government extension produces and services sell Trichogramma at a subsidised rate to farmers. There are 36 laboratories in Tamil Nadu alone. • National Government has a new policy to provide funds to State Governments for the construction of biological control agent rearing laboratories. This is intended to encourage the use and increase the availability of biocontrol agents to farmers.	• Macrobiological control agents do not require registration in India, however, new legislation in 1999 requires that biopesticides be registered under the Pesticides Act. • There is no longer a subsidy on pesticides in India. • Fertilisers are subsidised • There is no direct subsidy on the production of biological control agents, but Government and State extension services sell them at a subsidised rate

Research and Production

Country	Research and Production institutions	Main biocontrol agents and commodities	Production cost	Constraints in production
Nicaragua	• National Agricultural University (UNA) • Nicaraguan National Autonomous University (UNAN) • UCA-Miraflor Farmers' Association	• *Beauveria bassiana* for coffee berry borer and for cabbage • *Metarhizium anisopliae* for control of rice bug, sweet pepper weevil and sugarcane and pasture spittle bugs	• UNA fungal products estimated at 8–12US$ per ha dose	• Spore harvesting is critical production bottleneck • Inadequate facilities and equipment • Limited physical and human resource capacity to meet demand • No national quality control body to oversee production standards
Vietnam	• Hanoi Agricultural University (HAU) • National Institute of Plant Protection	• *Trichoderma viride* for control of soil borne diseases, *Trichoderma harzianum* for vegetables		• Using the current system, production capacity is fairly low compared to that of LUBILOSA production facility in Cotonou . Although the *Trichoderma* is only an experimental product, they envisage that it will be further developed in their laboratories for commercial production.

India	• There are 56 private companies producing biocontrol agents in India, the first having been established in 1981. • 26 State Central IPM Centres promote use of *Trichogramma* and other biologicals • State Extension services sell *Trichogramma* at a subsidised rate. • NGOs are starting to produce *Trichogramma* at local level.	• *Trichogramma chilonis* different strains exist for sugarcane borers, cotton bollworms and rice leaffolders. • *Trichogramma japonica* for rice stemborers • Most companies produce range of additional biocontrol agents (macrobial, biopesticides and antagonists) • Principal market for most producers in State Gov. Extension services.		• Contaminants in host culture — *Bracon* spp. Stored product weevils and mites • High temperature in summer • Rearing host is labour intensive and expensive • Health hazard from host adult scales

Distribution and Training

Country	Institutions and training offered	Main biocontrol agents and source	Cost	Constraints to delivery and uptake
Nicaragua	• UNAN, UCA-Miraflor: artesanal production methods • CATIE-IPM network: IPM training • ADSA, ADDAC, UNA, UNAN: BCA distribution to farmers			• Insufficient production to meet current demand • Distribution to isolated smallholders problematic • Awareness of biocontrol benefits low among untrained farmers and technical staff • Shelf life a problem for frozen viral products
Vietnam	• PPD through national IPM programme • National Institute of Plant Protection supported training to farmers through the national IPM programme (PAR) activity • ADDA train farmers in biocontrol • Pesticide shop in Hai Phong	• Delfin and V-Bt for use in cruciferous vegetables against diamondback moth and CWB. Company contracted to supply	• Delfin (3,600 VND / 10 g); V-Bt (8,500 VND / 50 g)	• All pesticides, including biopesticides stored at room temperature.

India	• Central IPM Centres offer field demonstrations of *Trichogramma* use. • IPM Centres train farmers in augmentative biocontrol techniques • NGOs and donor assisted projects train farmers.	• Central IPM Centres produce their own *Trichogramma* • State extension services buy most of their material from commercial producers • NGOs starting to produce their own	• Commercial company price per card (20,000 eggs) = Rs 46 • NGO price Rs = 20 • State extension service = Rs 5–10	• Short shelf life 4–6 days max • Lack of refrigerated delivery • Centralised production units a long way from users • Lack of availability • Poor quality • Lack of knowledge among farmers

Farmers views

Country	Source of information and training	Main biocontrol agents and commodities	Views on safety, efficacy and cost
Nicaragua	• CATIE-IPM training network of technical staff and NGOs • Private foreign consultants (for sugarcane estate)		• Trained farmers: BCAs are competitive with all but cheapest conventional insecticides but pests may be resistant to these • Trained farmers: Fungal and viral products require fewer applications than chemicals and work well . There are no residue or poisoning problems. • Trained farmers: BCAs should not be stored for long and need to be applied early am or late p.m. • Untrained farmers may perceive BCAs as too slow-acting
Vietnam	• *Bt.* is available in pesticide shops the farmers' co-operative • *Trichoderma* is obtained from NIPP through the IPM facilitators	• Bt. is used against *Pieris* and *Plutella. Trichoderma* is expected to suppress pathogens in the soil, not fully understood yet.	• Farmers used to chemical pesticides and are perceived to have problems with the slow action of biologicals. • Variable Bt quality between and within brands however.

India	• NGOs • Donor funded farmers field school programmes • Central IPM Centres	• *Trichogramma chilonis*	• Difficult to evaluate • Hard to get hold of • Some farmers want to produce their own • Questionable efficacy in some crops/ situations

Overall Case Study Recommendations

Despite differences between countries and the specific biocontrol agents used, a number of common constraints to the delivery of biocontrol technologies exist, including: the need for a specific biocontrol regulatory framework or exemption or special status with regard to existing chemical pesticide regulations, inadequate production capacity, problems with product quality and shelf life, inadequate product distribution systems and the lack of knowledge among farmers of biocontrol technologies. These and related findings suggest that the following subject areas should be explored as ways of removing barriers to delivery of biocontrol technologies in developing countries:

- The impact and value of incentives (tax exemption, product subsidies, government promotion) on the availability and uptake of biocontrol products.

- The means by which appropriate product shelf life and quality standards can be achieved, monitored and maintained.

- The means by which the necessary support, experience and information to assist in creating an environment conducive to appropriate regulation of biocontrol technologies can be provided to national regulatory authorities.

- The economics of scale in relation to biocontrol technology production, quality, safety, and product distribution/ availability.

- The different means by which farmer knowledge of biocontrol technologies can be improved and maintained.

- Defining the role of farmer participation in the development and evaluation of new biocontrol products and the mechanism by which this can be best achieved.

- It is proposed that the above issues should be addressed at a workshop later in 2000 to consider in more depth how best to remove the barriers to the delivery of biocontrol technologies to farmers.

Appendix 1

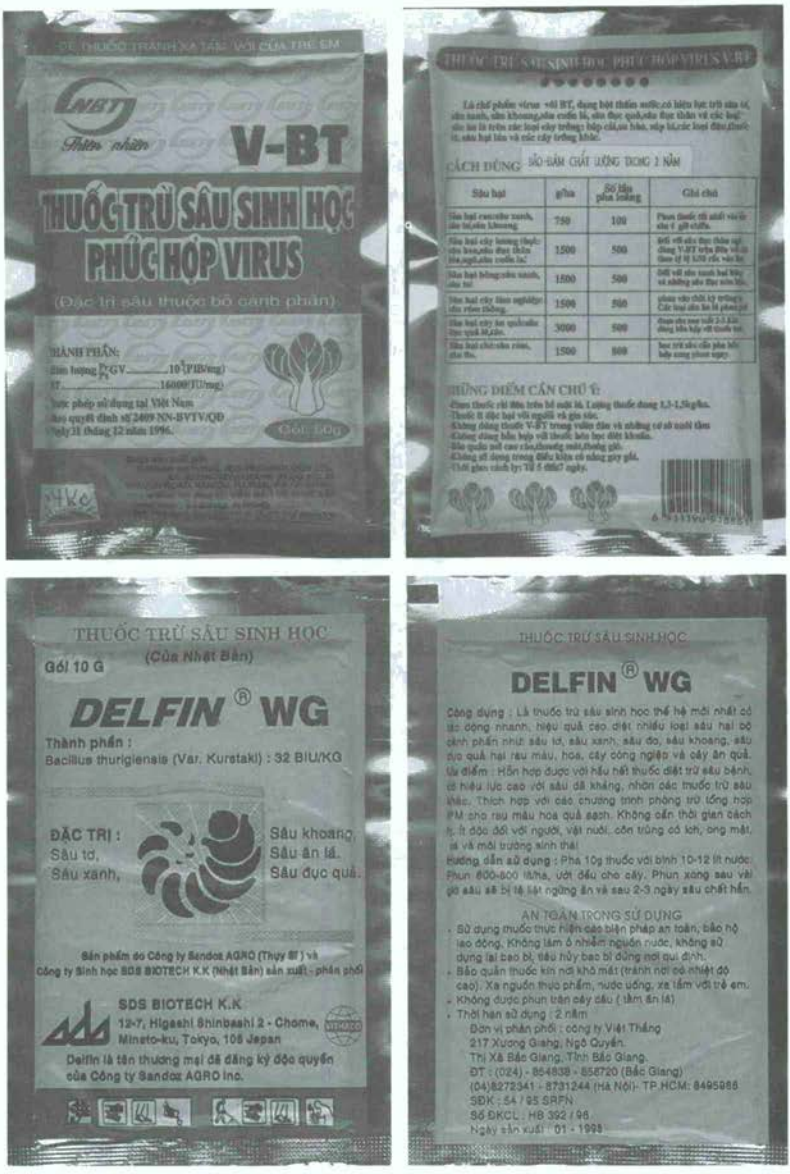

Figure 1. Product labels from two Bt based biopesticide products purchased from a pesticide shop in Hai Phong province.

Acronyms

ADDA	Agricultural Development Denmark Asia
BCPC	British Crop Protection Council
Bt	*Bacillus thuringiensis*
CABI	CAB International
Danida	Danish Ministry of Foreign Affairs
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmer Field School
HAU	Hanoi Agricultural University
HHTC	Hanoi Horticultural Technology Centre
IPM	Integrated Pest Management
MARD	Ministry of Agriculture and Rural Development
NGO	Non-government Organisation
NIPP	National Institute of Plant Protection
NPV	Nuclear Polyhedrosis Virus
NRI	Natural Resources Institute
PAR	Participatory Action Research
PPD	Plant Protection Department (of MARD)
PPSD	Plant Protection Sub-department (of MARD)
TOT	Training of Trainers
UNEP	United Nations Environment Programme

Index

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