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FARMERS' ACCESS TO NATURAL PEST CONTROL PRODUCTS: EXPERIENCE FROM AN IPM PROJECT IN INDIA

Robert Tripp and Arif Ali

Abstract

This study examines the outcome of an Integrated Pest Management (IPM) project in India. The study concentrates on the adoption and use of two novel pest control products for use on pigeonpea, neem seed kernel extract (NSKE) and nucleopolyhedrovirus (NPV). Both of these are natural products that can be produced by farmers, local-level enterprises, or commercial manufacturers. Farmers' and project experience are used to consider appropriate strategies for the provision of these products. The study compares results in two areas of Andhra Pradesh; in one, the IPM activities were managed by NGOs, while in the other the activities featured direct technical assistance. The study examines farmers' experience with using and maintaining these products and considers the sustainability of current strategies.

Research findings

Natural pest control products may be effective alternatives to conventional pesticides, but several issues deserve consideration.

- *When farmers adopt these new products, they use criteria of cost and efficiency, rather than the health and environmental considerations emphasised by IPM projects.*
- *Although natural pest control products may be produced by farmers or village enterprises, there are significant barriers to the sustainable establishment of this type of self-sufficiency.*
- *The widespread use of alternative pest control products will be encouraged by allowing farmers more opportunities to experiment with them and supporting the commercial manufacture of these products.*

Policy implications

- *Policy support is required for the commercial producers of alternative pest control products; attention is especially warranted for quality control and marketing issues.*
- *The existence of many independent donor IPM projects, often with competing philosophies and strategies, does not encourage the establishment of supportive policies for IPM.*

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Acronyms

DIPMP	Development of an IPM Programme for the Management of Pulse Pests in Southern Asia
DOA	Department of Agriculture
FFS	Farmer Field Schools
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
IFAD	International Fund for Agricultural Development
IPM	Integrated Pest Management
NGO	Non-Governmental Organisation
NSKE	Neem Seed Kernal Extract
NPV	Nucleopolyhedrovirus
RARS	Regional Agricultural Research Station
REEDS	Research in Environment, Education and Development Society

FARMERS' ACCESS TO NATURAL PEST CONTROL PRODUCTS: EXPERIENCE FROM AN IPM PROJECT IN INDIA

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1 INTRODUCTION

The use of broad-spectrum chemical pesticides is responsible for significant ecological damage, serious human health problems, and spiralling costs of production. Alternative pest control methods are often described as integrated pest management (IPM), although this term encompasses a wide range of strategies and technologies. It is generally acknowledged that an acceptable solution to the problem of pesticide misuse must include policy change, the establishment of knowledge-intensive and farmer-based approaches to pest management, and the utilisation of novel pest control techniques (Mumford and Stonehouse, 1994; Kenmore, 1996; Schillhorn van Veen et al., 1997).

This paper examines one part of the challenge of improving pest management practices, the introduction of new pest control inputs. IPM strategies are often based on the use of microbial pesticides, pest predators, or natural products narrowly targeted to control specific pests and with fewer health and environmental problems than most conventional pesticides. There are several attractive alternatives which are the subject of research, and some have already been incorporated in commercial agriculture (Marrone, 1999; Dent and Waage, 1999). Besides their safety and specificity, some of these natural products offer an additional advantage of allowing farmers to maintain or produce their own pest control products, rather than depending on outside markets. But these products present several challenges as well. First, their mode of action is often distinct from that of conventional pesticides, and farmers must learn to appreciate the differences. In addition, many natural pest control products are less stable than chemical pesticides and thus require particular care in manufacturing and distribution. Some of these problems can be addressed by more decentralised production, and this is linked to the principal issue addressed in this paper. What is the most appropriate scale and level of production for natural pest control products in order to ensure widespread adoption? Should they be the subject of farm-level or village-level production, or should they be provided by commercial firms?

The answers to these questions will vary according to the particular biocontrol product and the local farming and market conditions. The answers also depend on farmers' resources and their understanding of biological processes. This paper addresses these issues by examining two products that are part of an IPM project in India. The emphasis in the Indian case is on self-sufficiency, at either the farm or village level. We examine the degree to which this is an adequate strategy for the products in question.

The paper begins by describing the agricultural setting in which the IPM project takes place. The project focuses on pest control in pigeonpea (*Cajanus cajan*), one of the most important pulse crops in India's semi-arid regions. The paper then turns to describe a particular IPM project, the control products that were promoted, and the methods used to reach farmers. We then summarise the results of a small study that looked at the uptake of these new technologies; we look at who used the new products and examine the impact of adoption on other pest control practices. The next section discusses the implications of our findings, particularly for the challenge of identifying an appropriate strategy for the provision of innovative pest control products. This is followed by suggestions for improving IPM strategies and concluding remarks.

2 THE AGRICULTURAL SETTING

Pigeonpea is an important pulse crop in India, where it is grown on more than three million hectares, mostly in the semi-arid regions. Although it has traditionally been grown without chemical pesticides, the situation has changed rapidly in many parts of the country in the past decade. The widespread availability of broad-spectrum pesticides has encouraged their use on pigeonpea. Although these products were initially effective, their extensive use on many crops has caused the emergence of pesticide resistance in some insects, leading to further escalation in the range and frequency of pesticide application. The pesticide industry is well developed in India and both large and small companies vigorously promote their products for a wide range of crops. The use of high amounts of pesticide on pigeonpea is particularly worrying because the crop is often a mainstay of some of the poorest agricultural households, who are particularly likely to suffer adverse health and economic consequences.

Although pigeonpea is affected by several pests, by far the most serious in the area of our study is the pod borer (*Helicoverpa armigera*). The pod borer moths lay their eggs on the plant, the hatched larvae feed on the buds and flowers, and as they grow they begin to attack the pods and seeds. The life cycle is little more than a month, so several generations of pod borer can attack the developing pigeonpea crop (Reed and Lateef, 1990). This is not only an important pest of pigeonpea but also causes serious yield losses in other pulses, cotton and other crops.

Our study looked at pigeonpea pest management in two contrasting areas of the state of Andhra Pradesh. The areas were chosen because they were included in an important IPM project featuring the introduction of natural pest control products.

Part of our study focused on five villages in Mahboobnagar District. This site was chosen because it is typical of a broad area of the Telangana region of the Deccan Plateau, with relatively poor soils and uncertain rainfall. The majority of agricultural production in the area is based on dryland crops, particularly sorghum, maize, pulses (principally pigeonpea) and groundnut. Some farmers have access to tubewells for irrigating a portion of their farms, mostly for growing rice. The area is characterised by high levels of rural poverty, and farm yields and incomes are low. Prior to Independence most of this region was part of Hyderabad State, administered by the Nizam of Hyderabad, and its quasi-feudal organisation allowed little scope for agricultural innovation (Reddy, 1987).

The other part of our study was carried out in two villages in Guntur District, approximately 30km southwest of the town of Guntur. This is part of coastal Andhra Pradesh and represents a sharp contrast to Mahboobnagar. Guntur is one of the more advanced agricultural districts in Andhra Pradesh, and many farmers have access to canal irrigation. Although the study area has relatively little irrigation, it is still characterised by highly commercial agriculture, based on crops such as cotton, chilli, and soybeans. A significant minority of farmers grow pigeonpea. The area has been a centre of dynamic smallholder commercial agriculture for more than a century (Satyanarayana, 1990).

In the Mahboobnagar villages, 87% of the farmers said that pigeonpea was either their first or second most important source of crop income. In Guntur, many farmers do not grow pigeonpea, but we only interviewed those who had grown the crop in the past season. For the Guntur farmers who grew pigeonpea, 62% said that it was their first or second most important cash crop.

Table 1 presents an overview of the farmers and their practices. In the Mahboobnagar villages about half of the pigeonpea is planted as a monocrop and the rest is sown with green gram or groundnut. (In some other areas of Telangana pigeonpea is intercropped with sorghum or maize.) The Mahboobnagar farmers cropped an average of a little more than one ha of pigeonpea. Many of these farmers are illiterate and the average level of education is quite low.

In Guntur, the pigeonpea farmers generally used an intercrop of soybean, maize or other crops. Table 1 shows that the farm sizes are generally larger and the educational level is higher than in Mahboobnagar.

When survey farmers were asked to identify their major problem in pigeonpea production, 76% in Mahboobnagar and 44% in Guntur said pest damage. Drought was named as the major problem by 24% of the Mahboobnagar farmers and 56% of those in Guntur; most of these farmers identified pest damage as their second most pressing production problem. In Mahboobnagar, 92% of the farmers said that pigeonpea was either the first or second most important source of their pesticide expenses; the equivalent figure for Guntur was 61%. All farmers in both areas identified pod borer as the most important pigeonpea pest.

Pest control practices vary somewhat between the two study areas. Table 2 shows that farmers in Guntur use a wider array of pesticides. (They also are more likely to use these same pesticides on other crops.) Organophosphates are the most common type of product used in Guntur, while organochlorines (principally endosulfan) are the most common type of pesticide used by pigeonpea farmers in Mahboobnagar. The majority of farmers in both areas obtain pesticides on credit, although the proportion is higher in Guntur. In the majority of cases (in both areas) credit is obtained from the pesticide shop in the village or a nearby town. Only in a few cases did farmers report obtaining credit through a commission agent (who purchases pigeonpea at harvest).

The pesticides are applied with hand pumps in Mahboobnagar and motorised sprayers or tractor-mounted equipment in Guntur. Only a minority of the Mahboobnagar farmers own their sprayers, while the majority of the Guntur farmers using motorised sprayers own the equipment. Despite the wider range of pesticides used in Guntur, the number of pesticide applications in Guntur and Mahboobnagar is roughly equivalent, averaging about four times (Table 2). This average masks considerable variation, however, and a farmer's number of pesticide applications depends on the severity of pest attack and the status of the crop. In Guntur, farmers may have applied less pesticide in 2000 than in 1999 because it was a particularly dry year.

3 THE IPM PROJECT

The technologies

The study was done in conjunction with the project, 'Development of an IPM Programme for the Management of Pulse Pests in Southern Asia' (DIPMP). The project received financial assistance from the International Fund for Agricultural Development (IFAD) – and was coordinated by the International Crops Research Institute

Table 1 Farm characteristics in the two study areas

Area	Month of sowing pigeonpea	Intercrop	Total pigeonpea area (ha)	Total farmed area, kharif 2000 (ha)	Farmers' years of education	Farmers' age
Mahboobnagar (N=50)	June	Monocrop (47%) Green gram (42%) Groundnut (11%)	1.1	2.1	2.4	44.3
Guntur (N=29)	July	Soybean (38%) Maize (43%) Other (19%)	3.2	5.1	8	43.6

for the Semi-Arid Tropics (ICRISAT). Although the project involved pulse crop management in several countries, our study only looked at activities related to pigeonpea in the state of Andhra Pradesh. The project responded to the problem of pulse farmers' growing dependence on chemical pesticides as well as evidence of an increase in pesticide resistance for several major insects. The project sought to identify the most appropriate IPM strategies; to devise effective ways of testing, validating and demonstrating them on-farm; and to motivate farmers to adopt them. In the case of bio-pesticides that were not readily available in the market, the project helped organise local production strategies.

The DIPMP refined and promoted a wide range of technologies for pigeonpea management. These include the natural pest control products described below, other techniques for controlling pod borer (especially shaking the pigeonpea plants to dislodge the larvae and the installation of bird perches to attract insectiverous birds), and the use of pheromone traps to monitor pest levels to help plan control strategies. In addition, the project tolerated the judicious use of recommended chemicals in instances where other techniques for insect control were unsatisfactory. Finally, the project provided recommendations on seed treatment, fertilisation and weed management, as well as facilitating access to seed of several new varieties of pigeonpea.

Although the DIPMP was involved in a wide range of activities, this paper concentrates on the introduction and utilisation of two products, neem seed kernel extract and nucleopolyhedrovirus.

Neem seed kernel extract (NSKE)

Various products of the neem tree (*Azadirachta indica*) have long been utilised for pest control in traditional farming communities; dried neem leaves or neem leaf infusion are used for grain storage, for instance (Ahmed and Grainge, 1986). Neem provides a mixture of biologically active compounds with antifeedant, growth regulatory, repellent, hormonal or pesticidal properties (ibid.).

The DIPMP promoted the use of NSKE. This is prepared by collecting the neem fruits when they fall at the beginning of the rainy season (April–May). The fruits are soaked for several days in order to separate the seed. The seed is dried and shelled to leave the kernels. The kernels are soaked in water and crushed on a grinding stone or with a simple electrical grinder. The resulting paste is put in a cloth bag, soaked for several hours and then squeezed in water to produce a milky suspension. This suspension is filtered through a cloth, mixed with a small amount of detergent, and used to spray on the pigeonpea crop. NSKE is particularly recommended for spraying when the pigeonpea crop begins to flower, in order to discourage the feeding and egg-laying of the pod borer and other pests.

Table 2 Pesticide use in the two research areas*

Area	Number of different pesticides used	Number of applications, 2000	Number of applications, 1999
Mahboobnagar (N=50)	1.6	3.8	3.7
Guntur (N=29)	3.6	4	4.9

* These figures are for all farmers, including IPM participants

Although it is possible to prepare NSKE at the household level, there are several impediments. The preparation takes a certain amount of time and labour. Grinding the kernels is perhaps the most problematic aspect of the preparation, particularly because women object to the strong odour the neem imparts to the grinding stone. The collection of the neem fruits must be done at a time when land preparation and other tasks are being performed. In addition, some planning is required; the seed or kernels are usually stored for several months until the extract is needed (September–October) because their biological activity is relatively short-lived. In addition, neem trees are more prevalent in some areas than in others.

A number of non-governmental organisations (NGOs) have addressed these problems by encouraging the establishment of village-level NSKE production facilities, often organised by women's groups. Such groups may be given a small electrical grinder and they provide custom grinding for farmers who have collected neem kernels.

There are also many commercial neem products available on the market, including various types of neem oil, from a wide range of manufacturers. The government has attempted to promote these products (because they are environmentally benign) and the Andhra Pradesh Department of Agriculture (DOA) sometimes provides farmers access to subsidised neem oil.

Nucleopolyhedrovirus (NPV)

NPVs are a type of virus commonly found in insects. Ingestion of the virus by the target insect leads to infection in the mid-gut cells, which is followed by secondary viral replication in other cells, causing death (Winstanley and Rovesti, 1993).

An NPV specific to the pod borer has been identified (*H. armigera* NPV or Hear NPV). This NPV can be reproduced and maintained at the farm level, but it is also produced commercially. It is possible for an individual farmer to prepare NPV, after initial access to a virus preparation. The farmer must collect the dead larvae which have ingested the virus; approximately 500 larvae are needed to prepare enough NPV solution for 0.5 ha of pigeonpea. The dead larvae can be ground on a stone, crushed in water, and the filtered decoction can be diluted to give the appropriate concentration. Such a preparation can be kept for up to a year if it is stored in the dark in a cool place. NGOs provide instruction and advice on farm-level NPV production, and the DOA also promotes local-level NPV production.

The unpleasant task of grinding hundreds of dead and decaying larvae, as well as problems in collecting the larvae and storing the solution, suggest that a more centralised approach to NPV production is required. The DIPMP has helped several NGOs to establish NPV production units. The requisite equipment was also supplied to a farmers' club in Guntur. In the local NPV production strategy, farmers collect healthy larvae from their fields. These should be fairly well developed (third or fourth instar). Because of their voracious appetites and cannibalistic tendencies, the larvae must be kept separate. They are placed in specially designed plastic trays (not unlike those used for making ice cubes in a freezer); one larva and a chickpea soaked in virus solution are placed in each compartment. The larvae are allowed to feed on the infected chickpea and the virus develops; after five days dead larvae are removed and placed in a blender. The resultant liquid is filtered through muslin and centrifuged. The sediment (containing the virus) is retained, diluted to the appropriate concentration and stored in a refrigerator until use. The DIPMP provided the trays, food blender, centrifuge and a small refrigerator for local NPV units.

Because the virus is sensitive to UV radiation, farmers are instructed to spray the NPV suspension late in the afternoon. Farmers must also understand that the virus works more slowly than chemical pesticides and that they should not expect to see the effects until about four days after spraying.

Various NPVs have been used in specific circumstances for commercial agriculture in several industrialised and developing countries. NPV is produced commercially by a number of firms in India (Grzywacz and Warburton, 1999). Most of these commercial products are sold to government agencies or programmes for use in IPM endeavours. NPV is also produced by a number of government laboratories in India.

Promotion strategies

Our study examined two principal strategies for promoting the new technology. In Mahboobnagar the DIPMP worked with a network of NGOs, while in Guntur it worked intensively in one village, providing technical support and advice.

There is a remarkably wide range of NGOs operating in India; one author estimates that 15–20,000 NGOs are engaged in rural development activities in the country (Put, 1998). Some of these are literally one-person operations, while at the opposite extreme some are large organisations employing hundreds of staff. Many of those involved in agricultural activities receive foreign donor contributions. In 1987 there were 1,369 voluntary organisations registered in Andhra Pradesh under the Foreign Contribution (Regulation) Act (ibid).

NGOs working in agricultural development follow various strategies and philosophies, although those promoting IPM often share certain approaches. It is not uncommon to find that these NGOs establish themselves through activities of immediate interest to rural people, such as thrift groups (for savings and small loans) or access to water, before entering into agricultural technology. IPM is attractive to many of these NGOs because its techniques emphasise a reduction in the use of external inputs and the utilisation of local resources. NGOs differ in their approaches to agricultural technology; some take a pragmatic approach while others emphasise the elimination of all chemical inputs. These approaches depend on the leadership of the NGO and, not infrequently, the availability of funding. There are cases, for instance, where an NGO runs a strict 'non-pesticide management' programme in some villages while promoting more eclectic approaches to IPM in other villages, under different donor support.

A major effort of the DIPMP concentrated on building a network of NGOs to promote IPM for pigeonpea and chickpea. Several independent NGOs collaborated with the work, but the majority of the activity in Andhra Pradesh was managed by 12 NGOs, coordinated by an umbrella NGO. Each NGO was active in a limited area (often only a few villages). Our study was conducted in an area of Mahboobnagar District where REEDS (Research in Environment, Education and Development Society) was active. It had an established programme of development activities in place before taking on the IPM work, including thrift groups for women farmers. REEDS also had worked in other endeavours, including improving and maintaining the local water supply, joint forest management, and local government initiatives.

Strategies for IPM promotion varied somewhat among the NGOs, but several common elements were utilised by REEDS. Introductory presentations were made about the advantages of IPM during monthly meetings which were part of REEDS' activities. Cultural events such as plays were organised to present the IPM message. Demonstration plots were also established, showing a range of IPM technology. Interested farmers, often members of thrift groups (or their husbands), approached REEDS for help and advice on IPM. In one village a women's group was helped to begin management of an electric grinder for NSKE preparation. Some participants have also been given NSKE. REEDS at first distributed NPV provided by ICRISAT, but later they established their own NPV production unit. All of those farmers who use NPV were given the virus suspension; a few of these farmers provided larvae in return, and REEDS hopes to establish some charges for NPV in the future.

In summary, farmers who are designated in our study as 'participants' in the IPM programme in Mahboobnagar are not necessarily part of a formal group, but take advantage of advice or access to biocontrol inputs through the NGO.

Our study also included the village of Goddipadu in Guntur District, where a different promotion strategy was utilised. The DIPMP stationed a technician in the village for two years to carry out demonstrations and trials and to help interested farmers gain access to biocontrol inputs. NSKE was not promoted here, but our study reports the enthusiastic uptake of NPV by a small number of farmers in the village. Although part of this uptake can be credited to project activities, the unusual history of Goddipadu also contributes to patterns of technology diffusion. The village has been an 'adopted village' of Lam Farm, the nearby Regional Agricultural Research Station (RARS) of the state university, for more than a decade. Many of the farmers have experience in visiting Lam Farm to ask for advice or to learn about new technology, and Lam Farm has organised many demonstrations and visits in the village.

As in most such instances, a small core of interested farmers leads the way in establishing and maintaining contacts with outside technicians. In Goddipadu, a group of about twenty young men has recently established a farmers' club in order to facilitate these types of links. Several members of this club are among the most enthusiastic users of NPV. In 2000, the project donated the equipment for an NPV production facility to the farmers' group. Although many farmers in the village are familiar with the project activities, for the purposes of this study, Guntur 'participants' are those farmers who are currently using locally prepared NPV on pigeonpea.

4 TECHNOLOGY UPTAKE

The adoption study

This paper reports some of the results of an adoption study carried out in February 2001. More complete information is available in Tripp and Ali (2001). The study in Mahboobnagar included three villages which participated in the DIPMP through activities directed by REEDS. The survey included a village that had been one of the first to receive attention when the IPM programme began three years ago, a village that joined a year later, and a village that had just completed its first year in the programme. Information from these three villages was complemented by interviews with farmers in two nearby non-project villages.

In Guntur, the DIPMP concentrated in Goddipadu village. The survey included participating and non-participating farmers in this village. In selecting a second village for comparison, we chose one where a few farmers had purchased commercial NPV, prepared by a small firm near the town of Guntur. The second village (Uppalipadu) was within ten km of Goddipadu and seemed representative of the area in other ways, and we wished to take advantage of this relatively unusual instance of commercial biocontrol use to learn more about farmers' experience.

In those Mahboobnagar villages where the project was established, we made an attempt to interview farmers who were particularly active in following the IPM recommendations. We also obtained a list of all pigeonpea growers in these villages and randomly selected a sample of non-participating farmers. We were able to interview a total of 17 participants and 13 non-participants in the three villages. In the two non-project villages we approached the village authorities and obtained a list of all farmers. From these lists we randomly selected ten farmers from each village. In Guntur, we interviewed all eight of the current participants in Goddipadu village and used a village list to randomly select eight other pigeonpea growers for comparison. In Uppalipadu, we traced five of the six farmers who had purchased commercial NPV and interviewed an additional eight farmers who were randomly selected from a register provided by the village authorities. (In addition, we conducted a group interview in a third village where some farmers had experience with NPV through contacts with Lam Farm or through using the commercial product.)

Our study was carried out in a very restricted time frame and with a small budget, so our sample size is necessarily limited. In addition, the farmers in the survey fall into several different categories (e.g., divided by participation, region or type of village), so when we make comparisons among categories we will necessarily be referring to small numbers of farmers. This makes strict statistical tests difficult in many cases, but we believe that the data are sufficient to tell a consistent and useful story.

Technology utilisation

Neem seed kernel extract (NSKE)

All but one of the 17 IPM farmers in our Mahboobnagar sample used NSKE during the 2000 season. The number of applications varied from one to ten; the mean was 3.4 and 75% of the farmers applied NSKE between two and four times. Four of the farmers also reported using the NSKE on groundnut. All but two of the farmers were satisfied with the results and said they would continue.

There were, however, concerns from a number of the farmers regarding the labour requirements of kernel collection and/or grinding. Several farmers had used NSKE in the past but had found its preparation too laborious and discontinued its use. All but two of the NSKE users collected the kernels themselves; one farmer purchased all of the kernels and another purchased some to supplement his own collecting. Two of the farmers ground all the kernels at home and another two ground some at home, but the rest used the grinder provided through REEDS. Only two of the 12 farmers who relied exclusively on the NGO grinder reported paying anything for the grinding.

In both Mahboobnagar and Guntur a number of farmers also reported experience with commercial neem oil. This is available in a few shops and in some areas it is recommended and even subsidised by the DOA. In Mahboobnagar eight (16%) of the farmers in our sample had tried neem oil on pigeonpea in the past two years (including four of the IPM farmers), although only half were satisfied with the result. In Guntur 18 (62%) of the farmers had experience with neem oil, mostly on pigeonpea or cotton, but only two (11%) of them were satisfied with the result.

In summary, almost all of the IPM farmers in Mahboobnagar used NSKE, mostly derived from neem kernels they had collected themselves. They prepared the extract themselves, but in most cases the difficult task of grinding had been done without charge through the NGO. They were generally pleased with the results and claimed they would continue to use NSKE. Their experience is in contrast to many of the farmers in both areas who had tried commercial neem oil and found it unsatisfactory.

Nucleopolyhedrovirus (NPV)

Ten of the 17 IPM farmers in Mahboobnagar used NPV on their pigeonpea in 2000. In all cases the NPV was prepared for them by the NGO without charge, although two of the farmers reported providing larvae for the

Table 3 Knowledge and practices of NPV users

NPV users	Apply NPV only in late afternoon	Recognise that NPV is specific for pod borer
IPM farmers, Mahboobnagar (N=10)	30%	0%
IPM farmers, Guntur (N=8)	100%	88%
Commercial NPV users, Guntur (N=5)	100%	60%

virus multiplication. Four of the farmers used NPV once, four applied it twice, and two farmers applied it three times. On the instruction of the NGO, most of these farmers added some laundry bluing agent to the NPV (to help absorb UV light). All but one of the farmers were satisfied with the performance of NPV and all claimed they would use it again.

In Guntur, the eight IPM farmers in Goddipadu all used NPV that they prepared themselves, using equipment provided by the project. The average number of applications of NPV was 4.5, significantly higher than in Mahboobnagar. All of these farmers claim they will continue to use NPV.

In addition, we talked to five farmers in Uppalipadu who had purchased commercial NPV through a contact the company had made in the village. Three of these farmers applied it once, and one each used it two and three times, respectively. They all had been told by the company representative to add *jaggery* (raw sugar, to stimulate feeding) and bluing agent to the commercial product. Two of these farmers claim they will use NPV next year, one will not, and two are undecided. Farmers in a group interview in a third village who had experience with both locally produced and commercial NPV were generally pleased with NPV, although they were concerned about the length of time it took to act and expressed the opinion that high temperatures adversely affected its performance.

Table 3 shows two features of NPV use related to the unique nature of this product. Because NPV is sensitive to UV radiation, farmers are told to spray in the late afternoon. In this way the product has the rest of the evening and night to be ingested by the larvae, which tend to be more active in the evening in any case. However, farmers usually apply conventional pesticides earlier in the day, and changing the time of application may not be acceptable unless the farmer understands the rationale behind the recommendation. A minority of the NPV users in Mahboobnagar followed this recommendation but most applied NPV early in the morning. In contrast, all of the farmers in Guntur followed the recommendation for late afternoon application.

In addition, it is helpful if the farmer understands that NPV is a special product effective against only one kind of pest. None of the farmers in Mahboobnagar appeared to understand this message, while the majority in Guntur recognised the specificity of NPV.

In summary, virtually all of the farmers who used locally prepared NPV were satisfied with the results and will continue to use the product. Most of those farmers in Mahboobnagar have been provided the NPV free of charge. The farmers in Guntur, on the other hand, are accustomed to preparing their own NPV, and they use the NPV more extensively than do their counterparts in Mahboobnagar. The farmers in Guntur who tried commercial NPV gave it a cautious test, and their opinions are divided regarding its efficacy. Most farmers in Guntur have a better grasp of the specificity of NPV than do those in Mahboobnagar.

Impact

The project obviously has been successful in introducing farmers to two useful pest control products, NSKE and NPV. IPM farmers have either prepared these products for themselves or had them provided by an NGO. The majority of these farmers are satisfied with the performance of the new products and say they will continue to use them. However, there is very little evidence (at an admittedly early stage) that these practices are spreading spontaneously to other farmers.

Table 4 The effect of IPM participation on pesticide use in Mahboobnagar

Farmers	Pigeonpea area (ha)	Number of pesticide applications in 2000	Number of pesticide applications in 1999	Number of different pesticides
IPM farmers (N=17)	1.0[a]	2[b]	2.6	1.1[d]
Non-IPM farmers in project villages (N=13)	0.7[a]	3.5[b,c]	3.9	2.1[d]
Farmers in non-project villages (N=20)	1.5[a]	5.5[c]	4.4	1.7

a. differences significant by t-tests at p<.01
b. difference significant by t-test at p<.05
c. difference significant by t-test at p<.01
d. difference significant by t-test at p<.05

Does the use of NSKE and NPV alter other pest control practices? Table 4 shows that the IPM farmers make significantly less pesticide applications and use fewer different pesticides than their neighbours in the same villages. Their use of pesticide is also less than those farmers in non-project villages. It is difficult to say if these differences are solely due to participation in the programme, or if other factors (such as differences in farm type or self-selection of participants) also contribute. However, one answer is provided by the sample from the village in Mahboobnagar where farmers are in their first year of participation. The IPM farmers made less than half of the pesticide applications that they made the previous year (1999), while the non-participants made, on average, exactly the same number of applications. It also should be noted that in addition to using fewer pesticides, two-thirds of the instances of pesticide use by IPM farmers are endosulfan (which is one of the products tolerated by the IPM programme), while only about one-third of the pesticide use by farmers in the rest of the Mahboobnagar sample is endosulfan.

In Guntur, the study concentrated on NPV. Table 5 compares pesticide practices for the three types of farmers in Guntur (IPM farmers, commercial NPV users, and others). The IPM farmers made significantly fewer pesticide applications in 2000 (and in 1999, when they were also participating in project activities) than other farmers, and they used fewer different pesticides.

The sample of commercial NPV users in Uppalipadu is too small to be able to draw any firm conclusions, but it would appear that for the most part they are simply testing NPV as they would any conventional pesticide and that its use has not contributed to any significant change in their practices. In the village where we held the group interview, we found that NPV is treated as an additional pesticide, rather than as a radically different approach. These farmers often mix NPV with conventional pesticides, and claim that they usually reduce the normal dose of the conventional pesticide in such a mixture.

There is thus strong reason to believe that participation in the IPM programme has made a significant change in the pest control practices of farmers. Not only do they make fewer applications of pesticide but they also use fewer different pesticides. We may ask whether these changes represent a sustainable alteration in pest control practices. On the one hand, farmers' general enthusiasm for the new products is a positive sign. On the other hand, we must recall that the adopters in Mahboobnagar have been provided NPV at no charge and, in the majority of cases, have been provided access to grinding facilities for producing NSKE. In addition, many of the adopters (including a few farmers who have not used any pesticides in 2000) are beneficiaries of other activities of the NGO (such as thrift groups or the provision of other services) and thus have an added incentive to follow the IPM recommendations. Whether the use of these biocontrol products will continue in the absence of these subsidies and incentives or, more importantly, whether the practices will spread to other farmers, remains to be seen.

In Guntur, the members of the Goddipadu farmers' group are enthusiastic users of NPV and will certainly continue in the immediate future. But they too have been provided equipment for NPV production, and in any case are farmers who are particularly anxious to collaborate with the local research station. Most other farmers in the village whom we interviewed were familiar with NPV but professed little interest in using it. Indeed one non-participating farmer had decided to use no pesticides on his pigeonpea this year (based on experience with cotton). Although he was familiar with the NPV technology he believed the production process was too time-consuming to be worthwhile. In the nearby village of Uppalipadu, the few farmers who had tested commercial NPV were divided in their opinions about the product.

Another way of assessing the sustainability of the IPM recommendations is to examine farmers' opinions about pesticides and their rationale for using alternative products. The IPM message is based in part on concerns about the safety and efficacy of conventional pesticides. Table 6 summarises responses to questions that we asked Mahboobnagar farmers regarding the performance of pesticides and (in the case of NPV and NSKE users), the rationale for using natural pest control products. A little

Table 5 The effect of IPM participation on pesticide use in Guntur

Farmers	Pigeonpea area (ha)	Number of pesticide applications in 2000	Number of pesticide applications in 1999	Number of different pesticides
IPM farmers (N=8)	1.7	1.3[a]	2.3 [b]	1.9 [c]
Farmers using commercial NPV (N=5)	2.7	4	5.4	4.2
Other farmers (N=16)	1.7	5.4 [a]	5.8 [b]	4.1 [c]

a.Difference significant by t-test at p<.001
b.Difference significant by t-test at p<.01
c.Difference significant by t-test at p<.01

less than half of the farmers believe that conventional pesticides are still as effective as they were in the past. There is no difference in the opinions of the IPM and non-IPM farmers in this regard. Likewise, the vast majority of both types of farmer believe that pesticides have a positive effect on plant growth. Most of the farmers in both groups are also very casual in their concerns about health risks from pesticides. Although some acknowledge that they have suffered difficulties, this is often seen as a badge of honour, and many claim that pesticides are not dangerous if handled with care. A number of those who complain of the declining efficacy of pesticides joke that if the products don't even kill the insects anymore they can't be harmful to humans. On the other hand, there is evidence that a larger proportion of the IPM farmers have accepted the message that pesticides can be harmful to beneficial insects.

When the Mahboobnagar IPM farmers were asked to name the advantages of the alternative products, they only mentioned effectiveness and low cost. None mentioned any environmental or health justifications. Thus it appears that although the IPM farmers are now familiar with the new products, they have adopted relatively little of the reasoning behind their promotion. Their judgements are largely based, understandably, on a search for cheap and effective methods to control the pests that destroy part of their harvest.

The situation in Guntur is only slightly different. The most outstanding feature of Table 7 is that Guntur farmers in general are less satisfied with the performance of pesticides than are their counterparts in Mahboobnagar, and they are more likely to recognise the harmful effects of pesticides. However, with the exception of beliefs about pesticides' effect on plant growth, the opinions of the IPM farmers cannot be distinguished from those of the other farmers.

A notable difference between IPM farmers in the two study areas is that the majority in Guntur mention health or environmental concerns as a justification for the use of NPV. But farmers still place efficacy and cost uppermost in their considerations of pest control methods. Although NPV had caused some interest among farmers in all three Guntur villages that we visited, the arrival of a new pesticide (indoxacarb) on the market was capturing an increasing share of attention and hope.

5 CHALLENGES

The project approach to IPM

One of the problems in promoting IPM is the fact that the work is often carried out by a large number of uncoordinated projects. We have described the activities of one donor project, but similar IPM technologies are being promoted by other donor projects as well as by a number of government programmes and institutes. For delivering basic messages, such as the importance of reducing pesticide use, a wide range of efforts is certainly appropriate. But when the message concerns relatively complex technology (such as that described in this study), more coordination is necessary.

The promotion of most agricultural technology faces a difficult choice between widespread promotion, with an inevitable sacrifice in the quality of the message, and intensive activities in selected villages, in order to focus message delivery and demonstrate impact. There are several justifications for an intensive approach, especially for something as complex as alternative pest control products. However, there are also costs associated with an intensive strategy. Pilot projects and model villages quickly absorb most of a programme's attention, leaving little time or resources to invest in more general diffusion strategies. If one pilot village or

Table 6 Opinions about pesticides and biocontrol products, Mahboobnagar

Opinion	IPM farmers (proportion agreeing)	Other farmers (proportion agreeing)
Pesticides are as effective as they were in the past	6/13 = 46%	12/30 = 40%
Pesticides have a positive effect on plant growth	15/17 = 88%	31/33 = 94%
Pesticides harm beneficial insects	7/17 = 41%	5/32 = 16%
Pesticides have caused health problems	5/16 = 31%	11/33 = 33%
Health or environmental factors help justify the use of NSKE	0/14 = 0%	N/A
Health or environmental factors help justify the use of NPV	0/7 = 0%	N/A

Table 7 Opinions about pesticides and biocontrol products, Guntur

Opinion	IPM farmers (proportion agreeing)	Other farmers (proportion agreeing)
Pesticides are as effective as they were in the past	2/8 = 25%	5/20 = 25%
Pesticides have a positive effect on plant growth	0/8 = 0%	8/20 = 40%
Pesticides harm beneficial insects	7/8 = 87%	17/21 = 81%
Pesticides have caused health problems	4/8 = 50%	8/21 = 38%
Health or environmental factors help justify the use of NPV	5/8 = 63%	N/A

project (out of perhaps several attempts) demonstrates success, this quickly becomes a focus of attention and is seen, in Chambers' (1997) phrase, as an 'island of salvation'. Such islands are useful for demonstrating potential, but if they are found in the midst of a sea of indifference, then utility for promoting broader diffusion is questionable.

There is a growing tendency to rely on NGOs for the promotion of IPM. The more effective NGOs certainly provide significant advantages for the introduction of such techniques. They have staff based in or near the target villages who are generally well regarded by farmers. The NGO staff have the presence and the dedication to work with farmers in establishing alternative crop protection practices. However, the NGOs also present a number of limitations.

In the first place, with few exceptions, the NGOs have little technical expertise. This has long been recognised as a particular weakness in NGO participation in agricultural technology development (Farrington and Bebbington, 1993). Some larger NGOs or umbrella organisations may hire technical staff who can visit the generalist field workers. Although much of the promotion activity does not require highly trained personnel, a competent system of technical backstopping is needed. It is too easy to assume that because IPM involves 'natural' or 'local' inputs it requires little understanding or experience. In the case described in this paper, little emphasis is given to utilising the discovery learning techniques that are most useful for helping farmers gain ownership of IPM techniques (S. Williamson, pers. comm.). In addition, the NGOs do not have the technical capacity to provide quality control for the NSKE or NPV that they promote.

Another problem with over-dependence on NGOs for IPM promotion is that they have little incentive to collaborate among themselves (Put, 1998). This further diminishes the possibilities of establishing an effective technical backstopping system, and it limits the degree to which they are willing to learn from each other or create the critical mass necessary to push for widespread changes in attitudes and policies towards pest control.

Finally, it is difficult to escape the conclusion that much of the blame lies with the donors themselves. Each one is intent on carving out its own territory for a project. Jeger (2000:789) speaks of the phenomenon of proliferating IPM projects taking on 'many of the residual garments of neo-colonialism, with competing donors following different agendas'. A donor adopts a particular NGO and, if things go well, has at least one 'island of salvation' to describe in its annual report. The report is sufficient to help the donor argue for continued funding, and it has little incentive to look at the broader picture or to consider the wider impact of its activities. Indeed, because much donor support to NGOs is at a very modest level (i.e., a large number of small projects), there are few incentives or resources to do a careful evaluation of the long-term impact of the investment.

The goal of self-sufficiency

A second impediment to the promotion of novel pest control products is the emphasis of most projects on self-sufficiency. Both NSKE and NPV offer several provision options, including individual farm-level production, small-scale village enterprise, and more conventional commercial production. Each option offers advantages and disadvantages. The choice should be based on criteria of efficiency and effective farmer access to technology, but unfortunately many agencies allow the presentation of a self-sufficiency image to take precedence over ensuring a viable and sustainable provision system for alternative pest control products. In the case of many NGOs, self-sufficiency is an overriding objective. NGOs can distinguish themselves, and present an attractive face to donors, if they are seen to be promoting the development of farm-level or community-level capacities. Although this is a laudable goal, when it is combined with a deep antipathy to commercial activity or to the use of external inputs, the result is an exclusive focus on village-based provision. Government entities (DOA and universities) have somewhat different motivations, but they often share a mistrust of the commercial sector.

Any pest control method that farmers can manage and maintain on their own has obvious attractions. An additional argument relates to the targeting of these techniques, as small farmers only require minimal quantities of these products, which can supposedly be made at home, while larger farmers would have to seek commercial sources of the same products. But the argument overlooks the fact that small farmers have little time to devote to additional chores such as these.

In addition, smaller farmers are not necessarily impressed with the argument that they can make something at home that their wealthier neighbours might buy in the market. Both NSKE and NPV involve planning, production and storage requirements that can make them unacceptable at the household level. Their production involves the collection of raw materials, the use of household grinding stones for non-food products, and the careful storage of the products. The time and effort required for home production of these products may outweigh their advantages, and the possibility of home production may not be enough to persuade farmers to give up chemical pesticides. Indeed, the image of a rustic, 'homemade' product may make many farmers suspicious of even trying it.

It is quite possible that while donors and their agents see themselves as championing practices that are safe, natural and self-reliant, many farmers look upon these options as crude, unpleasant and time-consuming. Nevertheless, many agencies continue to offer instructions on farm-level production, despite the fact that relatively few farmers follow through on this advice. For government programmes, such instruction on household-level production helps fulfil bureaucratic targets for 'number of farmers trained'.

These comments should not be interpreted as discouraging farm-level production of these products, but rather as a warning of the limitations and possible counterproductive aspects of exclusive reliance on this strategy. Our study found instances of farmers engaged in home production of NSKE and NPV, and where this strategy is feasible it obviously warrants promotion. We also found a few farmers in Guntur who have interacted with Lam Farm and manage the production of NPV for their own use without any external technical support. But the limited spread of these techniques demands caution with respect to further promotion.

Local enterprise promotion

When agencies acknowledge that farm-level biopesticide production is not feasible, the next place to turn is local enterprise. There are a number of attempts to establish village-level enterprises for the production of NSKE and NPV.

Neem seed kernel extract (NSKE)

For NSKE production, one of the major bottlenecks is the grinding process. Grinding the moist neem kernels at home takes time, and the residue is difficult to clean from the stone. An alternative is a small electric grinder, readily available for under US$100. Although no individual household could afford such equipment, it is an input that projects (or government agencies or political parties) can provide to farmers' groups or women's associations. It is reasonable to propose that these groups can charge a fee for the custom grinding of neem kernels brought in by individual farmers. This process is already in place with several groups, although it remains to be seen if the groups can manage the process without continued external support. To be sustainable, the group enterprise must save enough from its earnings to cover electricity, repairs and depreciation. In addition, clear responsibilities must be defined within the groups for day-to-day operations and financial management.

If there is demand for such village-level custom grinding, and the local enterprise is well managed, it might consider expanding to the production and marketing of NSKE. This would appeal to those farmers who are unable to collect their own neem kernels. In many areas of Telangana the neem kernels are generally available for collection but sometimes they are sold to the agents of neem oil manufacturers. Thus enterprise members would either have to devote their own time to collecting the kernels or pay others to do so.

The highest priority for establishing a village NSKE enterprise would be in those communities in less advanced agricultural areas where locally-produced NSKE might be of interest and where the income-earning possibilities from contract grinding or kernel collection would be appreciated. It is possible to imagine such small operations being successful, especially when farmers learn the appropriate use, and limitations, of NSKE. It also has a higher chance of success in villages where the DOA does not provide subsidised commercial neem oil to farmers.

Nucleopolyhedrovirus (NPV)

The material and logistic requirements for local NPV production are greater than those for NSKE, although there are several possibilities. Our study found three different strategies for local NPV production.

The first is a model promoted by the DIPMP project, in collaboration with NGOs. Equipment has been provided in several locations for local NPV production; the total value is about US$450. The idea is that a local group will manage this equipment for NPV production. Farmers are to bring in larvae to the facility; these are infected, processed, and the resultant virus suspension returned to the farmer five or six days later.

This basic strategy raises a number of questions. First, in order to pay for the upkeep and maintenance of the equipment, as well as for the labour involved in NPV production, a fee will have to be charged to farmers. Second, it is not clear if farmers will be willing to wait while their larvae are processed, especially if their crop is being damaged by insects. It may be useful to offer a payment for larvae that farmers or labourers could collect and sell to the facility, in order to offer NPV immediately to buyers (several small commercial firms which produce NPV purchase larvae from farmers or labourers). In any case, careful screening of delivered larvae is required to select those of the appropriate growth stage for virus multiplication. (An alternative would be to establish some type of rearing facility, but this would require additional skills and resources.) In addition, a local-level NPV facility needs a secure room or building in which to store the equipment. Finally, such an operation obviously requires a trained operator and careful financial management.

Although several NGOs aspire to establish this type of enterprise, and some of them have experience in using the equipment for NPV production, none has yet attempted to charge for NPV (beyond an occasional token request for larvae), and it is not clear how the transition to a financially sustainable operation will take place.

A second example of NPV production is provided by the group of farmers at Goddipadu. Some of them have been using NPV for several years, through contacts with Lam Farm and with the project technician. A set of equipment was provided to them in 2000 and they used this to produce NPV for their own use. They store the equipment in a building which has been loaned to them, and are trying to convince the local authorities to provide them with a vacant storeroom. All of the farmers understand the NPV production process, and they propose that each farmer manages his own NPV production. Because the equipment has been donated and each farmer is to manage his own production, there are no current plans for any charges. It is not clear how the equipment is to be maintained, however. The operation is certainly viable at its current scale, as it is an activity managed by a small group within a farmers' club who share ties of kinship and caste affiliation. But there would be problems in any significant expansion of this model to accommodate many other farmers. At the present time, however, there appears to be little demand from other farmers for access to these facilities.

A third example of local-level NPV production is found at the village of Pasumaru (Guntur District), where we met with a group of farmers. The village has good contacts with scientists at Lam Farm and has in the past been the site of ICRISAT experiments. About seven years ago a farmer from the village read about NPV in the local agricultural magazine (*Anadata*) and went to Lam Farm to learn more. He was provided with an introduction to the technology and was given some of the virus. He used it on his farm, collected the infected larvae, and made a fresh preparation of NPV. (He used no special equipment; the infected larvae were soaked in water for several days to help them decompose, then crushed by hand. The home-made virus suspension was stored from one season to the next in a tightly sealed plastic jug buried in the ground.)

Several other farmers in the village became interested in the technique, and one man began to produce NPV for sale. The emerging entrepreneur is a local farmer of modest means, who professes no specialised training or background. Over a period of several years he developed his own production facility. He used a virus solution that he stored from year to year, although three years ago he returned to Lam Farm for a fresh supply. His production process depends on fresh larvae that he collects himself. These are fed on virus-infected chickpeas in a system of his own invention. Realising that the larvae must be kept separate during the feeding stage, he devised a method based on discarded injection vials available for a small cost at hospitals. He employed two local people to help in the production process. In the best year, he produced NPV from 100,000 larvae for sale to other farmers.

Unfortunately, this imaginative local enterprise has not been financially successful. The farmer has had difficulty collecting payments from his friends and neighbours to whom he supplies the virus. In 2000 he only produced enough NPV for his own needs. Several other farmers in the village produce their own NPV as well, and two farmers this year purchased commercial NPV.

The local-level enterprises for producing natural pest control products face several problems. Two of the most important are quality control and marketing.

Quality control is an issue that affects many agricultural inputs. In a local-level enterprise there is little concern about deliberate fraud, but the production of complex biological inputs requires careful oversight and supervision. NSKE is the easier case of the two examples, and presumably quality can be ensured as long as there is adequate attention given to the care and storage of the raw materials. For NPV, however, there are greater concerns. In theory, an initial quantity of virus is simply recycled through various generations of the pest. But the virus may be inadvertently lost, diluted or contaminated. There is no way to recognise such problems without a trained technician and an adequate microscope. Experience has shown that the quality of informally produced NPV is often deficient (D. Grzywacz, pers. comm.). Commercial NPV operations must be subject to some sort of periodic quality control (Jenkins and Grzywacz, 2000). It is not clear what provisions should be made for such quality control for village-level groups, or who would pay for it.

Perhaps the biggest uncertainty related to the viability of village-level enterprise is marketing capacity. Most of the groups formed to date are producing NSKE or NPV for their own use, and little or no money changes hands. The NGOs may aspire to seeing these operations placed on a firmer financial base, but no one has yet estimated what would have to be charged for the products in order to compensate enterprise members' time and to pay for materials and equipment. In addition, there is little thought to how, or how widely, these products would be marketed. Would the enterprise be confined to a single village? If not, how would the products be promoted and sold more widely? The Pasumaru case illustrates the difficulties for a local entrepreneur to convince his neighbours to pay for a home-made product.

The potential problems facing these village-level enterprises (access to source materials, quality control, financial management, marketing) are very similar to those facing the similar strategy of village-level seed enterprises. This strategy has been promoted in many countries (including India) by donors, NGOs and government agencies (Tripp, 2001). It has met with very limited success, for a variety of reasons. Among the most relevant to our interests are the very limited size of market that a local enterprise can serve, lack of assured access to technical advice and quality control, and almost total lack of experience in managing a commercial operation.

6 POSSIBLE SOLUTIONS

A coordinated approach

It is widely recognised that the successful introduction of IPM requires a comprehensive approach including attention to the policies that support farmer access to new technology (Mumford and Stonehouse, 1994). It is well beyond the scope of the present study to identify specific policies to make IPM a reality in India. Nevertheless, our results point to clear deficiencies in the coordination of activities such as village-level technology testing and the provision of adequate information to farmers. We have pointed out that much of the blame lies with the uncoordinated approach taken by various donors in their promotion of IPM. In addition, there are a numer of strategic changes that can be made in IPM projects.

One of the most important vehicles for promoting agricultural technology is farmer-to-farmer diffusion. Farmers learn about new techniques and inputs by watching their neighbours. But IPM technology is less likely to spread from one farmer to another if farmers do not understand the practices that are being promoted. Our study uncovered evidence of imperfect understanding of the IPM message. One way to promote farmer ownership of the technology is to provide more opportunities for experimentation and demonstration. The farmer field school (FFS) strategy is one way of doing this (Kenmore, 1996). But even without full-blown FFS, opportunities should be sought to provide farmers with small quantities of the new products that they can test for themselves. Equally important, demonstrations of these new inputs should focus on multiple (brief) field visits to ensure that farmers understand the applicability of particular inputs at different periods of the crop cycle (e.g., early use of NSKE), timing of application (e.g., afternoon spraying for NPV) and the mode of action of the new products.

Such extension techniques are to be distinguished from the current tendency to establish demonstration plots that contain all of the recommended technologies (from bird perches to solar-powered light traps). There has been much debate in the literature on adaptive agricultural research regarding the strengths and weaknesses of such a 'package approach', and we will not rehearse those arguments here. However, two points in favour of a simpler, component approach to demonstration can be made. First, the current IPM programme in pigeonpea is not a package, but rather a basket of possibilities from which farmers are making choices; this argues for expanding farmers' opportunities to understand the individual components. Second, the relatively few farmers who have 'sustainably' adopted the new technology (such as the farmers using NPV in Guntur) are those who have had the opportunity to experiment with it as a component.

There is a need for simple protocols and techniques that various agencies can use to help farmers become acquainted with biocontrol products. In addition, IPM projects must consider means of interacting with public agencies (the DOA and universities) which should be able to offer much wider possibilities for technology diffusion. Working through public agencies is admittedly a long and complex process, but it is difficult to imagine the widespread diffusion of IPM techniques and principles without significant public agency involvement.

One of the most important means of scaling up the accomplishments of IPM projects is through information provision. There is a need for simple, attractive reference material that farmers can use to help them understand and recognise IPM technologies. Although literacy rates are quite low among much of the farming population, children or neighbours can often help farmers appreciate the content of simple pamphlets or flyers, and much can be done pictorially. The tendency, however, is for each project to produce its own literature, usually in insufficient supply, and often aimed at an extension or advisor audience, rather than at widespread distribution to farmers. There is a need for modest investment in simple information materials that various projects can use and that can also be distributed through public agencies. However, such literature can only complement the experience that farmers gain from first-hand experience with the new techniques.

Support to the biopesticide industry

There is much speculation about a conspiracy within the chemical industry to limit the spread of IPM. In fact, one need look no further than the donors, NGOs and government agencies that promote IPM to find a concerted effort to block the growth of any commercial capability for producing alternative pest control products. We have seen that most NGO projects have no interest in supporting the use of commercial products. This contradicts their self-sufficiency image, and if they were to promote the use of commercial products they would be, in effect, working themselves out of a job. Although the DOA often provides commercial products as part of its IPM projects, this action does not necessarily support the industry. The products are usually provided with a subsidy, against which the firms cannot compete in an open market. In addition, the government distribution of these products has other disadvantages. The DOA is not always as careful as it should be about the quality of the products it buys and distributes; hence many of the inputs are substandard, lowering their reputation in the eyes of farmers. Among the few farmers we encountered who had used NPV distributed by the DOA, none had a positive experience.

Even without these problems, the commercial provision of alternative products faces an uphill battle. In the cases of neem oil and NPV, the products' mode of action is different from that of conventional pesticides and farmers have to be alerted to what to expect. Conventional pesticides, and the promotional mechanisms and dealer networks that support them, are much more familiar to farmers, and it will take much effort to make significant inroads

Nevertheless, there are significant opportunities for commercial biopesticide production, as a number of examples from industrialised countries testifies (Marrone, 1999). Several problems of biopesticides have limited the expansion of production in industrialised countries, including the cost of production (e.g., rearing larvae), the relatively short shelf life of many of the products, and their specificity. These problems argue for a more decentralised production strategy to encourage small-scale commercial enterprise (Dent and Waage, 1999; Marrone, 1999). A local enterprise can do a better job of getting biocontrol products into the field more rapidly, hence addressing the shelf-life problem. In addition, production of specific products can be located in zones where the target crop and pests are found.

A small enterprise must be of sufficient scale to afford adequate quality control mechanisms. Quality control and supervision are particularly crucial for many microbial pesticides (Jenkins and Grzywacz, 2000). Even neem preparations require scrutiny because of their variable composition. Small-scale, environmentally friendly enterprises do not eliminate the possibility of fraud, as Ahmed and Stoll (1996) describe for the proliferation of small neem pesticide producers in Thailand. Unless individual producer reputations are well established, the presence of low-quality products on the market threatens the entire industry.

Our research encountered several small-scale enterprises producing NPV in Andhra Pradesh, and there are a number of larger firms manufacturing NPV in other parts of India (Grzywacz and Warburton, 1999). It is worthwhile considering the provision of support for such enterprises. Technical assistance and advice could be provided to place these facilities on a firmer footing. A particularly important area for assistance would be the development of adequate quality control mechanisms. It is possible to envision commercial producers of natural pest control products subscribing to a voluntary quality control regime which would help strengthen their reputation, discourage fraudulent or incompetent behaviour, and increase farmers' confidence in these alternative products. An effective voluntary 'certification' scheme for these products could also serve as an example to the current government regulatory system for pesticides, which is far from adequate.

7 CONCLUSIONS

The small study summarised in this paper presents positive evidence for the introduction of novel pest control inputs to small-farm agriculture. Two products, NSKE and NPV, have been shown to be useful for controlling a major pest of pigeonpea. When provided with these products, or given the opportunity to prepare them, a number of farmers have enthusiastically incorporated them in their pest management practices, contributing to a reduction in the use of broad-spectrum pesticides.

Nevertheless, there are a number of major problems to be faced. In the first place, most of the use of the products reported here has benefited from outside support and subsidy. Whether farmers would be willing to pay the true cost of these products remains to be seen. In addition, the farmers' major criteria for choosing pesticides remain efficacy and cost. Even those farmers participating in an IPM project do not assign much importance to arguments regarding health and environmental protection.

IPM addresses crucially important problems and it is an attractive area for donors and governments to be seen supporting. The result is that there is a plethora of projects, each centred on a few villages and a few crops, and each with its own philosophy. Not only is there no clear message for farmers in these cases, there is little possibility of raising the critical mass necessary to establish consistent policies. Neither donors nor NGOs have sufficient incentives to collaborate with their counterparts, and government agencies maintain a bureaucratic distance from any effective engagement with farmers.

The dispersed project strategy does not contribute to providing attractive and widely available sources of information to help farmers learn about pest control alternatives. Nor do these projects devote enough effort to building farmers' capacities to experiment and learn about the options that are on offer. Finally, dispersed projects and an over-emphasis on self-sufficiency ensure that governments are not made to see the necessity of policies which support the emergence of a commercial sector able to supply the needs of IPM.

The situation will only be improved when donors, governments and NGOs are able to collaborate on longer-term strategies emphasising farmer capacity-building and policy reform, rather than relying on uncoordinated short-term projects.

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