

Developments in Diamondback Moth Management in the Philippines

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Abstract

A discussion of what is known about the individual components of pest management applied to the diamondback moth, *Plutella xylostella*, in the Philippines is presented. This includes aspects relating to the pest, the agroecosystem, the plant, and preventive and curative control measures. Some successes have been obtained with a few of the components but many have not been tried in the field nor have there been sustained efforts to apply pest management in its totality. From the identification of the constraints in adoption of a holistic approach, it is evident that while there are certainly technical problems, social problems are just as important. These constraints must be overcome if a successful DBM management program is to be established.

Introduction

The diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae), in the Philippines is a serious limiting factor in the production of crucifers. For example, Quebral and Caramacion (1972) reported that in the highlands, farmers concede much reduced yield (up to 100% yield loss) if insecticides are not used to control this pest. It is now widely accepted that in the lowlands also successive crucifer production is very difficult once this pest's population is allowed to build up, as usually occurs from the second crop.

The problem is compounded by the unreliability of control by chemicals as a consequence of, among others things: (1) the development of resistance by the pest, to the chemicals, (2) a much reduced rate of introduction of new compounds to the market, (3) the high cost of insecticides, and (4) problems of supply brought about by foreign exchange restrictions. The first problem also indirectly results in the build-up of residues in commodities because farmers are tempted to use cocktails or application rates higher than recommended. When cocktails or tank combinations of two or more chemicals are used, these compounds are often used at the dosages recommended for each compound individually, so that the actual application rate is double or triple the recommended rate.

Cabbage ranks first among all leafy vegetables in terms of quantity in the Philippines and in 1972, 7120 ha area was devoted to this crop with annual production estimated at 49,522 tons with a value of \$5.4 million.

This paper considers what has been done to manage this pest and also what could still be done. As in many developing countries, the individual components of what could constitute a dynamic technology package are known, and some of them have been evaluated, but much still remains to be done in terms of putting them into practice.

Aspects of Pest Management Applied to DBM in the Philippines

Pest management is not alien to the Filipino consciousness and Filipino scientists have long been advocating it. However, its full potential has not been realized. What we find therefore is the adhoc application of individual components based principally on the use of insecticides (Magallona 1981, Magallona et al 1982). It has been stressed that insect pest management requires a good working knowledge of the following aspects (Reynolds et al 1975, Beingolea et al 1982):

1. The agroecosystem, 2. the plant, 3. the pest, 4. preventive control methods (Host plant resistance and cultural management), 5. suppressive control methods (biological agents—parasitoids, predators, pathogens, and chemicals—synthetic or naturally-occurring compounds).

Let us now discuss briefly what is known in the Philippines about each of these aspects.

The agroecosystem

In the Philippines, two general types of agroecosystems can be identified, the highlands and the lowlands. The cool highlands include Benquet (La Trinidad, Atok, and Bugias), Kanlaon in Negros, and to some extent Claveria in Mindanao, Mantolongon in Cebu, Sariaya in Quezon, and Bongabon in Nueva Ecija (Figure 1). Benquet and Kanlaon grow quite extensively a variety of crucifers on a year-round basis. The setting is basically agricultural although in La Trinidad, urban encroachment has become serious of late.

Most of the other areas have been more recently cleared from forest lands. Poor accessibility to the market, and a market in itself small are the main constraints. In Nueva Ecija, the area is devoted to rice during the wet season.

Plantings of crucifers are also made in the lowlands with cabbage and petsai (*Brassica campestris* spp *chinensis*) being the two main crops; cabbage plantings have increased recently because of the introduction of superior hybrid cultivars. Three types of plantings are recognized here—those of traditional small farmers wherein crops are rotated in accordance with seasonality; those of the newly emerging agribusiness concerns; and opportunity plantings in urban or semi-urban settings.

In the traditional crucifer-producing areas of the highlands, crucifers are grown extensively the year-round and it is not unusual to observe virtually whole mountainsides devoted to crucifers. Furthermore, for obvious reasons, there is a continuous planting and harvesting of crucifers in these areas. DBM, therefore, has a year-round supply of host. By the same token, however, natural biotic mortality factors are present throughout the year. Insecticide use is heavy and this serves as selection pressure both to DBM and its biotic natural enemies. It is, therefore, natural that these organisms will develop resistance to these chemicals.

On the other hand, in the lowlands, DBM becomes a serious problem only in continuous plantings as it takes some time before a population builds up to infestation levels. Here, however, the farmer simply shifts to another crop, such as mungbean, tomatoes or green beans, to minimize the impact of DBM on his operations.

Besides cabbage and petsai, DBM has several other hosts in the Philippines. Barroga (1980b) listed cabbage, cauliflower, turnip, swede, kale, Chinese mustard, petsai, watercress, horse radish, sweet alyssum, candytuft, radish, and chickpea as DBM food plants. Alternate hosts are cruciferous weeds including ornamental cabbage and cactus. We have observed DBM in *Cassocephalum crepidiodes* (Benth) S. Moore. It is a lowland weed but has been encountered in Baguio as well. *Galinsoga parviflora* Cav and *Spergula*

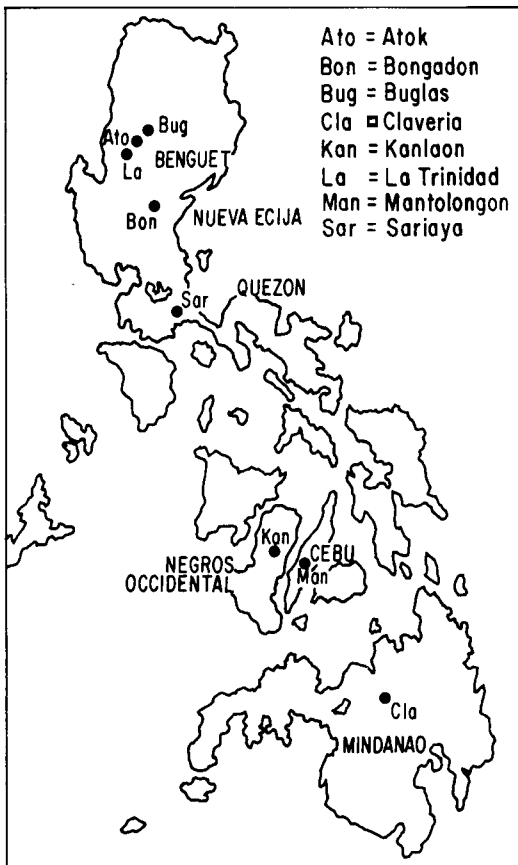


Figure 1.
Map of the Philippines showing major
crucifer growing areas

arvensis L are also notorious weeds in the highlands which could also serve as alternate hosts (Paller 1985). DBM adults are also attracted to marigold (*Tagetes* spp) in the field.

The importance of these weeds or crops as alternate hosts has not been assessed but is the subject of an on-going investigation. It should perhaps be noted that these weeds, if indeed they serve as alternate hosts to DBM, also ensure the perpetuation of natural enemies.

The plant

DBM subsists principally on crucifers. As pointed out by Gupta and Thorsteinson (1960) the free mustard oils of the crucifers are involved in confining DBM's host range amongst crucifers. Most crucifers thrive best in a cool moist climate so that the quality produce is obtained in the highlands. Here, a wide variety of crucifers are grown. In the lowlands, only petsai and cabbage are of importance.

The pest

In the Philippines, the biology of this pest has been reported by Otones and Sison (1927), Esguerra and Gabriel (1969), Gabriel and Cadapan (1970) Medina et al (1977), and Barroga (1980b).

It is known that the developmental period for this pest is 13 to 22 days or an average of 20 days; a shorter period is expected in the warmer lowlands than in the colder highlands. The adult is most active after sunset and mating begins one day after emergence with the female mating only once. Oviposition occurs shortly after dusk with the peak occurring about two hours later. Peak of oviposition occurs during the first evening of oviposition.

Preventive pest control methods

These are generally taken to prevent the establishment of a pest-plant relationship. They include among others the use of (a) resistant cultivars, (b) cultural management, and (c) protectant chemicals.

(a) Resistant cultivars The use of resistant cultivars offer a number of advantages in pest management because they easily supplement or can be supplemented by biological, chemical, and cultural controls. In the Philippines, while the potential for a variety/line resistant to pests in general and DBM in particular is realized, there has been no positive development so far. However, this is one of the concerns of the vegetable breeding group at the Department of Horticulture and the Institute of Plant Breeding, at UPLB (Rasco 1985).

(b) Cultural management The idea is to manage the immediate environment so that there is disruption of the lifecycle of the pest. Two basic principles are involved: (1) manipulation of the agroecosystem to make it less favorable for the pest, and (2) manipulation to make the agroecosystem favorable for DBM's natural enemies. Crop rotation, crop refuse destruction, and intercropping are among the approaches to cultural management. Not all of these are applicable at any given time and some reports have been contradictory in that some workers report success while others report failure. It is thus important to show that a technique will work rather than to assume that it will. Crop rotation: A crop which is not a host or is not attacked by the pest is introduced before or after a susceptible plant. This causes a disruption in the lifecycle of the pest or the insect may be forced to subsist on an alternate host which is not as abundant as the crop plant.

While crop rotation is certainly practised, many farmers do this not so much with pest control in mind as to take advantage of favorable growing conditions. Thus, in the highlands, an area may be shifted from crucifers to potatoes, carrots, sweet peas, strawberry, tomatoes, and so on but the adjoining fields may still be devoted to crucifers. Crucifers are also avoided during the wet season because of softrot and other diseases. In fact, during the wet season, DBM populations are low but production is also low because of these diseases (Magallona 1981).

In the lowlands, crucifers are considered cash crops so that they may be planted after rice or in rotation with tomato, mungbean and other crops.

Where agribusiness concerns have several plantations but require a continuous supply of crucifers, a different approach is used. Here plantings are rotated in different plantations, making sure that in any firm's operations, there is a crucifer-free period. This deprives DBM populations of food, thus forcing them to subsist on alternate hosts. When crucifers are reintroduced, the early planting (up to two months of continuous plantings) generally have manageable DBM populations. The moment this population becomes serious, another farm takes over production. While this approach appears opportunistic, it reduces the intensity of insecticidal control, assures continuous supply of crucifers, and reduces costs considerably. Crop refuse destruction: DBM can complete its lifecycle in crop residues or refuse. For example, when cabbage is harvested, the leaves

are left behind. Unfortunately, this is where DBM congregates so that unharvested areas or new plantings have a ready reservoir of the pest. Prompt removal of these crop residues, a tedious job the value of which is not appreciated by many farmers, followed by burning or burying, would eliminate this reservoir.

It is only after the first harvest, when crop residues are left in the field, that DBM population surges (Manalastas 1985).

Intercropping: Tomatoes have been claimed by some researchers as a good intercrop with cabbage. Thus, Buranday and Raros (1973) observed significantly more DBM adults and eggs in a plot of cabbage as the sole crop than in a plot of cabbage-tomato intercrop. This is presumably because of the repellent effects of tomatoes. They recommended a planting pattern of two rows of cabbage between two rows of tomatoes.

In a later experiment, Magallona (1980) evaluated tall and short tomatoes and sweet peas as barrier plants. Tall tomatoes gave better cabbage yields while sweet peas were not considered a good barrier because of their shading effect. However, insecticide application gave better yields than barrier plants, though this does not detract from the potential of the barrier plant approach especially at low DBM population levels.

Barriers: This approach holds tremendous promise especially for agribusiness concerns that can afford the large capital requirement. Crucifers are grown in areas protected from DBM by mechanical barriers such as fine-mesh netting and plastic sheets. In this manner, the crop can be raised throughout the year and pesticide application is minimized, if it is needed at all. Furthermore, biological control with natural enemies may have greater effectiveness because of the enclosed space.

In using this approach, the following advice is offered: 1. the area should be fully enclosed even at the top because DBM can climb up the net or plastic wall; 2. while in the nursery, the seedlings should be kept free of DBM; 3. considering that DBM has been observed to oviposit on the green net at the top, crop rotation may still be advisable. Tomato appears to be a promising rotation crop.

Suppressive control methods

In this case, the pest-plant relationship is sufficiently well understood for efforts to be made to reduce pest population to an acceptable level.

Biological agents These organisms are being hailed as replacements for pesticides but so far, their potential has not been realized. Parasitoids: Several of these have been reported. This include *Nythobia insularis* and *N. plutellae*, *Microplitis* sp, *Apanteles* sp, *Angitia maculipennis* (Esguerra and Gabriel 1969, Gabriel and Cadapan 1970, Barroga 1974, 1980a, Velasco 1982, Magallona 1980).

Velasco (1982) studied the field parasitism of *A. plutellae* on DBM as a continuation of earlier research (Magallona 1980). This parasite was considered the predominant biotic mortality agent in Baguio City but its effects were antagonized by *Erynia*(= *Entomophthora*) *radicans* Brefeld, a fungus which is also a significant biotic agent. From cage-field releases, it was concluded that this parasite is worth pursuing. The parasite prefers second and third larval instars. It also has a hyperparasite, *Trichomalopsis* sp.

Pathogens:-*Entomophthora sphaerosperma* or *E. radicans* appear to be effective pathogens (Esguerra and Gabriel 1969, Magallona 1980, Velasco 1982). Other disease organisms include nuclear polyhedrosis and granulosis viruses (Barroga 1974, 1980, Liquido 1975). The potential of these organisms remains to be explored.

On the other hand, *Bacillus thuringiensis* has been widely used to control DBM and notwithstanding its erratic results and inability to compare with the synthetic insecticides from the point of view of efficacy, was nevertheless a major insecticide in the Baguio-La Trinidad area in 1982 (Magallona et al 1982). In as much as it is easily

produced by fermentation, there have been attempts to produce this using locally available materials. Perez (1972) and Ocampo (1973) tried coconut water but failed to obtain ideal conditions for growth. Guevarra (1974) tried alcohol slop waste, lambanog slop waste, coconut water, cow and poultry manure, and nutrient broth. They found cow and poultry manure to be better media than nutrient broth for the growth and sporulation of *B. thuringiensis* var *thuringiensis*. Batalla (1975) later determined the best concentration of the above substrates for the commercial production of this bacterium.

Further work is done on the production and formulation of this agent at the National Crop Protection Center and at the Institute of Biotechnology and Microbiology at UPLB.

Insecticides Insecticides are considered the most powerful tool for pest management. However, there has been a complete turnaround in philosophy so that instead of being the first method of choice, the use of insecticides is now considered the technique of last resort. Insecticides naturally draw their usefulness from their rapid action and convenience in use.

Almost all the insecticides used in other countries have been tried in the Philippines and the trend has been essentially the same—there was a shift from the early botanicals to the organochlorines, then to the organophosphorus and carbamates, and now to the pyrethroids. This shift was due in a large part to the development of resistance by DBM to the insecticides. In fact, the problem pests before the advent of organic pesticides were the sulfur butterflies (*Pieris* spp) but they were edged out from this niche by DBM which was better adapted to these chemicals; this view is also shared by Barroga (1980). This statement is borne by the studies of Agpad (1959) who reported that DBM was an insignificant pest of petsai and that endrin, diazinon, *Ryania*, and rotenone were effective against the cabbage moth, *Crociodolomia binotalis* Zeller. De Los Reyes (1960) and Retuerma (1961) also focused attention on the cabbage moth, a serious pest at that time, and tested endrin, diazinon, and DDT for controlling this insect. It was only later that insecticides were tested against DBM (Barroga 1967, Cadapan and Gabriel 1972, Calora et al 1968, Sanchez et al 1968). Granular insecticides were tested in the hope that they would solve the problem (Calora et al 1968, Pajarillo 1978).

The development of resistance is nowhere better attested to than by the number of compounds which were effective against DBM when first introduced only to become ineffective or marginally effective later; Barroga (1980) gave an extensive summary of these. More recently, in a survey of 155 farmers in 1982 (Magallona et al 1982) it was shown that cypermethrin, triazophos, *B. thuringiensis*, cartap, fenvalerate, deltamethrin, and metamidophos were most widely used (Table 1). These compounds, especially the pyrethroids, came onto the market only in the late 1970s, except for triazophos which was introduced in the early 1970s. The development of resistance to insecticides can be assessed through the comparative LD₅₀ values of insecticides tested by topical application in 1978 in 1982 (Table 2) (Magallona et al 1982).

To get around the problem of resistance, farmers resort to mixtures of two or more compounds; the 1982 survey showed that about 50% of the farmers interviewed used mixtures (Magallona et al 1982). In the field, a hit-or-miss approach is used although some researchers have tried to provide a more scientific basis for the practice. Thus, Morallo-Rejesus and Eroles (1974) tried pairing such compounds as EPN, mevinphos, malathion, methyl parathion, dichlorvos, and carbaryl while Barroga (1980a) elucidated the mechanism of joint action of insecticides on malathion-resistant DBM.

Some attempts have also been made to place pesticide usage on a sound scientific basis by determining the critical time for application. Lumaban and Raros (1975) showed that the injury caused by DBM was most critical, thus requiring pesticidal treatment, four to five weeks after transplanting; damage before and after the period did not appear

Table 1. Main insecticides used in the Baguio-La Trinidad area, March, 1982^a

Insecticide	Users	%
Kafil (cypermethrin)	29	18.7
Hostathion (triazophos)	26	16.8
Thuricide (<i>Bacillus thuringiensis</i>)	21	13.5
Vegetox (cartap)	19	12.2
Sumicidin (fenvalerate)	19	12.2
Decis (decamethrin)	18	11.6
Tamaron (methamidophos)	11	7.1
Others		7.9

^aSource: Magallona et al 1982.

Table 2. Changes in toxicity of different insecticides tested against DBM^a

Insecticides	LD ₅₀ mg/kg body weight	
	1978	1982
Deltamethrin	0.00048	0.089
Fenvalerate	0.0012	0.446
Rotenone	0.0023	0.275
Mevinphos	0.002	0.069
Triazophos	0.013	2.759

^aSource: Magallona et al 1982.

to be critical. As reported in Velasco (1978), Magallona and Velasco (1980) showed that at high infestation levels, insecticidal protection is required four to seven weeks after transplanting whereas at low infestation levels, only marginal advantages are obtained with insecticidal application. However, these studies, which were done in the lowlands, appear to be too optimistic compared to actual practice in the Baguio-La Trinidad area, as shown by our survey (Magallona et al 1982). As seen in Figure 2, most farmers (about 73%) apply insecticides on the first nine days of transplanting while 58% apply them within 10 days of harvest.

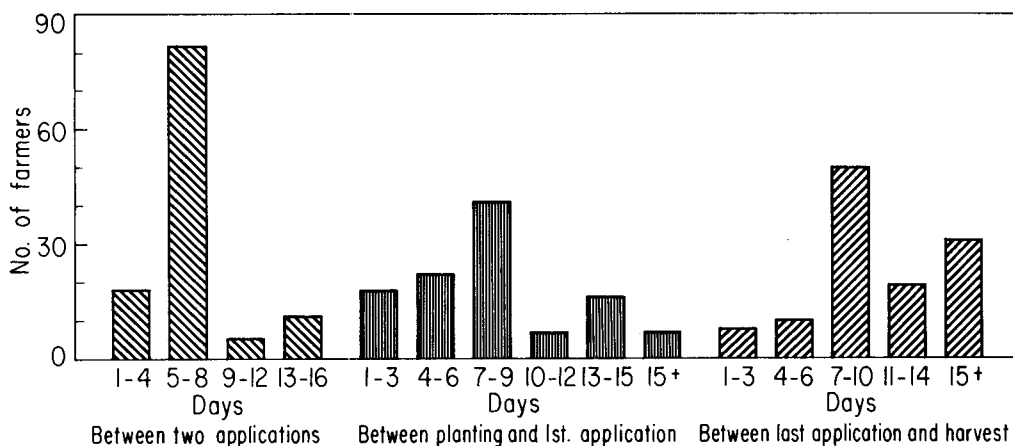


Figure 2. Results of the survey of farmers' insecticide application practices for crucifer pest control in Baguio-La Trinidad area

Medina (1979) reported the injury threshold of cabbage to DBM. DBM larvae of 3rd and 4th instars cause more damage than 1st instar ones. Significant yield reduction was observed with 1st instar larvae at 16 to 20 days after transplanting. The economic threshold is one larvae per plant. Gonzaga (1981) also developed a forecasting system for economical chemical control of DBM based on analysis of chemical control data. He found that early infestation up to the 26th or 32nd day after transplanting was critical for providing protection to cabbage. Late infestation did not have a significant effect on yield.

The residue aspects of pesticide usage against the DBM have also received attention. An earlier concentration was on residues in crops and soil as a consequence of application

(Morallo-Rejesus et al 1972, Magallona et al 1977, Magallona and Callejas 1977, 1979). On cabbage, the residues were concentrated in the leaves and wrapper leaves; removal of the wrapper leaves and washing should reduce residues considerably. In soil, degradation rates are rapid depending on the insecticide as well as on soil type. A shorter preharvest interval than in temperate countries can be allowed. These findings are generally in accord with expectations about the behavior and fate of pesticides in the tropics (Magallona 1983, Tejada et al 1976).

Subsequently, a systemic approach to residue data generation was developed using petsai as the example (Magallona et al 1981). The data are expected to be useful for the tropics and, as shown in Table 3 for methyl parathion and mevinphos, the residues obtained are much lower than the FAO/WHO-proposed maximum residue limits at the indicated preharvest interval. Washing and cooking further reduce the residue level in the crop (Table 4).

Table 3. Comparison of preharvest interval (PHI) as basis for FAO/WHO maximum residue limit (MRL) and UPLB^a data on selected vegetables^b

	FAO/WHO		UPLB level at PHI (mg/kg)
	MRL (mg/kg)	PHI (days)	
I. Methyl parathion			
Beans	1.0	14-21	0.01
Crucifers	1.0	14-21	0.05
II. Monocrotophos			
Beans	0.2	15-30	0.05
III. Malathion			
Beans	2.0	3	0.04
IV. Mevinphos			
Beans	0.1	1-14	0.01
Cabbage	1.0	1-14	—
Lettuce	0.5	1-14	0.05

^a University of the Philippines at Los Banos.

^b Source: Magallona 1983.

Table 4. Effect of washing and cooking on the residue level of some organophosphorus insecticides in treated petsay^a

Treatment	Uncooked			Cooked			
	Unwashed mg/kg	Washed mg/kg	Reduction (%)	Unwashed mg/kg	Reduction (%)	Washed mg/kg	Reduction (%)
Malathion	1.0	0.7	31.7	0.4	65.4	0.3	72.1
Methyl paration	1.8	1.1	37.3	1.1	36.2	0.3	81.4
Mevinphos	1.7	0.5	70.1	0.4	78.2	0.2	90.8
Triazophos	1.0	0.4	56.9	0.6	43.1	0.4	62.7

^a Source: Magallona et al 1981.

There is a perceptible shift back to botanical pesticides at present. This is premised on the farmer being able to raise his own pesticide or develop small industries based on pesticides produced in the backyard. Extracts containing active principles from several plants have been tested against DBM. Reyes et al (1977) and Reyes (1982) evaluated *Tephrosia vogelii* Hooker, Eroles (1977) evaluated *Tagetes* spp, Carino (1981) tested *Tethonia diversifolia*, Javier (1981) used red and black pepper (*Capsicum annum* L. and *Piper nigrum*, respectively), Alcantara (1981) used *Ageratum conyzoides* while Ferrolino-Calumpang (1983) used *Artemisia vulgaris*.

Some efforts have also been directed to evaluating the more exotic types of chemicals. Morallo-Rejesus and Tetangco-Fabellar (1976), and Tetangco (1976), reported the ED₂₅ and ED₅₀ of *Attacus* and *Cecropia* juvenile hormones on DBM. Application of the juvenile hormones, reduced larval survival, pupation and adult emergence, larval-pupal intermediates, and increased the proportion of abnormal adults. Sterility effects such as reduced egg production and hatchability were transferred to F₁ and F₂ progenies.

Potentials for a Technology Package

A technology package is taken here to mean the application of viable technology components with flexibility at strategic times; it is not a rigid set of procedures as the term implies. Obviously however, the use of such a package depends on: (1) applicability of the components or their adaptation by the farmer, (2) in-depth knowledge of these components by those transferring the technology to the end user, and (3) willingness to use a technology package in an integrated manner rather than relying on a single component that offers temporary benefits.

From the standpoint of suitability, it is evident that while many components are already known, they have not been adapted sufficiently to be adopted by farmers. This is unhelpful because an aura of preparedness is projected and the end user finds out only later that much still remains to be done. Two examples are often mentioned with much optimism.

1. Tomato-cabbage intercropping: Unfortunately, only the success stories are reported in the published literature while the probably just as numerous unsuccessful efforts have remained unreported. For example, would this approach work at high DBM population levels or under continuous cropping? Under what conditions would it be guaranteed to work?

2. Beneficial organisms: This very promising approach has remained unexploited with the knowledge apparently remaining in research and academic circles. There has been no real effort to apply it in field crop protection.

A requirement for the adoption of a pest management system is also an in-depth knowledge of the components, either on the part of the farmer himself or of those extending the technology to him. This is lacking in the Philippines. Since the stimuli for advancement in knowhow and in extension capability have been absent, the consequence are extension agents who are themselves not satisfied with their careers.

This state of affairs is evidenced in our 1982 insecticide management survey of the Baguio-La Trinidad area (Magallona et al 1982). Of the 155 farmers interviewed 34% relied on the technicians of chemical companies, 26% on government technicians, 23% on pesticide dealers, and 17% on their neighbors. It is necessary, therefore, to give on-the-job training and incentive to the extension agents.

The willingness to use a technology package rather than to rely on a single, temporarily beneficial component should also be present. Already, everybody is aware of the potential of pesticides and their apparent simplicity, which makes them attractive to farmers. Against pesticides, the other components appear too cumbersome and complicated. Clearly then if the farmer is unwilling to take the initiative, government (or non-government) organizations should step in first to illustrate the utility of the other components and later to ensure continuity in their use.

In the case of agribusiness concerns, the problem appears to be one of unwillingness to obtain the services of a pest management specialist. Generalist types of workers appear to be more desirable notwithstanding their limitations in solving serious production problems. Of course, it is also to be emphasized that pest management components have to be worked out but these agribusiness concerns are in the best position to conduct development work (as against research) for the more lasting control of DBM.

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