

Integrated Pest Management of Diamondback Moth: Practical Realities

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Abstract

Diamondback moth, *Plutella xylostella* (L.), is a serious and important pest of crucifers in many parts of the world, particularly in the tropics. Although many studies have been conducted on this pest, the development of realistic integrated pest management (IPM) for it is not progressing as it should, and even less so on its practical implementation. The many reasons for this include overreliance on chemical control, overemphasis on basic and narrow-aspect research which lacks a holistic outlook, inadequate understanding of the farmer, particularly his pest perception and realistic needs, and the subtle influence of the existing socio-marketing factors. In this paper, these constraints are critically examined, with attempts also made to identify the positive steps to be taken to expedite the current initiatives in IPM development and implementation. The currently known integrating components/techniques are appraised and several common key elements important for successful IPM are identified. The latter mainly includes harnessing key natural enemy species, using microbials, and applying relatively safer insecticides when these are necessary as guided by appropriate action thresholds. Other useful but less commonly exploited elements include proper timing of planting, crop rotation, physical barriers and trapping. With respect to promoting greater IPM implementation, special emphasis is necessary to generate increased awareness and transfer of available practical IPM programs. The strategic steps will include determination of farmers' pest management knowledge, attitude and practices, IPM trial demonstrations, and appropriate training of extension personnel and farmers. Particularly in farmer training, suitable development support communication is to be utilized, encompassing pre-tested posters and pamphlets, and other audiovisual media. Also, the field school approach should be adopted.

Past Efforts in the Control of Diamondback Moth

One of the causes for the slow development of IPM program for diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera:Yponomeutidae), is the limited effort devoted to the investigations concerning this aspect. This is clearly reflected in publications (Talekar et al. 1985), wherein only 2.4% directly concerned IPM (Table 1). Of the remainder, 16.8% were of a general nature, covering descriptive, biological and ecological studies, 17.9% dealt with basic studies, and 62.9% and 65.3% on various control methods.

In general, a large proportion of the past efforts was devoted to studies of a basic nature which lacked adequate appreciation of the real field situation. Other than those which dealt directly with control aspects of DBM in the field there was little implementation consciousness or other practical considerations.

Another limiting factor is the overemphasis on chemical control. At least a third of past research efforts was concerned with insecticidal investigations, mostly (22.7%) on simple

Table I. Relative efforts on DBM research as reflected by published articles on studies made until 1985.

Aspect of research	Published papers	
	Number	%
General		
Descriptive, biological and ecological	171	16.8
Basic studies	182	17.9
Morphology and taxonomy	15	1.5
Physiology and development	15	1.5
Biology	52	5.1
Ecology	100	9.8
Control Methods	639	62.9
Biological control	238	23.4
Predators and parasitoids	138	13.6
Microbials	100	9.8
Cultural control	24	2.4
Host-plant interaction	25	2.5
Chemical control	302	29.7
Insecticide toxicology	40	3.9
Insecticidal control	231	22.7
Insecticide resistance	31	3.1
Pheromones, juvenile hormones, chemosterilants and repellents	50	4.9
Integrated control	24	2.4

screening for effective chemicals. The remaining was on more specialized aspects and of a fundamental nature, such as insecticide toxicology and resistance studies.

Many different control components for DBM are often investigated in isolation from one another. Such a compartmentalized approach normally lacks a holistic outlook, and has hindered the development of an IPM program. Moreover, discontinuity in research activities due to frequent changes in research interest of investigators further aggravated the situation. Consequently, a sufficiently long-term aim geared towards eventual IPM development was lacking. The problem was accentuated by repetition of many short-term projects, mainly by different individuals in isolation and over different time periods. All these have in one way or another resulted in the limited development of IPM for DBM.

Status of the Available Integrating Components

Notwithstanding that past research efforts were mostly confined to aspects not directly aimed at the conscious development of IPM, much of the knowledge generated has constituted the basis for recent IPM programs of DBM. Invariably, the separate studies on the various aspects have helped to provide deeper insights into the potential of the different elements. The depth of understanding varies, however, being largely governed by the extent and nature of investigations undertaken. Presently, numerous potential management components are known and their current status is as follows.

Biological Control

Considerable effort has gone into biological control of DBM in many parts of the world, including the use of microorganisms, predators and parasitoids, with most effort having gone into the latter.

Parasitoids: In Southeast Asia, efforts aimed at biological control of DBM by introduced parasitoids from abroad were first attempted in the 1920s by Indonesia (Sastroiswojo and Sastrodihardjo 1986). Although the early efforts failed, subsequent attempts (Vos 1953) where *Diadegma semiclausum* Hellen was introduced from New Zealand succeeded. The parasitoid became established as an effective biological control agent around Pacet, West Java. Following this, further attempts were made to introduce it to other cabbage areas in Indonesia. Although success in establishment was achieved after several attempts, the level of parasitization during the period 1968-70 was still relatively low (<60%) and inadequate to control DBM. But firm establishment was achieved in 1971-75 when the parasitoid was commonly found in Java, and in many parts of Sumatra, though not in Sulawesi (Sudarwohadi and Eveleens 1977). The parasitism rate was well beyond 60%, and in many places averaging more than 80% and providing effective suppression of DBM.

In Malaysia two parasitoids (*Oomyzus sokolowskii* and *Cotesia plutellae*) were introduced into the Kundasang (Sabah) in the 1970s. In spite of no recoveries initially, *C. plutellae* was recently found in Sabah and is contributing significantly towards the biological control of DBM there.

Between 1975 and 1977, attempts were also made to establish three exotic species (*D. semiclausum*, *Diadromus collaris* and *O. sokolowskii*) into the Cameron Highlands (Ooi and Lim 1989) because the existing parasitoids (*C. plutellae* and *Tetrastichus ayyari*) could not provide full DBM control (Ooi 1979; Lim 1982). However, only the first two have become established and have dispersed all over the Cameron Highlands. Presently, the parasitoid complex, consisting mainly of *D. semiclausum*, *C. plutellae* and *D. collaris*, serves as the core element and foundation of an IPM program for DBM, which is being gradually transferred to highland farmers (Lim et al. 1988).

Biological control of DBM is also given importance in Thailand. Emphasis is placed mainly on augmentation, particularly on mass releases of egg parasitoids (*Trichogramma* spp.). By releasing *Trichogramma confusum* at the rate of 375,000 parasitoids/ha in the highlands of Pechaboon Province, the field parasitism can be greatly increased, reaching up to 65.5% during 1987-88 (Vattanatangum 1988). Another species of potential utilization is *Trichogrammatoidea bactrae*. Presently, studies are being intensified on how to use these agents more effectively, particularly in the lowlands.

Outside Southeast Asia the importance of parasitoids in controlling DBM has also been clearly demonstrated. In Taiwan, for instance, in addition to *C. plutellae* the newly introduced *D. semiclausum* has become established in the crucifer-growing areas in the highlands (Talekar 1990). In these areas all farmers have reported considerably less DBM damage. Consequently, there was also very little use of insecticides except *Bacillus thuringiensis*. Based on insecticidal expenses for DBM control before and after parasitoid introductions, this biological control project represents potential savings of over US\$365,000 per year. In addition, environmental contamination is also reduced because of less insecticidal inputs.

The introductions of parasitoids for the effective suppression of DBM have also been achieved in New Zealand (Muggeridge 1939) and Australia (Goodwin 1979; Waterhouse and Norris 1987).

In Zambia it was claimed (Yaseen 1978) that a combination of *C. plutellae*, *D. collaris* and *O. sokolowskii* have provided an 80% reduction in damage by DBM. On Cape-Verde Islands, DBM, once the most important cabbage pest until 1981, is now scarce following the introduction and establishment of *C. plutellae* and *O. sokolowskii* (Cock 1983). The encouraging results were, however, also assisted by the use, where necessary, of *B. thuringiensis*.

The effective contributions of parasitoids are particularly evident in areas where the infestations of DBM are generally low, as in many parts of Canada, Europe and the United States (Muggeridge 1939; Hardy 1938; Sutherland 1966; Oatman and Platner 1969). In England, only very occasionally were large economic losses involved, resulting from mass immigration (French 1965). In Germany, France and Italy, DBM is not present in sufficient numbers to be a serious pest, and in the last-named country it is comparatively rare (Muggeridge 1939). DBM appears to be held in check in most of these regions by effective parasitoids, and Marsh (1917), in outlining the situation in the United States, pointed out that DBM was a striking example of a potentially serious pest normally held in repression naturally by parasitoids.

There is now overwhelming evidence that parasitoids do play a dominant role in the population dynamics of DBM (Lim 1986; Waterhouse and Norris 1987) and these must be given prime consideration in any management program of the moth. While full population suppression through these biological control agents is the prime objective, a partial biological control to be used in conjunction with IPM programs with attendant reduction of chemical usage is also considered important (Ooi and Lim 1989).

Predators: Among the natural enemies of vegetable pests, predators appear to be least studied and understood. In most cases, they merely constitute a listing of species. For example, spiders, coccinellid beetles, pentatomid bugs, phytoseiulus mites, chrysopids and *Ophionea* beetle were reported to attack DBM in Vietnam. These tend to build up only in the later part of the crop and can cause up to 70% prey mortality (Vu 1988). In Malaysia, syrphids, wasps and spiders are common predators (Ooi et al 1990). Ooi (1979) observed that syrphids will readily predate on DBM in cabbage fields, as was also noted by Robertson (1939) and Ullyett (1947), while Yasumatsu and Tan (1981) reported that the vespid wasp *Ropalidia sumatrae* frequently attacks DBM larvae in lowland crucifers.

In general, predators have been suggested to be important stabilizing agents for DBM populations (Ullyett 1947; Yamada and Yamaguchi 1985). Nemoto et al. (1985) explained that the higher numbers of DBM in their insecticide treated fields was because of lower predator numbers, while Sivapragasam and Saito (1988) suggested that large unknown mortalities in life table studies may be attributed to predators. Using a biological control check method, Keinmeesuke et al. (1988) demonstrated that 68% or more of DBM larval mortality was due to various predators including birds. Although predators have been suggested as major mortality factors, they presently are receiving little attention. More in depth studies are thus desirable.

Microbials: The use of microbial agents for controlling DBM has progressed most with *B. thuringiensis* where it is highly effective against the larvae. Many commercial formulations are now available and used. Recently, more promising activity is also obtained with the liquid formulation. However, in Vietnam the common presence of bacteriophage is noted to pose some constraints to using this microbial agent.

Because of increasing difficulties in achieving effective control with most chemical insecticides due to resistance development, there is in recent years more intensive and widespread use of *B. thuringiensis*. This has enabled better survival of parasitoids. Consequently, a greater abundance of both *D. semiclausum* and *D. collaris* has been observed in the Cameron Highlands in Malaysia, as well as trichogrammid egg parasitoids in Thailand.

Experimental studies with viruses have shown them to be potentially useful in the control of DBM. The main ones include granular virus (GV) and nuclear polyhedrosis virus (NPV). Among the latter are *Autographa californica* (AcNPV) (Vail et al. 1972) and *Galleria mellonella* (GmNPV) (Abdul Kadir and Payne 1989). Studies have shown that the GV is most pathogenic to DBM while GmNPV can kill faster.

Currently the practical employment of viruses for the control of DBM still faces a number of problems and needs further investigation. These encompass virus production, spray application techniques and formulation.

In the case of other microbials, the main ones are *Zoophthora radicans* and *Beauveria bassiana*. These two agents are considered to be particularly useful in Vietnam (Vu 1988). In Malaysia, *Z. radicans* is also considered an important mortality factor of DBM (Ooi 1981). Generally, as the host population increases, the infection level also rises. Under the tropical conditions of Asia where there is abundant rainfall and a high mean temperature these agents normally serve as a constant mortality factor.

Use of Plant Resistance

Plant resistance is a highly useful strategy that can be applied in the control of pests. It does not require any special action from growers and constitutes a cheap and practical input in the integrated control system.

In the case of DBM some specific components for resistance/susceptibility have been identified: allyl isothiocyanate, glucocheirolin, glucoerucin, gluconapin, gluconasturtiin, gluconringiin, glucotropaeolin, progoitrin, sinalbin and sinigrin (Hillyer and Thorsteinson 1969). Although differences in varietal resistance of crucifers to the moth are now known (Rudder and Brett 1967; AVRDC 1976; Dickson et al. 1986) the more tolerant varieties are generally not preferred because of other poorer agronomic features. Consequently, these cultivars are not generally cultivated.

Cultural Practices

Time of Planting: Because pest abundance can be greatly influenced by seasonal factors (e.g. rainfall) the time of planting may sometimes govern the final performance of a crop. For instance, DBM infestations are observed to be generally lower during the wetter period (Lim 1982). Thus, avoiding the cultivation of crucifers in the drier parts of the year has ensured less need for insecticidal inputs to control DBM.

On the other hand, disease occurrence on vegetables is generally higher during wet periods. Thus, for specific location and crop it is important to determine appropriate sowing time to mitigate the envisaged problem so as to obtain the maximum production.

Crop Rotation: This is one of the most effective cultural measures for reducing monophagous or oligophagous insects such as DBM as in Thailand (Vattanatum 1988). It is also widely practiced in Vietnam, especially in larger commercial cultivation. In upland areas the rotation is mainly among crucifers, cucurbits and beans. Two common rotational systems are: cabbage-peas-turnip or cabbage-luffa, and tomato-turnip or cabbage-squash or cucumber (Vu 1988). By this means, DBM on crucifers can be suppressed substantially.

Intercropping/Mixed Cropping: Rational intercropping of various vegetables maximizes the use of rotation and this can help localize the spread of many arthropod pests.

In both Philippines and Malaysia, tomato intercropping with cabbage was observed to reduce DBM larval infestations (Buranday and Raros 1975; Sivapragasam et al. 1982), possibly due to volatile compounds which have a repellent effect on adult DBM. In some instances this has resulted in higher cabbage yield (Embuido and Hermana 1981). However, inconsistent results of others (Magallona 1977) suggest the need for further investigations.

Alternative Food Source and Shelter Plants

Many adult beneficial insects often require foods such as honey and/or pollen. Refuge or shelter plants may also be important for their survival, particularly in avoiding excessive pesticide sprays. For the key parasitoids of DBM, some plants found to be important have included many species of wild flowering plants and cultivated legumes (e.g. beans and peas) (Lim 1982). The more important wild plants are *Malastoma malabathricum*, *Crotalaria* spp. and *Cleome*

ruidosperma. These plants are found capable of increasing greatly the lifespan of the parasitoids. In practice, encouraging the planting of such useful plants in the crop vicinity would be desirable.

Sanitation: Sanitation is a simple, but important preventive measure of pest control. Even simple removal can greatly reduce the infesting potential. Removal may also include alternate hosts, weed hosts, volunteer plants and crop residues. For instance, some farmers in Thailand practice destroying crop residues to disrupt the development of DBM (Vattanatangum 1988).

Fallowing and land drying can also be critical. In Vietnam, for example, the land is usually plowed over and left exposed to the hot sun for at least a week prior to cultivation. This helps in cleaning up sources of DBM as well as improving general soil conditions (Vu 1988).

Regulated Irrigation: Regulated irrigation with sprinklers has been demonstrated to be capable of reducing substantially the infestations of DBM (Talekar et al. 1986). Here, the water sprays interfere with mating and oviposition of the moth. In addition young larvae may also be drowned during periods of heavy rain.

Physical/Mechanical Methods

Some physical and mechanical methods have also been explored in Thailand in relation to DBM control (Vattanatangum 1988). The blue-light traps, for instance, are capable of capturing large numbers of adult DBM. Planting crucifers such as Chinese kale, pakchoi, Chinese cabbage and cabbage under fine-mesh netting houses also gave satisfactory yields. There was good protection from DBM as well as many other common pests. This control method is now being further investigated in the central plain of Thailand where DBM is rapidly developing resistance to nearly all insecticides.

The use of yellow sticky traps in conjunction with other conventional methods has also been reported to be effective in controlling DBM in Thailand.

Recent and Novel Techniques

These techniques include the use of pheromones, chitin inhibitors or insect growth regulators (IGRs), chemosterilants, antifeedants, and sterile male release, and botanicals.

Except for IGRs, pheromones and some botanicals which are being given increasing attention recently, most of these techniques are still exploratory and are presently of no practical use. A few IGRs have so far been used against DBM but are already facing problems similar to those of conventional insecticides.

Natural products are also receiving increasing attention for possible use against DBM. For example, in Thailand, extracts of neem (*Azadirachta indica*) have been found effective and used against DBM on Chinese kales and cabbage. In Malaysia and the Philippines exploratory studies have also been initiated.

Chemical Pesticides

Currently, chemical insecticides still constitute the main control tactics for DBM in most parts of the world where this pest is serious. A wide range is available and are being used, often indiscriminately and resulting in many undesirable problems.

In terms of using chemical insecticides there is an urgent need to refocus their employment towards a supplementary function, and integrating them within a more holistic IPM approach. To enable them to be used more prudently, the investigatory aspects will need to include identifying more selective chemicals, improvement in application technology, and applying wide-spectrum chemicals to achieve ecological selectivity, such as correct time and method of application, use of minimal effective dose, and applying appropriate formulations.

Attempts in IPM Programs

It is now clear that many diverse and potential elements for IPM development against DBM are now available. Unless some of these are assembled together into appropriate IPM programs the integrated approach to DBM management will not fully materialize. In this regard, it is encouraging to note that some efforts have already been initiated, even though still limited presently (Table 2).

In all these efforts many common features are evident, the more important ones being:

- (1) Only a few of the potential elements have so far been practically incorporated.
- (2) The most common components used are biological control (particularly parasitoids), action thresholds and monitoring, and judicious use of chemical insecticides when the pest thresholds are exceeded. In a few cases there have been additional elements incorporated such as crop rotation, proper timing of planting, light trapping and use of physical barrier.
- (3) In general, none of the IPM programs are inferior to the existing prophylactic control methods presently practiced by farmers. Although crop yields may not always improve substantially, they generally are not less.
- (4) In cases where the thresholds are exceeded and insecticidal applications necessary, both the frequency and amounts of insecticides used are substantially reduced.
- (5) For most of the IPM program, *B. thuringiensis* has been incorporated, serving as a replacement to many broad-spectrum insecticides and providing the needed selectivity when quick action by chemical intervention is necessary.
- (6) In terms of profits there is usually a substantial increase, mainly because of savings from the enormous reductions in chemical inputs.
- (7) Most of the IPM programs are presently still at the experimental stage. Although there has been field adoption, this occurs only on a limited scale.
- (8) The IPM programs developed so far are still largely executed and confined within the domain of researchers. There is presently inadequate involvement of both the extension personnel and the farmers.

The overall attempts devoted to the development and implementation of IPM for DBM are in general still limited. Nonetheless, there have been many useful lessons gained and these can serve as important guides towards future IPM activities for DBM.

Discussion

The limited attempts of IPM for DBM have demonstrated that not only are such IPM programs feasible but there are also many benefits. In spite of this, IPM is not widely adopted. This is largely due to several constraints which must first be overcome. To expedite the current initiatives in IPM development for DBM and its implementation, a number of positive steps will need to be taken.

Firstly, since self-regulating processes to maintain stability must be present for an IPM program to have maximum and long-lasting impact, and several key DBM parasitoids can well satisfy this role, introductions of these species into areas where they are absent should be an important first step. The current effort of AVRDC (Talekar 1990) in establishing these parasitoids in Southeast Asia is therefore to be encouraged.

Experiences to date have shown that biological control agents are the core components in IPM programs of DBM. These therefore must not be disregarded. Presently, the main biological control agents are mostly parasitoids while the microbial is mainly *B. thuringiensis*. The role of predators and how they may be specifically employed is however, still unclear. Until further studies are made on how to use them, all efforts should be made to encourage conserving them as much as possible.

Table 2. Some attempts at IPM^a of DBM and their performance.

Country	IPM elements which are incorporated	Status	Benefits	
			Pesticide reduction	Profit
Indonesia ^b	Key parasitoids, <i>B. thuringiensis</i> , selective chemicals, simple monitoring, and use of action threshold.	Farm level	Types of insecticides, dosages and frequency greatly reduced.	Not available
Malaysia ^c	Avoid planting in drier period, key parasitoids, simple monitoring, use of action threshold, <i>B. thuringiensis</i> , selective chemicals.	Experimental, some at farm level. Now in process of transfer to farmers for adoption.	Number of applications reduced from 7 to 3. Amount chemical used reduced by 98% and expenses by 97%.	Crop yield increased by 22% and profit by 84%.
Taiwan ^d	Establishment of the key parasitoid <i>D. semiclausum</i> to supplement other important ones such as <i>C. plutellae</i> and <i>D. collaris</i> . Where sprays are needed, <i>B. thuringiensis</i> was encouraged.	Cabbage fields of farmers	Use of insecticides greatly reduced. Where used, they are mostly <i>B. thuringiensis</i> .	Estimated potential savings of over US\$370,000 per year.
Thailand ^e	Key parasitoids, monitoring, use of action threshold, selective chemicals, in some cases also under fine-netting and use of light traps.	Experimental, some at farm level, Now in process of transfer to farmers for adoption.	Amount of pesticides greatly reduced. Cost of insecticides spent reduced by 80%.	Profit tripled.
Vietnam ^f	Crop rotation (crucifers and cucurbits), separate nursery, main planting intersown with tomato, <i>B. thuringiensis</i> and other microbials, selective chemicals, monitoring and action threshold.	Now in process of transferring to farmers.	Pesticide inputs reduced by 51%.	Profit figures not available. However, pest infestations are greatly reduced, by 8-10 times when compared to farmer practices.

(Continued)

Table 2. Concluded

Country	IPM elements which are incorporated	Status	Benefits	
			Pesticide reduction	Profit
USA				
Lower Rio Grande Valley ^g	Insect sampling and action threshold (of 0.3 larva/plant) to manage complex of lepidopterous cabbage pests including DBM.	Large-scale tests in commercial cabbage fields.	On average two fewer insecticide applications were required.	Greater market-yields
Hawaii ^h	Parasitoid <i>C. plutellae</i> and overhead sprinkler irrigation system for DBM, and predators and timely applications of insecticides for other associated important pests.	Commercial farm level.	Insecticide inputs reduced substantially.	Commercially cost effective. Chemical control costs reduced by 89%, while production increased by 93%.

^aEstablishment of key parasitoids leading to effective suppression of DBM is also included since parasitoids are regarded as the cornerstone of DBM IPM. ^bSastrosiswojo and Sastrodihardjo 1986; ^cLim et al. 1988; ^dTalekar 1990; ^eVattanatangum 1988; ^fVu 1988; ^gCartwright et al. 1987; ^hNakahara et al. 1986.

Up to the present time, most DBM management practitioners have never needed or been encouraged to think in terms other than chemical. This must change. They should be made more aware of the need for IPM. Until the awareness attained is adequate, IPM can only expand slowly. In particular, special emphasis is necessary to generate increased awareness and transfer of available practical IPM programs. The strategic steps will include IPM trial demonstrations and appropriate training of extension personnel and the farmers. Particularly in farmer training the field school approach should be adopted, wherein hands-on training is to be conducted under actual farm situations.

Training must include practical field skills as well as delivering only relevant knowledge. Communication should use an appropriate variety of media channels in strategic campaigns to reach well-defined target audiences with specific messages whose impact can readily be measured. In particular, suitable development support communications are to be utilized, encompassing pre-tested posters and pamphlets, and other audiovisual media.

Pertaining to training and generating increased IPM awareness, regular follow-up visits on progress are particularly essential. This, however, can only be effectively achieved if there is adequate support of extension services. The latter is presently still very weak in many parts of the developing tropics where DBM is also most serious. An urgent need, therefore, is for increased government support to ensure an efficient extension program on IPM implementation for DBM.

Since vegetables are generally marketed through the private sector rather than government channels, promotion through social marketing campaigns aimed at all parts of this system should constitute a special necessary element of IPM for DBM.

In terms of research on DBM this must be pursued holistically. For too long there has been overfocusing within the confines of the different IPM components, wherein the research is most of the time conducted in isolation. This should now be avoided. Of special importance is that

there must be a true integration of research in developing IPM programs. Specifically, assembling and further improving appropriate IPM programs of DBM must be given prime focus.

To ensure practical impact research must also involve close collaboration with farmers. There are certainly crucial needs for both pure and applied science aimed at improving human life through improved crop protection. But practical requirements must be paramount in much of the developing tropics, especially where there are crisis conditions of food production (Way 1982) and excessive use of chemical toxicants as in the present case of DBM. Certainly while specialist IPM research needs to be continued and strongly supported, there must be adequate effort directed to involve vegetable growers in order to establish those elements of IPM that are likely to be useful in practice (Way 1985).

To date, most research programs on DBM management have been centered only on the biological aspects. But IPM technology adoption extends well beyond this. Thus, efforts must now also be directed at such areas. Although many social and marketing factors can influence pest control decisions for DBM, presently still very little is known of these aspects. In particular, it is critical that studies be initiated to understand the farmers better, such as their knowledge, perception, attitude, and practice relating to DBM. Arising from these will then be a truer understanding of the farmers' aspirations and constraining factors. This will better ensure that any follow-up research to be undertaken will consider the practical realities of the farmers. It will also improve the communicative processes crucial for translating IPM for adoption.

Now that feasible IPM programs for DBM are available, increased efforts must be devoted to speed up implementation of these programs. The primary goal should concentrate on the elements of transfer, that is, simplifying, assembling, delivering, monitoring, and evaluating the IPM of DBM. In this regard there must therefore also be adequate integration of people besides that of biological elements. Unless the key groups of people involved (in particular researchers, extension workers, farmers and the socio-marketing sectors) are well integrated, implementation of IPM for DBM cannot be expected to progress satisfactorily and rapidly. There should also be emphasis to ensure sustainable institutional support for the IPM programs. Only through such sustained efforts can IPM of DBM truly emerge to become a practical reality to a large number of vegetable growers, and bring a previously thought-to-be inaccessible technology to the many illiterate resource-poor farmers so that they may receive the many benefits of IPM. Of particular importance is the opportunity to free themselves from pesticide dependency, and reducing insecticidal inputs along with the many undesirable problems commonly associated with the overuse of chemical insecticides in DBM control.

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