TECHNOLOGIES FOR DEVELOPMENT



# UNDERSTANDING INSECT PESTS AND THEIR CONTROL

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## PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Maria Giannuzzi as editor, Julie Berman handling typesetting and layout, and Margaret Crouch as project manager.

The author of this paper, VITA Volunteer Harold R. Willson, is an extension entomologist and integrated pest management coordinator with the department of entomology, Ohio State University. A former Peace Corps Volunteer in India, Dr. Willson has performed many overseas consultancies concerned with pest management and entomology, and is widely published in these fields. The reviewers of this paper are also VITA Volunteers. Dr. Ernest C. Bay is superintendent and professor of entomology for the Washington State University Western Washington Research and Extension Center. He is a specialist in the biological control of mosquitoes and has consulted for the World Health Organization and VITA in Nicaragua, the Far East, Africa, and Haiti. Kenneth Haines worked in Ghana for several years where he supervised pest control as one of his duties as an agricultural extension specialist. R. Narasimhan is with the Asian Pacific American Chamber of Commerce.

VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers. For more information about VITA services in general, or the technology presented in this paper, contact VITA at 1815 North Lynn Street, Suite 200, Arlington, Virginia 22209 USA.

# UNDERSTANDING INSECT PESTS AND THEIR CONTROL

by VITA Volunteer Harold R. Willson

## I. INTRODUCTION

Insect control is the effort made to protect crops, animals, or other targets of insect attack from unacceptable injury or loss. If destructive insect populations are allowed to cause significant damage or injury to their target host, economic loss or a decline in human health may result.

Destructive insects threaten the value of most food crops both before and after harvest. In addition, insect pests can destroy structures and cause direct injury to animals including humans. However, not all insects are destructive. Some provide direct economic benefit by producing products such as honey or silk; others naturally control harmful insect pests. And of vital importance is the role of insects in pollinating flowering plants.

A population of a destructive pest and its target host (a crop, livestock, etc.) are part of a complex system that includes all other organisms living in a given physical environment or ecosystem. Elements of a natural system, such as a crop, are in a state of balance with one organism affecting the other. Problems occur when the natural balance between destructive and beneficial insects is upset. Corrective action is then required to control the problem or prevent similar pest problems in the future.

## II. METHODS OF INSECT CONTROL

### APPLIED CONTROL

Applied control includes a whole range of practices that become necessary when natural control factors fail to work adequately.

Important methods of applied control are:

1. chemical control;
2. biological control;
3. cultural control;
4. legal control; and
5. environmental control.

In discussing each method, note that only general information can be given since much depends on the type of insect pest, its habits, and the kind of damage it causes. Also important are the nature and condition of the target host to be treated, weather conditions, application equipment, and the method of application. For information to meet specific needs, consult an agricultural organization in your area.

## Chemical Control

The use of chemicals--generally referred to as insecticides--has become the most common approach to dealing with insect problems. An insecticide may be used as either a preventative or corrective treatment. In the case of preventative treatment, it is assumed that the probability of an insect becoming a problem is high. Action is taken on the assumption that preventative treatment is more economical or effective than taking corrective action after the fact. However, many insect pests are best controlled after their numbers are so high that they might become a threat to their target.

For crops the decision as to when to take corrective action is best based on an "economic injury level" previously established for the host and its insect pest. This involves the judgement of the extent to which a particular pest population can be allowed to grow before an insecticide must be applied to prevent further crop loss. The economic injury onset is determined by monitoring the insect pest population in relation to its natural enemies, weather, and host condition.

The timing of insecticide application can significantly affect the potential for crop contamination. The best times to apply insecticides, especially if they are sprayed, are in the early morning or early evening hours when the air is still. Insecticides should never be sprayed in wind or when heavy rains are expected. Sometimes, insecticides are applied early in the growing season; but since this usually coincides with the rainy season, the runoff merely carries the insecticides away. If possible, insecticides should be applied after crops have emerged, later in the season, or even after the season to prepare fields for the next season.

People who use an insecticide to control a pest problem must be warned of the possible harmful effects it may have on the environment, beneficial insects (e.g., pollinators such as bees), or the person who applies it. Safety precautions and directions for its use should be followed carefully. Failure to take safety precautions and to handle insecticides carefully may result in illness or death or contamination of water and food.

Continuous use of insecticides can destroy beneficial soil microrganisms and reduce soil fertility. Some soil microorganisms kill insect pests. Overuse and misuse of insecticides can interfere with the microorganism's ability to kill such pests. When this happens, pest problems can actually worsen: the pest may develop resistance to the insecticide, and since natural controls have been wiped out, the pest populations can be virtually uncontrollable, at least for a time.

Remember that many insecticides kill not only target species but other harmless or beneficial organisms such as honeybees, insect parasites, or predatory insects. In many instances, the use of insecticides to control one insect destroys the controlling natural enemies of other species, allowing these to become new pests.

If you need to use insecticides, check with local farmers or extension agency personnel to see what are the possible effects of using them. Also, look into alternative control measures that may meet your needs without harmful effects.

Biological Control

Biological control involves using an insect's own natural processes or enemies to control it. Some of these controls are the result of modern scientific research.

very few biological controls are as readily available and useful for controlling insect pests as insecticides. These are almost exclusively disease organisms, particularly Bacillus thuringieusis, which is effective against many Lepidopterous larvae and Bacillus thuringieusis Israelensis, which is useful for some mosquito species. Also, milky spore disease has long been marketed for Japanese beetle control in the United States.

A few insect predators and parasites, including lacewing larvae (Chrysopa), ladybird beetles (Coccinellidae) and Trichogramma species are sometimes marketed but their successful use requires a professional understanding of the elements in the ecosystem where they are used. More often these species are marketed more for their ease of production then for their effectiveness. A notable exception is the mosquito fish Gambusia affinis, which preys on some pool dwelling mosquito larvae. Many sites, however, are not suitable for mosquito control by Gambusia. Also, care must be taken that the fish does not become permanently established where it will eliminate other desired fish by competition.

The introduction of natural enemies to control imported insect pests has proven to be the most effective biological control. This usually requires the resources of government agencies, dedi-

cated research, and years of work. Where it is successful as with the classic case of the Vedalia beetle in the control of cottony cushion scale of citrus, it requires no further application of the natural enemy. It simply requires the observance of good agronomic and ecological practices to ensure the mutual survival of prey and predator at acceptable pest levels.

Other types of biological control include release of sterilized males, sterile hybrids, pheromones for attracting or confusing populations, and other innovative techniques. These have been used with varying success. These practices usually require institutional resources.

The use of chemical repellents is another method of controlling insect pests. For example, chemicals that function as repellents to household pests such as cockroaches can be used alone or in conjunction with an integrated control program to prevent the accumulation and reinfestation of cockroaches. In cases where immediate relief from, say, biting mosquitoes is needed but other control measures are impractical, repellents placed directly on the skin or sprayed on a piece of clothing can be very effective. Repellent-treated mesh jackets are effective for longer periods.

In some situations, the term biological control also refers to the presence of native beneficial insects that are natural predators of problem pests. It is when natural control fails that other controls are necessary. This is the basis of pest management and integrated control. It is important to be aware of the natural enemies of insect pests and to use those insecticides that are least destructive to them. As mentioned earlier, the destruction or disturbance of natural control by some insecticides can cause other insects previously under natural control to assume pest status.

Manipulation of beneficial insects to control problem pests generally requires extensive study and a long-term effort. However, awareness of naturally present beneficial insects and the use of chemicals least destructive to these insects may prevent new pest development.

Biological control methods have worked well in some small-scale applications but may or may not work in other situations. They should be considered as alternatives that may be used alone or in combination with other pest control practices.

## Cultural Control

Many insect pest problems can be prevented by adopting crop culture practices that adversely affect the development of certain pests. For example, rotation of certain crops can prevent

development of a given pest population that requires the presence of the host crop over more than one growing season. Effective weed control often reduces the probability of some pests infesting a crop. The use of cultural insect controls may or may not provide an economical alternative to chemical control depending on the situation.

Cultural controls can also be used to alleviate forest pest problems. Forest culture practices include removing high-risk trees, promptly treating pest-infested trees, disposing of logging residues, and promptly harvesting damaged trees.

In nurseries, cultural control practices include carefully controlling irrigation, improving soil fertility, and regulating seedling density. Proper timing between lifting, fallowing, and planting can also be useful in reducing pest populations in nursery beds.

### Legal Control

Regulatory action by a governmental agency may be advisable where insect pests pose a threat to society. Examples of legal control include isolating a pest-infested area to prevent insects from spreading to other areas or requiring farmers to adopt cultural controls to reduce the impact of a given pest over an area.

### Environmental Control

Environmental control involves changing the environment in such a way as to destroy insect life. Three environmental control methods are discussed below.

**Physical Control.** Examples of some physical means of excluding insect pests include properly designed machinery or equipment, constructing airtight doors, screening windows, controlling and filtering air, segregating commodities (e.g., grain products) subject to high pest infestation, rotating commodities in storage facilities, and developing insect-resistant packaging.

**Temperature Control.** Temperatures below 5°C (40°F) prevent insect activity and temperatures much below 0°C (32°F) for an extended period usually kill insects. Also, temperatures above 38°C (100°F) for long periods or 60°C (140°F) for short periods are lethal.

**Sanitation Control.** Sanitation involves good housekeeping practices. Although sanitation by itself does not usually prevent insect infestation, it often enhances the effect of insecticides should these be needed.

The regular removal of dirt, dust, and grease from household objects helps to prevent infestation. Rotating heavy pieces of furniture is also important because household pests usually feed in areas where cleaning is difficult rather than in the open where thorough cleaning, light, and the movement of people make infestation difficult.

Cereals and foods high in protein are attractive to household pests. Take care in kitchen cabinets and other storage areas not to let these materials accumulate in cracks and crevices. Routinely removing other food sources such as garbage also prevents pests from breeding.

## INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a comprehensive approach that uses available control methods in an ecologically and economically balanced program. Its objective is to optimize pest control in terms of overall economic, social, and environmental values. By using a combination of the insect pest control practices described thus far, an effective IPM program can reduce insecticide use and thus prevent the damage to the environment caused by the continuous use of insecticides. Also, it can provide alternate controls should any one method fail.

To ensure that an IPM program is economical, an IPM specialist may recommend the use of low-cost insect control methods for a field that has a low cash value per acre. Thus, an IPM program aims to incorporate cost-effective control practices into a practical pest management system.

IPM specialists are also aware of the important role beneficial parasites and predators play in reducing insect pest populations. In many vegetable production areas, trained IPM specialists try to reduce insecticide treatments by making full use of beneficial insects. They recommend insecticide applications for insect pests only when needed, thus hoping for the least harm to beneficial insects.

IPM specialists are also trying to reduce the use of hazardous chemicals and to manage target hosts in a manner less likely to contribute to pest problems. In forestry, for example, the amount of direct chemical control of forest pests has been declining in recent years. Biological control agents are often used to replace conventional chemicals.

Before undertaking an integrated pest management program, one needs to (1) learn as much as possible about the life cycle and environmental requirements of the insect pest; (2) find out

where or when the pest is most susceptible to control; and (3) determine the least ecologically harmful way or combination of ways to control it.

## III. DESIGNING THE SYSTEM RIGHT FOR YOU

Design of a pest management program for a given pest or combination of pests, whether affecting a crop, livestock, or other aspect of human welfare, depends on the availability of adequate information. First, the pest must be identified. Accurate identification of a pest enables review of the pest's biology, population activity, nature of damage to host, etc. Following identification, a survey of the site should be conducted to assess the degree of the problem. Such a survey will provide an idea of the relative importance of the pest in regard to a particular situation. Selection of appropriate pest control measures will depend on the type of insect and available control methods.

The easiest and most common method for controlling destructive insects is chemical control. Before a decision is made to use an insecticide, one should consider: (1) the economic cost/benefit of the action, and (2) the environmental implications of the action, including the safety of the applicator.

Specific questions that need to be addressed before applying insecticides to control crop pests include:

- Does the pest threat justify the investment in the insecticide?
- At what stage of the pest's development will the pest population cause substantial injury to the crop?
- Is the pest population still present to warrant chemical treatment? If so, is it vulnerable to such treatment?
- Do any parasites, predators, or diseases exist that might lead to a decline in the pest population?
- What effect will prevailing climatic factors have on the pest population or the host crop?
- Does timing the application of an insecticide have an effect on the ability of the insecticide to control the pest population?
- What effect will an insecticide have on beneficial insects in the immediate environment?

- What is the distribution of the pest problem and should all areas be treated?

- Has the application been calibrated recently to deliver the desired treatment?

- If insecticide use is warranted, which insecticides can be obtained and applied within the remaining pre-harvest period?

- What is the effectiveness of available insecticides?

- Are the insecticides available in your area registered for use? Have you checked with local authorities to see if there are specific laws governing the use of insecticides?

- Have adequate precautions been taken to protect workers from insecticide poisoning during transport, storage, and application of insecticides? Are instructions available in local languages?

- Could the insecticide suggested for use kill beneficial soil microorganisms or beneficial insects?

- Have you considered all pest management options?

- Is it likely that erosion will carry insecticides into downstream water bodies? If so, could such insecticides affect fisheries and domestic water use?

- Can a species-specific insecticide be used?

- Is it possible to switch insecticides to reduce the likelihood of target species developing resistance to an important insecticide?

- Have you contacted local universities and government agencies for information on local pest species and their control practices to be sure you have considered all the alternatives to insecticides?

To answer the above questions, the decision maker needs adequate information on the status of the crop threatened by a pest problem. Such information includes (1) identification of the pest problem and associated organisms; (2) knowledge of the biology and population dynamics* of the pest population(s);

*The aggregate of processes that determine the size and composition of any population.

(3) familiarity with the host crop's capability to withstand pest injury; and (4) knowledge of the effectiveness of available insecticides under prevailing environmental conditions.

The suitability of chemical controls for an insect pest depends on the availability of insecticides registered for use on the site in question. The effectiveness of a given insecticide on a new pest problem should be evaluated to determine appropriate treatment, rates, time of application, and impact on the local environment.

Deciding whether or not to use biological or natural controls requires detailed knowledge of related organisms that may be parasites or predators of the pest in question. Use of cultural methods to control a pest requires a thorough understanding of the pest under various cultural practices. Implementation of biological or cultural control methods often depends on years of research and evaluation. If effective chemical methods are available to control an insect pest, efforts to develop a program that integrates biological and cultural controls with chemical controls should be made to minimize dependence on any single control method.

Once an insect control program has been established, the program's effectiveness must be monitored regularly, especially if the program depends heavily on the use of insecticides. Effective biological or cultural control methods, once established, tend to be long lasting. In contrast, dependence on insecticides often requires continued re-evaluation and development of new compounds to maintain adequate control of the pest. This is due to the ability of insect populations to develop resistance to chemicals over time. The development of resistance by an insect population to insecticides is most likely in situations where a single insecticide is used extensively. Thus, any effort to minimize excessive use of chemical controls and incorporate biological or cultural controls will enable more effective use of chemical controls.

Methods of insect control differ with each combination of pests and affected site. Insects pass through various stages and the stage targeted for treatment may or may not be the damaging stage in the life cycle of the pest. The environment of the host site also has a significant effect on the control method adopted. Insect pests inhabit a diversity of environments ranging from aquatic to soil ecosystems, and each environment presents a different set of ecological factors for consideration.

Information on insect control is available from a number of agricultural institutions throughout the world having entomological expertise. Agricultural chemical industries often provide

extensive information on important pests. Documentation exists on over a million insect species around the world, of which only a few thousand are considered destructive insects of economic importance. However, the most important step in dealing with an insect problem is the collection of accurate observations in the field which form the basis for future decisions.

## IV. LABOR REQUIREMENTS

Development or selection of a pest management program for a given pest problem requires the services of personnel with training and experience in the field of applied entomology. Such personnel may be entomologists or specialists in the host commodity field with substantial training or experience in pest control.

Where new insect control methods must be developed, the services of research entomologists with training or research experience in a particular specialty may be required. Entomologists specialize in a number of areas depending on the commodity, method of control, or level of technology being developed. Insect toxicologists study the response of insects to toxic substances in the lab. Physiologists study various aspects of insects in regard to their function. Biological control specialists study the relationship between pests and natural agents that may be implemented for control. Taxonomists are often necessary to accurately identify pest species. Entomologists who develop and implement field methods are often referred to as economic entomologists or pest management specialists. Such applied field entomologists often specialize by commodity fields (e.g., field crops, vegetables, fruit, forestry, livestock, stored products, human health, etc.).

The institutional source for entomological expertise includes both public and private agencies. In the United States, expertise in entomology is primarily based in a network of state agriculture experiment stations operated by state universities having agriculture colleges. In addition, research and regulatory entomologists operate out of state and federal departments of agriculture. Implementation of new technology is performed by extension entomologists associated with agricultural colleges. Within each state, entomology extension specialists work through the county extention agents to educate farmers and the public concerning new pest control technology and the safe and proper use of pesticides.

Private industry--especially the agricultural chemical industry--represents an important source of pest control expertise. In many cases, the level and extent of expertise within private industry exceeds that available from public resources. Most chemical companies have personnel with specific responsibility in

either (1) research, (2) product development, (3) technical support, or (4) sales and marketing. The geographical areas served by industry personnel vary with the scope of the market served. However, all geographical areas of the world are serviced by this private network of pest control specialists. In general, a close working relationship exists between government and private industry in the development and implementation of pest control programs.

One of the most important sources of information for farmers is the local chemical dealer, who often has more contact with local farmers than do public development personnel or other pest control specialists. Provision of education programs on the safe and proper use of pesticides for such local dealers or merchants is important if the local user of pesticides is to receive accurate recommendations. Education of local chemical dealers or merchants in the appropriate pest control technology depends on programs available from both public and private institutions. Public personnel should realize that the local chemical dealer is often the primary source of pest control information and target educational programs accordingly. Potential customers should bear in mind that the chemical dealer or merchant has a vested interest in his products and thus may not be the best source of information on controlling a pest problem.

Chemical marketing programs should stress that the proper use of a chemical to achieve effective control depends on the level of expertise available from local dealers. Education of local chemical dealers and applicators often depends on the implementation of an educational program leading to certification in the proper use of chemical pesticides. Such programs often emphasize pest identification, pest population assessment and control, and pesticide safety. If participation in such training programs is a requirement for the sale, purchase, or use of toxic chemicals, then participation in the educational program is facilitated and improper use of pesticides may be prevented.

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