Biointensive Integrated Pest Management (IPM)

Fundamentals of Sustainable Agriculture

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***Abstract:** This publication provides the rationale for biointensive Integrated Pest Management (IPM), outlines the concepts and tools of biointensive IPM, and suggests steps and provides informational resources for implementing IPM. It is targeted to individuals interested in agriculture at all levels.*

By Rex Dufour
NCAT Agriculture Specialist
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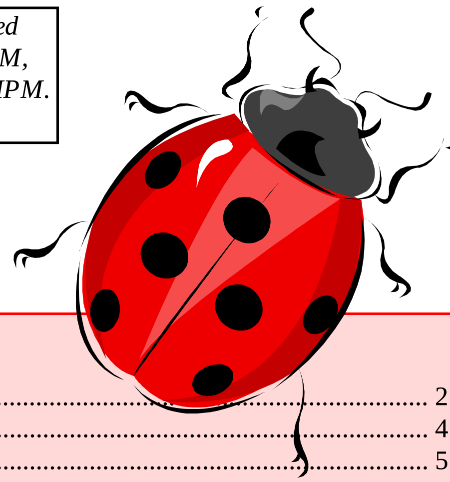


Contents

"Conventional" and "Biointensive" IPM 2
Why Move to Biointensive IPM? 4
Components of Biointensive IPM 5
  How to Get Started 5
  The Pest Manager / Ecosystem Manager 5
  Proactive Strategies (Cultural Controls) 6
  Biological Controls 11
  Mechanical and Physical Controls 12
  Pest Identification 12
  Monitoring 13
  Economic Injury & Action Levels 14
Special Considerations 14
  Cosmetic Damage and Aesthetics 14
  Record-keeping 14
  Chemical Controls 14
Integrated Weed Management Systems 17
Current Status of IPM 19
  Crops with Developed IPM Programs 19
  Government Policy 19
The Future of IPM 20
  Food Quality Protection Act 20
  New Options 20
  More Weed IPM 20
On-farm Resources 21
IPM On-line 21
IPM Certification and Marketing 21
Summary 22
References 23
Appendices:
  A: IPM Planning Considerations 25
  B: Microbial Pesticides 27
  C: Microbial Pesticide Manufacturers and Suppliers 34
  D: Conservation Security Act 2000 37
  E: Pest Management Practices in Major Crops 38
  F: IPM Information Resources 39

“Conventional” and “Biointensive” IPM

Pest management is an ecological matter. The size of a pest population and the damage it inflicts is, to a great extent, a reflection of the design and management of a particular agricultural ecosystem.

We humans compete with other organisms for food and fiber from our crops. We wish to secure a maximum amount of the food resource from a given area with minimum input of resources and energy. However, if the agricultural system design and/or management is faulty—making it easy for pests to develop and expand their populations or, conversely, making it difficult for predators and parasites of pests to exist—then we will be expending unnecessary resources for pest management. Therefore, the first step in sustainable and effective pest management is looking at the design of the agricultural ecosystem and considering what ecological concepts can be applied to the design and management of the system to better manage pests and their parasites and predators.

The design and management of our agricultural systems need re-examining. We’ve come to accept routine use of biological poisons in our food systems as normal. But routine use of synthetic chemicals represents significant energy inputs into the agricultural system, and carries both obvious and hidden costs to the farmer and society. Attempting to implement an ecology-based discipline like IPM in large monocultures, which substitute chemical inputs for ecological design, can be an exercise in futility and inefficiency.

IPM, as it was originally conceived, proposed to manage pests though an understanding of their interactions with other organisms and the environment. Most of the 77 definitions for IPM listed in *The Database of IPM Resources (DIR)* website, <http://www.ipmnet.org/DIR/>, despite some differences in emphasis, agree with this idea and have the following elements in common:

- A conception of a managed resource, such as a cropping system on a farm, as a component of a functioning ecosystem. Actions are taken to restore and enhance natural balances in the system, not to eliminate species. Regular monitoring makes it possible to evaluate the populations of pest and beneficial organisms. The producer can then take steps to enhance natural controls (or at least avoid or limit the disruption of natural controls) of the target pest(s).

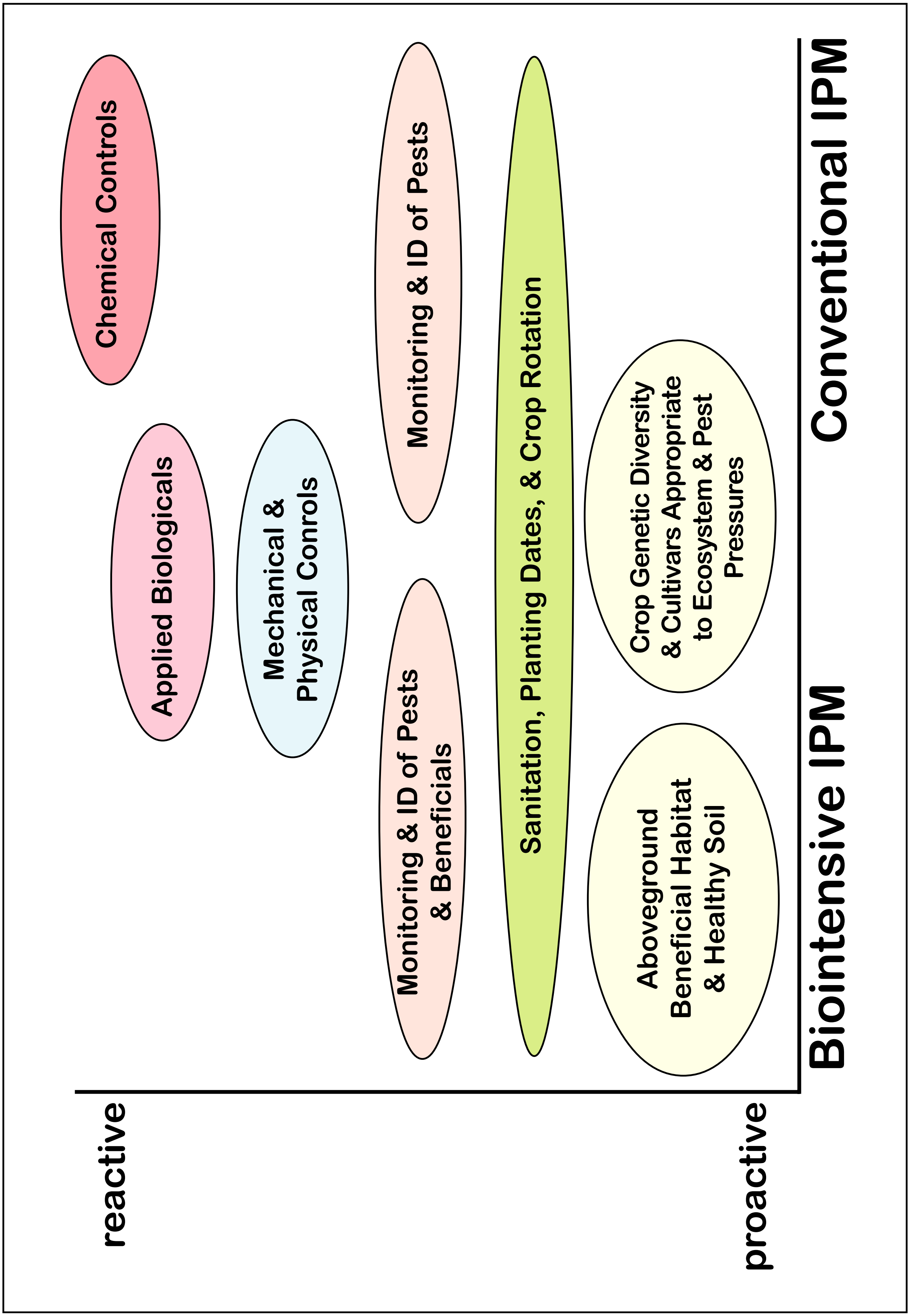
- An understanding that the presence of a pest does not necessarily constitute a problem. Before a potentially disruptive control method is employed, appropriate decision-making criteria are used to determine whether or not pest management actions are needed.

- A consideration of all possible pest management options *before* action is taken.

- A philosophy that IPM strategies integrate a combination of all suitable techniques in as compatible a manner as possible; it is important that one technique not conflict with another (1).

However, IPM has strayed from its ecological roots. Critics of what might be termed “conventional” IPM note that it has been implemented as Integrated Pesticide Management (or even Improved Pesticide Marketing) with an emphasis on using pesticides as a tool of first resort. What has been missing from this approach, which is essentially reactive, is an understanding of the ecological basis of pest infestations (see first bullet above). Also missing from the conventional approach are *guidelines for ecology-based manipulations of the farm agroecosystem* that address the questions:

- Why is the pest there?
- How did it arrive?
- Why doesn’t the parasite/predator complex control the pest?


Chemical Controls
Applied Biologicals
Mechanical & Physical Conrols
Monitoring & ID of Pests
Monitoring & ID of Pests & Beneficials
Sanitation, Planting Dates, & Crop Rotation
Crop Genetic Diversity & Cultivars Appropriate to Ecosystem & Pest Pressures
Aboveground Beneficial Habitat & Healthy Soil
Biointensive IPM
Conventional IPM
reactive
proactive

Why Move to Biointensive IPM?

Biointensive IPM incorporates ecological and economic factors into agricultural system *design* and *decision making*, and addresses public concerns about environmental quality and food safety. The benefits of implementing biointensive IPM can include reduced chemical input costs, reduced on-farm and off-farm environmental impacts, and more effective and sustainable pest management. An ecology-based IPM has the potential of decreasing inputs of fuel, machinery, and synthetic chemicals—all of which are energy intensive and increasingly costly in terms of financial and environmental impact. Such reductions will benefit the grower and society.

Over-reliance on the use of synthetic pesticides in crop protection programs around the world has resulted in disturbances to the environment, pest resurgence, pest resistance to pesticides, and lethal and sub-lethal effects on non-target organisms, including humans (3). These side effects have raised public concern about the routine use and safety of pesticides. At the same time, population increases are placing ever-greater demands upon the "ecological services"—that is, provision of clean air, water and wildlife habitat—of a landscape dominated by farms. Although some pending legislation has recognized the costs to farmers of providing these ecological services (see Appendix D), it's clear that farmers and ranchers will be required to manage their land with greater attention to direct and indirect off-farm impacts of various farming practices on water, soil, and wildlife resources. With this likely future in mind, reducing dependence on chemical pesticides in favor of ecosystem manipulations is a good strategy for farmers.

> Prior to the mid-1970s, lygus bugs were considered to be the key pest in California cotton. Yet in large-scale studies on insecticidal control of lygus bugs, yields in untreated plots were not significantly different from those on treated plots. This was because the insecticides often induced outbreaks of secondary lepidopterous larvae (i.e., cabbage looper, beet armyworm, and bollworm) and mite pests which caused additional damage as well as pest resurgence of the lygus bug itself. These results, from an economic point of view, seem paradoxical, as the lygus bug treatments were costly, yet the treated plots consistently had lower yields (i.e., it cost farmers money to lose money). This paradox was first pointed out by R. van den Bosch, V. Stern, and L. A. Falcon, who forced a reevaluation of the economic basis of *Lygus* control in California cotton (5).

Consumers Union, a group that has carried out research and advocacy on various pesticide problems for many years, defines biointensive IPM as the highest level of IPM:

> "a systems approach to pest management based on an understanding of pest ecology. It begins with steps to accurately diagnose the nature and source of pest problems, and then relies on a range of *preventive* tactics and biological controls to keep pest populations within acceptable limits. Reduced-risk pesticides are used if other tactics have not been adequately effective, as a last resort, and with care to minimize risks." (2)

This "biointensive" approach sounds remarkably like the original concept of IPM. Such a "systems" approach makes sense both intuitively and in practice.

The primary goal of biointensive IPM is to provide guidelines and options for the effective management of pests and beneficial organisms *in an ecological context*. The flexibility and environmental compatibility of a biointensive IPM strategy make it useful in all types of cropping systems.

Even conventional IPM strategies help to prevent pest problems from developing, and reduce or eliminate the use of chemicals in managing problems that do arise. Results of 18 economic evaluations of conventional IPM on cotton showed a decrease in production costs of 7 percent and an average decrease in pesticide use of 15 percent (4). Biointensive IPM would likely decrease chemical use and costs even further.

Components of Biointensive IPM

An important difference between conventional and biointensive IPM is that the emphasis of the latter is on proactive measures to *redesign* the agricultural ecosystem to the disadvantage of a pest and to the advantage of its parasite and predator complex. At the same time, biointensive IPM shares many of the same components as conventional IPM, including monitoring, use of economic thresholds, record keeping, and planning.

How To Get Started With IPM — PLANNING, PLANNING, PLANNING

Good planning must precede implementation of any IPM program, but is particularly important in a biointensive program. Planning should be done *before* planting because many pest strategies require steps or inputs, such as beneficial organism habitat management, that must be considered well in advance. Attempting to jump-start an IPM program in the beginning or middle of a cropping season generally does not work.

When planning a biointensive IPM program, some considerations include:

- Options for design changes in the agricultural system (beneficial organism habitat, crop rotations)
- Choice of pest-resistant cultivars
- Technical information needs
- Monitoring options, record keeping, equipment, etc.

The table in *Appendix A* provides more details about these and other ideas that should be considered when implementing a biointensive IPM program.

The Pest Manager / Ecosystem Manager

The pest manager is the most important link in a successful IPM program. The manager must know the biology of the pest and the beneficial organisms associated with the pest, and understand their interactions within the farm environment. As a detailed knowledge of the pest is developed, weak links in its life cycle

Blocks on the Pesticide Treadmill

Resistance: Pesticide use exerts a powerful selection pressure for changing the genetic make-up of a pest population. Naturally resistant individuals in a pest population are able to survive pesticide treatments. The survivors pass on the resistance trait to their offspring. The result is a much higher percentage of the pest population resistant to a pesticide. In the last decade, the number of weed species known to be resistant to herbicides rose from 48 to 270, and the number of plant pathogens resistant to fungicides grew from 100 to 150. Resistance to insecticides is so common — more than 500 species — that nobody is really keeping score (2).

Resurgence: Pesticides often kill off natural enemies along with the pest. With their natural enemies eliminated, there is little to prevent recovered pest populations from exploding to higher, more damaging numbers than existed before pesticides were applied. Additional chemical pesticide treatments only repeat this cycle.

Secondary Pests: Some potential pests that are normally kept under good control by natural enemies become actual pests after their natural enemies are destroyed by pesticides. Mite outbreaks after pesticide applications are a classic example.

Residues: Only a minute portion of any pesticide application contacts the target organism. The remainder may degrade harmlessly, but too often water, wind, and soil will carries pesticides to non-target areas and organisms, affecting the health of human and wildlife populations. Public concerns over residues are deepened by the lack of research and knowledge about possible synergistic interactions between pesticide residues and the hundreds of other synthetic chemical residues now found in the environment.

become apparent. These weak links are phases of the life cycle when the pest is most susceptible to control measures. The manager must integrate this knowledge with tools and techniques of biointensive IPM to manage not one, but several pests. A more accurate title for the pest manager is "ecosystem doctor," for he or she must pay close attention to the pulse of the managed ecosystem and stay abreast of developments in IPM and crop / pest biology and ecology. In this way, the ecosystem manager can take a proactive approach to managing pests, developing ideas about system manipulations, testing them, and observing the results.

IPM options may be considered proactive or reactive. Proactive options, such as crop rotations and creation of habitat for beneficial organisms, permanently lower the carrying capacity of the farm for the pest. The carrying capacity is determined by factors like food, shelter, natural enemies complex, and weather, which affect the reproduction and survival of a species. Cultural controls are generally considered to be proactive strategies.

The second set of options is more reactive. This simply means that the grower responds to a situation, such as an economically damaging population of pests, with some type of short-term suppressive action. Reactive methods generally include inundative releases of biological controls, mechanical and physical controls, and chemical controls.

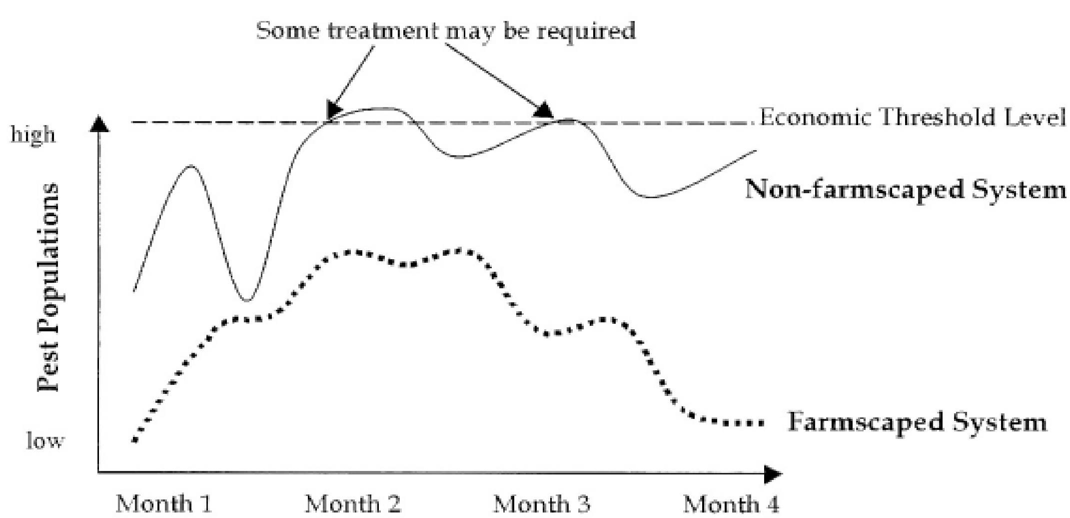
Proactive Strategies (Cultural Control)

- Healthy, biologically active soils (increasing belowground diversity)
- Habitat for beneficial organisms (increasing aboveground diversity)
- Appropriate plant cultivars

Cultural controls are manipulations of the agroecosystem that make the cropping system less friendly to the establishment and proliferation of pest populations. Although they are designed to have positive effects on farm ecology and pest management, negative impacts may also result, due to variations in weather or changes in crop management.

Carrying Capacity of Farm Systems for Pest Populations:

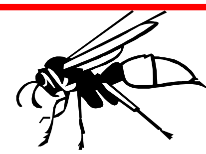
In a non-farmscaped system, where pests have fewer natural controls and thus reach higher average populations, they are more likely to approach or exceed the economic threshold level for the crop, making pesticide treatments likely. In a farmscaped system, greater and more consistent populations of beneficial organisms put more ecological pressure on the pests, with the result that pest populations are less likely to approach the economic threshold. In other words, the ecological carrying capacity for a pest will probably be lower in a farmscaped system. *For more on farmscaping, see p. 11.*



Maintaining and increasing biological diversity of the farm system is a primary strategy of cultural control. Decreased biodiversity tends to result in agroecosystems that are unstable and prone to recurrent pest outbreaks and many other problems (5). Systems high in biodiversity tend to be more "dynamically stable"—that is, the variety of organisms provide more checks and balances on each other, which helps prevent one species (i.e., pest species) from overwhelming the system.

There are many ways to manage and increase biodiversity on a farm, both above ground and in the soil. In fact, diversity above ground influences diversity below ground. Research has shown that up to half of a plant's photosynthetic production (carbohydrates) is sent to the roots, and half of that (along with various amino acids and other plant products) leaks out the roots into the surrounding soil, providing a food source for microorganisms. These root exudates vary from plant species to plant species and this variation influences the type of organisms associated with the root exudates (6).

"When we kill off the natural enemies of a pest we inherit their work"— Carl Huffaker



Factors influencing the health and biodiversity of soils include the amount of soil organic matter; soil pH; nutrient balance; moisture; and parent material of the soil. Healthy soils with a diverse community of organisms support plant health and nutrition better than soils deficient in organic matter and low in species diversity. Research has shown that excess nutrients (e.g., too much nitrogen) as well as relative nutrient balance (i.e., ratios of nutrients—for example, twice as much calcium as magnesium, compared to equal amounts of both) in soils affect insect pest response to plants (7, 8). Imbalances in the soil can make a plant more attractive to insect pests (7, 8), less able to recover from pest damage, or more susceptible to secondary infections by plant pathogens (8). Soils rich in organic matter tend to suppress plant pathogens (9). In addition, it is estimated that 75% of all insect pests spend part of their life cycle in the soil, and many of their natural enemies occur there as well. For example, larvae of one species of blister beetle consume about 43 grasshopper eggs before maturing (10). Both are found in the soil. (Unfortunately, although blister beetle larvae can help reduce grasshopper populations, the adult beetles can be a serious pest for many vegetable growers.) Overall, a healthy soil with a diversity of beneficial organisms and high organic matter content helps maintain pest populations below their economic thresholds.

Genetic diversity of a particular crop may be increased by planting more than one cultivar. For example, a recent experiment in China (11) demonstrated that disease-susceptible rice varieties planted in mixtures with resistant varieties had 89% greater yield and a 94% lower incidence of rice blast (a fungus) compared to when they were grown in monoculture. The experiment, which involved five townships in 1998 and ten townships in 1999, was so successful that fungicidal sprays were no longer applied by the end of the two-year program.

Species diversity of the associated plant and animal community can be increased by allowing trees and other native plants to grow in fence rows or along water ways, and by integrating livestock into the farm system. Use of the following cropping schemes are additional ways to increase species diversity. (See ATTRA's *Farmscaping to Enhance Biological Control* for more information on this topic.)

Crop rotations radically alter the environment both above and below ground, usually to the disadvantage of pests of the previous crop. The same crop grown year after year on the same field will inevitably build up populations of organisms that feed on that plant, or, in the case of weeds, have a life cycle similar to that of the crop. Add to this the disruptive effect of pesticides on species diversity, both above and below ground, and the result is an unstable system in which slight stresses (e.g., new pest variety or drought) can devastate the crop.

An enforced rotation program in the Imperial Valley of California has effectively controlled the sugar beet cyst nematode. Under this program, sugar beets may not be grown more than two years in a row or more than four years out of ten in clean fields (i.e., non-infested fields). In infested fields, every year of a sugar beet crop must be followed by three years of a non-host crop. Other nematode pests commonly controlled with crop rotation methods include the golden nematode of potato, many root-knot nematodes, and the soybean cyst nematode.

When making a decision about crop rotation, consider the following questions: Is there an economically sustainable crop that can be rotated into the cropping system? Is it compatible? Important considerations when developing a crop rotation are:

- What two (or three or several) crops can provide an economic return *when considered together as a biological and economic system that includes considerations of sustainable soil management?*
- What are the impacts of this season's cropping practices on subsequent crops?
- What specialized equipment is necessary for the crops?
- What markets are available for the rotation crops?

A corn / soybean rotation is one example of rotating compatible economic crops. Corn is a grass; soybean is a leguminous broadleaf. The pest complex of each, including soil organisms, is quite different. Corn rootworm, one of the major pests of corn, is virtually eliminated by using this rotation. Both crops generally provide a reasonable return. Even rotations, however, create selection pressures that will ultimately alter pest genetics. A good example is again the corn rootworm: the corn / bean rotation has apparently selected for a small population that can survive a year of non-corn (i.e., soybean) cropping (12).

Management factors should also be considered. For example, one crop may provide a lower direct return per acre than the alternate crop, but may also lower management costs for the alternate crop (by reducing weed pressure, for example, and thus avoiding one tillage or herbicide application), with a net increase in profit.

Other Cropping Structure Options

Multiple cropping is the sequential production of more than one crop on the same land in one year. Depending on the type of cropping sequence used, multiple cropping can be useful as a weed control measure, particularly when the second crop is interplanted into the first.

Interplanting is seeding or planting a crop into a growing stand, for example overseeding a cover crop into a grain stand. There may be microclimate advantages (e.g., timing, wind protection, and less radical temperature and humidity changes) as well as disadvantages (competition for light, water, nutrients) to this strategy. By keeping the soil covered, interplanting may also help protect soil against erosion from wind and rain.

Intercropping is the practice of growing two or more crops in the same, alternate, or paired rows in the same area. This technique is particularly appropriate in vegetable production. The advantage of intercropping is that

Intercropping French beans with cilantro —a potential control for symphylans.

the increased diversity helps "disguise" crops from insect pests, and if done well, may allow for more efficient utilization of limited soil and water resources. Disadvantages may relate to ease of managing two different crop species—with potentially different nutrient, water, and light needs, and differences in harvesting time and method—in close proximity to each other. For a detailed discussion, request the ATTRA publication, *Intercropping: Principles and Production Practices*.

Strip cropping is the practice of growing two or more crops in different strips across a field wide enough for independent cultivation (e.g., alternating six-row blocks of soybeans and corn or alternating strips of alfalfa and cotton or alfalfa and corn). It is commonly practiced to help reduce soil erosion in hilly areas. Like intercropping, strip cropping increases the diversity of a cropping area, which in turn may help "disguise" the crops from pests. Another advantage to this system is that one of the crops may act as a reservoir and/or food source for beneficial organisms. However, much more research is needed on the complex interactions between various paired crops and their pest/predator complexes.

The options described above can be integrated with no-till cultivation schemes and all its variations (strip till, ridge till, etc.) as well as with hedgerows and intercrops designed for beneficial organism habitat. With all the cropping and tillage options available, it is possible, with creative and informed management, to evolve a biologically diverse, pest-suppressive farming system appropriate to the unique environment of each farm.

Other Cultural Management Options

Disease-free seed and plants are available from most commercial sources, and are certified as such. Use of disease-free seed and nursery stock is important in preventing the introduction of disease.

Resistant varieties are continually being bred by researchers. Growers can also do their own plant breeding simply by collecting non-hybrid seed from healthy plants in the field. The plants from these seeds will have a good chance of being better suited to the local environment and of being more resistant to insects and diseases. Since natural systems are dynamic rather than static, breeding for resistance must be an ongoing process, especially in the case of plant disease, as the pathogens themselves continue to evolve and become resistant to control measures (13).

Sanitation involves removing and destroying the overwintering or breeding sites of the pest as well as *preventing* a new pest from establishing on the farm (e.g., not allowing off-farm soil from farm equipment to spread nematodes or plant pathogens to your land). This strategy has been particularly useful in horticultural and tree-fruit crop situations involving twig and branch pests. If, however, sanitation involves removal of crop residues from the soil surface, the soil is left exposed to erosion by wind and water. As with so many decisions in farming, both the short- *and* long-term benefits of each action should be considered when tradeoffs like this are involved.

Spacing of plants heavily influences the development of plant diseases and weed problems. The distance between plants and rows, the shape of beds, and the height of plants influence air flow across the crop, which in turn determines how long the leaves remain damp from rain and morning dew. Generally speaking, better air flow will decrease the incidence of plant disease. However, increased air flow through wider spacing will also allow more sunlight to the ground, which may increase weed problems. This is another instance in which detailed knowledge of the crop ecology is necessary to determine the best pest management strategies. How will the crop react to increased spacing between rows and between plants? Will yields drop because of reduced crop density? Can this be offset by reduced pest management costs or fewer losses from disease?

Altered planting dates can at times be used to avoid specific insects, weeds, or diseases. For example, squash bug infestations on cucurbits can be decreased by the delayed planting strategy, i.e., waiting to establish the cucurbit crop until overwintering adult squash bugs have died. To assist with disease management decisions, the Cooperative Extension Service (CES) will often issue warnings of "infection periods" for certain diseases, based upon the weather.

In some cases, the CES also keeps track of "degree days" needed for certain important insect pests to develop. Insects, being cold-blooded, will not develop below or above certain threshold temperatures. Calculating accumulated degree days, that is, the number of days above the threshold development temperature for an insect pest, makes the prediction of certain events, such as egg hatch, possible. University of California has an excellent website that uses weather station data from around the state to help California growers predict pest emergence: <http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html>.

Some growers gauge the emergence of insect pests by the flowering of certain non-crop plant species native to the farm. This method uses the "natural degree days" accumulated by plants. For example, a grower might time cabbage planting for three weeks after the *Amelanchier* species (also known as saskatoon, shadbush, or serviceberry) on their farm are in bloom. This will enable the grower to avoid peak egg-laying time of the cabbage maggot fly, as the egg hatch occurs about the time *Amelanchier* species are flowering (14). Using this information, cabbage maggot management efforts could be concentrated during a known time frame when the early instars (the most easily managed stage) are active.

Optimum growing conditions are always important. Plants that grow quickly and are healthy can compete with and resist pests better than slow-growing, weak plants. Too often, plants grown outside their natural ecosystem range must rely on pesticides to overcome conditions and pests to which they are not adapted.

Mulches, living or non-living, are useful for suppression of weeds, insect pests, and some plant diseases. Hay and straw, for example, provide habitat for spiders. Research in Tennessee showed a 70% reduction in damage to vegetables by insect pests when hay or straw was used as mulch. The difference was due to spiders, which find mulch more habitable than bare ground (15). Other researchers have found that living mulches of various clovers reduce insect pest damage to vegetables and orchard crops (16). Again, this reduction is due to natural predators and parasites provided habitat by the clovers. Vetch has been used as both a nitrogen source and as a weed suppressive mulch in tomatoes in Maryland (17). Growers must be aware that mulching may also provide a more friendly environment for slugs and snails, which can be particularly damaging at the seedling stage.

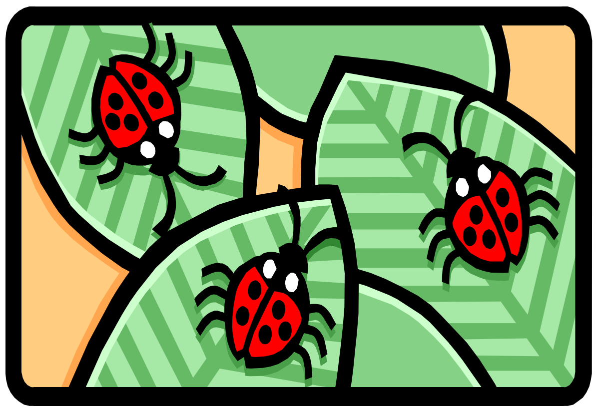
Mulching helps to minimize the spread of soil-borne plant pathogens by preventing their transmission through soil splash. Mulch, if heavy enough, prevents the germination of many annual weed seeds. Winged aphids are repelled by silver- or aluminum-colored mulches (18). Recent springtime field tests at the Agricultural Research Service in Florence, South Carolina, have indicated that red plastic mulch suppresses root-knot nematode damage in tomatoes by diverting resources away from the roots (and nematodes) and into foliage and fruit (19).

Biotech Crops. Gene transfer technology is being used by several companies to develop cultivars resistant to insects, diseases, and herbicides. An example is the incorporation of genetic material from *Bacillus thuringiensis* (Bt), a naturally occurring bacterium, into cotton, corn, and potatoes, to make the plant tissues toxic to bollworm, earworm, and potato beetle larvae, respectively.

Whether or not this technology should be adopted is the subject of much debate. Opponents are concerned that by introducing Bt genes into plants, selection pressure for resistance to the Bt toxin will intensify and a valuable biological control tool will be lost. There are also concerns about possible impacts of genetically-modified plant products (i.e., root exudates) on non-target organisms as well as fears of altered genes being transferred to weed relatives of crop plants. Whether there is a market for gene-altered crops is also a consideration for farmers and processors. Proponents of this technology argue that use of such crops decreases the need to use toxic chemical pesticides.

Biological Control

Biological control is the use of living organisms—parasites, predators, or pathogens—to maintain pest populations below economically damaging levels, and may be either *natural* or *applied*. A first step in setting up a biointensive IPM program is to assess the populations of beneficials and their interactions within the local ecosystem. This will help to determine the potential role of natural enemies in the managed agricultural ecosystem. It should be noted that some groups of beneficials (e.g., spiders, ground beetles, bats) may be absent or scarce on some farms because of lack of habitat. These organisms might make significant contributions to pest management *if provided with adequate habitat*.



Beneficial organisms should be viewed as mini-livestock, with specific habitat and food needs to be included in farm planning.

Natural biological control results when naturally occurring enemies maintain pests at a lower level than would occur without them, and is generally characteristic of biodiverse systems. Mammals, birds, bats, insects, fungi, bacteria, and viruses all have a role to play as predators and parasites in an agricultural system. By their very nature, pesticides decrease the biodiversity of a system, creating the potential for instability and future problems. Pesticides, whether synthetically or botanically derived, are powerful tools and should be used with caution.

Creation of habitat to enhance the chances for survival and reproduction of beneficial organisms is a concept included in the definition of natural biocontrol. *Farmscaping* is a term coined to describe such efforts on farms.
Habitat enhancement for beneficial insects, for example, focuses on the establishment of flowering annual or perennial plants that provide pollen and nectar needed during certain parts of the insect life cycle. Other habitat features provided by farmscaping include water, alternative prey, perching sites, overwintering sites, and wind protection. Beneficial insects and other beneficial organisms should be viewed as mini-livestock, with specific habitat and food needs to be included in farm planning.

The success of such efforts depends on knowledge of the pests and beneficial organisms within the cropping system. Where do the pests and beneficials overwinter? What plants are hosts and non-hosts? When this kind of knowledge informs planning, the ecological balance can be manipulated in favor of beneficials and against the pests.

It should be kept in mind that ecosystem manipulation is a two-edged sword. Some plant pests (such as the tarnished plant bug and lygus bug) are attracted to the same plants that attract beneficials. The development of beneficial habitats with a mix of plants that flower throughout the year can help prevent such pests from migrating *en masse* from farmscaped plants to crop plants.

See ATTRA's *Farmscaping to Enhance Biological Control* for a detailed treatment of this subject.

Applied biological control, also known as augmentative biocontrol, involves supplementation of beneficial organism populations, for example through periodic releases of parasites, predators, or pathogens. This can be effective in many situations—well-timed inundative releases of *Trichogramma* egg wasps for codling moth control, for instance.

Most of the beneficial organisms used in applied biological control today are insect parasites and predators. They control a wide range of pests from caterpillars to mites. Some species of biocontrol organisms, such as *Eretmocerus californicus*, a parasitic wasp, are specific to one host—in this case the sweetpotato whitefly. Others, such as green lacewings, are generalists and will attack many species of aphids and whiteflies.

Information about rates and timing of release are available from suppliers of beneficial organisms. It is important to remember that released insects are mobile; they are likely to leave a site if the habitat is not conducive to their survival. Food, nectar, and pollen sources can be "farmscaped" to provide suitable habitat.

The quality of commercially available applied biocontrols is another important consideration. For example, if the organisms are not properly labeled on the outside packaging, they may be mishandled during transport, resulting in the death of the organisms. A recent study by Rutgers University (20) noted that only two of six suppliers of beneficial nematodes sent the expected numbers of organisms, and only one supplier out of the six provided information on how to assess product viability.

While augmentative biocontrols can be applied with relative ease on small farms and in gardens, applying some types of biocontrols evenly over large farms has been problematic. New mechanized methods that may improve the economics and practicality of large-scale augmentative biocontrol include ground application with "biosprayers" and aerial delivery using small-scale (radio-controlled) or conventional aircraft (21).

Inundative releases of beneficials into greenhouses can be particularly effective. In the controlled environment of a greenhouse, pest infestations can be devastating; there are no natural controls in place to suppress pest populations once an infestation begins. For this reason, monitoring is very important. If an infestation occurs, it can spread quickly if not detected early and managed. Once introduced, biological control agents cannot escape from a greenhouse and are forced to concentrate predation / parasitism on the pest(s) at hand.

An increasing number of commercially available biocontrol products are made up of microorganisms, including fungi, bacteria, nematodes, and viruses. Appendix B, *Microbial Pesticides*, lists some of the formulations available. Appendix C, *Microbial Pesticide Manufacturers and Suppliers*, provides addresses of manufacturers and suppliers.

Mechanical and Physical Controls

Methods included in this category utilize some physical component of the environment, such as temperature, humidity, or light, to the detriment of the pest. Common examples are tillage, flaming, flooding, soil solarization, and plastic mulches to kill weeds or to prevent weed seed germination.

Heat or steam sterilization of soil is commonly used in greenhouse operations for control of soil-borne pests. Floating row covers over vegetable crops exclude flea beetles, cucumber beetles, and adults of the onion, carrot, cabbage, and seed corn root maggots. Insect screens are used in greenhouses to prevent aphids, thrips, mites, and other pests from entering ventilation ducts. Large, multi-row vacuum machines have been used for pest management in strawberries and vegetable crops. Cold storage reduces post-harvest disease problems on produce.

Although generally used in small or localized situations, some methods of mechanical / physical control are finding wider acceptance because they are generally more friendly to the environment.

Pest Identification

A crucial step in any IPM program is to identify the pest. The effectiveness of both proactive and reactive pest management measures depend on correct identification. Misidentification of the pest may be worse than useless; it may actually be harmful and cost time and money. Help with positive identification of pests may be obtained from university personnel, private consultants, the Cooperative Extension Service, and books and websites listed under **Useful Resources** at the end of this publication.

After a pest is identified, appropriate and effective management depends on knowing answers to a number of questions. These may include:

- What plants are hosts and non-hosts of this pest?
- When does the pest emerge or first appear?
- Where does it lay its eggs? In the case of weeds, where is the seed source? For plant pathogens, where is the source(s) of inoculum?
- Where, how, and in what form does the pest overwinter?
- How might the cropping system be altered to make life more difficult for the pest and easier for its natural controls?

Monitoring (field scouting) and economic injury and action levels are used to help answer these and additional questions (22).

Monitoring

Monitoring involves systematically checking crop fields for pests and beneficials, at regular intervals and at critical times, to gather information about the crop, pests, and natural enemies. Sweep nets, sticky traps, and pheromone traps can be used to collect insects for both identification and population density information. Leaf counts are one method for recording plant growth stages. Square-foot or larger grids laid out in a field can provide a basis for comparative weed counts. Records of rainfall and temperature are sometimes used to predict the likelihood of disease infections.

Specific scouting methods have been developed for many crops. The Cooperative Extension Service can provide a list of IPM manuals available in each state. Many resources are now available via Internet (see Appendix F for IPM-related websites).

The more often a crop is monitored, the more information the grower has about what is happening in the fields. Monitoring activity should be balanced against its costs. Frequency may vary with temperature, crop, growth phase of the crop, and pest populations. If a pest population is approaching economically damaging levels, the grower will want to monitor more frequently.

Monitoring for squash pests (aphids and whiteflies).

Economic Injury and Action Levels

The economic *injury* level (EIL) is the pest population that inflicts crop damage greater than the cost of control measures. Because growers will generally want to act before a population reaches EIL, IPM programs use the concept of an economic *threshold* level (ETL or ET), also known as an action threshold. The ETL is closely related to the EIL, and is the point at which suppression tactics should be applied in order to prevent pest populations from increasing to injurious levels.

In practice, many crops have no established EILs or ETLs, or the EILs that have been developed may be static over the course of a season and thus not reflect the changing nature of the agricultural ecosystem. For example, a single cutworm can do more damage to an emerging cotton plant than to a plant that is six weeks old. Clearly, this pest's EIL will change as the cotton crop develops.

ETLs are intimately related to the value of the crop and the part of the crop being attacked. For example, a pest that attacks the fruit or vegetable will have a much lower ETL (that is, the pest must be controlled at lower populations) than a pest that attacks a non-saleable part of the plant. The exception to this rule is an insect or nematode pest that is also a disease vector. Depending on the severity of the disease, the grower may face a situation where the ETL for a particular pest is zero, i.e., the crop cannot tolerate the presence of a single pest of that particular species because the disease it transmits is so destructive.

Special Considerations

Cosmetic Damage and Aesthetics

Consumer attitudes toward how produce looks is often a major factor when determining a crop's sale price. Cosmetic damage is an important factor when calculating the EIL, since pest damage, however superficial, lowers a crop's market value. Growers selling to a market that is informed about IPM or about organically grown produce may be able to tolerate higher levels of cosmetic damage to their produce.

Record-keeping: "Past is prologue"

Monitoring goes hand-in-hand with record-keeping, which forms the collective "memory" of the farm. Records should not only provide information about when and where pest problems have occurred, but should also incorporate information about cultural practices (irrigation, cultivation, fertilization, mowing, etc.) and their effect on pest and beneficial populations. The effects of non-biotic factors, especially weather, on pest and beneficial populations should also be noted. Record-keeping is simply a systematic approach to learning from experience. A variety of software programs are now available to help growers keep track of—and access—data on their farm's inputs and outputs.

Time and Resources

A successful biointensive IPM program takes time, money, patience, short- and long-term planning, flexibility, and commitment. The pest manager must spend time on self-education and on making contacts with Extension and research personnel. Be aware that some IPM strategies, such as increasing beneficial insect habitat, may take more than a year to show results.

A well-run biointensive IPM system may require a larger initial outlay in terms of time and money than a conventional IPM program. In the long run, however, a good biointensive IPM program should pay for itself. Direct pesticide application costs are saved and equipment wear and tear may be reduced.

Chemical Controls

Included in this category are both synthetic pesticides and botanical pesticides.

Synthetic pesticides comprise a wide range of man-made chemicals used to control insects, mites, weeds, nematodes, plant diseases, and vertebrate and invertebrate pests. These powerful chemicals are fast acting and relatively inexpensive to purchase.

Pesticides are the option of last resort in IPM programs because of their potential negative impacts on the environment, which result from the manufacturing process as well as from their application on the farm. Pesticides should be used only when other measures, such as biological or cultural controls, have failed to keep pest populations from approaching economically damaging levels.

The pesticide Agrophos used in a new planting. The red color code denotes the most hazardous class of chemical. In this instance, the farmer had applied the product in the bag (a granular systemic insecticide) by hand.

If chemical pesticides must be used, it is to the grower's advantage to choose the *least-toxic* pesticide that will control the pest but not harm non-target organisms such as birds, fish, and mammals. Pesticides that are short-lived or act on one or a few specific organisms are in this class. Examples include insecticidal soaps, horticultural oils, copper compounds (e.g., bordeaux mix), sulfur, boric acid, and sugar esters (23).

Biorational pesticides. Although use of this term is relatively common, there is no legally accepted definition (24). Biorational pesticides are generally considered to be derived from naturally occurring compounds or are formulations of microorganisms. Biorationals have a narrow target range and are environmentally benign. Formulations of *Bacillus thuringiensis*, commonly known as Bt, are perhaps the best-known biorational pesticide. Other examples include silica aerogels, insect growth regulators, and particle film barriers.

Particle film barriers. A relatively new technology, particle film barriers are currently available under the tradename Surround® WP Crop Protectant. The active ingredient is kaolin clay, an edible mineral long used as an anti-caking agent in processed foods, and in such products as toothpaste and Kaopectactate. There appears to be no mammalian toxicity or any danger to the environment posed by the use of kaolin in pest control. The kaolin in Surround is processed to a specific particle size range, and combined with a sticker-spreader. *Non-processed kaolin clay may be phytotoxic.*

Surround is sprayed on as a liquid, which evaporates, leaving a protective powdery film on the surfaces of leaves, stems, and fruit. Conventional spray equipment can be used and full coverage is important. The film works to deter insects in several ways. Tiny particles of the clay attach to the insects when they contact the plant, agitating and repelling them. Even if particles don't attach to their bodies, the insects may find the coated plant or fruit unsuitable for feeding and egg-laying. In addition, the highly reflective white coating makes the plant less recognizable as a host. For more information about kaolin clay as a pest management tool, see ATTRA's publications *Kaolin Clay for Management of Glassy-winged Sharpshooter in Grapes* and *Insect IPM in Apples: Kaolin Clay*.

Sugar Esters. Throughout four years of tests, sugar esters have performed as well as or better than conventional insecticides against mites and aphids in apple orchards; psylla in pear orchards; whiteflies, thrips, and mites on vegetables; and whiteflies on cotton. However, sugar esters are not effective against insect eggs. Insecticidal properties of sugar esters were first investigated a decade ago when a scientist noticed that tobacco leaf hairs exuded sugar esters for defense against some soft-bodied insect pests. Similar to insecticidal soap in their action, these chemicals act as contact insecticides and degrade into environmentally benign sugars and fatty acids after application. AVA Chemical Ventures of Portsmouth, NH hopes to have a product based on sucrose octanoate commercially available by the end of 2001. Contact: Gary J. Puterka, ARS Appalachian Fruit Research Station, Kearneysville, WV, (304) 725-3451 ext. 361, fax (304) 728-2340, e-mail <gputerka@afrs.ars.usda.gov>.

Because pest resistance to chemical controls has become so common, susceptibility to pesticides is increasingly being viewed by growers as a trait worth preserving. One example of the economic impact of resistance to insecticides has been documented in Michigan, where insecticide resistance in Colorado potato beetle was first reported in 1984 and caused severe economic problems beginning in 1991. In 1991 and following years, control costs were as high as $412/hectare in districts most seriously affected, in contrast to $35–74/hectare in areas where resistance was not a problem (25). The less a product is applied, the longer a pest population will remain susceptible to that product. Routine use of any pesticide is a problematic strategy.

Botanical pesticides are prepared in various ways. They can be as simple as pureed plant leaves, extracts of plant parts, or chemicals purified from plants. Pyrethrum, neem formulations, and rotenone are examples of botanicals. Some botanicals are broad-spectrum pesticides. Others, like ryania, are very specific. Botanicals are generally less harmful in the environment than synthetic pesticides because they degrade quickly, but they can be just as deadly to beneficials as synthetic pesticides. However, they are less hazardous to transport and in some cases can be formulated on-farm. The manufacture of botanicals generally results in fewer toxic by-products.

Compost teas are most commonly used for foliar disease control and applied as foliar nutrient sprays. The idea underlying the use of compost teas is that a solution of beneficial microbes and some nutrients is created, then applied to plants to increase the diversity of organisms on leaf surfaces. This diversity competes with pathogenic organisms, making it more difficult for them to become established and infect the plant.

An important consideration when using compost teas is that high-quality, well-aged compost be used, to avoid contamination of plant parts by animal pathogens found in manures that may be a component of the compost. There are different techniques for creating compost tea. The compost can be immersed in the water, or the water can be circulated through the compost. An effort should be made to maintain an aerobic environment in the compost/water mixture. ATTRA has more information about compost teas, available on request.

<u>Pesticide application techniques</u>

As monetary and environmental costs of chemical pesticides escalate, it makes sense to increase the efficiency of chemical applications. Correct *nozzle placement*, *nozzle type*, and *nozzle pressure* are very important considerations. Misdirected sprays, inappropriate nozzle size, or worn nozzles will ultimately cost the grower money and increase the risk of environmental damage.

If the monitoring program indicates that the pest outbreak is isolated to a particular location, *spot treatment* of only the infested area will not only save time and money, but will conserve natural enemies located in other parts of the field. The grower should also *time* treatments to be least disruptive of other organisms. This is yet another example where knowledge about the agroecosystem is important.

With the increasing popularity of no-till and related conservation tillage practices, herbicide use has increased. One way to increase application efficiency and decrease costs of herbicide use is through *band application*. This puts the herbicide only where it is needed, usually in soil disturbed by tillage or seed planting, where weeds are most likely to sprout.

Baits and *microencapsulation* of pesticides are promising technologies. For example, Slam™ is an insecticide-bait mixture for control of corn rootworm. It is a formulation of a bait, curcubitacin B, and carbaryl (Sevin™) in microspheres. It is selective, and reduces the amount of carbaryl needed to control the rootworm by up to 90%. (Remember that crop rotation will generally eliminate the need for *any* corn rootworm chemical control.)

Another example of bait-insecticide technology is the boll weevil bait tube. It lures the boll weevil using a synthetic sex pheromone. Each tube contains about 20 grams of malathion, which kills the boll weevil. This technique reduces the pesticide used in cotton fields by up to 80% and conserves beneficials. It is most effective in managing low, early-season populations of the boll weevil.

Integrated Weed Management Systems

Weeds as competitors in crops present a number of unique challenges that need to be recognized when developing management strategies. The intensity of weed problems during a growing season will be influenced by weed population levels in previous years. The axiom "one year's seeding equals seven years' weeding" is apt.

Weed control costs cannot necessarily be calculated against the current year's crop production costs. Weeds present a physical problem for harvesting. Noxious weed seed mixed with grain reduces the price paid to growers. If the seed is sold for crop production the weed can be spread to new areas. For example, the perennial pepperweed, thought to have been introduced to California in sugar beet seed, now infests thousands of acres in the state. In addition, weed economic thresholds must take into account multiple species and variable competetive ability of different crops. For example, 12.7 cocklebur plants in

Sustainable Agriculture and IPM

Sustainable agriculture is a system of agriculture that is ecologically, economically, and socially viable, in the short as well as long term. Rather than standing for a specific set of farming practices, a sustainable agriculture represents the goal of developing a food production system that:

☞yields plentiful, affordable, high-quality food and other agricultural products

☞does not deplete or damage natural resources (such as soil, water, wildlife, fossil fuels, or the germplasm base)

☞promotes the health of the environment

☞supports a broad base and diversity of farms and the health of rural communities

☞depends on energy from the sun and on natural biological processes for fertility and pest management

☞can last indefinitely

IPM and sustainable agriculture share the goal of developing agricultural systems that are ecologically and economically sound. IPM may be considered a key component of a sustainable agriculture system.

A premise common to IPM and sustainable agriculture is that a healthy agroecosystem depends on *healthy soils* and *managed diversity*. One of the reasons modern agriculture has evolved into a system of large monocultures is to decrease the range of variables to be managed. However, a system with few species, much like a table with too few legs, is unstable.

10 sq. meters of corn cause a 10% yield loss. Only 2 cocklebururs in the same area planted to soybeans will cause the same 10% crop loss (12).

> *"Rotation crops, when accompanied by care in the use of pure seed, is the most effective means yet devised for keeping land free of weeds. No other method of weed control, mechanical, chemical, or biological, is so economical or so easily practiced as a well-arranged sequence of tillage and cropping."*
>
> Source: Leighty, Clyde E. 1938. Crop Rotation. p. 406-429. In: Soils and Men, 1938 Yearbook of Agriculture. U.S. Govt. Print. Office, Washington, DC.

Tactics that can be integrated into weed management systems include:

- Prevention — The backbone of any successful weed management strategy is prevention. It is important to prevent the introduction of seeds into the field through sources like irrigation water or manure.

- Crop rotation —A practical and effective method of weed management (discussed in previous sections).

- Cultivation — *Steel in the Field: A Farmer's Guide to Weed Management Tools* shows how today's implements and techniques can handle weeds while reducing or eliminating herbicides (26).

- Flame weeding — good for control of small weeds.

- Delayed planting — Early-germinating weeds can be destroyed by tillage. And with warmer weather, the subsequently planted crop (depending on the crop, of course) will grow more quickly, thus competing better with weeds.

- Staggered planting schedule — This will allow more time for mechanical weed control, if needed. This also lessens the weather risks and spaces out the work load at harvest time.

- Surface residue management — As mentioned earlier, a thick mulch may shade the soil enough to keep weed seeds from germinating. In addition, some plant residues are allelopathic, releasing compounds that naturally suppress seed germination.
- Altered plant spacing or row width — An example is narrow-row (7–18" between rows compared to conventional 36–39" between rows) soybean plantings. The faster the leaves shade the ground, the less weeds will be a problem.
- Herbivores — Cattle, geese, goats, and insects can be used to reduce populations of specific weeds in special situations. Cattle, for example, relish Johnson grass. Weeder geese were commonly used in cotton fields before the advent of herbicides. Musk thistle populations can be satisfactorily reduced by crown- and seed-eating weevils. Goats may be used for large stands of various noxious weeds.
- Adjusting herbicide use to situation — Herbicide selection and rate can be adjusted depending upon weed size, weed species, and soil moisture. Young weeds are more susceptible to chemicals than older weeds.

By integrating a variety of tactics, farmers can reduce or eliminate herbicide use. For more information about weed management options see ATTRA's publication, *Principles of Sustainable Weed Management for Croplands*.

> ***WEED PREVENTION***
>
> - Have a long, diverse rotation
> - Sow clean seed
> - Prevent weed seed formation
> - Avoid imported feeds or manures
> - Compost all manure thoroughly
> - Control weeds in field borders
> - Delay planting the crop (for faster crop growth and quicker ground coverage)
> - Maintain good soil quality

Crops with Developed IPM Programs

In the last twenty years or so, IPM programs have been developed for important pests in corn, soybeans, cotton, citrus, apples, grapes, walnuts, strawberries, alfalfa, pecans, and most other major crops. These programs are constantly being revised or fine-tuned, and occasionally undergo a significant overhaul as the introduction of a new technology or new pest makes the present IPM program obsolete.

The best source of information on conventional IPM is the Cooperative Extension Service (CES) associated with the land-grant university in each state. Booklets and fact sheets describing IPM programs and control measures for a wide range of crops and livestock are available free or for a small charge. For the address of a state IPM coordinator, refer to the *Directory of State Extension Integrated Pest Management Coordinators*. A free copy can be obtained from the Cooperative State Research, Education, and Extension Service (27), or through the world wide web at <http://www.reeusda.gov/ipm/ipmdirectory.pdf>. (Adobe Acrobat Reader must be loaded on your computer in order to access this page.)

Government Policy

In 1993, leaders from USDA, EPA, and FDA announced a goal of placing 75% of U.S. crop acreage under IPM by the year 2000. The IPM Initiative described three phases:

1. Create teams of researchers, Extension personnel, and growers to propose projects to achieve the 75% goal.

2. Fund the best of those projects.

3. Facilitate privatization of IPM practices developed in the process.

Although some progress is evident, the Initiative has not received full funding from Congress (28). In addition, the USDA's criteria for measurement have been criticized for not distinguishing between practices that are related to "treatment" and those that are "preventive," that is, based on altering the biological and ecological interactions between crops, pests, and beneficial organisms. Practices that constitute "treatment" with or contribute to the efficiency of pesticides are considered as "indicative of an IPM approach" by USDA's criteria, as are practices that draw upon and are most compatible with biological relationships on the farm (29).

A 1998 USDA-funded survey of pest management practices was published in August 1999 and is available at <http://www.reeusda.gov/ipm/publications.htm>. Highlights of this report are excerpted in Appendix E, ***Pest Management Practices: 1998 USDA Survey Summary Highlights.***

The primary goal of biointensive IPM is to provide guidelines and options for the effective management of pests and beneficial organisms *in an ecological context*. This requires a somewhat different set of knowledge from that which supports conventional IPM, which in turn requires a shift in research focus and approach. Recommended actions to better facilitate the transition to biointensive IPM are:

- Build the knowledge/information infrastructure by making changes in research and education priorities in order to emphasize ecology-based pest management

- Redesign government programs to promote biointensive IPM, not "Integrated Pesticide Management"

- Offer consumers more choices in the marketplace

- Use the market clout of government and large corporations

- Use regulation more consciously, intelligently, and efficiently

The Future of IPM

As this publication has highlighted, IPM in the future will emphasize biological and ecological knowledge in managing pests. Beyond that, specific areas are described here that will impact research and implementation of IPM in the future.

Food Quality Protection Act (FQPA)

The FQPA, the amended Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), requires the EPA to review all federally registered pesticides in the next 10 years and to use a more comprehensive health standard when allowing re-registration. The ultimate impact is unknown, but FQPA will most likely result in stricter regulations concerning pesticide residues in food, particularly with respect to organochlorines, organophosphates, and carbamates. Some of the most toxic pesticides have already been "de-registered" with respect to some of their former uses. These regulations may provide incentive for more widespread adoption of IPM. More information, including implementation status (from an August 1999 Progress Report) can be found at the FQPA homepage: <http://www.epa.gov/opppsps1/fqpa/>.

> ***"A convergence of technical, environmental and social forces is moving agriculture towards more non-pesticide pest management alternatives like biological control, host plant resistance and cultural management."***
>
> *—Michael Fitzner, National IPM Program Leader, USDA Extension Service*

New Options

Pest control methods are evolving and diversifying in response to public awareness of environmental and health impacts of synthetic chemical pesticides and resulting legislation. The strong growth of the organic foods market—20% annual expansion for the past several years—may also be a factor in the accelerated development of organic pest management methods.

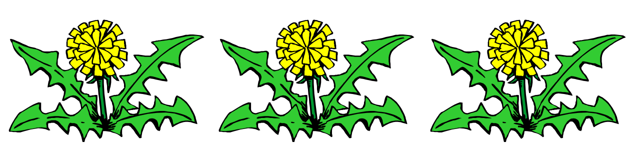
Agricultural pests are developing resistance to many synthetic agrichemicals, and new synthetic chemicals are being registered at a slower rate than in the past. This situation has helped open the market for a new generation of *microbial pesticides*. For more information about microbial and "biopesticides", see Appendix B, *Microbial Pesticides*, and Appendix C, *Microbial Pesticide Manufacturers and Suppliers*, and visit EPA's biopesticides website at: <http://www.epa.gov/pesticides/biopesticides/>. (Please note that this website will be discontinued sometime in 2001.)

Research is proceeding on natural *endophytes* — fungi or bacteria that have a symbiotic (mutually beneficial) relationship with their host plant—and their effects on plant pests. This research might yield products that could be used to inoculate plants against certain pests.

Synthetic beneficial attractants such as Predfeed IPM™ and L-tryptophan may help increase the efficacy of natural controls by attracting beneficials to a crop in greater numbers than usual.

More Weed IPM

Weeds are the major deterrent to the development of more sustainable agricultural systems, particularly in agronomic crops. Problems associated with soil erosion and water quality are generally the result of weed control measures like tillage, herbicides, cultivation, planting date and pattern, etc. (30). In the future, research will focus not on symptoms, such as soil erosion, but on basic problems such as how to *sustainably* manage soils. Weeds, as an important facet of sustainable soil management, will consequently receive more emphasis in IPM or Integrated Crop Management (ICM) programs.



On-farm Resources

As farm management strategies become increasingly fine-tuned to preserve a profitable bottom line, the conservation, utilization, and development of on-farm resources will take on added importance. In the context of IPM, this will mean greater emphasis on soil management as well as on conserving beneficial organisms, retaining and developing beneficial habitats, and perhaps developing on-farm insectaries for rearing beneficial insects.

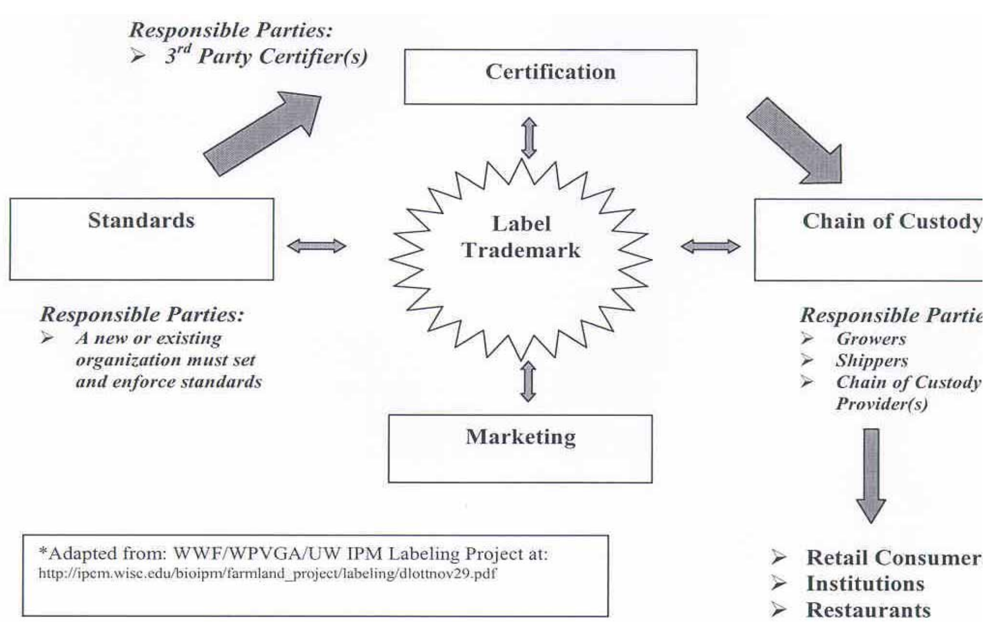
IPM On-line

There is an increasing body of information about production, marketing, and recordkeeping available to growers via the Internet. The Internet is also a good source of information about IPM, beneficial insects, products, and pest control options for individual crops. IPM specialists are generating high-quality websites as a modern educational delivery tool, and many Extension Service leaflets are now being made available in electronic format only. This trend will only accelerate as more and more agriculturists familiarize themselves with the Internet. See Appendix F for a thorough listing of IPM resources available on the Internet.

IPM Certification and Marketing

Certification of crops raised according to IPM or some other ecology-based standards may give growers a marketing advantage as public concerns about health and environmental safety increase. For example, since 1995, Wegmans has sold IPM-labeled fresh-market sweet corn in its Corning, Geneva, Ithaca, Syracuse, and Rochester, New York stores. Wegmans has also added IPM-labeled corn, beets, and beans to its shelves of canned vegetables. One goal of the program, in addition to being a marketing vehicle, is to educate consumers about agriculture and the food system. Another goal is to keep all growers moving along the "IPM Continuum." Growers must have an 80% "score" on the IPM program elements within three years, or face losing Wegmans as a buyer.

One Generic Model for Ecolabel/IPM Certification Standards*



These "ecolabels," as they're known, are becoming more popular, with over a dozen brands now in existence. They may provide for a more certain market and perhaps a price premium to help growers offset any costs associated with implementing sustainable farming practices. A possible downside to implementing such programs is that they require additional paperwork, development of standards and guidelines, and inspections. There is concern from some quarters that IPM labeling will cause consumers to raise more questions about pesticide use and the safety of conventional produce. Some advocates of organic farming worry about consumer confusion over the relationship of the ecolabel to the "Certified Organic" label.

Mothers & Others for a Livable Planet, a national, non-profit, consumer advocacy and environmental education organization, has partnered with apple farmers in the Northeast region to create a supportive market environment for farm products that are locally grown and ecologically responsible. The result is the Core Values eco-label:

A CORE Values Northeast apple is locally grown in the Northeast (New York and New England) by farmers who are striving to provide apples of superior taste and quality while maintaining healthy, ecologically balanced growing environments. Growers whose apples bear the CORE Values Northeast seal are accredited in knowledge-based biointensive Integrated Pest Management (IPM) production methods. For more information about this program, visit: <http://www.corevalues.org/cvn/home.html>.

The ecolabel to the right is a result of a collaboration between the World Wildlife Fund (WWF), the Wisconsin Potato and Vegetable Growers Association (WPVGA), and the University of Wisconsin. Raising consumer demand for biology-based-IPM farm products is the goal of the program.

There has been an IPM labeling program casualty in 2000. Massachusetts's "Partners with Nature" marketing program closed its doors after losing funding support from the Massachusetts Department of Food and Agriculture. The program, which included IPM production guidelines, had operated since 1994, with 51 growers participating in 1999.

A bibliography of IPM Certification, Labeling, and Marketing can be found at: <http://www.ipminstitute.org/ipm_bibliography.htm>.

Summary

IPM can be a flexible and valuable tool when used as a *concept* with which to approach pest management. IPM is not a cookbook recipe for pest control, but a flexible approach for dealing with agriculture's ever-changing financial, regulatory, and physical environment.

The key to effective IPM is the farmer's understanding of its concepts. In 1916, Liberty Hyde Bailey wrote a small book, entitled *The Principles of Fruit Growing*, as part of a Rural Science Series published by MacMillan Co. The text is a marvelous mix of scientific theory and practice. Bailey ended with the following note:

> "We have now completed the fruit book, having surveyed the field. It is a field of great variety, demanding many qualities on the part of the successful grower. The grower should first apprehend the principles and the underlying reasons, and to teach this is the prime purpose of the book. ***If the grower knows why, he will teach himself how***" (31).

Feedback

Help us better help farmers. If you have suggestions for improvement of this publi-cation, areas about which you'd like more information or detail, ideas, case studies, or sources of good IPM information (articles or websites), please call Rex Dufour at 530-756-8518 ext. 39, or e-mail at <rexd@ncat.org>.

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Wendy Leight / Michael Fitzner
Ag Box 2220
Coop State Research, Education, &
Extension Service, USDA
Washington, D.C. 20250-2220
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APPENDIX A:
IPM PLANNING CONSIDERATIONS

Technical/Information Need	Comments and Considerations
Agricultural Ecosystem Management (Proactive pest management options)	• What effects does soil quality have on plant attractiveness and susceptibility to insect pests and damage? (For example, are "dead soils" creating a pest problem through lack of balanced plant nutrition?)What are options for better soil management (cover crops, green manures, adding compost, reduce tillage, etc) • What cultural or habitat options can be implemented before the crop is planted? (See ATTRA's *Farmscaping to Enhance Biological Control)* • What are crop rotation options and their effect on pest management (insects, weeds and plant pathogens)? • What are cover crop options and their effect on pest management?
Pest-resistant cultivars (Proactive pest management options)	• Cultivars should be resistant to major pest(s). • Cultivars should have appropriate mode of resistance. • Cultivars should be appropriate for the area. • Cultivars should be commercially available . • Cultivars must have a market (a concern with some genetically modified crops)
IPM Technical Information	• Develop sources for biointensive IPM information and information about cropping systems ecology, farmscaping, and ecological soil management.. • Check with state or county Extension for the latest IPM program for a particular crop/pest complex . • IPM program should establish an Economic Injury Level (EIL) for major pests, including (ideally) weeds. • How do major pest EILs change with time and how does this influence management practices?
Monitoring options	• Will scouting be done in-house, by independent pest control advisors (PCA) , or by chemical salesmen? Compare estimated cost per acre, expertise, potential conflict of interest, etc. • What is the purpose of monitoring: To determine number of pests present? To determine stage of development? To determine type of damage being done? To determine injury levels? To time treatments? • Which pests & beneficials will be sampled? What are the key pests and their natural enemies? • What sampling method will be used? • What other factors should be monitored? Consider conditions that may increase or decrease severity of pest problems, such as soil moisture, soil nutrient status, temperature, humidity, stage of crop development.
Record-keeping	• Keep field maps, and record the history of fields, the problems that recur every year and where, the most problematic fields or sections of fields. • Develop a record-keeping system that is user-friendly and "field-friendly." Evaluate available software options. • Develop a method of displaying monitoring information that will facilitate decision-making. Evaluate available hardware and software options.

Technical/Information Need	Comments and Considerations
Pest identification: who can help?	• Help can be obtained from PCA's, county/state Cooperative Extension, nurseries, universities and websites.
Pest monitoring equipment	• Determine types of equipment needed: pheromone traps, sweep nets, hand lens, D-VAC™, etc. A PCA will have much of this information. • Determine sources of equipment.
Reactive pest management options	• Pest management options and "fallback" positions (what if first option fails?) should be planned in advance. • What are least-toxic alternatives to "hard" chemicals that can inhibit pests? What are commercial sources for these alternatives? • If "hard" pesticides are necessary, what are the best times for treatment in order to decrease pest populations while conserving beneficials? • What weed-free period does the crop require? • What are the costs/benefits of tillage vs. herbicide use for weed control?
IPM program evaluation	• All components of the IPM system – soil management, habitat management, pest/beneficial monitoring, decision-making (including EIL's), and treatments – should be evaluated for overall efficacy. Are the most recently-developed EIL's and action thresholds being used? • The IPM system should be modified and continually fine-tuned after evaluation.
Farm equipment	• What specialized equipment is needed – mowers, cultivators, no-till drills, flamers, beneficial organism application equipment, etc.? Is it more economical to own , rent, or contract? • Availability of pesticide spray equipment? Keep in mind that timing of applications is often critical for good pest control. Is equipment grower-owned or contracted? • Will IPM increase or decrease equipment use and maintenance?

APPENDIX B: MICROBIAL PESTICIDES

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Agrobacterium radiobacter	Norbac 84-C™ Nogall™ Galltrol-A™	New BioProducts New BioProducts AgBioChem	Crown gall caused by *A. tumefaciens*	Antagonist	U.S. (Norbac and Nogall)
Ampelomyces quisqualis	AQ-10™	Ecogen	Powdery mildew	Hyperparasite	U.S.
Bacillus popilliae	Doom ™ Japademic™	Fairfax Biological Laboratory	Larvae of Japanese beetles, Oriental beetles, chafers, some May & June beetles	Stomach poison	
Bacillus subtilis	Epic™ Kodiak™ MBI 60 Seranade (QST713) System3 (+metalaxyl +PCNB) Companion (EPA Experimental Use Permit) HiStick N/T (a *Rhizobium* and *B. subtilis* mix) Subtilex	Gustafson, Inc. Gustafson, Inc. Gustafson, Inc AgraQuest Inc Helena Chemical Co. Growth Products MicroBio Group MicroBio Group	*Rhizoctonia, Fusarium, Alternaria, & Aspergillus*, that cause root rots & seedling diseases. May also be effective against some foliar diseases.	Biological fungicide/ antagonist, applied directly to seed. It will grow with root system.	U.S.
Bacillus subtilis FZB24	Rhizo-Plus, Rhizo-Plus Konz	KFZB Biotechnik	For management of *Rhizoctonia solani, Fusarium* spp., *Alternaria* spp., *Sclerotinia, Verticillium, Streptomyces* scabies on field (potatoes, corn), vegetables, and ornamental plants		
Bacillus thuringiensis var. aizawai	XenTari DF™ Agree™ *(Turex outside US)* Design™ (*discontinued in 2000*) Mattch™	Abbott Thermo Trilogy Thermo Trilogy Ecogen	Lepidotera in vegetables and corn	Stomach poison	
Bacillus thuringiensis var. israelensis	Gnatrol™ VectoBac™ Bactimos™ Skeetal™ Aquabac™ Bacticide™ Vectocide Teknar™	Abbott Abbott Abbott Abbott Becker Microbial Biotech Int'l Nu-Gro Group Thermo Trilogy	Larvae of mosquitoes, black flies & midges	Stomach poison	

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Bacillus thruingiensis var. kurstaki	Dipel™ Biobit XL FC™ Biobit HP WP™ Foray 48B™ Foray 68B™ Foray™ BMP 123™ Biolep™ Condor™ Cutlass™ Crymax™ Foil BFC™ Lepinox™ M-Peril™ MVP II™ Raven™ Forwabit™ Bactosid K™ Turibel™ Agrobac™ Able™ Deliver (is replacing CoStar) JavelinWG™ (Delfin™ outside US) Thuricide™ Larvo-BT™ Troy-BT™ Halt™	Abbott Abbott Abbott Abbott Abbott Abbott BeckerMicrobial Biotech Int'l Ecogen Ecogen Ecogen Ecogen Ecogen Ecogen Ecogen Ecogen Forward Int'l Nu-Gro Group Probelte, S.A. Tecomag SRL, Thermo Trilogy Thermo Trilogy Thermo Trilogy Thermo Trilogy Troy Biosciences Troy Biosciences Wockhardt Ltd	Most lepidoptera larvae with high gut pH, some formulations active against leaf beetles (i.e. Raven™)	Stomach poison	
Bacillus thuringiensis var. Tenebrionis/san diego	Novodor™	Abbott (dist. by Valent Biosciences)	Colorado potato beetle and some other leaf beetles	Stomach poison	U.S.
Beauveria bassiana	Naturalis-L™ Naturalis-H&G™ (Home&Garden) Naturalis-T&O™ (Turf&Ornamentals) Ostrinil™ Mycotrol ™ Mycotrol-O* *(OK'd by OMRI) Botanigard22WP™	Troy Biosciences Troy Biosciences Troy Biosciences Natural Plant Protection (NPP) Mycotech Mycotech Mycotech	Mole cricket, chiggers, white grubs, fire ants, ants, flea beetle, boll weevil, whiteflies, plant bug, grasshoppers, thrips, aphids, mites, and many others	Insect specific fungus	U.S., Europe

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Burkholderia cepacia (formerly *Pseudomonas cepacia)*	Deny™	Stine Microbial Products (distributed by Market VI LLC)	Soil pathogens — *Fusarium, Pythium, Fusarium*, and disease caused by lesion, spiral, lance, and sting nematodes on alfalfa, barley, beans, clover, cotton, peas, grain sorghum, vegetable crops, and wheat	Seed treatment or seedling drench	U.S.
Candida oleophila	Aspire™	Ecogen	postharvest pathogens — *Botrytis, Penicillium*	Colonizes fruit surface, especially wounded tissues, thereby inhibiting other microbial colonization	U.S., Israel
Coniothyrium minitans	Contans KONI	Prophyta BIOVED, Ltd	*Sclerotinia sclerotiorum* and *S. minor on* canola, sunflower, peanut, soybean, and vegetables (lettuce, bean, tomato)		Germany
Fusarium oxysporum nonpathogenic	Biofox C Fusaclean	SIAPA Natural Plant Protection	*Fusarium oxysporum, Fusarium moniliforme* on basil, carnation, cyclamen, tomato	seed treatment or soil incorporation	Italy France
Gliocladium catenulatum	Primastop	Kemira Agro Oy	For management of *Pythium* spp., *Rhizoctonia solani* spp., *Botrytis* spp., and *Didymella* spp. on greenhouse crops		
Gliocladium spp.	GlioMix™	Kemira Agro Oy	Soil pathogens		Finland
Gliocladium virens	Soil Guard12G™	Thermo Trilogy	Soil pathogens that cause damping off and root rot, esp. *Rhizoctonia solani & Pythium* spp.	Antagonist	U.S.
Granulosis virus	Capex™	Andermatt	Leafroller	Disease-causing virus	Switzerland
Granulosis virus	Cyd-X™ (discontinued)	Thermo Trilogy	Codling moth	Disease-causing virus	
Heterorhabditis bacteriophora	Cruiser™ (also marketed by species name of nematode)	Ecogen Hydro-Gardens (over a dozen manufacturers and 2 dozen distributors in the US)	Many types of lepidopteran larvae, turf grubs (including Japanese beetle) and other soil insect pests	Insect eating nematode	U.S.

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Heterorhabditis megidis.	Larvanem™	Koppert Biological Systems	Black vine weevil	Insect eating nematode	U.S.
Metharizium anisopliae	Bay Bio 1020™ Bio-Blast™ Bio-Path™	Bayer AG EcoScience EcoScience	Soil-inhabiting beetle, termites, cockroaches (Bio-Path)	Disease-causing fungus	
Nuclear polyhedrosis virus (NPV) for *Autographa californica*	VFN80™ (discontinued)	Thermo Trilogy	Alfalfa looper (*Autographica californica*)	Causes disease in larvae	U.S., Central America
NPV for *Anagrapha falcifera*	To be introduced in 2001	Thermo Trilogy		Disease-causing virus	
NPV for *Helicoverpa zea Heliothus virescens*	Gemstar LC™	Thermo Trilogy	American bollworm, cotton bollworm= tobacco budworm (*Helicoverpa virescens*), corn earworm=tomato fruitworm (*Helicoverpa zea*)	Disease-causing virus	
NPV for *Spodoptera exigua*	Spod-X LC	Thermo Trilogy	beet armyworm (*Spodoptera exigua*), lesser armyworm, pig weed caterpillar, small mottled willow moth	Disease-causing virus	
Paecilomyces fumosoroseus	PFR97™	Thermo Trilogy (marketed through Olympic Hort. Products)	Whiteflys, aphids, and thrips in greenhouses		
Paecilomyces lilacinus	Paecil (also known as Bioact)	Technological Innovation Corporation	For managing various nematode spp. on banana, tomatoes, sugar cane, pineapple, citrus, wheat, potatoes, and others		Australia
Phelbia gigantea	Rotstop™	Kemira	Summer control of rust caused by *Heterobasidion annosum* on pine and spruce trees	Biofungicide	Britain, Sweden, Norway, Switzerland, Finland, but not U.S.
Phytophthora palmivora	DeVine™	Abbott Lab.	Strangler vine (*Morenia odorato*)	Initiates root infection	Florida only
Pseudomonas cepacia	Intercept™	Soil Technologies	Soil pathogens: *Rizoctonia, Fusarium, Phythium*		U.S.
Pseudomonas chlororaphis	Cedomon	BioAgri AB	Leaf stripe, net blotch, *Fusarium* spp., spot blotch, leaf spot, and others on barley and oats	Seed treatment	Sweden

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Pseudomonas flourescens	Conquer™	Mauri Foods Sylvan Spawn	*P. tolasii* on mushrooms		Europe, Australia
Psuedomonas flourescens	Blight Ban A506™	Plant Health Technologies	*Erwinia amylovora* on apple, cherry, almond, peach, pear, potato, strawberry, tomato		U.S.
Pseudomonas solanacearum	PSSOL™	Natural Plant Protection	*P. solanacearum* in vegetables		France
Pseudomonas syringae	Bio-Save 100, 110, 1000™	EcoScience	Postharvest pathogens on apples, pears (Biosave 100) and citrus (Biosave 1000)	Antagonist/competitor	U.S.
Pseudomonas sp. plus *Azospirillum*	BioJet™	Eco-Soil	Soil pathogens that cause brown patch, & dollar spot	Antagonist/competitor	
Pythium oligandrum	Polyversum (formerly Polygandron)	Plant Production Institute	Management of *Pythium* spp., *Fusarium* spp., *Botrytis* spp., *Phytophthora* spp., *Aphanomyces* spp., *Alternaria* spp., Tilletia caries, *Pseudocercosporella herpotrichoides, Gaeumannomyces graminis, Rhizoctonia solani, Sclerotium cepivoru* in various crops including vegetables (tomatoes, potatoes, pepper, cucumbers, Brassicaceae vegetables), fruits (grapes, strawberries, citrus), legumes, cereals, canola, forest nurseries and ornamental plants *Phythium ultimum* in sugar beets	Seed treatment or soil incorporation	Czech Republic
Syngrapha falcifera Nuclear Polyhedrosis Virus (NPV)	Celery looper virus	Thermo Trilogy	Lepidoptera	Causes disease in larvae	U.S.
Spodoptera exigua NPV	Otienem-S™ Spod-X™	Ecogen Thermo Trilogy	Beet armyworm (*Spodoptera exigua*)	Causes disease in larvae	

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Steinernema carpocapsae	Bio-Safe-N™ Biovector 25™ Ecomask™ Scanmask™ Guardian™	Thermo Trilogy Thermo Trilogy Biologic ARBICO Harmony Farm IPM Labs. Praxis Hydro Gardens	Black vine weevil, strawberry root weevil, cranberry girdler, and many other larval insects	Insect eating nematode	U.S. U.S.
Steinernema feltiae	Nemasys™ Nemasys M™ Otienem-S™ Entonem™ X-Gnat	MicroBio Ecogen Biobest Koppert Thermo Trilogy	Larvae of vine weevils and fungus gnats	Insect eating nematode	
Steinernema riobravis	Biovector 355™	Thermo Trilogy	For management of citrus weevils on citrus		U.S.
Streptomyces griseoviridis	Mycostop™	Planet Natural (formerly Bozeman Biotech) Kemira Agro Oy (AgBio Dev. is US distributor for Kemira) Rincon Vitova	Soil pathogens — *Fusarium, Alternaria, Rhizoctonia, Phomopsis, Phythium, Phytopthora, Pythium, Botrytis* — that cause wilt, seed, root, & stem rots	Competition/antagonism	U.S., Finland
Talaromyces flavus, isolate V117b	Protus WG	Prophyta Biolgischer Pflanzenschutz	For management of *Verticillium dahliae*, *V. albo-atrum*, and *Rhizoctonia solani* in tomato, cucumber, strawberry, rape oilseed		Germany
Trichoderma harzianum	RootShield™ BioTrek 22G™ Supresivit™ T-22G™ T-22HB™	BioWorks, Wilbur-Ellis, Borregaard	Soil pathogens — *Pythium, Rhicozoktonia, Verticillium, Sclerotium*, and others	Parasite, competitor	U.S. , Europe
Trichoderma harzianum	Trichodex™	Makhteshim	*Botritis cinerea* and others	Mycoparasite living on other fungi	Israel
Trichoderma harzianum & T. polysporum	Binab™	Bio-Innovation	Tree-wound pathogens	Mycoparasite	U.K., Sweden

Beneficial Organism	Trade Name	Manufacturers and Suppliers	Pests Controlled	Type of Action	Country Registered
Trichoderma harzianum & T. viride	Trichopel™ Trichojet™ Trichodowels™ Trichoseal™	Agrimm Technologies	*Armillaria, Botryoshaeria*, and others		New Zealand
Trichoderma spp.	Promot™ Trichoderma 2000 Biofungus	J.H. Biotech Mycontrol, Ltd. De Ceuster	Growth promoter, *Rhizoctonia solani, Sclerotium rolfsii, Pythium* spp., *Fusarium* spp. on nursery and field crops		U.S. U.S. Belgium
Trichoderma viride	Trieco	Ecosense Labs	For management of *Rhizoctonia* spp., *Pythium* spp., *Fusarium* spp., root rot, seedling rot, collar rot, red rot, damping-off, Fusarium wilt on wide variety of crops		India
Verticillium lecanii	Vertalec™	Koppert	Aphid species, except Chrysanthemum aphid, *Macrosiphoniella sanborni*	Insect eating fungus (VERTALEC requires a temp. of 18-28 degrees Celsius and a minimum relative humidity of 80% for 10-12 hours a day for several days after application.)	Europe

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APPENDIX C

MICROBIAL PESTICIDE MANUFACTURERS AND SUPPLIERS

Abbott Laboratories
See Valent entry below.

AgBio
9915 Raleigh Street
Westminster, CO 80030
303-469-9221
303-469-9598 Fax

AgBioChem, Inc.
Richard Bahme
3 Fleetwood Ct.
Orinda, CA 94563
925-254-0789

AgraQuest, Inc.
1530 Drew Avenue
Davis, CA 95616
530-750-0150
530-750-0153 Fax
http://www.agraquest.com
E-mail:
agraquest@agraquest.com

Agricola del Sol
30 calle 11-42, zona 12, 01012
Ciudad de Guatemala,
Guatemala, Centro America
502-2 760496 Telefax
E-mail: restrada@guate.net

Agimm Technologies, Ltd.
P.O. Box 13-245
Christchurch, New Zealand
64-13-366-8671
64-13-365-1859 Fax

Andermatt Biocontrol AG
Unterdorf, CH-6146
Grossdietwil, Switzerland
062-927-28-40
062-927-21-23 Fax

American Cyanamid Co.
(See BASF)
800-327-4645

Amycel Spawn Mate
P.O. Box 560
Avondale, PA 19311
800-795-1657
610-869-8456 Fax
U.S. Distributor of MicroBio's Nemasys M®.

ARBICO Environmentals
P.O. Box 4247
Tucson, AZ 85738-1247
520-825-9785
800-827-2847
520-825-2038 Fax
http://www.arbico.com/

Bactec Corp.
2020 Holmes Rd.
Houston, TX 77045
713-797-0406
713-795-4665 Fax

Bayer AG
Business Group Crop Protection
Development/Regulatory Affairs
Agrochemical Center Monheim
D-51368 Leverkusen, Germany
49-2173-38-3280
49-2173-38-3564 Fax
http://www.bayer.com

Becker Microbial Products, Inc.
9464 NW 11th St.
Plantation, FL 33322
305-474-7590
305-474-2463 Fax
E-mail: tcouch@icanect.net

Biobest N. V., Biological Systems
Ilse Velder 18
Westerlo B-2260 Belgium
32-14-231701
32-14-231831 Fax

Bio-Care Technology Pty. Ltd.
RMB 1084, Pacific Highway
Somersby, NSW 2250, Autralia

Bio-Innovation AB
Bredholmen
Box 56, S-545 02
ALGARAS, Sweden
46-506-42005
46-506-42072 Fax

BioLogic Co.
P.O. Box 177
Willow Hill, PA 17271
717-349-2789/2922
717-349-2789 Fax

Biopreparaty Ltd.
Tylisovska 1, 160 00
Prague 6, Czech Republic
(4202) 311 42 98
(4202) 3332 12 17 Fax
E-mail:
biopreparaty@mbox.vol.c

BIOVED, Ltd.
Ady Endre u. 10
2310 Szigetszentmiklos, Hungary
36-24-441-554
E-mail: boh8457@helka.iif.hu

BioWorks, Inc. (formerly TGT, Inc.)
122 North Genesee St.
Geneva, NY 14456
315-781-1703
315-781-1793 Fax

Bozeman Biotech
See listing for Planet Natural

Borregaard Bioplant
Helsingforsgade 27 B
DK 8200 Aarhus N
Denmark
45-8-678-6988
45-8-678-6922

Caffaro, S.p.A.
Via Fruili, 55
20031 Cesano Maderno, Italy
39-362-51-4266
39-362-51-4405 Fax

Calliope S.A. (commercial export office)
16 Rue Antonin Raynaud
92300 Levallois Perret, France
33-1-47-58-4745
33-1-47-58-4339 Fax

Certis USA
9145 Guilford Road, Suite 175
Columbia, MD 21046
1-800-847-5620
Formerly Thermo Trilogy.

Ciba-Geigy Corp.
See Novartis entry below.

Ecogen, Inc.
2000 W. Cabot Blvd. #170
Langhorne, PA 19047-1811
215-757-1595
215-757-2956 Fax
http://www.ecogeninc.com

EcoScience Corp.
17 Christopher Way
Eatontown, NJ 07724-3325
732-676-3000
732-676-3031 Fax
http://www.ecosci.com

Ecosense Labs (I) Pvt. Ltd.
54 Yogendra Bhavan
J.B. Nagar, Andheri (E)
Mumbai–400 059 India
834-9136/830-0967
(91-22) 822-8016 Fax
E-mail: ecosense.mamoo
@gems.vsnl.net.in

Eco Soil Systems, Inc.
10740 Thornmint Road
San Diego, CA 92127
619-675-1660
800-331-8773
619-675-1662 Fax
http://www.ecosoil.com/

Grondortsmettingen DeCuester
Fortsesteenweg 30
B-2860 St.-Katelijne-waver,
Belgium
32-15-31-22-57
32-15-36-15 Fax

Growth Products
P.O. Box 1259
White Plains, NY 10602
800-648-7626
http://
www.growthproducts.com

Gustafson, Inc.
1400 Preston Road, Suite 400
Plano, TX 75093-5160
972-985-8877
972-985-1696 Fax
http://www.gustafson.com

Harmony Farm Supply
3244 Hwy 116 North
Sebastopol, CA 95472
707-823-9125
707823-1734 Fax
http://www.harmonyfarm.com

Helena Chemical Co.
6075 Poplar Avenue Suite 500
Memphis, TN 38119-0101
901-761-0050
901-683-2960 Fax
http://
www.helenachemical.com

Hydro-Gardens, Inc.
P.O. Box 25845
Colorado Springs, CO 80936
800-634-6362
719-495-2266
719-495-2267 Fax
E-mail: hgi@usa.net
http://www.hydro-
gardens.com

IPM Laboratories, Inc.
P.O. Box 300
Locke, NY 13092-0300
315-497-2063
315-497-3129 Fax
http://www.imptech.com

J.H. Biotech
4951 Olivas Park Drive
Ventura, CA 93003
805-650-8933
805-650-8942 Fax
E-mail: biotech@rain.org
http://www.jhbiotech.com

Kemira Agro Oy
Porkkalankatu 3
P.O. Box 330
FIN-00101
Helsinki, Finland
358-0-10-861-511
358-0-10-862-1126 Fax
http://www.kemira-agro.com/

Ki-Hara Chemicals Ltd
Lifford Hall
Lifford Lane
Kings Norton
Birmingham
0121-693-5900
0121-693-5901 Fax

Koppert B.V.
Veilingweg 17
P.O. Box 155
2650 AD Berkel en Rodenrijs
The Netherlands
31-010-514-04444
31-010-511-5203 Fax
http://www.koppert.nl/
english/index.html

Makhteshim–Agan of N.America
551 5th Ave., Suite 1000
New York, NY 10175
212-661-9800
221-661-9038/9043 Fax
http://www.makhteshim.co.il/
html/mcw.html

Market VI LLC
Contact: Vern Illum
6613 Naskins
Shawnee KS 66216
Illiumv@aol.com
913-268-7504
816-805-0120 Mobile

Mauri Foods
67 Epping Rd.
North Ryde, Australia

MicroBio Group Ltd.
17 High Street, Whittlesford
Cambridge, CB2 4LT. UK
44 (0)1223 830860
44 (0)1223 830861 Fax
http://
www.microbiogroup.com/
See website for listing of U.S. distributors.

MicroBio (USA) Ltd.
104-A W. Dozier St.
Marion SC 29571
843-423-2036
843-423-2044 Fax

Mycogen Corp.
(an affiliate of Dow
AgroSciences)
9330 Zionsville Rd
Indianapolis, IN 46268-1054
800-MYCOGEN
http://www.mycogen.com

Mycontrol, Ltd.
Alon Hagalil M.P.
Nazereth Elit 17920,
Israel
972-4-9861827 ph./Fax
E-mail:
mycontro@netvision.net.il

MycoTech Corporation
P.O. Box 4109
Butte, MT 59702-4109
Carla Elias, Customer Service
Representative
celias@mycotech.com
406-782-2386
406-782-9912 Fax
http://www.mycotech.com/

Natural Plant Protection
B.P. 80
Route D'Artix
64150 Noguères, France
33-59-84-1045
33-59-84-8955 Fax

New BioProducts, Inc.
2166 NW Fritz Pl
Corvallis, OR 97330
541-752-2045
541-754-3968 Fax
http://www.newbioproducts.com

Novo Nordisk BioChem
North America, Inc.
77 Perry Chapel Road
Box 576
Franklinton, NC 27525
919-494-3000
919-494-3450 Fax

Nu-Gro Professional
& Consumer Group
2270 Speers Rd
Oakville Ontario
Canada L6L 2X8
800-461-6471

Planet Natural
(formerly Bozeman Biotech)
1612 Gold Ave.
Bozeman, MT 59715
800-289-6656
406-587-5891
E-mail: ecostore@ycsi.net
http://www.planetnatural.com/
plantdiseasecontrol.html

Plant Health Technologies
Steve Kelly, Biological Products
7525 Postma Rd
Moxee City, WA 98936
509-452-7265

Praxis
2723 116th Ave
Allegan, MI 49010
616-673-2793
http://www.praxis-ibc.com
E-mail: praxis@allegan.net

Rincon-Vitova
P.O. Box 1555
Ventura, CA 93002-1555
800-248-2847
805-643-5407
http://www.rinconvitova.com

Sandoz Agro, Inc
Sandoz merged with Ciba Geigy in 1996 to form a new company, Novartis
http://www.novartis.com

Sanex, Inc. (see Nu-Gro Group)

San Jacinto Environmental
Supplies
2221-A West 34th Street
Houston, TX 77018-6004
713-957-0909
800-444-1290
713-957-707 Fax
http://sanjacorganic.com
E-mail: sjes@aol.com

S.I.A.P.A.
Via Vitorio Veneto
1 Galliera, 40010
Bologna, Italy
39-051-815508
39-051-812069 Fax

Soil Technologies Corp.
2103 185th St.
Fairfield, IA 52556
515-472-3963
http://www.soiltechcorp.com

Stine Microbial Products
2225 Laredo Trail
Adel, IA 50003
Contact: Vern Illum of:
Market VI LLC
(exclusive marketers of Deny)
913-268-7504
http://www.stine.com/

Sun Moon Chemical Co., Ltd.
K.W.T.C.
P.O. Box 7
Seoul, Korea
82-2-565-1653
82-2-565-1654 Fax
http://www.kwtc.com

Sylvan Spawn Laboratory
West Hills Industrial Park Bldg
#1
Kittanning, PA 16201
724-543-2242
http://www.sylvaninc.com

Technological Innovation
Corporation Pty. Ltd.
Innovation House
124 Gymnasium Dr.
Macquarie University
Sydney NSW, 2109 Australia
61 2 9850 8216
61 2 9884 7290 Fax
http://www.ticorp.com.au

Tecomag SRL
Via Quattro Passi 108
Formigine (Modena) Italy 41043
39-59-573745
39-59-572170 Fax
http://www.tecomag.com
E-mail: inc@tecomag.com

Thermo Trilogy
See Certis entry above.

Troy BioSciences
113 S. 47th Ave
Phoenix, AZ 85043
602-233-9047
http://
www.troybiosciences.com

Uniroyal Chemical B.V.
Ankerweg 18
1041 AT, Amsterdam
The Netherlands
31-20-587-1871
31-20-587-1700 Fax
http://www.uniroyalchem.com

Valent Biosciences
870 Technology Way
Libertyville, IL 60048
800-323-9597
http://www.valent.com
Bought Abbott Laboratories in 2001.

Vyskumny ustav rastlinnej
(Plant Production Institute)
Bratislavsk cesta 122
921 68 Piestany
Slovak Republic
838-223 11-12
223 26-27
838 263 06 Fax

Wilbur-Ellis
Agricultural Services Corp. Office
191 W. Shaw Ave., Suite 107
Fresno, CA 93704
559-226-1934
http://www.wilburellis.com/

APPENDIX D

New Legislation that's being considered in the 2002 Farm Bill, with components that support implementation of IPM

Conservation Security Act 2000

Summary: The Conservation Security Act (CSA) of 2000 provides financial assistance to help farmers and ranchers find viable solutions to agricultural, environmental, and economic concerns. The CSA helps agriculture respond to site-specific environmental challenges on a voluntary basis with a flexible program designed to address these challenges in a cost-effective and results-oriented fashion. The CSA rewards producers for good stewardship in appreciation of the many nonmarket environmental and social benefits that these practices provide society. The Act balances federal funding for conservation on working lands with existing funding for land retirement, providing farmers access to payments for whole-farm resource planning.

Conservation Purposes: The Conservation Security Program (CSP) created by the CSA addresses the full range of conservation concerns related to agriculture, including: conservation of soil, water, energy, and other related resources; soil, water, and air quality protection and improvement; on-farm conservation and regeneration of plant germplasm; wetland and wildlife habitat restoration, conservation, and enhancement; greenhouse gas emissions reduction and carbon sequestration; and other similar conservation goals.

Participation: Participation in the program stipulates that land practices must achieve resource and environmental benefits, but does not require the removal of land from production. In addition, practices do not need to be newly introduced to the farm / ranch; producers can be rewarded for good stewardship practices implemented prior to enrollment in the CSP. Participants are responsible for developing conservation security plans that identify targeted resources, practices, and implementation schedules. Participants are granted maximum flexibility for choosing land management, vegetative, and structural practices suitable for individual farms. In certain instances, the plan may include an on-farm research or demonstration component.

Tiers: Participants have the choice of enrolling in one of three tiers:

- **Tier I** participants address priority resource concerns on all or part of their farms / ranches. Practices may include soil and residue management, nutrient management, pest management, irrigation management, grazing management, wildlife habitat management, contour farming, strip cropping, cover cropping, and related practices.
- **Tier II** participants address priority resource concerns on the whole farm / ranch and meet applicable resource management system criteria. Tier II practices entail adoption of land use adjustment practices such as resource-conserving crop rotations, rotational grazing, conversion to soil-conserving practices, installing conservation buffer practices, restoration of wildlife habitats, prairies, and / or wetlands, and other related practices.
- **Tier III** participants satisfy the requirements of tiers I and II, while integrating land use practices into a whole-farm, total-resource approach that fosters long-term sustainability of the resource base.

Payment and Eligibility: Payments are based on the natural resource and environmental benefits expected from plan implementation, the number and timing of management practices established, income forgone due to land use adjustments, costs related to on-farm research, and several other factors. Bonuses are also offered for beginning farmers, joint participation by operators within a small watershed, and plans that optimize carbon sequestration and minimize greenhouse gas emissions. Payments may not exceed $20,000, $35,000, and $50,000 for Tier I, II, and III contracts, respectively.

APPENDIX E

Pest Management Practices: 1998 USDA Survey Summary Highlights

Barley: The leading pest management practice was rotating crops. Sixty-three percent of the farms used this practice on 71 percent of the acres across the U.S. The following practices were used on over 40 percent of the barley acres across the nation: using tillage practices to manage pests, cleaning implements after fieldwork, rotating crops to control pests, scouting, and alternating the use of pesticides.

Corn: Rotating crops to control pests was the leading pest management practice, used on 77 percent of the nation's corn acres. It was also the most widely used practice in terms of number of farms, at 67 percent. Scouting for pests was reported on 52 percent of the corn acres. Alternating pesticides and using tillage practices to manage pests were also common, each being reported on nearly half of the corn acres.

Cotton: Almost three-fourths of the U.S. cotton acres were scouted for pests, on 65 percent of the cotton farms. Prevention practices, such as using tillage practices to manage pests, removing or plowing down the crop residue, and cleaning implements after fieldwork were also widely used practices, being used on more than half of the cotton acres. Other practices reported on 50 percent or more of the acres: alternating pesticides, using records to keep track of pests, and using pheromones to monitor pests.

Soybeans: The most common pest management practice was rotating crops to control pests, which was done on 78 percent of the U.S. soybean acres and on 76 percent of the soybean farms. Other practices used on 40 percent or more of the acres were: using tillage to manage pests, scouting for pests, using seed varieties that were genetically modified to be resistant to specific herbicides, and alternating pesticides.

All Wheat: The leading pest management practice was rotating crops to control pests, which was used on 58 percent of the acres and by 53 percent of the farms. Cleaning implements after fieldwork was the second most widely used practice, with 49 percent of the acres and 33 percent of the farms. Using tillage to manage pests and scouting for pests were each reported on 40 percent or more of the acres.

Alfalfa Hay: Rotating crops to control pests was the most widely used pest management practice on the U.S. alfalfa acreage, at 33 percent. Scouting for pests and using tillage to control pests were used on 26 percent and 23 percent of the acres, respectively.

Other Hay: Twelve percent of the U.S. producers of hay other than alfalfa utilized tillage practices to manage pests. Five percent or more of the hay producers used the following practices on their farms: cleaning implements after fieldwork, rotating crops to control pests, and scouting for pests.

Fruits and Nuts: The most widely used pest management practice was scouting for pests, which occurred on 82 percent of the U.S. fruit and nut acres. Using tillage to manage pests was the second most common practice, used on 79 percent of the acres. Alternating pesticides and keeping records to track pest problems were used on 72 and 62 percent of the acres, respectively.

Vegetables: Eighty percent of the U.S. vegetable acres were scouted for pests, making it the most common pest management practice for vegetable crops. Rotating crops was reported on 78 percent of the acres, while using tillage to manage pests was used on 74 percent of the acres.

All other Crops and Cropland Pasture: This group includes crops that were not specifically targeted during the survey such as sorghum, oats, rice, peanuts, etc. The most widely used pest management practice was rotating crops to control pests, at 52 percent of the acres. Using tillage to manage pests, scouting for pests, and cleaning implements after fieldwork were each utilized on more than 40 percent of the acres.

Genetically modified crop varieties: The practices showing the most change from the 1997 crop year to the 1998 crop year were the use of varieties that were genetically modified to be resistant to insects or to specific herbicides.

For **corn**, there was an increase from 5 percent of the acres in 1997 to 20 percent of the acres in 1998 that were planted to varieties that were modified through genetic engineering or conventional breeding to be resistant to insects.

For **cotton**, there was an increase of 9 percentage points, from 13 percent of the acres in 1997 to 22 percent in 1998.

The use of **crop varieties resistant to specific herbicides** on **corn** increased from 2 percent in 1997 to 11 percent of the acres in 1998. The use of these varieties for cotton and soybeans showed a greater increase. For **cotton**: an increase from 5 percent in 1997 to 34 percent in 1998. The proportion of **soybean** varieties used: 10 percent in 1997 and 48 percent in 1998.

APPENDIX F: IPM INFORMATION RESOURCES

ATTRA Resources related to IPM

Farmscaping to Enhance Biological Control
http://www.attra.org/attra-pub/farmscape.html

Sustainable Management of Soil-borne Plant Diseases
http://www.attra.org/attra-pub/PDF/soildiseases.pdf

Alternative Nematode Control
http://www.attra.org/attra-pub/nematode.html

Compost Teas for Plant Disease Control
http://www.attra.org/attra-pub/comptea.html

Disease Suppressive Potting Mixes
http://www.attra.org/attra-pub/dspotmix.html

Use of Baking Soda as a Fungicide
http://www.attra.org/attra-pub/baksoda.html

Alternative Controls for Late Blight in Potatoes
http://www.attra.org/attra-pub/lateblight.html

Management Alternatives for Thrips on Vegetable and Flower Crops in the Field
http://www.attra.org/attra-pub/thrips.html

Phenology Web Links: Sequence of Bloom, Floral Calendars, What's in Bloom
http://www.attra.org/attra-pub/phenology.html

Grasshopper Management
http://www.attra.org/attra-pub/grasshopper.html

Fire Ant Management
http://www.attra.org/attra-pub/fireant.html

Integrated Pest Management for Greenhouse Crops
http://www.attra.org/attra-pub/gh-ipm.html

Greenhouse IPM: Sustainable Thrips Control
http://www.attra.org/attra-pub/gh-thrips.html

Greenhouse IPM: Sustainable Aphid Control
http://www.attra.org/attra-pub/gh-aphids.html

Greenhouse IPM: Sustainable Whitefly Control
http://www.attra.org/attra-pub/gh-whitefly.html

ATTRA Resources in print only
Call 800-346-9140

- **Colorado Potato Beetle: Organic Control Options**
- **Corn Earworm: Organic Control Options**
- **Downy Mildew Control in Cucurbits**
- **Flea Beetle: Organic Control Options**
- **Organic Control of Squash Bug**
- **Organic Control of Squash Vine Borer**
- **Powdery Mildew Control in Cucurbits**

General IPM Reference Materials

Contacts/Coordinators

State IPM Coordinators & Web Sites
http://www.reeusda.gov/agsys/ipm/coordinators.htm

Resource Centers

IPM Access: Integrated Pest Management Information Service
http://www.efn.org/~ipmpa/index.shtml

Pest Management Resource Center
http://www.pestmanagement.co.uk

StudyWeb | Science| Integrated Pest Management
http://www.studyweb.com/links/2509.html

StudyWeb | Science| Pest Management
http://www.studyweb.com/links/2510.html

IPM Guides

There are numerous books, manuals and websites that address insect and disease pests of vegetable crops.

APS Press
American Phytopathological Society
3340 Pilot Knob Road
St. Paul, MN 55121-2097
651-454-7250
651-454-0766 Fax
aps@scisoc.org
http://www.scisoc.org/

- Diseases of Vegetables CD-ROM
- Advances in Potato Pest Biology and Management
- Compendium of Bean Diseases
- Compendium of Beet Diseases
- Compendium of Corn Diseases, 3rd Edition
- Compendium of Cucurbit Diseases

- Compendium of Lettuce Diseases
- Compendium of Pea Diseases
- Compendium of Tomato Diseases

Bio-Integral Resource Center (BIRC)

BIRC publishes The IPM Practitioner and Common Sense Pest Quarterly as well as an annual Directory of IPM Products and Beneficial Insects. BIRC also produces booklets and reprints on least-toxic controls for selected pests. The IPM Practitioner is published ten times per year. Must be a member of the Bio Integral Resource Center (BIRC) to receive The IPM Practioner. Memberships: $50/yr. for institutions; $25/yr. for individuals; $18/yr. for students. Dual memberships available if you wish to receive the Common Sense Pest Control Quarterly.

Bio-Integral Resource Center (BIRC)
P.O. Box 7414
Berkeley, CA 94707
510-524-2567
510-524-1758 Fax
birc@igc.apc.org
http://www.igc.org/birc/

Common Sense Pest Control. 1991. Olkowski, W., S. Daar and H. Olkowski. The Tauton Press, Newton, CT. 715 p.
A good reference and resource book for IPM of a wide range of pests.

Complete Guide to Pest Control With and Without Chemicals, 3rd Edition. 1996. By George Ware. Thompson Publishing Co., California. 350 p.

Entomological Society of America
9301 Annapolis Road
Lanham, MD 20706-3115
301-731-4535
301-731-4538 Fax
esa@entsoc.org
http://www.entsoc.org/catalog/

- Complete Guide to Pest Control With and Without Chemicals, 3rd Edition
- Insect Pests of Farm, Garden and Orchard, 8th Edition
- Integrated Pest Management for Onions (Cornell)
- Manual on Natural Enemies of Vegetable Insect Pests (Cornell)
- Pests of the West, Revised
- Farmscape Ecology of Stink Bugs in Northern California
- Numerous standard reference books: IPM, biological control, ecology, and behavior

The Florida Cooperative Extension Publications Resource
http://hammock.ifas.ufl.edu/
EDIS—The Florida Cooperative Extension Publications Resource—has a wealth of information on a wide variety of topics of interest to IPM practitioners. Brief overviews are provided for all topics, and more detailed information is accessible if you have Adobe Acrobat Reader.

Integrated Pest Management (IPM): Concepts and Definitions
http://www.ippc.orst.edu/cicp/IPM.htm

IPMnet NEWS Archives
http://www.IPMnet.org/IPMnet_NEWS/archives.html

IPMnet News is published monthly and provides information about new research, articles, resources, and activities of interest to IPM practitioners. IPMnet NEWS is accessible through FTP, TELNET, and FINGER and also via e-mail using FTPMAIL. For more information send e-mail to: deutscha@bcc.orst.edu Fax: 01-503-737-3080, Phone: 01-503-737-6275

IPM Solutions
Gempler's IPM Almanac
http://www.ipmalmanac.com/solutions/archive.asp
This site's IPM section is an excellent resource for folks working on-the-ground in IPM. It has a wide variety of tools, hardware, traps, etc. that are useful to the IPM professional.

Pest Management & Crop Development Bulletin
University of Illinois Extension
http://www.ag.uiuc.edu/cespubs/pest/

Pests of the Garden and Small Farm:
A Grower's Guide to Using Less Pesticide. 1991. By Mary Louise Flint. University of California, Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources, Publication 3339. 257 p.

Radcliffe's IPM World Textbook
http://ipmworld.umn.edu/

UC Pest Management Guidelines
http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html

University of California Statewide Integrated Pest Management Project
http://www.ipm.ucdavis.edu/

UC Statewide IPM Project
University of California
One Shields Avenue
Davis, CA 95616-8620
530-752-7691
http://www.ipm.ucdavis.edu/

For-Sale Publications:
- IPM for Tomatoes
- IPM for Cole Crops and Lettuce
- IPM for Potatoes
- Managing Insects and Mites with Spray Oils
- Natural Enemies Are Your Allies! (poster)
- Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control
- Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide, 2nd edition
- UC IPM Pest Management Guidelines
- IPM in Practice: Principles and Methods of Integrated Pest Management
- IPM for Floriculture and Nurseries
- Pierce's Disease
- Grape Pest Management
- IPM for Apples & Pears, 2nd Edition
- Organic Apple Production Manual
- Aquatic Pest Control
- Turfgrass Pests
- IPM for Citrus

On-Line Publications:
- UC IPM Pest Management Guidelines

Vegetable Guidebooks

Crop Knowledge Master: Vegetables
University of Hawaii at Manoa
http://www.extento.hawaii.edu/kbase/crop/crops/vegetabl.htm

Database of IPM Resources (DIR): Internet Resources on Potato IPM
http://www.ippc.orst.edu/cicp/crops/potato.htm

Database of IPM Resources (DIR): Internet IPM Resources on Tomato
http://www.ippc.orst.edu/cicp/crops/tomato.htm

Database of IPM Resources (DIR): Internet Resources on Vegetable Pest Management
http://www.ippc.orst.edu/cicp/Vegetable/veg.htm
Internet Resources on Vegetable Pest Management is a sub-category of DIR that provides links to materials on insect and disease problems associated with vegetable production. A great starting point!

Integrated Crop and Pest Management Guidelines for Commercial Vegetable Production
Cornell Cooperative Extension
http://www.nysaes.cornell.edu/recommends/

IPM — Fruits & Vegetables at University of Illinois
http://www.aces.uiuc.edu/~ipm/fruits/fruits.html

IPM in New York State Vegetables
http://www.nysaes.cornell.edu/ipmnet/ny/vegetables/

USDA/OPMP Crop Profiles Database
USDA Office of Pesticide Management Programs, (OPMP) & Pesticide Impact Assessment Program (PIAP)
http://cipm.ncsu.edu/CropProfiles/
A great place to find out what the standard pest controls are for vegetable crops.

VegEdge — Vegetable IPM for the Midwest
http://www3.extension.umn.edu/vegipm/

Vegetable Production and Pest Control Guides from Land-Grant Universities
Oregon State University http://www.orst.edu/Dept/NWREC/veglink.html

VegNet
Ohio State University
http://www.ag.ohio-state.edu/~vegnet/index.html

Newsletters/Alerts

The Georgia Pest Management Newsletter
http://www.ces.uga.edu/Agriculture/entomology/pestnewsletter/newsarchive.html

Integrated Crop Management Newsletter
Iowa State University
http://www.ipm.iastate.edu/ipm/icm/

Pest Alert
Colorado State University
http://www.colostate.edu/programs/pestalert/index.html

Pest & Crop Newsletter
Purdue University http://www.entm.purdue.edu/entomology/ext/targets/newslett.htm

Vegetable Newsletters

The Illinois Fruit and Vegetable News
http://www.aces.uiuc.edu/ipm/news/fvnews.html

Pay Dirt—Newsletter for Vegetable Growers
North Carolina State University
http://henderson.ces.state.nc.us/newsletters/veg/

Plant & Pest Advisory, Vegetable Edition
Rutgers University, New Jersey
http://www.rce.rutgers.edu/pubs/plantandpestadvisory/index.html

South Carolina Pumpkin News
http://virtual.clemson.edu/groups/hort/vegprog.htm

Vegetable Crop Advisory Team (CAT) Alert
Michigan State University
http://www.msue.msu.edu/ipm/vegCAT.htm

Vegetable Crops Hotline
Purdue University http://www.entm.purdue.edu/entomology/ext/targets/newslett.htm

The Vegetable Gazette
The Pennsylvania State University
http://www.ento.psu.edu/vegetable/veggaz/veggazette.htm

Vegetable IPM Message
University of Massachussetts
http://www.umass.edu/umext/programs/agro/vegsmfr/Articles/Newsletters/Newsletters.htm

Vegetable Newletter
Nova Scotia Department of Agriculture
http://agri.gov.ns.ca/pt/hort/newslets/vegetable/index.htm

VegNet Newsletter
Ohio State University
http://www.ag.ohio-state.edu/~vegnet/news/newslist.htm

VegNews
University of Arizona
http://ag.arizona.edu/hypermail/vegnews/index.html

Insect Lifecycles and Management

Destructive and Useful Insects. 1993. Metcalf, R.L. & R.A. Metcalf. 5th ed. McGraw-Hill Inc, New York, NY.
A good reference for lifecycle information for agricultural pests and beneficials.

Entomology Index of Internet Resources: A Directory and Search Engine of Insect-Related Resources on the Internet
Iowa State University
http://www.ent.iastate.edu/list/

Entomology on World-Wide Web
Colorado State University
http://www.colostate.edu/Depts/Entomology/www_sites.html

Featured Creatures: The Good, The Bad, and The Pretty
University of Florida Department of Entomology and Nematology
http://www.ifas.ufl.edu/~insect/index.htm
This University of Florida website is a great first-step IPM site to find quick, essential knowledge about pest insects: Introduction - Hosts - Distribution - Description - Life Cycle - Damage - Economic Injury Level - Management - Selected References.

Insect Pests of Farm, Garden and Orchard, 8th Edition. 1987. By R. Davidson & W. Lyon. John Wiley & Sons, New York. 640 p.

Insects on WWW
Virginia Tech
http://www.isis.vt.edu/~fanjun/text/Links.html

Land Grant University Entomological Resources
University of Florida jump site
http://www.ifas.ufl.edu/~pest/vector/link_sub.htm#Land

Mites Injurious to Economic Plants. 1975. Jeppson, L.R., HH Keifer and E.W. Baker. U C Press. Berkeley, CA. 679 p.

Rodale's Color Handbook of Garden Insects. Carr, Anna. 1979. Rodale Press, Emmaus, PA. 241 p.
An identification guide. Over 300 color photographs of insects in the egg, larval, pupal, and adult stages. Descriptions include range, life cycle, host plants, feeding habits, natural controls.

Vegetable Insect Fact Sheets
University of Kentucky — Department of Entomology
http://www.uky.edu/Agriculture/Entomology/entfacts/efveg.htm

Vegetable Insect Management: With Emphasis on the Midwest. 1995. By Rick Foster and Brian Flood (eds.) Meister Publishing Co., Willoughby, OH. 206 p.
A comprehensive 206-page manual produced by the Purdue Research Foundation, published by Meister Publishing Company. This is one of the best pest management guides on vegetables compiled by the Extension Service.

Vegetable IPM Insect Notes
North Carolina State University
http://www.ces.ncsu.edu/depts/ent/notes/Vegetables/vegetable_contents.html

Diseases

Commercial Biocontrol Products For Use Against Soilborne Crop Diseases
USDA-ARS
http://www.barc.usda.gov/psi/bpdl/bpdlprod/bioprod.html

Disease Management for Vegetables and Herbs in Greenhouses Using Low Input Sustainable Methods
North Carolina State University
http://www.ces.ncsu.edu/depts/pp/notes/oldnotes/vg2.htm

Minimizing Vegetable Disease
Cornell University
http://plantclinic.cornell.edu/vegetable/minimizevege/minimizevege.htm

An Online Guide to Plant Disease Control
Oregon State University
http://plant-disease.orst.edu/index.htm
This site, hosted by Oregon State University, provides pictures as well as fact sheets about a range of plant pathogens found in the Pacific Northwest. This site is a very good reference for the control and management tactics for important plant diseases in the Pacific Northwest.

Plant Pathology Internet Guide Book
http://www.ifgb.uni-hannover.de/extern/ppigb/ppigb.htm

Texas Plant Disease Handbook
http://cygnus.tamu.edu/Texlab/tpdh.html

Traditional Practices for Plant Disease Management in Traditional Farming Systems
H. David Thurston, Cornell University
http://www.tropag-fieldtrip.cornell.edu/Thurston_TA/default.html

Vegetable Diseases and their Control, 2nd Edition. 1986. By Arden F. Sherf and Alan A. MacNab. John Wiley & Sons, New York. 728 p.

Vegetable MD Online
Cornell University Vegetable Disease Web Page
http://ppathw3.cals.cornell.edu/Extension/VegetableDiseases/Home.htm

Organic Pest Control

Organic Pest Control Guide for Insect and Disease Control
University of Georgia
http://www.ces.uga.edu/Agriculture/entomology/pest99/hort/organic/organic.htm

Organic Vegetable IPM Guide
Mississippi State University
http://ext.msstate.edu/pubs/pub2036.htm

Praxis Website
http://www.praxis-ibc.com/id88.htm
For Vegetable Crops & Fruit Production—Directed to growers who want to eliminate pesticides, herbicides, and fungicides from their production systems. Offers consultation about growing alternatives for vegetable, grain, and fruit crops. Consultation includes biological control of major and minor crop pests, and reduction of non-point pollution and groundwater contamination

Cultural Controls

General

Cultural Control
Radcliffe's IPM World Textbook
http://ipmworld.umn.edu/chapters/ferro.htm

Cultural Control for Management of Vegetable Pests in Florida
University of Florida
http://www.imok.ufl.edu/LIV/groups/cultural/pests/insects.htm

Crop Rotations

Conservation Crop Rotation: Effects on Soil Quality
NRCS Soil Quality Institute, Agronomy Technical Note No. 2.
http://www.statlab.iastate.edu/survey/SQI/pdf/agronomy2.pdf

Crop Rotation: The Future of the Potato Industry in Atlantic Canada
Eastern Canada Soil and Water Conservation Centre
http://www.cuslm.ca/ccse-swcc/publications/english/rotation.pdf

Crop Rotations in Direct Seeding
Alberta Agriculture, Food and Rural Development
http://www.agric.gov.ab.ca/agdex/500/519-28.html

Having Problems Controlling Vegetable Crop Diseases - Try Rotation
University of Connecticut, IPM Program
http://www.canr.uconn.edu/ces/ipm/veg/htms/rotate.htm

Biological Control

Approaches to Biological Control of Insect Pests
Department of Entomology, Connecticut Agricultural Experiment Station
http://www.state.ct.us./caes/fsen0004f.htm

Arizona Biological Control Inc
http://www.arbico.com/
This site, run by Arizona Biological Control Inc. (ARBICO), has a wide range of tools available for the IPM practitioner, provides basic information about beneficials and application rates.

Association of Natural Bio-Control Producers — Natural Enemy Fact Sheets
http://ipmwww.ncsu.edu/biocontrol/anbp/Factsheets.html

Beneficial Insects and Mites
University of Florida
http://edis.ifas.ufl.edu/IN078

Beneficial Insects Sheet 1
University of Florida
http://edis.ifas.ufl.edu/in002

Beneficial Insects Sheet 2
University of Florida
http://edis.ifas.ufl.edu/in003

Beneficial Insects Sheet 3
University of Florida
http://edis.ifas.ufl.edu/in012

Beneficial Insects Sheet 4
University of Florida
http://edis.ifas.ufl.edu/in013

Biological Control: A Guide to Natural Enemies in North America
Cornell University
http://www.nysaes.cornell.edu/ent/biocontrol/
This site provides photos and descriptions of over 100 biological control (or biocontrol) agents of insect, disease, and weed pests in North America. It is also a tutorial on the concept and practice of biological control and integrated pest management (IPM). Excellent photos and lifecycle descriptions supplemented with diagrams.

Biological Control of Insect and Mite Pests
University of Nebraska Cooperative Extension
http://www.ianr.unl.edu/pubs/insects/g1251.htm

Biological Control of Insect Pests of Cabbage and Other Crucifers. 1993. By Susan E. Rice Mahr, Daniel L. Rice,
and Jeffrey A. Wyman. North Central Region Publication No. 471. Cooperative Extension Service, University of Wisconsin. 55 p. *To place an order, see:*
http://www1.uwex.edu/ces/pubs/

Biological Control: Predators and Parasitoids
University of Minnesota, Center for Urban Ecology and Sustainability
http://www.ent.agri.umn.edu/cues/dx/pred-par.htm

Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and their Use in Pest Management. 1993. By Daniel L. Mahr and Nino M. Ridgeway. North Central Region Publication No. 481. Cooperative Extension Service, University of Wisconsin 91 p. *To review contents and place an order, see:*
http://muextension.missouri.edu/xplor/regpubs/ncr481.htm

Biological Control News
University of Wisconsin
http://www.entomology.wisc.edu/mbcn/mbcn.html

Field Guide to Predators, Parasites, and Pathogens Attacking Insect and Mite Pests of Cotton. Knutson, Allen and John Ruberson. 1996. Texas Agricultural Extension Service, The Texas A & M University System, Bryan, TX. 125 p.
Applicable to many other crops where same "good bugs" are present. Excellent color photos and written descriptions.

Identification and Management of Major Pests & Beneficial Insects in Potato
Oregon State University
http://ippc2.orst.edu/potato/

Integrated Pest Management for Greenhouse Crops
ATTRA
http://www.attra.org/attra-pub/gh-ipm.html
Appendix II: Beneficial Organisms

Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control. Publication 3386B4. University of California, Statewide Integrated Pest Management Project. 164 p. *To review contents and place an order, see:*
http://www.ipm.ucdavis.edu/GENERAL/naturalenemiesflyer.html

Natural Enemies of Vegetable Insect Pests. 1993. By Michael P. Hoffman and Anne A. Frodsham. Cornell Cooperative Extension Service, Ithaca, New York. 63 p. *The complete manual can also be found on the web at*: **Biological Control: A Guide to Natural Enemies in North America** http://www.nysaes.cornell.edu/ent/biocontrol/

Praxis Website
http://www.praxis-ibc.com/id88.htm
See p. 43 for description.

Predatory Insects in Fruit Orchards
Publication 208, Ontario Ministry of Food and Agriculture. 32 pages.
Predatory Insects in Fruit Orchards identifies over 100 beneficial insects that work in the orchard. It features detailed color pictures and life cycle descriptions for each insect. Though this particular bulletin is geared to fruit orchards, much of the information is universally applicable to horticulture crops. To review contents and place an order, see:
http://www.gov.on.ca/OMAFRA/english//products/newpubs.html#insects

Suppliers of Beneficial Organisms in North America.
Hunter, Charles D. 1997. California Environmental Protection Agency, Sacramento, CA. 32 p.
For a free copy, write to:
California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring and Pest Management Branch
1020 N Street, Room 161
Sacramento, CA 95814-5624
Ph: (916) 324-4100
A web-based version can be found at:
http://www.cdpr.ca.gov/docs/dprdocs/goodbug/benefic.htm

Biological Control: Systems Approaches

Farmscaping to Enhance Biological Control. 2000.
Dufour, R. ATTRA, Fayetteville, AR. 25 p.
http://www.attra.org/attra-pub/farmscape.html
The on-line ATTRA publication that summarizes habitat manipulation as a means to create insect refugia and attract beneficial insects to the farm, thus enhancing natural biological control. It provides an introduction to farmscaping, practical examples of habitat manipulation employed by farmers, and pointers to useful print and web resources.

Naturalize Your Farming System: A Whole-Farm Approach to Managing Pests
Sustainable Agriculture Network, USDA-SARE
http://www.sare.org/farmpest/index.htm
http://www.sare.org/farmpest/farmpest.pdf

Phenology Web Links: Sequence of Bloom, Floral Calendars, What's in Bloom
ATTRA
http://www.attra.org/attra-pub/phenology.html

A Total System Approach to Sustainable Pest Management —The Image
Biological Control as a Component of Sustainable Agriculture, USDA-ARS
http://sacs.cpes.peachnet.edu/lewis/ecolsyst.gif

A Total System Approach to Sustainable Pest Management —The Story
Biological Control as a Component of Sustainable Agriculture, USDA-ARS
http://sacs.cpes.peachnet.edu/lewis/lewis1.pdf
This is a classic biointensive IPM article from the November 1997 issue of Proceedings of the National Academy of Science. It is accompanied by the diagrammatic illustration that shows an unstable pyramid on the left (Pesticide Treadmill) transitioning through boxes in the middle (Therapeutics) + (Ecosystem Manipulation) to get to a stable pyramid on the right (Total System Management).

Biological Control: Beneficial Nematodes

Beneficial Nematodes: Suppliers and Pesticide Compatibility,
Nematology Pointer No. 45
University of Florida
http://edis.ifas.ufl.edu/in096

Insect Parasitic Nematodes
http://www.oardc.ohio-state.edu/nematodes/
Ohio State U., UC Davis, U. Florida, Rutgers U., EPA, Society of Invertebrate Pathology, Dodge Foundation, OceanSpray, Cranberry Institute, and Thermo Triology support this website. This site has much useful information about the use of insect parasitic nematodes: the biology and ecology of nematodes, how to use nematodes, a list of suppliers, and more! An extremely useful section provides full citation for research papers according to author, title, or abstract. Research papers can also be searched for according to Order and Family of target insect. To get to this section, click on: Search PublicationsÞKeyword Search Page (just underneath the "author, title, abstract" search engine)ÞInsects. Then you may choose the Order and Family of your choice.

Insect Parasitic Nematodes
Ohio State University
http://www2.oardc.ohio-state.edu/nematodes/

Suppliers of Beneficial Organisms in North America
California Environmental Protection Agency
http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm

Biological Control: Nematodes

Alternative Nematode Control
ATTRA
http://www.attra.org/attra-pub/nematode.html

Nematode Suppressive Crops
Auburn University
http://www.aces.edu/department/extcomm/publications/anr/anr-856/anr-856.htm

Soil Organic Matter, Green Manures and Cover Crops For Nematode Management
Entomology and Nematology Department, University of Florida
http://hammock.ifas.ufl.edu/txt/fairs/vh/17728.html

Pesticides

Pesticide Registration

Kelly Pesticide Registration Systems
http://www.kellysolutions.com/
Some states provide free access to pesticide registration databases. Use them to identify pest control products for target pests.

Alternatives to Pesticides

Methyl Bromide Alternatives Newsletter
USDA
http://www.ars.usda.gov/is/np/mba/mebrhp.htm

Methyl Bromide Phase Out Web Site
EPA
http://www.epa.gov/ozone/mbr/

Biorational Pesticides

Biorational pesticides, also known as least-toxic pesticides, are those that are pest-specific and cause the least amount of harm to beneficial organisms or the environment. Examples include microbial insecticides, insecticidal soaps, horticultural oils, insect growth regulators, sorptive dusts like diatomaceous earth, pheromones, and to some extent, botanical plant extracts.

Alternatives in Insect Pest Management: Biological & Biorational Approaches. 1991. By Rick Weinzierl and Tess Henn. North Central Regional Extension Publication 401.
http://spectre.ag.uiuc.edu/%7Evista/abstracts//aaltinsec.html

Alternatives in Insect Pest Management: Biological & Biorational Approaches
North Central Region Extension Publication 401
http://spectre.ag.uiuc.edu/%7Evista/abstracts aaltinsec.html

Commercial Biocontrol Products For Use Against Soilborne Crop Diseases
USDA-ARS
http://www.barc.usda.gov/psi/bpdl/bpdlprod/bioprod.html

Hydrated Lime as an Insect Repellent
University of Connecticut Integrated Pest Management Program
http://www.canr.uconn.edu/ces/ipm/veg/htms/hydlime.htm

Insect Management: Botanicals
Sustainable Practices for Vegetable Production in the South, Dr. Mary Peet, NCSU
http://www.cals.ncsu.edu/sustainable/peet/IPM/insects/botan.html

Integrated Pest Management
ATTRA
http://www.attra.org/attra-pub/ipm.html
Appendix A: Microbial Pesticides
Appendix B: Microbial Pesticide Manufacturers and Suppliers

Integrated Pest Management for Greenhouse Crops
ATTRA
http://www.attra.org/attra-pub/gh-ipm.html
Appendix III: Biorational Pesticides

Least Toxic Materials for Managing Insect Pests
IPM Access - An Integrated Pest Management Online Service
http://www.efn.org/~ipmpa/leastox.html

Use of Baking Soda as a Fungicide
ATTRA
http://www.attra.org/attra-pub/bakingsoda.html

What are Biorational Pesticides?
University of Minnesota, Center for Urban Ecology and Sustainability
http://www.ent.agri.umn.edu/cues/dx/bugs/bio1.htm

What are Biopesticides
EPA Office of Pesticide Programs: Biopesticides
http://www.epa.gov/pesticides/biopesticides/what_are_biopesticides.htm
The EPA Classifies biopesticides into three major categories:

(1) Microbial pesticides contain a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. For example, there are fungi that control weeds, and bacteria that control plant diseases.

(2) Plant-pesticides are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, the gene for the Bt pesticidal protein has been introduced into corn.

(3) Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are synthetic materials that usually kill or inactivate the pest. Biochemical pesticides include substances, such as pheromones, that interfere with growth or mating of the pest.

Weed Control

Weed Identification

New Jersey Weed Gallery
Rutgers, The State University of New Jersey
http://www.rce.rutgers.edu/weeds/index.html

UC IPM Weed Photo Gallery
University of California Statewide IPM Project
http://www.ipm.ucdavis.edu/PMG/weeds_common.html

General

Controlling Weeds with Fewer Chemicals.
Cramer, Craig (ed.). 1991. Rodale Institute, Emmaus, PA. 138 p.

Integrated Pest Management Plan for Lower Klamath and Tule Lake NWRs — Weeds
National Center for Appropriate Technology
http://refuges.fws.gov/NWRSFiles/HabitatMgmt/KBasin/Weeds.html

Integrated Weed Management in Vegetable Crops
University of Illinois Extension Service
http://www.aces.uiuc.edu/ipm/fruits/iwm/iwm.html

Principles of Integrated Weed Management
Ontario Ministry of Agriculture, Publication 75
http://www.gov.on.ca/OMAFRA/english/crops/facts/IWM.htm

Weed Control Practices
Oregon State University
http://www.orst.edu/dept/hort/weeds/weedcontrol.htm

Weed Prevention
Alberta Practical Crop Protection
http://www.agric.gov.ab.ca/agdex/000/pp6063s1.html

Weeds in Agroecosystems
Dalhousie University, Canada
http://is.dal.ca/~dp/reports/mcpheest.htm

A Whole-Farm Approach to Weed Control: A Strategy for Weed-Free Onions
Anne & Eric Nordell, Sharing the Lessons of Organic Farming Conference, January 30–31, 1998, University of Guelph
http://gks.com/library/OrgConf/1998d.html
An online conference paper that summarizes the methods Anne & Eric Nordell use to control weeds in onion fields.

A Whole-Farm Approach to Weed Control: A Strategy for Weed-Free Onions (Video)
Anne & Eric Nordell
The Nordells work with horses to raise a 6-acre market garden in Pennsylvania, growing dried flowers, herbs, lettuce, potatoes, onions, and other vegetables. They use a combination of cover crops, fallowing, tillage, and hand weeding for weed control. To provide a visual image of how they integrate different components of their farm into a whole, the Nordells videotaped a slide presentation they use at organic farming workshops. The 52-minute tape is available for $10 postpaid from:

Anne and Eric Nordell
RDI Box 205
Trout Run, PA 17771

1988 REAP: Guide to Economical Weed Control
Roger Samson, Canada-REAP
http://eap.mcgill.ca/MagRack/SF/Spring%2089%20D.htm

Biological Control

Biological Control of Weeds Handbook. 1993. Watson, Alan K. (ed.) Weed Science Society of America, Champaign, IL. 202 p.
Included are introduced natural enemies, native or naturalized insects and nematodes, plant pathogens, and vertebrate herbivores specifically managed to control weeds.

Cultivation

Cultivation Basics for Weed Control in Corn. 1997. By Jane Mt. Pleasant. Cornell University. Publication 125IB241. 10 p.
Cultivation is discussed as an alternative to herbicides, as well as in combination with herbicides through a mixed weed control approach. A description of six inter-row and in-row tools is provided, accompanied by color photos. Research on mechanical weed control field trials at Cornell is summarized.

Innovative Cultivating Tools
University of Connecticut, IPM Program
http://www.canr.uconn.edu/ces/ipm/weeds/htms/
culttools.htm

Photo Gallery & Glossary of Cultivators and Implements Used in Physical Weed Control
European Weed Research Society
http://www.ewrs.org/physical-control/glossary.htm
Rotary hoe, flexible chain harrow, spring tine harrow, Lilliston rolling cultivator, horizontal-axis brush hoe, vertical-axis brush hoe, finger weeder, torsion weeder

Steel in the Field: A Farmer's Guide to Weed Management Tools. 1997. By Greg Bowman (ed.). Sustainable Agriculture Network, Handbook Series No. 2. Sustainable Agriculture Publications, University of Vermont. 128 p.

Cultivation techniques and the tools used in association with mechanical weed control are less familiar to farmers after several decades of widespread chemical weed control. Steel in the Field, a handbook in the Sustainable Agriculture Network series, provides illustrations, descriptions, and practical examples of 37 specialized tools used to control weeds. It features profiles of farmers using reduced- or non-chemical weed control strategies, and contains a listing of suppliers of these specialized tools.

Vegetable Farmers and Their Weed-Control Machines
A 75-minute educational video on cultivation and flaming equipment produced in 1996 by Vern Grubinger, UVM Extension System and Mary Jane Else, UMass Extension with funding from USDA-SARE. Cost is $12.00 from:
The Center for Sustainable Agriculture
University of Vermont & State Agricultural College
590 Main Street
Burlington, Vermont 05405-0059
802-656-0233
802-656-8874 Fax
http://moose.uvm.edu/~susagctr/index.html

Cover Crops

Contribution of Cover Crop Mulches to Weed Management
University of Connecticut, IPM Program
http://www.canr.uconn.edu/ces/ipm/weeds/htms/
cvrcrps.htm

Cover Crops For Weed Control In Lettuce
New Alchemy Quarterly, No. 40
Mark Schonbeck, Judy Browne and Ralph DeGregorio
http://www.fuzzylu.com/greencenter/q40/weed9009.htm

Cover-Cropping with Rye and Bellbeans in California Vegetable Production
Center for Agroecology and Sustainable Food Systems, UC Santa Cruz
http://www.agroecology.org/cases/rbcovercrop.htm

Mechanisms of Weed Suppression By Squash Intercropped in Corn
Phillip Thomas Fujiyoshi, UC Santa Cruz
http://www.agroecology.org/people/phillip/dissertation.htm

Watermelon Cover Cropping with Wheat and Barley in Niigata, Japan
Center for Agroecology and Sustainable Food Systems, UC Santa Cruz
http://www.agroecology.org/cases/watermeloncover.htm

Organic/Non-chemical

Integrating Non-Chemical Methods to Enhance Weed Management
Horticultural Sciences Department
University of Florida
http://www.imok.ufl.edu/LIV/groups/cultural/pests/weed_man.htm

Non-Chemical Weed Control
Ray Bauml
Options in Agriculture: Exploring Organic Alternatives, Saskatoon, February 8–10, 1998.
http://www3.sk.sympatico.ca/hhaidn/conference98/page29a.htm

Nonchemical Weed Management Strategies
University of Illinois Extension Service
http://www.aces.uiuc.edu/ipm/fruits/nonchem.html

Organic Field Crop Handbook — Weed Management
Canadian Organic Growers, COG
http://eap.mcgill.ca/MagRack/COG/COGHandbook/COGHandbook_1_7.htm

A Review of Non-Chemical Weed Control Techniques
S. Parish
Biological Agriculture and Horticulture, Vol. 7.
http://eap.mcgill.ca/MagRack/BAH/BAH%205.htm

Sustainable Weed Management in Organic Herb & Vegetable Production
University of New England, NSW (Australia)
http://www.une.edu.au/agronomy/weeds/organic/organic.html

Weed Control Beyond Herbicides. Willis, Harold. Midwestern Bio-Ag, Blue Mounds, WI. 24 p.
Presents weed control in terms of working with and understanding natural processes.

Weed Management Strategies in Organic Farming Systems
David Oien
1997 Direct Seeding Conference, Saskatchewan Soil Conservtion Association
http://ssca.usask.ca/97-Proceed/Oien.htm

Weather

Weather — especially temperature & humidity — plays a crucial role in insect and disease development. A modern feature of IPM is the use of weather monitoring to predict periods of heavy infestation. The following weather sites on the Internet specialize in agricultural data; in most instances these sites focus on IPM at the regional level.
Here you can find data on degree days to predict insect emergence, frost prediction, and pest specific data such as blight forecasts (onions, tomatoes, potatoes); maggot emergence (onions); European corn borer forecasts and trap catches (sweet corn); phenology; etc.

Information Services

Agricultural Weather.com
http://www.agriculturalweather.com

Agricultural Weather Information Service (AWIS)
http://www.awis.com

The Arizona Meteorological Network (AZMET)
http://Ag.Arizona.Edu/azmet/

DTN Kavouras Weather Services
http://www.dtn.com/weather/

NEWA, The Northeast Weather Association
http://www.nysaes.cornell.edu/ipmnet/ny/program_news/newa/newa99.html

Oklahoma Mesonet
http://okmesonet.ocs.ou.edu/body.html

PAWS Weather Data (Pennsylvania)
http://frost.prosser.wsu.edu

SkyBit, Agricultural Weather Information Service
http://www.skybit.com

Texas A&M Meteorology
http://www.met.tamu.edu/personnel/students/weather/current.html

WeatherSites: Jump Site from University of Michigan
http://cirrus.sprl.umich.edu/wxnet/servers.html

WI–MN Cooperative Extension Agricultural Weather
http://bob.soils.wisc.edu/wimnext/

UK Agricultural Weather Center
University of Kentucky
http://wwwagwx.ca.uky.edu/
http://wwwagwx.ca.uky.edu/Agwx.html

Pest Forecasters

California PestCast: Disease Model Database
http://www.ipm.ucdavis.edu/DISEASE/DATABASE/diseasemodeldatabase.html

Cucurbit Downy Mildew Forecasts
North Carolina State University
http://www.ces.ncsu.edu/depts/pp/cucurbit/

IPM Weather Data and Degree-Days: For Pest Management Decision Making in the Pacific Northwest
http://www.orst.edu/Dept/IPPC/wea/

Leaf Wetness Observations
University of Florida http://www.imok.ufl.edu/weather/archives/2000/Leaf%20Wetness/leafwetness2000.htm

MELCAST
http://www.hort.purdue.edu/hort/ext/veg/melcast.html

TOMCAST
http://www.ag.ohio-state.edu/%7Evegnet/tomcats/tomfrm.htm

The Vegetable Crops Planner—Weather
Ohio State University
http://www.ag.ohio-state.edu/~vegnet/planner.htm

Weather Data / Precipitation Totals
Connecticut Agricultural Experiment Station
http://www.state.ct.us/caes/Weather/wxdata.htm

IPM Certification and Labeling

IPM guidelines, or best management practices, have been established by several state and private organizations. IPM guidelines are being used: (1) As a checklist for farmers to evaluate their on-farm pest management programs and identify areas where management can be improved; (2) To verify and document that IPM is practiced on the farm; and (3) As an educational tool that describes the scope and complexity of IPM to farmers, government officials, community groups, and the general public.

In addition to pest management education, IPM labeling has emerged as a green marketing strategy parallel to organic food channels.

Some food processing companies—for example Wegman's in the Northeastern U.S.—now display an IPM logo on canned or frozen vegetable labels, with accompanying text that touts the environmental benefits of IPM.

The IPM Institute of North America
http://www.ipminstitute.org/links.htm
This site has information about IPM labeling ("ecolabeling") programs around the country, standards, certification and links to many organizations sponsoring ecolabeling programs with IPM components. Also has information about IPM in schools.

Massachusetts IPM Guidelines: Commodity Specific Definitions
http://www.umass.edu/umext/programs/agro/ipm/ipm_guidelines/
The Massachusetts IPM Guidelines have been used to verify IPM use by the USDA Farm Service Agency in Massachusetts since 1990, and by the Partners with Nature IPM certification program since 1993. For certification in the Partners with Nature program, a crop must be grown using a minimum of 70% of the Adjusted Total Practice Points. Qualified growers are licensed to use the Partners with Nature logo and are provided with marketing assistance including posters, leaflets, brochures and documentation of their certification.

Elements of New York State IPM
Cornell University
http://www.nysaes.cornell.edu/ipmnet/ny/vegetables/elements/index.html
New York state growers can market vegetables under the Cornell IPM logo if they follow these IPM guidelines and meet at least 80% of the recommended practices.

The Food Alliance
http://www.thefoodalliance.org
The Food Alliance is a non-profit organization in the Pacific Northwest that offers a brand label to farms transitioning to sustainable agriculture. Farms that bear the Food Alliance label meet or exceed standards in three areas: (1) Conserving soil and water; (2) Pest and disease management; and (3) Human resources.

CORE Values Northeast
http://www.corevalues.org/cvn/consumers/olabel.html
CORE Values is a northeastern apple label based on biointensive growing methods.

Bibliography of IPM Certification, Labeling and Marketing
http://www.ipminstitute.org/ipm_bibliography.htm
An online bibliography listing over 70 in-print and online articles associated with the topic of IPM certification,labeling, and marketing.

Eco-Spuds: Prince Edward Island Farmers Work with WWF to Reduce Pesticide Use
Spudman Magazine
http://www.spudman.com/pages/issue00vol6_eco_spuds.html

IPM Databases & Search Engines

IPM is knowledge intensive, so easy access to IPM materials and information is a big help. The Internet has turned into a premier source of information on IPM. Here, dozens of university programs and IPM specialists make their materials available online, for free.

A few websites are designed to organize all this information and make it available through databases and directories. Powerful *search engines* allow visitors to find information by typing in *keywords*.

Database of IPM Resources (DIR)
http://www.ipmnet.org/DIR/
http://www.ippc.orst.edu/cicp/Index.htm
Database of IPM Resources (DIR) is an information retrieval system that searches through a compendium of directories containing IPM information resources on the Internet. This site has hundreds of links to other IPM-related sites as well as a powerful search engine with which one can search by keyword. Various resource pages are arranged by a useful variety of topic areas.

Database of IPM Resources (DIR): Internet Resources on Vegetable Pest Management
http://www.ippc.orst.edu/cicp/Vegetable/veg.htm
Internet Resources on Vegetable Pest Management is a sub-category of DIR that provides links to materials on insect and disease problems associated with vegetable production. A great starting point!

Database of IPM Resources (DIR): Internet Resources on Potato IPM
http://www.ippc.orst.edu/cicp/crops/potato.htm

Database of IPM Resources (DIR): Internet IPM Resources on Tomato
http://www.ippc.orst.edu/cicp/crops/tomato.htm

IPMlit —The Database of Current IPM Literature
http://ippc.orst.edu/IPMlit/index.html
An online searchable database that focuses on current research and technical papers focused on Integrated Pest Management (IPM) and related topics. Titles are selected from a wide array of technical and professional journals. IPMlit broadly groups listed papers by pest or tactic categories, e.g., Biocontrol, Entomology, Nematology, Plant Pathology, Vertebrate Management, and General.

National IPM Network
http://www.reeusda.gov/nipmn/
National IPM Network, which has IPM documents, decision aids, farmland-use-planning software and other interesting crop production information (weather, crop prices, futures, etc). A search engine allows searches by commodity, pest, state/region, and tactics. The system includes graphics and hyperlinks to most of the IPM information currently on the World Wide Web, including literature from Virginia Polytechnic Institute, Purdue University, University of Colorado, Cornell University, Michigan State University, University of Florida, USDA, and many more. For more information, contact Ron Stinner, NIPMN Steering Committee Chairman at <cipm@ncsu.edu>.

National IPM Network Search Engine (North Central Region)
http://www.ipm.iastate.edu/ipm/ncrsearch/
A search engine for IPM materials published by land grant institutions of the North Central Region.

Canadian IPM Information System (IPMIS)
IPM Information System (IPMIS) is an electronic library of IPM information. It is now available to the public on the Internet. IPMIS contains information on pest management with particular emphasis on British Columbia. The focus is primarily on IPM and least-toxic and alternative pesticides. Under continuing development by the Pesticide Management Section of BC Environment, the project is supported by funding from the Canada-British Columbia Green Plan for Agriculture, Environment Canada and Agriculture and Agri-foods Canada. The IPMIS database is available through Free-nets or other service providers carrying access to British Columbia World Wide Web servers. Access to the database is also available through the use of Mosaic for SLIP, PPP or other TCP/IP connections at:
http://www.env.gov.bc.ca/

This Appendix was compiled by NCAT Agriculture Specialist Steve Diver. It is adapted from his *Sustainable Vegetable Production Resource List.*

The electronic version of **Biointensive Integrated Pest Management** is located at:
HTML
http://www.attra.ncat.org/attra-pub/ipm.html
PDF
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by Rex Dufour
NCAT Agriculture Specialist
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