Integrated Pest Management (IPM)

Integrated pest management is a unified program of multiple strategies used to avoid economic damage to crops and to minimize environmental disturbance. IPM includes cultural and mechanical practices to prevent pest outbreaks from developing; biological control to encourage the pest's natural enemies to survive and attack the pests; and chemical control, which is usually used when cultural and biological controls are inadequate and a crop needs to be rescued from a damaging pest population. During the years from the mid-1940s to the mid-1970s, chemical control of pests was widely used on most commercial crops in the United States, often to the exclusion of other methods. Due to increasing incidence of some pests developing resistance to pesticides and to concerns about pesticides contributing to environmental contamination, there has been a trend since the mid-1970s towards using pesticides more judiciously and taking a more multi-tactic or integrated approach to pest management. Although the term 'pest' means 'insects' to many people, in IPM the term 'pest' is usually used in a broader sense that includes disease-causing microorganisms and weeds as well as certain insects, mites, birds, and mammals.

For some commercial crops in some regions of the world, a comprehensive IPM program has been worked out and simple instructions are available to growers who want to follow an IPM program. In these cases, the only knowledge required of the grower is how to identify the important pests and natural enemies in the system, and how to follow the recommended procedures for preventive cultural practices, monitoring, and control decisions.

For other commercial crops or in other regions of the world, no guidelines are yet available for a comprehensive IPM program. This does not mean that a grower cannot attempt to manage a crop with an IPM approach, but it means that the grower may have to learn more about the habits and life cycle of all pests and natural enemies found in a crop, and be willing to experiment with various thresholds and control measures in order to develop an appropriate management strategy.

In the case of small fruit, some very good information has been generated in the Northeast on certain components of the IPM system. An excellent source of comprehensive IPM guidelines for strawberries, blueberries, summer raspberries, and grapes is the publication Massachusetts Integrated Pest Management Guidelines: Commodity Specific Definitions. C.S. Hollingsworth and W.M. Coli (eds). Univ. Mass. Ext. Bull. IP-IPMA. 66 pp. This publication can be obtained from the UMass Extension Bookstore by calling (413)545-2717.

Monitoring Pests and Making Control Decisions

From:1999 Midwest Small Fruit Pest Management Handbook, Bulletin 861

Action thresholds: Many crops can tolerate a certain amount of pest damage. Some pests cause economic damage only when they occur in large numbers (for example, spider mites and aphids), while others are considered serious even at very low levels (for example, strawberry clipper and plum curculio). A rescue treatment is not needed until the pest population reaches a critical density usually referred to as a threshold or an action threshold. A threshold is the density of pests that signals the need for control if economic damage is to be avoided. Thresholds for different pests may vary greatly and may be expressed as a number of pests per leaf or per plant, or as a percentage of leaves infested.

One goal in the development of IPM programs is to have an appropriate action threshold for each pest. For example, spider mite control on strawberries is suggested if the percentage of mite-infested leaflets is 25% or greater in a random sample of 60 leaflets. Grape berry moth control is suggested on grapes if the average percentage of infested clusters is 5% or greater in a sample of 100 clusters from the interior of a vineyard and a sample of 100 clusters from the edge of a vineyard. Tarnished plant bug control in brambles is suggested if there is at least 0.5 plant bug per cluster in a sample of 50 clusters.

Monitoring overview: One basic principle of pest management is that you do not take action against a pest unless you are certain the pest is present and is a threat to your crop. Growers who practice IPM as part of their fruit production operation need to know how to monitor pests, because pest control decisions are based on knowledge of which pests are present in their plantings, how many of each are present, and when they are present, as well as how many are economically tolerable.

Two common types of pest monitoring methods are *scouting* and *trapping*. Scouting and trapping each have their merits. Scouting may be somewhat time consuming but can provide accurate information on the presence of the pest in its damaging life stage. Trapping is more easily done, but because it is often done to monitor the adult stage of pests that cause damage in the larval stage, the results may not be directly applicable to making a control decision for the larval form. Both methods should be used, where appropriate, to provide information on which pest control decisions can be based. Another monitoring method that is more predictive of when pests are likely to appear is based on weather monitoring. Development of several fungal diseases can be predicted by monitoring temperature, leaf wetness, and rainfall. Activity of some insects can be predicted by monitoring temperatures and calculating degree-days.

Scouting: Scouting means walking through the planting and looking for pests or symptoms of their presence. The purpose of scouting is to evaluate the effectiveness of preventive measures and the possible need for a rescue treatment. Scouting is done by examining a representative sample of each crop to determine the average infestation or infection level. Infestation may be expressed as presence or absence of pests on each sample, or as the number of pests on each sample, or as the percentage of plant parts damaged. The number of plants or plant parts to examine can vary according to the crop, size of the planting, and time of the year.

For some crops and pests, *very specific* scouting procedures have been developed so that a minimum number of leaves or fruit need to be examined in order to confidently make a decision about the need for applying a control measure. For other crops or pests, specific scouting procedures have not yet been worked out, and a general scouting plan can be followed, such as examining 25 whole plants per field. Under a *general* scouting plan, fruit plantings should be scouted on a regular basis, generally once per week. When examining plants, it is important to look at them closely in order to see small egg masses or small larvae that may be present before damage is evident. In a general scouting plan, all parts of the plant should be examined, even if they are not parts that will be harvested. Pests may be found on the underside of leaves, on top of leaves, on stems, in stems, in buds, on or in developing fruit, or in the crown. A prerequisite to scouting is knowing how to recognize the pests that can attack the crop.

Insect trapping: Traps that have the ability to catch insects are useful in some cases as a mechanical control method and in other cases as monitoring tools. Insect traps are a good method of determining if an insect species is present, and they can also give an estimate of the insect's concentration and distribution. Insects can be attracted to traps by visual appearance or by odor. *Visual* traps use light, color and/or shape to attract certain insects. *Odor* traps attract certain insects by using scents associated with food or mates. Another form of trap more often used in gardens than on commercial farms are *shelter* traps, such as shingles or boards placed on the ground to attract pests such as slugs that can then be collected and killed mechanically.

Food attractant traps: Traps based on the scent of a food source are now commercially available for rose chafer and Japanese beetle. Although these are most often used as mechanical control devices, they can also be used for monitoring purposes. A well-known bag trap for Japanese beetles uses a food attractant scent to lure both male and female beetles into the trap. This trap is so effective at attracting beetles that it can actually increase the number of beetles in the vicinity of the trap. Despite the sometimes bad reputation the Japanese beetle trap has earned because of its super-attractiveness, the trap still can be effectively used if it is placed at some distance away from the fruit planting to be protected.

Colored sticky traps: The adult form of blueberry maggot is a true fruit fly that is attracted to yellow and to the scent of ammonium. Traps commercially available for monitoring blueberry maggot flies are yellow cardboard or plastic cards coated with a sticky material, which come with an ammonium bait included in the sticky material. The bait is effective for about one week. Small capsules of ammonium bait can also be purchased separately to prolong the attractive life of a trap. Another example is white sticky traps that are sold for monitoring the tarnished plant bug. An alternative to sticky traps is colored bowls filled with soapy water.

Pheromone traps: The most common type of trap used for monitoring certain pests in recent years is the pheromone trap. Pheromones are natural scents produced by insects for purposes such as attracting mates. The main advantage of pheromones is that they are specific to individual pest species; for example, the pheromone for grape berry moth attracts only grape berry moth and not the redbanded leafroller or other related moths. Man-made imitations of pheromones are commercially available as lures that can be placed in traps. Most commercial pheromones are imitations of secretions from unfertilized adult female insects, which are used to attract male insects of the same species. Most commercial pheromones are used to monitor various species of moths. Some of the fruit pests that can be monitored with pheromone traps are the grape berry moth, red-banded leafroller, grape root borer, Sparganothis fruitworm, variegated cutworm, and black cutworm.

Traps used with pheromone lures come in a variety of styles and materials; one of the most common types is called a wing trap. A *wing trap* is made of plastic or cardboard top and a sticky cardboard bottom held together by a wire hanger; the pheromone lure can be placed in the middle of the sticky bottom or glued to the trap top. Another style is a *bucket trap* such as a Unitrap or Multi-Pher trap. Bucket traps have a funnel entry system for keeping the pest from escaping, and do not require a sticky coating; the lure is placed near the top of the funnel. The traps can be hung from a vine or be mounted on fence posts. In either sticky wing traps or bucket traps, the pheromone lures need to be replaced periodically, usually every four weeks or as recommended by the manufacturer. Although it is convenient to buy traps ready-made, homemade traps can also be used, with materials such as cardboard milk cartons as a base and Tanglefoot as an adhesive; Tanglefoot is a sticky material available at many garden supply shops.

While it is the larval stage that often causes the damage, traps catch many pests when they are in the moth (adult) stage of their life cycle because only adult males are attracted by the odor of the pheromone. The moths lay eggs that develop into larvae that feed on crops. To complete their life cycle, the larvae pupate, then change to moths that in turn lay more eggs thus producing more larvae. By knowing when the moth stage of a pest is present, using traps, the grower can be on the lookout for damaging larvae that are likely to follow. The appearance of the first moth can also be used as a starting point for calculating the number of degree days before the emergence of the larvae, if such information is available for a specific pest. This information can help the grower determine the best time to spray for insect control. Some of the insects that follow this pattern of development in apples are the codling moth and San Jose scale; initial catches of either of these in their respective traps determine the timing and/or need of insecticide treatments against these pests. Similar management guidelines may be developed in the future for pests of small fruit crops.

Insect pheromone trapping guidelines:

- Use a minimum of two traps for each pest species in representative locations.
- Examine traps at least twice per week.
- Count and record the number of captured insects in each trap. Remove the captured insects during each visit with a wire or twig, wipe them on a rag or paper towel, and dispose of them away from the field.
- Record trap catches on each date in an IPM scouting log. It can help to keep a running graph of the information.
- Sticky panels (the bottom half of wing traps), should be changed regularly to maintain trap effectiveness; replace the panel each month or when covered with debris. Replace the complete trap if drooping or broken.
- Change pheromone lures (baits) every 4 weeks or according to the manufacturer's directions. DO NOT dispose of used pheromone lures in the fruit planting; these would compete with traps and cause lower trap catch numbers. It is useful to establish a pattern when changing lures, such as the first week of every month.
- Store replacement lures in a freezer or refrigerator. It is best to purchase only a one-year supply at a time, but lures can be stored from one season to the next in the freezer. On each package, write the date the lures were purchased and placed in the freezer so that you can use the oldest ones first.
- If you are trapping for more than one species, change gloves or wash your hands when handling pheromones for different species of insects to prevent cross contamination. Minute traces of one pheromone on another can render the second repellent completely ineffective to its target pest.
- If you are trapping for more than one species, be sure to label each trap with the target pest name and be sure to place the correct pheromone lure into the correct trap.

Sources of traps and lures, weather and other monitoring supplies are listed at the end of this guide.

Weather monitoring. The optimum weather conditions for development of some diseases can be monitored to determine the optimal time to control the disease with pesticides. Temperature, leaf wetness, rainfall, and other weather factors can be measured either manually or by a computer. Weather data obtained then can be plugged into equations or computer programs for disease development to determine management actions. An example is management of powdery mildew on grapes, for which a computer forecasting program is available.

Insect development & degree days. While scouting and trapping can give information about which pests are present at a given time, another monitoring tool of a more predictive nature is temperature-based development models. Temperature plays a major role in determining the rate at which insects develop. Each insect has a temperature range at which it is the most comfortable. Below that temperature range they will not develop, and above that temperature range development will slow drastically or stop. Each insect also has an optimum temperature at which it will develop at its fastest rate. By using this relationship, you can make predictions on the rate of development of insects. By being able to predict when an insect will appear, you can estimate when your crop is most likely to be damaged and when to intervene to prevent damage from occurring.

A method of estimating development time is called the degree day method. The *degree day* method can be used to predict when insects will reach a particular stage of their life cycle, if you know three things: the *threshold* temperature, the average daily temperature, and a thermal constant. Each insect species has a threshold temperature. Below this temperature no development of the insect occurs. The *threshold* temperature is 50 degrees F for many insect species or 43 degrees F for other species. A degree day is the number of degrees above the threshold temperature over a one day (24-hour) period. For example, if the threshold temperature of an insect is 50 degrees F and the average temperature for the day is 70 degrees F, then 20 degree days would have accumulated on this day (70 - 50 = 20).

The accumulation of degree days can be used to predict when insects will hatch, pupate and emerge as adults. By using accumulated degree days, a farmer can estimate when a pest should appear in his crop, then scout for the pest and determine if treatment is needed. However, for degree days to be used to make these predictions, researchers must have determined the number of degree days necessary for the event to occur. That is called the *thermal constant.* The *thermal constant*, just like the threshold temperature, will be different for different insects and for different events in the life cycle.

The easiest way to calculate degree days for a date is to subtract the threshold temperature from the average daily temperature. The average daily temperature can be determined by simply averaging the high temperature and low temperature for the date [(maximum temp + minimum temp)/2]. For example, if the high temperature for the day was 90 degrees F and the low was 60 degrees F, then the average temperature for the day would be [(90 + 60)/2 = 150/2 = 75]. If the threshold temperature for an insect were 50 degrees F, the degree days accumulated on this day would be 25 because 75 - 50 = 25.

Temperature extremes add variables to this simple method of calculating degree days. To overcome these and to more accurately predict when insects will be present, follow the following rules.

1. If the maximum temperature for a 24-hour period is not greater than the threshold temperature, no degree days are accumulated. For example: maximum daytime temperature = 45 degrees F
   threshold temperature = 50 degrees F
2. If the high temperature for the day is greater than the threshold temperature but the low temperature for the day is less than the threshold temperature, then when calculating the average temperature for the day the threshold temperature is used as the low temperature for that day. For example: maximum daytime temperature = 65 degrees F
   low daytime temperature = 45 degrees F
   threshold temperature = 50 degrees F
   The threshold temperature of 50 degrees F would be used as the low day-time temperature when calculating the average daily temperature.
3. If the high temperature for the day is greater than the optimum temperature, the temperature at which the insect will develop at the fastest rate, then you use the optimum temperature as the high temperature for the day when calculating the average temperature for the day. For example: maximum daytime temperature = 98 degrees F optimum temperature = 95 degrees F

The optimum temperature of 95 degrees F would be used as the high temperature for the day when calculating the average temperature for that day.

Biologicals

There are a number of natural products and biological control agents that can be used to manage insect pests of small fruit. Biological pesticides (bio-rational pesticides) are formulated products that use toxins produced by plants (such as rotenone, pyrethrum, sabadilla, ryania, and azadirachtin), or by microorganisms (bacteria, fungi, and viruses). **Rotenone** is extracted from the roots of leguminous plants in the genera Derris spp. (Far East), or Lonchocarpus spp. (Amazon basin, South America). Indigenous people use crude extracts that contain rotenone to kill fish in streams and lakes for harvest, so be careful when using this material around fish bearing waters. *Pyrethrum* is extracted from the flowers of *Chrysanthemum coccineum* and *C. carneum*. The primary source of pyrethrum today is Kenya. Pyrethrum is a complex of chemicals that attack the peripheral nervous system, and for this reason it is quick acting. *Sabadilla* is extracted from the seeds of the lily-like Schoenocaulon officinale plant from Venezuela. The principal ingredients of sabadilla are two alkaloids, cevadine and veratridine. **Ryania** is extracted from ground stemwood of Ryania speciosa. These botanical insecticides have broad-spectral activity, and are harmful to insect pests and their natural enemies, while azadirachtin is toxic to insect pests and relatively nontoxic to biological control agents. **Azadirachtin** is one of a complex of chemicals (over 20 active ingredients) extracted from the foliage and seeds of the neem tree (*Azadirachta indica*).

There are different strains of ***Bacillus thuringiensis*** that produce different Cry toxins. These toxins must be ingested to be effective, and are most effective against small larvae, and for this reason timing of applications is critical. Toxins from B.t. aizawai (Cry 1C) and B.t. kurstaki (Cry 1Aa, 1Ab, & 1Ac) are toxic to Lepidoptera larvae (caterpillars), while the B.t. tenebrionis (Cry 3A) toxin is specific to Colorado potato beetle larvae, and a few other leaf feeding beetles that attack trees. Formulated products may contain toxins from one or more strains of Bt. There are other products derived from toxins produced by microorganisms.

Spinosyns are a naturally derived group of chemicals produced by an Actinomycete fungus, Saccharopolyspora spinosa, and formulated as **SpinTor**. This product is very effective against a wide range of insect pests, yet relatively harmless to natural enemies. Avermectin B1a (80%) and B1b (20%) are formulated as **Agri-Mek**. The avermectins are derived from another Actinomycete fungus, Streptomyces avermitilis. Agri-Mek is very effective against spider mites, and relatively harmless against natural enemies.

Several bio-rational products have been developed by reacting oleic acid with potassium hydroxide to produce potassium oleate, or soap. Potassium oleate used to be available as “Castile Soap.” This soap was made from olive oil, while the insecticidal soaps are made from oleic acid extracted from animal fat. The insecticide product is **Safer’s Soap**, and the herbicide is **Scythe**.

Natural Enemies and Predators

There are a wide range of insect natural enemies, such as other insects, nematodes, fungi, and viruses that can be used to control insect pests of small fruits. Many of these biological control agents are mass-produced and available for purchase. The cost-effectiveness of using biological control agents varies significantly from one situation to another. Often, inundative releases of purchased organisms are quite expensive and may not “pay-off” if another alternative is available. It is best to take advantage of existing populations of natural enemies and to engage in practices that protect these agents. To this end, it is important to use “soft insecticides,” i.e. insecticides that are toxic to the target pest, but relatively nontoxic to natural enemies, or to use other practices that disrupt the pest’s biology, such

Warning! Pesticides are poisonous. Read and follow all directions and safety precautions on labels. Handle carefully and store in original labeled containers out of reach of children, pets and livestock. Dispose of empty containers immediately in a safe manner and place. Contact your state Department of Agriculture for current regulations.

as crop rotation, delayed planting, early harvest, etc. However, if a release of a commercially reared natural enemy, predator, parasite, or competitive agent is desired, contact your local Extension Specialist for recommended sources.

Pesticide Safety and Use

All pesticides listed in this publication are registered and cleared for suggested uses according to federal and state regulations in effect on the date of this publication. Follow the current label.

Trade names are used for identification only; no product endorsement is implied, nor is discrimination intended against similar materials.

Label Formulations

The recommendations within this publication list only one formulation of a given pesticide. Growers should be aware of other formulations. The rates to be applied are on the product label.

Before Using Pesticides

Read and post safety rules and list of poison control centers. See instructions on safe storage of pesticides on page 22. You should become familiar with the information on storage and toxicity of pesticides listed in the appendix of this guide. Similar pesticide products may not have the same crop uses. Always be certain the crop is listed on the product label before ordering or using the product.

DO NOT use concentrations greater than stated on the label. DO NOT apply more pesticide per acre or more frequently than the fewest number of days between applications recommended by the label.

Instruct your family, co-workers and farm laborers on the safe use of pesticides, protective clothing and reentry regulations concerning pesticides. See farm worker protection standards on page 20.

DO NOT spray or dust when bees are active in the field. Morning or late evening is usually the best time to spray.

Precautions

- Read and follow all directions and safety precautions on labels.
- Store pesticides in original containers, out of reach of children, pets and livestock.
- Dispose of empty containers immediately in a safe manner and place. Triple rinse.
- DO NOT contaminate forage, watersheds or water sources.
- Become familiar with life cycles of pests to properly time applications.
- Keep a complete diary of applications: crop, date of planting, pests, weather conditions, materials, date of application and amounts applied.
- Adhere to farm worker protection standards.

Poison Control Centers for the New England states are listed on the back cover. **For an emergency, EPA maintains a 24-hour medical consultation service in case of pesticide poisoning: 1-800-424-8802.** DO NOT use this number on a regular basis; use it only in an emergency! It is set up primarily for consultation with physicians and other health professionals needing assistance in the treatment of pesticide poisonings.

Reentry Period

Be sure all treated areas are posted to keep out unauthorized persons.

Persons must not be allowed to enter the treated area until after sprays have dried or dusts have settled and until sufficient time has passed to insure that there is no danger of excessive exposure. Follow label reentry restrictions. At no time during the reentry period are farm workers allowed to enter the treated area to engage in activity requiring substantial contact with the treated crop. Protective clothing and safety equipment may be needed for all persons, including farm workers, entering the treated areas.

Information About Pesticides

A pesticide is referred to: (1) by a common name or (2) by a trade or brand name (trade names are capitalized in this guide).

Labeled Formulations: The recommendations within this publication usually list only one formulation. Growers should be aware of other formulations. The rates to be applied are on the label.

Note: There may be several products registered with the same active ingredient. Each label is different, and some crops may be listed on some