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Integrated Pest Management

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Management of pests and diseases can be challenging for Florida growers, even under optimum conditions, given the diversity of pest problems in our state and a generally favorable environment for their growth and development.

Integrated Pest Management (IPM) is a process consisting of the balanced use of cultural, biological, and chemical procedures that are environmentally compatible, economically feasible, and socially acceptable to reduce pest populations to tolerable levels while maximizing productivity in a way that is ecologically sound and safe.

IPM is based on taking preventive measures to avoid or solve a pest problem. Often, but not always, it means limiting the use of broad-spectrum pesticides

General IPM principles include regular scouting or monitoring for problems, identifying pests and their life stages, keeping good records of pest management practices, using exclusion techniques, practicing good sanitation, testing soil or plants for nutrients, using biological controls when possible, and using selective pesticides, properly timed and applied.

Goals of This Chapter

- •Be able to define integrated pest management.
- •Understand the benefits and components of integrated pest management.
- •Learn about various non-chemical pest management strategies.
- •Learn what is meant by the term economic threshold.
- •Understand the role of monitoring and assessment in an IPM program.

Pests are unwanted organisms that are a nuisance to man or domestic animals, and can cause injury to humans, animals, plants, structures, and possessions.

Management is the process of making decisions in a systematic way to keep pests from reaching intolerable levels. Small populations of pests can often be tolerated; total eradication is generally not necessary and is often impractical or impossible to achieve.

IPM implies management of all crop pests, including insects, mites, diseases, nematodes, and weeds.

There are several good reasons for adopting an integrated approach to pest management even though it may seem that chemical pesticides provide an adequate level of pest control.

- Ecological benefits. Every ecosystem including agricultural cropping systems are made up of living things and their non-living environment in some sort of balance and the actions of one creature in the ecosystem usually affect other, different organisms. The introduction of chemicals into the ecosystem can change this balance, destroying certain species and allowing other species (sometimes pests themselves) to dominate.
- Beneficial insects such as the ladybird beetle and lacewing larvae, both of which consume pests, can be killed by pesticides, leaving few natural mechanisms of pest control.
- Pesticides may be ineffective. Chemical pesticides are not always effective. Pests can become resistant to pesticides. In fact, approximately 600 cases of pests developing pesticide resistance have been documented to date in the US, including a variety of insects, weeds and diseases. In addition, pests may survive chemical applications in situations where the chemical does not reach pests, is washed off, is applied at an improper rate, or is applied at an improper life stage of the pest.
- IPM Is not difficult and involves a number of common sense approaches such as accurately identifying the pest, determining the extent of the damage, and making a decision on the appropriate action to take. An IPM approach provides a producer with a variety of additional management tools beyond just chemical pesticides.'
- IPM can save money through avoiding crop loss (due to pests), and avoiding unnecessary pesticide expense. For example, onion growers who followed IPM recommendations in 1987 saved more than $23 an acre in insecticide costs. Applicators are able to save on sprays because the calendar is not the basis for spraying; the need is.
- Promote a Healthy Environment. Fewer pesticides means less risk to surface water and groundwater, and less hazard to wildlife and humans.

- Public Image. Recent public attention on the presence of pesticide residues on produce has heightened pesticide applicator awareness of the level of public concern about chemicals. Consumers are pressuring food stores, which in turn are pressuring producers, for produce that has been grown with as few pesticides as possible. Growing food using integrated pest management can help alleviate public concerns and may provide a marketing advantage.

The Basic Steps of IPM

All of the components of an IPM approach can be grouped into four major steps. The first step is taking preventative measures to prevent pest buildup, the second is monitoring, the third step is assessing the pest situation, and the fourth is determining the best action to take.

A number of general IPM principles and tactics apply to the control pest and diseases. These include regular scouting or monitoring for problems, identifying pests and their life stages, keeping good records of pest management practices, using exclusion techniques, practicing good sanitation, testing soil or plants for nutrients, using biological controls when possible, and using selective pesticides, properly timed and applied.

Crop Scouting and Monitoring

In order to detect pests and diseases and the damage they cause before a problem becomes serious, it is essential that growers visually inspect plants at once or twice a week. The process of monitoring and inspecting plants for pest and disease presence is often referred to as crop scouting.

Monitoring or scouting involves:

- regularly checking fields;
- early detection of pests;
- proper identification of pests; as well as
- identification of the effects of biological control agents.

As a first step, growers should observe the overall plant, looking for abnormalities, holes and other damage caused by chewing insects, spots, rots or lesions resulting from diseases, distorted growth, and fruit damage.

Plants should be carefully inspected from ground or stem level up to the growing tip. Growers must become proficient at quickly examining the entire plant and recognizing the presence of pests and diseases. Workers engaged in cultural practices should also be trained to recognize problems and alert management.

Both the upper and lower leaf surfaces must be thoroughly inspected. Many insects, as well as some diseases, begin their infestation or infection from the lower side of the leaf. Many insects and mites only feed on the underside of the leaf and may never move to the upper leaf surface or other plant parts until populations become so great that overcrowding forces movement.

Attention should be given to the midrib area under the leaf and along large, lateral, lower leaf veins. The leaf axils, growing tips, and terminal buds should be also carefully inspected.

Weeds often serve as hosts for insects, mites, and diseases that can move to vegetable crops and should be removed.

Some insects, particularly thrips, will be found within the blossoms, so these inspected as well. Tap the blossoms over a white pan or card to see these tiny insects. The area under the calyx or stem end of tomatoes and cucumbers can also be an attractive hiding place for insects such as thrips and mites.

Yellow sticky traps are useful for monitoring the adult (flying) stages of many insects. Traps are usually placed vertically at or just above the plant canopy.

Traps should be inspected weekly and replaced regularly. A system of numbered traps can facilitate sampling and simplify record keeping. Yellow sticky traps are available from many online distributors.

Many of the arthropod pests that infest vegetable crops are very small. Mites are 1/50–1/60 of an inch long. Thrips, aphids, whitefly crawlers, and the eggs of other harmful insects are not much larger.

Growers should have at least a 10x hand lens but a 16x–20x is preferred.

With a good hand lens, a grower can quickly identify many of the arthropod pests and some fungal structures that are otherwise difficult to see. If at all possible, growers should buy and learn to use a common dissecting microscope. They have approximately 10x–200x magnification. With a microscope, a grower can see small mites, such as broad mites, and disease lesions clearly. This tool can be very helpful in detecting and diagnosing problems early.

Identification of Pest and Diseases

Proper identification of insects and mites and the damage they cause is absolutely critical. If the grower knows exactly which pests are present, proper chemical or biological controls can be selected and steps taken to exclude or limit further introductions.

In addition to correct identification, growers should have a working knowledge of the biology of the pest or disease so that insecticide, fungicide or miticide application can be aimed at the weakest, most vulnerable stage or size. Since most fungicides are protectant in nature they must be applied before the infection occurs.

Some stages of insects and mites, such as the egg stage, can seldom be controlled. Young larval or nymphal stages are more easily controlled and require less insecticide or miticide than older stages. Pesticides generally do not affect pupae (large larvae nearing this stage are also difficult to control).

Likewise, proper management of any plant disease must begin with an accurate identification of the pathogen or pest causing the problem. There are many different types of pathogens (i.e. fungi, bacteria, viruses and nematodes) involved in diseases of vegetable crops, which can require very different management strategies.

It is also important that growers and scouts be able to recognize beneficial insects, if they are present pests may be kept in check naturally and growers should avoid any management practice such as application of broad spectrum insecticides that may upset the balance between beneficial and pest insects.

In order to assess which management strategy is most appropriate, you must have information about the pathogen present in a field. This information can be gained by either assessing the crop yourself and/or with the aid of a professional.

There are many guides and applications available for disease identification; however, proper identification often requires submission of samples to a lab where the use of a microscope to identify key structures or more complex tests (e.g. DNA/RNA-based and serological tests) may be employed. The University of Florida maintains a number of Plant Diagnostic Clinics in Gainesville and around the state at UF/IFAS Research and Education Centers which are available to help growers diagnose problems. For more information on how to submit samples, go to **http://plantpath.ifas.ufl.edu/extension/plant-diagnostic-center/**

There are many printed and electronic (e.g. EDIS; University of Florida - **http://edis.ifas.ufl.edu**) resources available for disease identification, but if a producer is unsure about how to identify a disease they should contact their local extension office or nearest University of Florida Plant Disease Clinic for help.

In Florida, Cooperative Extension Service offices in each county are able to help with pest identification. To find your local Extension Office, visit **http://solutionsforyourlife.ufl.edu/map/**). UF/IFAS Extension routinely offers classes and workshops on pest scouting and identification, and there are many

publications and online resources available at **http://ipm.ifas.ufl.edu** as well.

Record Keeping

Good records can help growers see trends in pest and disease infestations, keep track of the success or failure of control efforts, and determine how the environment affected the crop.

Pesticide application records are essential. In addition to information on the time and date of application, product name, EPA registration number, active ingredient which is required by law, growers should also record, amount used, the target pest, and notes on effectiveness.

Some things that general records should include are daily minimum and maximum temperatures, rainfall and other weather data, measurements of plant growth and development, irrigation records and any other pertinent information on environmental conditions and cultural activities that may that may have influenced pest and/or disease development.

Assessment

Assessment is the process of determining the potential for pest populations to reach an economic threshold or level at which failure to implement control will result in financial loss. Is a grower likely to suffer financially? Is the pest likely to transmit a disease?

Forecasting can help determine if weather conditions will be favorable for the development of diseases and insect pests.

In some cases, scientists have developed “forecast models” which growers can use to “plug in” values (such as the number of rainy days and the temperatures for those days) allowing them to accurately predict outbreaks and spray only when conditions are favorable for diseases.

Growers who have kept good records of pests in previous years may be able use those records to help determine if problems such as weeds, insects, and diseases will reoccur. They might be able, for example, to apply the most effective herbicides at the proper time for early control of a problem.

Thresholds, or more specifically economic thresholds, are levels that mark the highest point a pest population can reach without risk of economic loss. Populations above these thresholds can reach the economic injury level, where they cause enough damage for the grower to lose money. At the economic injury level, the cost of control is equal to the loss of yield or quality that would result otherwise.

Thresholds for many pests and crops have been scientifically determined. The advantage of thresholds is that if a pest has not reached threshold, there is no risk of economic loss. Therefore, there is no need to spray. Once the pest density (number of pests per unit area) has reached threshold, action is justified. The costs of control will be less than equal to the estimated losses that the pests would cause if left uncontrolled.

IPM Practices

Many IPM practices are used before a pest problem develops to prevent or stall the buildup of pests and diseases.

- Cultural Controls are those that disrupt the environment of the pest. Disking, crop rotation, staking, mulching, drainage, nutrient and irrigation management are all cultural practices that are employed to modify the environment making it more favorable to plant growth and make it less conducive for disease development.

  Highly reflective or metalized plastic mulches have been effectively used in agriculture to repel certain insects such as aphids and whiteflies. Metalized mulches can provide early season protection when used in field production by covering the beds with reflective mulches in a full-bed polyethylene mulch production system.

- Sanitation - Crop residues should be removed immediately after the final harvest. Destruction of crop debris through tillage, herbicide application or the planting of a non-host plant can remove food and habitat for insect pests and/or remove a source of inoculum for diseases which could spread to adjacent crops.

  Likewise, use of certified seed and clean pest and disease free transplants can help avoid introducing a pest or disease into your fields. Plants coming from other locations should be carefully inspected for insects, mites, and diseases to be sure the plants are free of pests.

- Biological Controls – involves the use natural enemies (biological control agents) to keep pests in check can be put into place before pest problems increase. Examples of biological control agents are beneficial predatory mites that feed on spider mites in strawberries and Minute Pirate Bugs *Orius insidiosus*, a small predatory bug that that preys on whiteflies, aphids, thrips and other small soft bodied insect pests.

  One of the oldest and most widely used insecticides is Bt or *Bacillus thurengensis* which produces insecticidal cry-toxins that are specific to certain insects such as the immature larvae of caterpillars of insect species in the order Lepidoptera. Many biological control agents are commercially available.

  Growers can also take advantage of naturally occurring beneficial insect predators and parasitoids maintaining refugia by judiciously selecting insecticides which have a minimal effect on beneficial populations.

  Biological control, however, requires much more intensive management than using conventional pesticdes and requires a greater knowledge of pest biology and pest numbers. Many factors contribute to success or failure of biological control: type and quality of the natural enemy selected, release rates, timing, placement, temperature and humidity, and the previous use of insecticides and miticides.

  Suppliers can provide technical advice on the optimum use of their products. Some have detailed websites. In general, releases must be made when or before the pest population is first detected. High pest populations will be difficult to control biologically. Some predators and parasitoids are better adapted to particular temperature and humidity conditions than others, and some do better on some crops than others.

- Physical Barriers such as screening over greenhouse vent fans and positive air pressure can prevent crop damage by preventing entry of insects such as thrips and whiteflies into structures.
- Use of Pheromones (naturally occurring scents used to attract a mate) has become widely used in pest management. Sometimes a manufactured “copy” of the pheromone that a female insect emits to attract mates can be used to confuse males and prevent mating. This technique is used in curbing damage in tomato from the tomato pinworm.
- Genetic resistance – plant breeders have been successful in selecting and developing disease-resistant plant lines to produce a number of pest and disease resistant cultivars of a wide range of crops which are less susceptible than other varieties to certain insects and diseases. Use of resistant varieties often means that growers do not need to apply as many pesticides as with susceptible varieties.

  While plant diseases can be controlled by use of pesticides and other practices such as crop rotation, tillage, planting density, disease-free seeds and cleaning of equipment, plant varieties with inherent (genetically determined) disease resistance are generally preferred.

Action

Once a pest has reached the economic threshold, or intolerable level, some action should be taken. In some situations, cultural controls can destroy pests. One example is early harvesting to avoid pest problems, which prevents crop loss and can sometimes be more economical than a pesticide application.

Chemical pesticides are used as a control measure when no other strategies will bring the pest population under the threshold. In fact, the success of waiting until a pest reaches threshold usually hinges on the availability of a pesticide that will bring the pest populations down quickly.

In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, non-target organisms, and the environment.

An IPM program, should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

Insecticides and Miticides

Even when a good biological control program has been established, there may be times when a conventional insecticide or miticide is needed.

Bio-rational insecticides, such as insecticidal soaps, oils, neem products, and Bacillus thuringiensis (Bt) can be much less harmful to beneficial insects, although active against pest species. Systemic insecticides, insect growth regulators, and pheromones used for mating disruption also fall into this category.

Some products are harmful to some stages of some beneficial insects and not others. Oils, for example, are toxic to lacewing eggs and adult parasitoid wasps, but have relatively little effect on adult lady beetles and lacewings.

Soaps on the other hand are toxic to young lady beetle larvae. Neem and Bt products are generally safe for use with natural enemies. Other advantages of biorational insecticides are shorter reentry intervals and safety for workers.

Conventional insecticides and miticides also have a place in IPM, if it is not feasible to use biological controls and/or if biorational insecticides do not offer sufficient control.

The development of resistance to insecticides is more likely if a product is used repeatedly. Therefore, pesticides with different modes of action should be used in a sequence that will help prevent resistance.

Using Pesticides

The following steps are suggested when using any pesticide:

Be sure to choose the right insecticide, fungicide or miticide after correctly identifying the pest or disease. Products that are effective against one pest or disease may be useless against another pests or disease.

Properly identifying the pest or disease and understanding its biology and life cycle allow the grower to make wiser decisions when choosing a pesticide.

Growers should consult local Extension Office, pesticide companies and dealers, published literature, and, ultimately, the pesticide label, for helpful information.

Chemicals with the same mode of action should not be used continuously on the same field in order to avoid development of resistance.

Use the correct amount of pesticide. After choosing the appropriate pesticide, the grower must carefully read the label to determine the correct amount to use. Sometimes this decision will be based on the size or stage of the pest and whether the population is high or low. For example, small caterpillars may be controlled with the lowest recommended label rate, while large ones may require the highest labeled rates for adequate control.

Accurate measurement is essential for efficacy against the target pest, a safe range of pesticide residues on the crop, efficient use of chemicals and money, and the reduction or elimination of phytotoxicity (burning).

Pesticide concentrates are usually handled when the sprayer is loaded and diluted sprays are being prepared. Special handling precautions are necessary at this time. The applicator must be particularly careful in handling finished sprays but even more so in dealing with the more concentrated material.

Workers must be mindful, cautious, and use all pesticides according to the label.

If applicators use too much pesticide, the following problems can result:

- The crop can have more residue than the law allows, which can pose health hazards to consumers and can result in seizure and confiscation by authorities for excessive residues and destroyed without any compensation to the grower.
- Resulting negative publicity can harm the future markets for that commodity.
- Reentry by workers into overdosed areas could be dangerous and lead to illnesses, medical costs, and liability to the grower.
- Production costs could increase without the benefit of added profits.
- Phytotoxicity is more likely to occur.

It is important not to exceed the label rates. If the maximum labeled rate is not achieving the desired results, look for other reasons for failure, such as poor coverage or resistance to the insecticide in the target insect population.

Apply pesticides at the right time. The appropriate pesticide should be applied at the correct time. This is one of the most difficult tasks any grower faces. Determining the best time to apply chemical control is a very dynamic undertaking. Failure to treat in a timely manner is one of the major reasons for unsuccessful pest management outcomes.

It is generally best to apply pesticides in the late afternoon or evening hours when temperatures start to decrease. This also allows for maximum exposure before "airing" out the sprayed area for employees. In addition, many insects are most active at night.

The risk of phytotoxicity is greater when applications are made during the middle of the day when temperatures are high.

Pesticides should not be applied when plants are water stressed.

Apply pesticides correctly. Proper application, like proper timing, is one of the most important steps in pest control efforts. It does little good to follow the suggestions provided above and then fail to deliver the material to the target area. There are many factors and components of spray methods that add up to proper application of pesticides.

Spray equipment must be properly calibrated. A calibration mistake can result in applying too little pesticide and not achieving control, or applying too much, which is wasteful and illegal.

Growers should purchase the proper type of equipment to meet the needs of the operation and use equipment designed for the target pest. A single piece of equipment may not meet all needs.

High-volume sprayers are probably the most widely employed and have been used for years. They can accommodate a wide range of pesticide types and offer flexibility in their operation. However, high-volume sprayers require a great deal of labor, are time consuming to use, and are considered to be low in application efficiency. It has been estimated that less than 10% of the active ingredient reaches the actual target when using high-volume systems.

To reach the bottom and sides of the leaves in thick canopy crops, a driving, directed spray may be required. In some cases, an ultra-low volume sprayer or electrostatic applicator may be more effective.

Another consideration when correctly applying pesticides is the proper maintenance of spray equipment. Many spray operations are hampered and their effectiveness drastically reduced because the spray cannot be delivered at the proper pressure, droplet size, or pattern due to excessive wear, improper adjustment, or broken or improperly working parts.

Growers should regularly check nozzles for wear and tear and replace them when they do not meet specifications. nozzles wear fast when flowables, suspensions, and wettable powder formulations are used.

Workers should be aware of spray pressure and have accurate gauges. Inaccurate pressure—even small errors—can result in improper droplet size and failure to deliver the desired coverage. Equipment upkeep also factors heavily in the overall success of spray operations.

Many pesticides are corrosive and will react with hoses, lines, nozzles, tanks, and other components. The resulting corrosion can affect the spray patterns and lead to the formation of foreign particles that clog the equipment.

Applicators should mix only the amount of spray that is needed for the job and should use the spray as soon as it is mixed and thoroughly clean and rinse the equipment as soon as they are finished spraying.

Once mixed with water, the pesticide begins to change. The effective life of certain pesticides can be only hours once they are mixed with water. Water with a pH over 7.0, which is neutral, can be particularly detrimental to many pesticides. Generally speaking, the higher the pH, the faster the pesticide is broken down and rendered useless. Under Florida conditions, where the underground water is frequently high in calcium carbonate with resulting water pH of 8.0 to 8.5, it is even more important not to allow finished spray to sit any longer than necessary.

Leftover spray allowed to sit in the sprayer can quickly destroy it and other sprayer parts, lines, and components. Leftover spray also must be carefully and legally disposed of by application to a labeled site.

Clean water should be used for spraying. Water is the most commonly used diluent (carrier) for pesticide sprays. Water frequently contains dirt, sand, or corrosion from the pipes or lines that may enter the spray tank. These contaminants can cause problems. Sprayers should have strainers and filters to remove any contamination. Strainers should be used between the source of water and the tank mouth. Filters should also be present in the lines between the tank and nozzles and in each nozzle.

These IPM principles and practices are combined to create IPM programs.

In summary, while situation is different, the following major components are common to all IPM programs:

- Pest identification
- Monitoring and assessing pest numbers and damage
- Guidelines for when management action is needed
- Preventing pest problems
- Using a combination of biological, cultural, physical/mechanical and chemical management tools
- After action is taken, assessing the effect of pest management

An IPM approach means that pest managers use multiple tactics to prevent pest buildups, monitor pest populations, assess the damage, and make informed management decisions, keeping in mind that pesticides should be used judiciously.

Integrated pest management (IPM) is socially acceptable, environmentally responsible and economically practical crop protection.

Practicing Integrated Pest Management (IPM) can reduce the quantity of chemical pesticides entering the environment and can save money.

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