Integrated Pest Management in the Commercial Ornamental Nursery [1]

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Description of IPM

Integrated Pest Management (IPM) is an approach to managing insects, mites, pathogens, nematodes, weeds, and other pests in which multiple practices are implemented throughout the entire production period of the crop. IPM can be viewed as a series of steps that is repeated or modified as needed: **Prevention/avoidance**, **Monitoring**, **Decision making, Intervention, Evaluation**.

IPM includes judicious use of pesticides in careful coordination with other pest management practices. Restricted labeling of pesticides, pest resistance, safety to nursery personnel, and environmental issues are all concerns to nursery managers. Thus, nursery managers should seek methods of pest control other than scheduled, preventative, nursery-wide pesticide applications.

Decision—Making Factors in IPM

I. BIOLOGICAL FACTORS (Under control of the pest)

A. Damage Potential

1. As pest species
    a. High—(direct) ex. spider mites
    b. Low—(indirect) ex. aphids
2. Effect on plant
    a. Quality only—ex. azalea leafminer
    b. Mortality – ex. borers
3. Multiple pests present
4. Infestation type
    a. Old—previous decision
    b. New—first time decision

B. Reproductory Rate of Pest

1. High/low—ex. mites, borers
2. Time of year
    a. Winter (rapid or slow population growth, species dependent)

1. This document is ENY-336, one of a series of the Department of Entomology and Nematology, UF/IFAS Extension. Original publication date January 1998. Revised July 2018. Visit the EDIS website at http://edis.ifas.ufl.edu.

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b. Summer (rapid or slow, species dependent)

c. Spring or Fall (variable related to temperature)

3. Host plant species

a. Preferred (rapid population growth)

b. Non-preferred (slower population growth)

4. Plant stress (favoring pest)

a. Injury

b. Water
- Low
- High

c. Nutrients

d. Other—cultural and management practices

5. Current infestation (judgment on population growth)

a. Increasing

b. Static

c. Decreasing

C. Host Range (threat of population to spread)

1. Specialist—narrow, specific to one or few plant species

2. Generalist—broad, many host susceptible

3. Opportunist (related to plant vigor)

4. Proximity to other susceptible plants (secondary spread)

D. Risk From Disease Dispersal—Vector of plant disease

E. Natural Enemies (predatory insects and mites, diseases, etc.)

1. Positive impact

2. Little or unknown impact

3. Previous toxic pesticide use

II. OPERATIONAL FACTORS (Under control of the grower):

A. Survey and Detection (population monitored adequately)

1. Quantitative methods available (numbers meaningful)

2. Qualitative methods only (presence or absence)

3. Monitoring intensity (scouting frequency)

4. Pest identification certain

B. Choice of Control (when and what to use)

1. Legal factors

a. Regulatory (FDACS-DPI/APHIS) Guidelines, Certification

b. Legally limited: only chemical labeled (see pesticide label or consult local extension office)

c. Safety (worker reentry, see pesticide label)

2. Logistics—Strategy

a. Critical timing required
- Preventative
- Remedial
- Shipment soon, certification needs

b. Cultural practices scheduled (related to control needs)
- Pruning in near future (could remove pest mechanically)
- Fungicide next treatment (could add insecticide as tank mix)

c. Weather limitations

d. Equipment limitations

3. Efficacy (expected % mortality)

a. Ease of control
- Plant factors
- Pest characteristics

b. Chemical's properties
- Kills all stages
- Does not kill all stages
- Systemic

c. Number of applications needed
- Residual
- Contact only

d. Applicator's efficiency—coverage
- Airblast
- Handgun

4. Economics of available tactics

a. Relative cost (per application x days of residual)

b. Residual activity (days) (see label)

c. Previous controls (rotation or change of chemicals)

d. Availability and cost of alternative tactics

e. Spectrum of pesticide activity (if more than one pest present)

f. Risk of pesticide resistance
- Chemicals used previously
- Chemical class
- Rotation/alternation
- Pest life cycle

5. Environmental

    a. Impact on nontarget organisms

    b. Available alternative chemicals or practices

    c. Environmental risk factors (pollution) (see Butler et al. 1991)

C. Evaluation and followup

1. First treatment

2. Detected and treated previously

III. Extrinsic Factors

A. Plant Value

1. Inherent

    a. Species

    b. Size/investment

    c. Market

2. Plant sales status (relative to damage threshold)

    a. Immediate

    b. After growth flush

    c. Uncertain, but in future

B. DecisionConfidence (knowledge x application)

1. Novice

2. Experienced

3. Advice from outside expert

C. Summary assessment of knowledge for this situation

1. Old and familiar pest

2. New pest

Integrated Is the Key Word

Integrated means combining a variety of strategies and pest management tactics that can either prevent pest introduction, eradicate pests, or reduce pest populations to lessen their economic impact while maintaining plant quality. Doing nothing is often the most cost-effective option. Some damage can be tolerated, letting nature take its course. Emphasis should be placed on preventative practices such as sanitation (e.g., weed control, removal of plant debris), proper fertilization, irrigation, pruning, etc. Examples of management activities that affect pests and diseases include selection of resistant plant species, regulation of irrigation timing and frequency, alteration of the relative humidity level in the greenhouse, use of least toxic pesticides as needed to preserve beneficial organisms and reduce environmental contamination or application of biological control agents.

IPM Strategies and Tactics

IPM strategies and tactics and the relative sequence of tactic implementation necessary to develop and implement a successful IPM program.

Prevention or Avoidance of Pests and Their Damage:

- Maintain vigorous, healthy plants by using proper culture and management practices
- Practice IPM and realize that all culture and management factors can affect pests
- Use host plant resistance: select and grow cultivars or species that have fewer pests
- Scout plants for pests, use phenology records and thresholds to make spray decisions
- Use soaps, oils and biologicals (least toxic chemicals) whenever possible
- Spot spray only infested plants that exceed the threshold
- Destroy heavily infested or injured plants
- Match beneficial species to pest and plant
- Conserve and promote beneficial insects by selective pesticide use

Using Host Plant Resistance:

- Determine the pest profile of target species and cultivars in the target habitat
- Grow and evaluate the germplasm under the range of conditions it will be exposed to
- Select species or cultivars with lowest numbers of pests
- Determine the effects of culture and management practices interacting with the environment on pest occurrence (plant x environment interactions)
- Determine the impact of different cultivars on beneficials
- Grow the less susceptible stock and monitor for efficacy of tolerance/resistance

Use Biological Control Agents (Beneficials) (Conservation and Augmentation):

- Reduce overall pesticide use and especially toxic pesticides by practicing IPM
- Sample pest populations and use economic/aesthetic thresholds
- Keep accurate records of the pest's seasonal abundance

- Know pest profile of plant, multiple pests may present problem
- Tolerate low level pest populations to sustain beneficials
- Use soaps, oils and biologicals as preventatives to conserve natural beneficials
- Use selective pesticides that are easy on beneficials
- Match beneficial species to pest and plant
- Release beneficials when pest populations are expected (records) or first detected
- Evaluate results as with other controls

Managing Pesticide Resistance:

- Reduce pesticide use by practicing IPM and prevent pest outbreaks
- Use soaps, oils and biologicals as much as possible to avoid resistance pressure
- Spot treat: apply pesticides only to infested plants so as to maintain susceptible pest populations
- Use an economic or aesthetic threshold to make control decisions—tolerate low pest populations
- Rotate chemicals by class (either in sequential applications or by pest generations)
- Manage pesticide use rate, use lowest dose that provides control

Myths About IPM

1. IPM always reduces costs. Monitoring for pests is time consuming. Costs may initially be higher in the short term, as scouts learn more about the pests. As knowledge is gained over time and scouting and suppression become more efficient, costs will be reduced.
2. IPM always reduces pesticide use. Again in the short-term, new knowledge may indicate more or different pesticide use. However, over the long-term pesticides will be reduced, eliminated or substituted with less costly alternatives.
3. IPM relies strictly on organic controls. IPM does not by definition eliminate or specify what controls will be necessary.
4. IPM relies strictly on biological controls. While IPM does advocate using the least toxic alternative that minimizes side effects and input costs, often pesticides are the only efficient controls available to treat certain pest outbreaks. Clearly, unilateral reliance on chemical controls for any type of pest is a thing of the past. Alternative approaches should be developed. Integrated pest management (IPM) is an approach which seeks to minimize energy inputs of all types.

Pest Prevention and Avoidance

The easiest way to prevent, avoid or eliminate pest problems is to eliminate the plants that pests infest. In reality, few plant species are pest-free, but each plant species has its individual complement of pests. No plant is attacked by all pests. Host plant resistance (HPR) is the term that describes a plant's lack of susceptibility to pests. Nursery plant species and cultivars also exhibit a range in host plant resistance. Nurseries should grow the most pest resistant plants possible because resistant plants grown in the landscape will reduce the need for pest management. "Right plant, right place" is the mantra of the landscaping industry and matching a plant with resistance to pests to its normal site requirements is important to maintain the natural factors that promote pest resistance. Even naturally pest-resistant plants can become susceptible to pests (see Opportunists below) when they are stressed.

Several practices affect nursery stock susceptibility to pests. Many pest problems in production areas originate from infested stock. Only pest-free seeds, cuttings, or plants should be placed in the production area. Use of irrigation systems which apply water at the soil surface or at the base of containers will extend the life of foliar applied insecticide residues. Overhead irrigation washes off residues, making them less effective in pest control programs. Eliminate weeds in greenhouses, shade houses and surrounding areas because they frequently support populations of insects and mites that can quickly migrate onto ornamental crops. Screen barriers around propagation greenhouses help prevent pest entry. Turf around nurseries should be mowed frequently to prevent excessive growth that may also harbor pests. Discarded pest-infested plants or plant parts should be containerized and removed from growing areas to minimize reinfestation and sanitation.

Organizing Information and Implementing IPM

Plant diversity is high in nurseries and landscapes. Despite the diversity most problems are confined to a few plants and pests. One technique in an effort to better allocate limited resources and to deal with the plant/pest diversity present is the KEY PLANT/KEY PEST concept.

This is the recognition that certain problem plants and/or their problem pests exist. Use them as tools to focus resources and as indicators of the timing of other pest problems that they may herald. Monitor these plants more closely for the occurrence and early detection of chronic pests. Maintaining specific records of local areas will develop the necessary information on key plants and pests. Bloom patterns or other plant phenological events can be used to predict the occurrence of pests in the same local environment.

Another approach to help synthesize information for IPM decision making is focused around the feeding behavior or "role" that pests display in the ecosystem. While all plant feeders are specialized feeders in the strict sense, three categories of pests can be loosely recognized relative to their feeding habits on host plants: specialists, generalists, and opportunists. SPECIALISTS feed on one or a few host plant species. These arthropods are more closely linked chemically and behaviorally to their limited range of host plants. An example is the crapemyrtle aphid which feeds only on crape myrtle. Other examples include the azalea leafminer and many lace bug species. Since the biology and behavior of host specific pests are often more closely tied to the physiology and biochemistry of the host plant, their seasonal abundance is often more predictable and more closely related to host plant phenology.

GENERALIST pests have a broader host range and the risk of an infestation spreading to other plant species is greater. Twospotted spider mites are generalists. While generalists pests may have a broad host range, they may do better on certain preferred host plants or under specific environmental or cultural and management practices. Twospotted spider mite and silverleaf whitefly each have hundreds of host plant species.

OPPORTUNISTS are pests which often naturally act as decompers and attack weak and dying plants. They may have a narrow or broad host range but their presence often indicates that the plant is injured or stressed. Examples of opportunists are the boring insects such as the clearwing moths (Sesiidae), the bark and ambrosia beetles (Curculionidae), the flatheaded wood borers (Buprestidae), and the longhorn beetles (Cerambycidae). Some boring insects have long life cycles with extended emergence and oviposition periods not readily predictable. Others like the bark beetles, have short life cycles and mass attack trees, quickly killing them, making control difficult. Culture and management practices and site factors associated with plant vigor often correlate with borer susceptibility.

Growers can use their knowledge of the natural role and feeding behavior of pests to provide answers to many practical management questions. For example, will the pest infestation spread to other nearby plants? Specialist pests will only spread if plants nearby are the same species, generalist pests may or may not. If the pest is an opportunist, spread to other plants is unlikely. Moreover, treatments are likely to be inadequate as opportunist species are often secondary invaders and indicate that other primary problems are occurring to the plant. Resistance to specialist pests by individual cultivars is often known and enables selection of cultivars resistant to these pests. It should be clearly recognized that much of the potential pest management required by a specific plant species is inherit and predictable and in fact is purchased along with the plant. Thus, knowledge of the plant's pest profile is very useful and important.

Scouting or Monitoring

Scouting or monitoring is one of the most important tools of any IPM program. The timely detection of pests and accurate assessment of population densities of the pests and their natural enemies are fundamental to IPM decision-making. Early detection of pests enables the nurseryman to reduce plant damage, improve plant quality, reduce production costs, avoid production delays and increase profits. Continuous pest monitoring and accurate record-keeping (Table 1) help predict when pests most frequently occur and will increase the ability to anticipate and schedule activities related to pest management. Detection should be followed closely with appropriate controls when necessary to prevent pest outbreaks. Scouting provides the overview and the raw data by which preventative and pest management options are chosen.

Pest management systems cannot be implemented if a grower does not know which pests exist and whether populations are significant. Therefore, a scouting plan must be devised for each greenhouse or container nursery. To be successful, scouting must be performed routinely and consistently. Knowledge of the plant and its pests forms the background for successful monitoring. Several prerequisites must be satisfied to implement a successful monitoring program. The scout must do the following:

a. Divide the nursery into logical units and make maps of these units so that all areas can be efficiently monitored on a routine basis. Scout should communicate pest and crop information clearly and consistently to those responsible for acting on that information.

b. Define key plants/key pests with nursery ownership. Both scout and management must agree on those plants that are key plants for purposes of routine scouting. The average nursery has far too many plant species for all to be scouted on each visit.

The frequency of monitoring is determined by the crop production cycle. Short-cycle crops (e.g., plug production) may require scouting every three to four days during the entire production season. Longer-cycle crops such as potted bedding plants, floral crops and foliage plants may require weekly or biweekly monitoring. Long-cycle woody ornamental plants can be monitored effectively on a biweekly basis.

Scouts should enter each block or bench of plant material looking for abnormal plant symptoms, direct evidence of insects, mites or pathogen signs and situational problems such as malfunctioning sprinkler heads. Walk at random through the area in a zigzag pattern. At least 10 minutes should be spent inspecting 20 or more plants for every 1,000 square feet of production area.

Make an effort to select those plants that appear less healthy for visual inspection. In other words, conduct biased sampling. Lift a few suspect plants out of the pot. Check to see whether the root ball is of normal size and color. Look for sections of dark, soft, decayed feeder roots along the face of the root ball. Examine roots on the surface of the rootball for galls typical of root-knot nematodes, dark lesions and discoloration or dry decay that might be induced by lesion or burrowing nematodes.

Examine foliage for signs of trouble, checking both new and old growth, but predominately the new growth. Examine both leaf surfaces, especially the undersides, and also the leaf axils for large insects and symptoms of foliar nematodes and diseases. Use the 15× to 20× hand lens to facilitate observation of the smaller pests such as mites and thrips, or the reproductive signs of fungal pathogens. During individual plant inspection, strike the foliage over a white sheet of paper or a paper plate to dislodge small pests, primarily mites and thrips, for easier viewing. When problem spots are identified, increase the number of plants inspected in those areas. Determine a rough count of plants per block with symptoms of disease or insect injury. It is also important to look closely at certain problem areas such as weedy spots around the outside of greenhouse or nursery beds. Weeds host many pests between and during production cycles. However, they may also provide resources to natural enemies such as pollen, nectar, alternate hosts or shelter.

In container or field nurseries, pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas, and block centers. The scout should follow the same general pattern at each sampling. Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection. Vary the entrance point in the sampling area 3 to 10 feet for each subsequent sampling so that the same plants are not inspected each time.

In greenhouses, scouts should walk every aisle and move from bench to bench in a snakelike path. Maps should be made of the greenhouse, and scouting should not follow the same pattern every time. Scouting should always begin at a major doorway, which is usually an entry point for pests or pathogens. Concentrate on the beginning, middle and the end of each bench. Insect and mite infestations often build up on the ends and edges of benches. Also concentrate on areas near vents and other openings that might allow pests to enter and are likely initiation points for foliar pathogens. In addition, scout where temperatures are highest for early detection of spider mite infestations. Three or more randomly chosen plants should be inspected on every bench. Hanging baskets should also be inspected randomly.

Yellow sticky traps (cups, plates, or cards) which attract and capture whiteflies, aphids, thrips, leafminer flies, shore flies, and fungus gnats are valuable aids in monitoring for early invasions and serve as an index of activity for these pests. Place on stakes just above the plant canopy. Check for insects stuck on the trap at least two to three times a week. Time may be saved by counting insects within a 1-inch-wide, vertical column on the sticky trap. Aphids and thrips tend to be caught on the bottom half of the traps. Leafminer flies are caught more often along the top, and whiteflies tend to be spread uniformly on the trap. Because insects are not distributed evenly horizontally across the trap, columns counted should be vertical and near the middle of the trap. The traps should be placed in the same position each time to allow a true picture of insect activity to emerge. Place the traps in a grid-like fashion at least one per 1,000 square feet of production area and replace weekly.

Indicator plants for detecting insects and mites are often used to good advantage. The first plant showing symptoms becomes an indicator plant. This plant is marked with a flag or in some manner that allows the scout to check the same plant every few days for arthropod development. Pests on this plant are monitored for population increases and the occurrence of specific life stages. For example, scales are most vulnerable to controls in the egg and crawler stage. Schefflera plants are good trap crops for most pests in a foliage plant greenhouse or interiorscapes. Other highly susceptible plants that may be placed in the nursery as indicator plants, and the pests they attract, are as follows: tomato, lantana, gerbera, pentas, poinsettia (whiteflies); marigold, rose, *Ficus* spp., *Hedera* spp. (spider mites); hibiscus, chrysanthemum, rose (aphids); impatiens, gloxinia (thrips). Information on which of the pest's life stages are present will make decision-making easier, enabling the nursery owner to better target controls to the most vulnerable stage. Along with indicating proper timing for application of controls, this information may determine that only small infestations exist and spot treatments may be appropriate. At this time, an effort should be made to determine if the pest population is increasing, decreasing or apparently static. Note the presence of any beneficial insects or mites found on the infested plants.

This information can be combined with historical records, sticky trap data, random plant counts, and indicator plant records so that predictions and decisions can be made concerning pesticide applications. Record an estimate of the percent of the pest populations in each life stage in relation to the sample unit. This data will help assess the risk of further damage and the pest population status. Immediate application of control measures is usually only cost-effective for populations that are increasing. Much money is wasted by treating infestations that are declining. This error results in further negative impact because of the detrimental impact of chemical controls on beneficials which are often most abundant at the end of a pest infestation.

Biological Control

Biological control, the free and natural first line of defense against pests, is the use of natural enemies (beneficials) of pests to keep them below economically important levels. Conservation of competitors, antagonists and beneficials by judicious use of pesticides is extremely important. Beneficials and pests are similarly affected by nursery practices. Beneficials often have additional food and shelter requirements to sustain them that nursery plants do not provide. Augmentative releases of mass reared predators is also an option. However, indiscriminate release of natural enemies is not recommended.

Pesticides

Proper selection of pesticides is critical in IPM. Read the Label, THE LABEL IS THE LAW! Factors to consider in selecting chemicals are: recommended for the target pests, non-target impact, cost, toxicity to workers, worker reentry interval, risk of pollution, risk of phytotoxicity and the availability of more benign alternatives. Make sure proper safety precautions are taken including applicator safety equipment and methods at mix/load sites. Sprayers should be properly calibrated to deliver the correct rate and to provide proper coverage of the target plants. It is advisable to use the lowest recommended rate for safety, environmental and cost considerations, etc. The strategy is to minimize the side effects.

Integration of Biological Control and Pesticides

Conservation and promotion of natural enemies and judicious use of pesticides make good sense. Can we integrate chemical and biological controls? The impact of conventional pesticides on natural enemies is termed selectivity. Most broad spectrum insecticides are toxic (not selective) to arthropod natural enemies and fungicides are toxic to entomopathogens (diseases of arthropod pests). Families, species and different life stages of the same species may respond differently to pesticides. Acaricides and pyrethroids are mostly safe to insect natural enemies but many are harmful to predatory mites. Formulations of the bacteria or endotoxins of *Bacillus thuringiensis* and fungicides are selective of arthropod natural enemies. Pyrethroids are selective of most lacewing species but show mixed results versus other predators and parasitoids. Organophosphate pesticides are toxic to most arthropod natural enemies. Botanicals show mixed results with most being selective. Growth regulators are more host specific and usually are selective. Pesticides based on new chemistry just coming on the market are in general less toxic to biological control organisms and many labels now include data about the effect of the active ingredient on natural enemies.

Modification of application methods such as using reduced rates, spot treatment and better timing can be used to help conserve natural enemies. Granulars, systemics or baits can better target the pests so that natural enemies are not exposed to harmful pesticides.

Table 1. A calendar for developing pest seasonal abundance data. Other categories can be added such as the host plant species and numbers and types of beneficials present. Accurate, quantitative data will have the greatest value in decision-making.

Insects	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mite												
Aphid												
Scale												