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CHECKLIST
PEST MANAGEMENT

- ✓ Know the plant's normal habits of growth.
- ✓ Use proper cultural practices.
- ✓ Know what a specific pest looks like and understand the biology and timing of each individual pest species.
- ✓ Monitor for pests. Methods of monitoring include visual inspection, collection of small pests by shaking branches over a white piece of paper, and use of pheromone and colored traps.
- ✓ Predict when pests are vulnerable or when pest activity should begin for insects and mites by using the calculation of growing degree days (GDD) and correlation of pest development with plant phenology.
- ✓ Prevent or alleviate a problem by changing a horticultural practice like fertilization, watering method, culling out diseased plants, planting in the correct place, and pruning to increase air circulation.
- ✓ Access weekly and bi-weekly updates throughout the growing season for current insect activity and management strategies along with updates for pathogens, weeds, and weather information through the UMass Extension Landscape, Nursery, and Urban Forestry program. To access this very valuable and timely information, visit http://www.umassgreeninfo.org and click on "Landscape Message."
- ✓ Correctly identify the problem, have the correct product, and apply the product at the correct time for maximum effectiveness.
- ✓ Keep continuous records of as many factors as possible: temperature, rainfall, emergence time for specific pests, developmental stage of plants, soil pH, soil fertility, the source of water used for the spray tank and its mineral content as well as pH, specific pest and their life stage when 'managed,' method or material for management, and whatever else seems pertinent at the time.

Plant Health Care (PHC)

- ✓ Research individual crop needs, susceptible pests, their timing, population levels, when to act, and how to implement the least toxic means of management.
- ✓ Be pro-active rather than reactive.
- ✓ Review and implement cultural practices like soil testing and proper plant nutrition, pruning, and correct watering techniques to enhance plant health.

PEST MANAGEMENT

Integrated Pest Management (IPM) and Plant Health Care (PHC)

Various definitions for Integrated Pest Management (IPM) exist, but all contain the essential foundation philosophy of striving to manage pests of plants in a logical manner that reduces pest numbers to acceptable levels while considering and protecting the environment, non-target organisms, and human health. It has been said that IPM is a toolbox and the most important tool in that box is the practitioner's knowledge. IPM does allow for the use of pesticides but only after a rigid examination of all available options. Once it is decided that a pesticide is necessary, the least toxic materials are always considered first. Currently, public concerns and legislation at the state and federal levels have forced pesticide manufacturers to develop newer compounds that fit into this IPM philosophy. As a result, many new products now exist that work via unique modes of action that target specific pest groups while leaving most others unharmed (see New Products and How They Work in this section).

Integrated Pest Management (IPM) can be broken down into seven essential steps that can be customized for any agricultural commodity (e.g. vegetable production, lawn care, greenhouse, landscape, nursery, and all other sectors of agriculture). The definitions of these steps are as follows:

1) Identification:

Know the Plants

Every practitioner of IPM needs to be familiar with the plants in their care. This does not just include being able to identify the genus and species (and, in some cases, variety) but also knowing the plants' normal habits of growth and their biological needs. All too often, plants are subjected to incorrect soil pH or fertility or environmental conditions (e.g. plants that grow very well in the shade suffer when planted in sunnier locations). A recent trend in the nursery and landscape industries is the use of plants that are not native to the region. We create landscapes with plants that originate from various parts of the country and even the world, and we expect these plants to perform well together. All too often, we experience failure. If we know an individual plant's biological needs and are able to recognize early the signs that tell us that a plant is not healthy, we can avoid much greater problems in the future and reduce the need for human input (i.e. pesticides). Being successful with nursery and landscape plants means having a vision of what they will look like in 40 or more years and taking care of them properly now to ensure that reality.

Know the Pests

In addition to knowing the plants, a practitioner also needs to be familiar with the pests common to those plants. One needs to know more than just what specific pests look like; it is also necessary to understand the biology and timing of individual pest species. Many of the newer insecticides, in particular, work extremely well but need to be applied at critical times during an insect's life cycle to be fully effective. Many of the insect and mite pests of woody nursery and landscape plants are actually named after their preferred host (e.g. birch leafminer, euonymus scale, azalea lacebug). Some pathogens, like fungi, are also named for preferred hosts (e.g.

Dutch elm disease, oak anthracnose). Virtually every plant has at lest one or two specific pests that can at any time become a very serious problem for that plant. Therefore, it is essential to be knowledgeable about these pests. A section follows later in this manual detailing some of the important insect, mite, disease, and weed pests found in the nursery and landscape. However, a complete list of these pests is extensive and seeking professional advice is often necessary. For the nursery and landscape industries in Massachusetts, essential diagnostic services are provided by UMass Extension, in Amherst (see Resources).

2) Monitoring

Methods

Visual Observation

Monitoring is the backbone of any IPM program. If one is not inspecting plants and the activity of potential pests on a regular basis then he or she is not practicing IPM. Methods for monitoring pest problems are varied. The most common method is visual observation. Once one knows what a healthy plant should look like then all that needs to be done is to visually inspect that plant on a weekly basis for any abnormalities (e.g. stunting, yellowing, brown spots on foliage, chewed foliage). Most professionals who have been in the nursery and landscape business for years perform this task without being aware that they are even doing it. The general public, overall, is not accustomed to seeing individual plants as the professional does and therefore it is common for them to not recognize problems until they are extensive.

Branch Shaking

Monitoring for small pests, like spider mites, can be achieved via a process known as "branch shaking" or "jarring." Quite simply, a clipboard with a white piece of paper is placed under a branch and the branch is shaken vigorously. The material that falls onto the paper is then examined with a hand lens. Notes are taken as to the number of spider mites found. If population numbers of spider mites continue to increase on a weekly basis, coupled with an insufficient number of predatory mites being present, intervention may be required.

Traps

Ronald Kujawski

Traps are also useful tools for monitoring insect presence and for obtaining rough estimates of numbers. Pheromones, which are a form of chemical communication, are very common in the insect world. Often, the female of a given species emits a pheromone that only the male of her species can detect. Many of these pheromones have been identified and synthesized and are available in traps which can be hung in potential host trees and monitored. Also, certain insects are attracted to specific colors, such as bright yellow; colored sticky cards can be used to monitor these insects. Traps only let one know when a specific pest is active and perhaps provide a sense of population numbers. Traps are never used to "trap out" or eliminate a pest; they are not effective that way.

Predicting Pest Activity

There are several ways to predict when pests are vulnerable to treatment or when monitoring for pest activity should begin. Calendar approximation, calculation of growing degree days (gdd), and correlation of pest development with plant phenology are the three most commonly used prediction methods for insects and mites. The best management practice uses a combination of gdd and plant phenology to predict pest activity.

Calendar

The calendar method is based on following the historical record and past experience and is expressed as an approximate date. For example, gypsy moth egg hatch occurs in Massachusetts somewhere between late April and late May. As each spring in New England is unique and the season progresses differently in different areas, scheduling treatments by the calendar method alone can result in poor control, wasting both material and labor time.

Growing Degree Day (GDD)

Knowing when a specific insect is active on the host allows us to know if management strategies are necessary and when, exactly, to implement those practices. Insects, being arthropods, are 'cold-blooded,' which basically means that they are more active when temperatures are warmer and less active when temperatures are cooler. Extreme temperatures on both ends of the scale results in greatly reduced activity and dormancy. Insect development is strongly driven by temperature as well. This has been researched extensively for insects in the Northeast and by monitoring daily temperature highs and lows we can predict with near certainty exactly when most of our insect species will become active. Quite simply, the high temperature for each day is recorded along with the lowest temperature. They are then added together and divided by two to get an average daily temperature for that day. This number is then subtracted from 50, which is considered to be the average temperature where most insects in the Northeast break dormancy and become active in the spring. The number obtained is known as the number of growing degree days that were accumulated for that day. This exercise needs to be performed every day and the obtained numbers are accumulated. As an example, we know that once we have accumulated 90 to100 gdd, the eggs of gypsy moth will hatch and once we reach 950 to 1,000 gdd, we will start to see Japanese beetle adults. For those insects that live in soil (e.g. Japanese beetle grubs) it is important to monitor soil temperatures and not air temperature. The accumulation of 90 to 100

David Cappaert, Michigan State University, Bugwood.org gdd typically falls within the first week of May in Massachusetts and 1,000 gdd are usually accumulated by the last week in June or early July. Occasionally, we have very warm springs or very cool springs which alter the normal accumulation of gdd's. It is not uncommon during warm springs for gypsy moth eggs to hatch in mid-April and if one relies solely on a calendar to manage pests, they may miss their window of opportunity by two to three weeks. Also, Massachusetts is extremely small geographically but it has some very complex and differing climates between the mountains of the Berkshires, the Connecticut River Valley, and the coastal areas. Often in the spring, specific pest activity can be staggered by as much as two full weeks over less than 200 miles of terrain within the state. Therefore, it is strongly recommended that managers of insect problems rely on the use of GDD, which can be obtained on a weekly basis during the growing season by going to http://www.umassgreeninfo.org and clicking on 'Landscape Message.'

Plant Phenology

Plant growth also responds to accumulating heat units to some degree. Bud swell, leaf emergence, flowering, fruiting, and other growth stages can be correlated to the growth stages of some insects and mites. In the example of gypsy moth, egg hatch is said to occur about the time *Amelanchier* (shadbush) is in bloom. However, as day length and other environmental factors can affect specific events in a plant's life cycle and cultivars frequently have different bloom periods, these correlations are less precise than using GDD, but more accurate than using calendar dates. As landscapers and nursery workers can easily observe bloom and other plant events as they perform their normal routines, this is an attractive method for basing monitoring and management. Plant phenology and GDD information relative to Massachusetts' plants and insects have been researched and incorporated into fact sheets and newsletters. Weekly GDD accumulations and current plant bloom are available through the University of Massachusetts Extension Landscape Message (see below). As caution should be used with the calendar approach, so should it be exercised when using GDD and phenology. Both are meant as an aid to monitoring, not as a substitute for visual confirmation.

A great source of monitoring information for the professional is UMass Extension's Landscape, Nursery, and Urban Forestry program Web site. For up-to-date information concerning insects, diseases, and weeds of the nursery and landscape, visit http://www.umassgreeninfo.org. In the upper right-hand corner of the homepage, click on "Landscape Message," which details current information broken down by regions of the state. The site also provides IPM-based recommendations for the management of most pests.

3) Knowing When to Act

Economic Threshold

In traditional (food) agriculture, the Economic Threshold is defined as "when the potential loss at harvest time (in dollars) equals the cost of treatment NOW." Virtually all of the known pests for food crops have had their tolerance levels established through decades of research. As an example, it is well known that if x-number of Colorado potato beetles are found per potato plant in June, then it relates directly to a known loss in harvest volume in September. Numbers of potential bushels lost can then be multiplied by the expected value per bushel to come up with a fair estimate of what the loss to the grower will be if steps are not taken to suppress the population early in the season. If the estimated loss per acre is determined to be $80 per acre, which is determined by the number of beetles present in June, and if it costs approximately $80 per acre to treat that pest in June, then this is the Economic Threshold and actions should be taken. Landscape plants have value in their appearance; there is no “harvest.” In the nursery, the “harvest” is when plants are ready for resale to the garden center, landscaper, or homeowner. For landscape and nursery plants, the real value is in appearance and this is known as the Aesthetic Value, which is a subjective value determined by the one buying or observing. Nursery and garden center plants can suffer damage from insects that is minimal in terms of how it affects the health of the plant; however, if it renders the plant unattractive then the dollar value (economic value) of that plant can be severely affected.

4) Knowing the Correct Management Strategy

The old style for managing pests was always referred to as “control.” In IPM, “management” is the preferred term for dealing with pests. “Control” implies a total dominance that suggests eradication. When dealing with insects, pathogens and weeds, this is nearly impossible to achieve. Therefore, learning what level of pest population is tolerable and how best to maintain pests at that level requires a great deal of understanding and thoughtful management practices. Many serious pest problems in the past were actually created by our attempts to “control” some other pest. Our tools were broad-spectrum and harsh on the natural controls (parasites and predators) thus creating new problems in an endless cycle of pesticide application. More importantly, the word “management” should not immediately lead us to consider pesticides as the only options available. Many times in the nursery and landscape, pests are encouraged by our horticultural practices, and preventing or alleviating a problem can be as simple as changing one of those practices (e.g. fertilization, watering method, culling out of diseased plants, planting in the correct place, pruning techniques to increase air circulation).

5) Knowing the Correct Timing for Implementing Management Strategies

In past decades, practitioners could get very close to the economic threshold with insect pests and then apply a broad-spectrum nerve toxin insecticide and achieve high levels of control almost immediately. Today, because many pests are able to quickly develop resistance to those compounds and because of our concern for health and the environment, we have different products that work very well but perhaps only at specific times in pests’ life cycles. Therefore, being able to correctly identify a problem and having the correct product may not be enough to fix the problem; we also need to apply the product at the correct time for maximum effectiveness. (See New Products and How They Work in this section.)

6) Record Keeping

Keeping continuous records of as many factors as possible will result in a great tool for the IPM practitioner. Nature is diverse and often unpredictable. Records help us gain knowledge and understanding of such fluid dynamics and ultimately allow the IPM professional to better perform their job. Consider recording information about temperature, rainfall, emergence time for specific pests, developmental stage of plants, soil pH, soil fertility, the source of water used for the spray tank and its mineral content as well as pH, specific pest and their life stage when ‘managed,’ method or material for management, and whatever else seems pertinent at the time.

7) Evaluation
This step allows the practitioner to always work towards improvement. Examining practices, learning new techniques, staying current with research via Extension educational endeavors, and striving to manage problems in a holistic manner contribute greatly to the development of the professional. Having quality records to refer to provides much insight into where one is performing well and to where changes may be necessary.

Being a good IPM practitioner does not mean that one adheres to a strict set of rules but rather that he or she has a strong underlying commitment to keeping plants healthy, reducing pesticide use, and protecting the environment, and is open to adopting new practices as technology and understanding develops.

Plant Health Care (PHC)

IPM was first developed for fruit and vegetable production and later adapted to non-food agricultural commodities; Plant Health Care (PHC) grew from that adaptation. It has been said that IPM's primary focus is the pest while that of PHC is the plant. Many PHC adopters often strive to separate PHC from IPM; in reality the two practices are remarkably similar with subtle, yet important, differences. As with IPM, PHC requires a keen understanding of plants, pests, their timing, and population levels; knowing when to act; and implementing the least toxic means of management. Many consider PHC to be the most holistic approach for managing potential problems of trees and shrubs. The major tenet of PHC is "Be pro-active rather than reactive," which is not only sound advice, but creates a valid doctrine for managing pests of plants. It is much easier to prevent a pest outbreak than to 'cure' one that has exploded into a massive problem. PHC includes involving customers, mapping of clients' properties, recording potential pests for monitoring and perhaps later treatment, as well as implementing horticultural practices such as soil testing and soil amendments, pruning to enhance plant health, correct watering techniques, mulching, and many other horticultural aspects. PHC is better adapted to the landscape setting than it is to the nursery.

New Products and How They Work

For decades, the standard method for managing most of the insect and mite problems on woody ornamentals was heavily reliant on the use of chemical insecticides. Although very useful tools, many of these products raised questions about their long-term effects on the environment, human health, and the loss of beneficial organisms like parasites and predators; the fact that they were "broad-spectrum" products meant that not only did they kill the target pest but also that they were detrimental to most of the incidentals. In the modern era, many of these products no longer meet the requirements of a well-educated general public, and it has been this evolving attitude that has driven legislatures at the state and federal levels to seek stronger laws to address these issues. As a direct result, many new laws have been enacted in the past decade that have greatly changed the status of pesticide availability and registered uses.

New laws, such as the Food Quality Protection Act of 1996 (FQPA), uses data gathered over many years from national scientific studies, which strongly indicate that children, with their developing bodies, are at a 10-times greater risk than adults to potential ill-effects that may be generated by pesticide exposure. The law also considers aggregate exposures to specific chemical products that children may encounter, which include pesticide residue on foods, exposure from landscape and turf applications, and exposure from parks and athletic fields that have been treated. These new criteria for considering residues and potential effects to children's development have been responsible for many of the well-known compounds disappearing from standard use in recent years.

Chlorpyrifos (Dursban®), Diazinon, and Carbaryl (Sevin®) are a few of the products that have been heavily affected by this new legislation. Many of these are organophosphate and carbamate insecticides that work on the peripheral nervous system as cholinesterase inhibitors.

The loss of so many familiar products initially created a void in the war on insect management. However, "Necessity is truly the mother of invention" in this case, and many new products with very unique modes of action are now emerging onto the market for professionals in the green industry. Also, previous to the FQPA of 1996, the Environmental Protection Agency (EPA), in 1993, defined "Reduced Risk Pesticides" as those that pose a lower risk to the environment and human health. This was coupled with incentives for the development of new products with modes of action to fit these new criteria.

Many of the newer products today tend to be rather "surgical" in their method for reducing the numbers of pest insects by targeting only the pest and for having a reduced negative effect on beneficial organisms, such as parasites and predators. As examples, some of the newer miticides will kill pest spider mites (family: Tetranychidae) but not harm predatory mites (family: Phytosiidae), while some of the new insecticides are only effective on Lepidopteran caterpillars (moth larvae) and not on other orders of insects that are incidental or perhaps beneficial. Also, the potential for these products to harm the environment, human health, or to persist in the environment are for the most part significantly different from the chemicals of years past.

Insect Growth Regulators (IGRs)

Insect Growth Regulators, commonly known as IGRs, have been around for decades but very few products have been available for the green industry until recently. These compounds work in specific ways to disrupt the normal developmental processes, often by interfering with the molting process. There are several modes of action for IGRs:

- Chitin Synthesis Inhibitors. Chitin is the major building block molecule of an insect' s exoskeleton. If an insect cannot process compounds in order to build a new exoskeleton when it is about to molt, then molting becomes lethal. Compounds like Diflubenzuron (Dimilin®) have been utilized for many years against such lepidoperan pests as gypsy moth, browntail moth, and spruce budworm. A new member with this mode of action is Cyromazine (Citiation®) and is labeled mostly for Dipteran (true flies) pests, such as fungus gnats and certain leaf miners. These compounds, while fairly specific to their labeled target pests, are also very toxic to aquatic invertebrates and great care must be taken to avoid contaminating streams, rivers, ponds, and other natural bodies of water.

- Juvenile Hormone Mimics / Inhibitors. The developmental and molting process of insects is quite complicated but all of it is strongly driven by specific hormones in their bodies. One such hormone is called "Juvenile Hormone." When high levels of this hormone are present, it informs the insect's brain that the insect is still very immature. As the insect feeds, grows, and molts (sheds an old exoskeleton) the concentration of juvenile hormone continually goes down until it reaches an almost non-existent level, which then tells the brain that the insect is now ready to molt for the last time into the adult stage. The IGR products that mimic or inhibit this physiological process trick the insect's brain into "thinking" that the insect is at a different stage of development than it actually is. The IGR compounds that inhibit juvenile hormone usually result in a very immature insect physically trying to molt into the adult stage when it is not physiologically ready, thus resulting in a lethal action for the insect. One such compound available now is Tebufenozide (Confirm®) and is labeled for lepidopteran caterpillars. It has become a valuable tool against such serious defoliators as gypsy moth, forest tent caterpillar, and the new invasive in Massachusetts and Rhode Island—the winter moth caterpillar.

- Molting Hormone Agonists / Inhibitors. Ecdysone, commonly known as "the molting hormone," is active in virtually every aspect of the molting process in insects. Novaluron (Pedestal®), which is labeled for whiteflies, thrips, armyworms, and others in the nursery and for containerized plants, works by mimicking or inhibiting this hormone in the insect's body. If an insect experiences a premature molt, or can't molt when it needs to, then death of the insect results.

Some of the overall aspects of IGRs include:

- Some can be very toxic to aquatic invertebrates and much care during mixing, application, clean-up, and disposal needs to be taken to avoid contamination of water bodies.
- IGRs attack the egg stage (ovicidal) and / or the immature stages. They are not effective against the adult stage of insect pests.
- Some may be more phytotoxic than others and pre-testing may be necessary before large-scale applications occur.
- Some have the potential to be leachers and can wind up in ground water.
- Once a pest population is exposed to these products, it usually ceases feeding within 24 hours but may not die for another 2 to 3 days.
- IGRs, in general, may be currently more expensive than other management options.

Mite Growth Regulators (MGRs)

Many new products are now available for the management of spider mites that are basically classified as "growth regulators" but they have very different modes of action than the ones for insect control. Even though it is known in general what physiological process these compounds interfere with, the exact mechanism may not always be understood. Therefore, we often see such descriptions of their modes of action as "New compounds with modes of action that are not entirely understood but they interfere with normal development." A few of the somewhat recent compounds in this category are Etoxazole (TetraSan® 5WDG), Clofentezine (Ovation®SC), Bifenazate (Floramite®), Pyridaben (Sanmite®), and Hexythiazox (Hexygon®).

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Some of these are very specific to Tetranychids (spider mites) and do not harm the Phytosiids (predatory mites) that may be on the same plant. However, some of these (such as Pyridaben) can be more toxic to predators, and this issue should be understood before application. The target stages for mite growth regulators are often the egg stage or the immatures. MGRs are not known to kill adult spider mites but in some cases they may sterilize adult female mites thus preventing them from laying viable eggs. Most of these products work best when spider mite populations are low to moderate in size. Plants that are experiencing a spider mite outbreak probably should not be treated with one of these products until the population has been significantly lowered by other means. A few of these miticides, such as TetraSan®, have translaminar attributes that aid in their success. Within this group, there is a wide range of variability in their toxicity to vertebrate organisms.

Unique Modes of Action (MOA):
Insect and mite control is now at a very exciting time, given the current wave of development and availability of new compounds. We are now, and will be more so in the near future, controlling pests in ways unimaginable just a few years ago. Frequently, another new MOA gets discovered. In addition to the above described MOAs, we currently have the following compounds either already on the market or they are just coming onto the market, for our battle against insects and mites:

- Spiromesifen (Forbid®4F). This compound is a "Lipid Synthesis Inhibitor." By preventing this necessary biological process in the insect's body, it becomes lethal. Currently, it is labeled for the control of whiteflies (nymphs and "pupae") and mites in all stages.
- Fermentation Products (Spinosad [Conserve SC®] and A vermectin). These have been around for a number of years and are now experiencing greater use. These products start out as a bacterium, but are then put through a fermentation process to obtain the end compound(s) which has insecticidal and, sometimes, miticidal properties. The EPA has designated this group as Reduced Risk Pesticides. Spinosad works very well on all types of caterpillars including sawfly larvae, leafbeetle larvae, and thrips. Its MOA "affects nicotine acetylcholinesterase receptors" and is possibly a "GABA (a neurotransmitter) inhibitor." Products in this group tend to have a low mammalian toxicity rating. However, the label for Spinosad, in particular, states that it is very toxic to foraging honeybees but this factor diminishes significantly after the spray has dried.

Plant Disease and Fungicides:
The world of plant disease (pathogen) management has also benefited recently from new products. Many of these fall into the "reduced risk" category. One of the greatest advancements has been with the development of the Strobilurin fungicides. These commercial compounds were initially derived from the fungus *Strobilurus tenacellus*. The active ingredient is Strobilurin A, which is now available as a synthetic. The presence of Strobilurin inhibits the growth of other fungi. When it is already present on a plant, and a new pathogen arrives, the Strobilurin greatly inhibits that pathogen from successfully colonizing (invading) that plant. Strobilurin fungicides can be applied as a foliar spray as well as a soil drench, in some cases. They also have translaminar capabilities. Strobilurin fungicides are labeled as being protective, curative, and

systemic; they are deemed to be "reduced risk;" and they are active against the major groups of disease-causing fungi. They are labeled for such problems as powdery mildews, scab, downy mildews, crown and root rots (*Pythium* and *Phytophthora*), *Fusarium*, leaf spots, leaf blights, and rusts. They are even being investigated for possible uses against Ramorum Blight (*Phytophthora ramorum* = "Sudden Oak Death").

As with all pesticide products, it is strongly recommended that Strobilurin products not be relied upon exclusively and that rotation with other modes of action be implemented into plant disease management programs in order to avoid the development resistance.

A very thorough article about the new fungicides, including detailed information about the Strobilurins, was written by Dr. Janna Beckerman from the University of Minnesota and appeared in the June 15, 2005 (Issue 12, Volume 201) issue of *American Nurseryman* magazine and is highly recommended reading. The article is entitled "Fairly New Fungicides."

Pesticide Products and Their Target Pests

In addition to reduced risk pesticides, conventional pesticides such as organophoshate and carbamate insecticides that work on the peripheral nervous system as cholinesterase inhibitors are still effectively used by growers today. Pesticide recommendations for pest management are available in the guide "Pesticide Recommendations for Insects, Diseases and Weeds in New England," available from the UMass Extension Bookstore (http://www.umassextensionbookstore.com).

Horticultural oils

- Oils work on soft-bodied and stationary pests, such as aphids, lacebugs (nymphs in particular), adelgids, whiteflies, scale insects (especially the crawler stage), very young caterpillars (both lepidoptera and hymenopotera), very young leaf beetle larvae, and spider mites. Oils are also effective for killing the egg stage when the individual egg can be covered by the spray.

Insecticidal Soap

- Soap works best on small and soft-bodied targets: aphids, adelgids, very young caterpillars, and spider mites. Overall, soap is probably not as effective as oil sprays. Like oils, the product must cover the pest at the time of application to be effective. Soap is not effective against the egg stage.

Fermentation Products (e.g. Spinosad)

- Fermentation products are very effective against all caterpillars of all ages (lepidoptera and hymenoptera) and against leaf beetle larvae (but not the adults). These products work well for certain piercing-sucking insects but not spider mites.

Bacillus thuringiensis Kurstaki

- This is a bacterium that specifically attacks lepidoptera caterpillars. It works best on the younger caterpillars, and does not work on hymenoptera caterpillars (sawflies).

Neonicotinoids

- These chemicals are nerve toxins but they mostly target specific nerve sites that, in certain insects, paralyze mouth muscles so the insects starve. Imidacloprid was the first labeled product in this category but now there are many others. Most of these work best against insects that have a piercing-sucking mouth type. Some of the newer products work well against certain insects with a chewing mouth type. Some (like imidacloprid) demonstrate great systemic qualities. Some others have translaminar qualities. Most are labeled for both armored and soft scales but really only show good results against soft scales and not the armored scales. However, one of the new neonicotinoids, Dinotefuran (Safari®), does work well against armored scales. Many of these products have a very long residual activity, especially those that are systemic.

Insect Growth Regulators (IGR's) and Mite Growth Regulators

- These attack the pest at a very specific part of their development and disrupt normal development. Some even target the developing embryo while still in the egg and keep it from ever developing and hatching. Most are fairly specific to an insect order OR mite family. There are 3 basic ways that these products work: Chitin Synthesis Inhibitors, Juvenille Hormone mimics OR Inhibitors, Molting Hormone mimics OR Inhibitors.

Entomopathogenic (Beneficial) Nematodes

- These need to stay wet long enough to be effective. Therefore, they work best for soil-inhabiting insects and those that live in wood but keep their tunnels open.

Nematodes get into the insect and a bacterium that they carry then starts to multiply. The nematode feeds on the bacteria. However, the bacteria produce by-products that kill the insect.

Pyrethroids

- These are nerve toxins and are the harshest and most broad-spectrum chemicals that are still mostly available. These are usually chosen when none of the above-mentioned products will work effectively. They mostly provide quick knockdown and a relatively short residual.

Why Products Fail

In the January 15, 2004 (Issue 2, Volume 199) issue of *American Nurseryman* magazine, another plant pathologist, Dr. Jim Chatfield from Ohio State University, wrote an article called "Why Fungicides Fail." His observations and recommendations within that article are highly pertinent when considering disease management. Furthermore, they also have merit for all areas of pest control, insects included, especially when the practitioner is working within the realm of IPM and Plant Health Care. The highlights from that article follow.

Why Products Fail

1) Not implementing continued observations. We all know that regular monitoring is the backbone of any IPM program. If one doesn't know what is happening in the "system" under his or her management, then that person is not truly practicing IPM.
2) Improper diagnosis. It is absolutely imperative that we know the exact problem before implementing any type of management. This is Step #1 in any pest management program. Incorrect diagnosis generally leads to improper treatment, which often results in greater problems.
3) The use of the incorrect pesticide for the problem at hand. See #2 above and then read the end

of this article for obtaining detailed information about the new pesticide products.
4) Over-reliance on pesticide products. Sprays are not always the answer, as we know. This is where our ever-increasing desire for new information plays a strong role. Using plant material that is resistant to key pests, culling out infested (infected) plants, watering properly so as not to encourage pathogen growth and to alleviate drought stress, planting the right plant in the right place to begin with, establishing aesthetic injury levels, and then only treating when necessary, are the real long-term solutions to successful, pest management that meets today's criteria.

How to Stay Current with New Products

The influx of new insecticide, miticide, and fungicide products coupled with the newer modes of action is almost overwhelming these days, even for the professional Extension entomologist whose job it is to understand and educate about such things. A couple of sources for information are outlined below and these should continue to offer tremendous benefit for those seeking information about both the older and newer products.

Kelly Solutions

http://www.kellysolutions.com/MA/pesticideindex.htm

This site gives registration status for commercial pesticide products in Massachusetts

Crop Data Management Systems, Inc

http://www.cdms.net

This site lists nearly 100 pesticide companies that produce products for the turf and ornamentals (T&O) market (as well as ag products). Users of this site can obtain specimen labels of specific products along with the Material Safety Data Sheets (MSDS) that accompany the labels.

Greenbook

http://www.greenbook.net

This site lists a phenomenal number of products and can be easily searched by company, active ingredient, and product trade name. Along with being able to obtain specimen labels and the MSDS, users can usually also access a "product summary sheet," Department of Transportation (DOT) information, mode of action sheet, state registration information, supplemental label information, as well as other valuable information about each product.

Bear in mind that pesticide labels that are provided on such sites are almost always the "Specimen Label," which means that it is the federal label as allowed by the EPA. However, another piece of federal legislation, the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) amendments of 1972, says that individual states reserve the right to make a pesticide label more strict (but not less). This means that any state has the right to prohibit uses in their state that appear on the specimen label. They can even refuse to register the product for any uses within the state even though the EPA has granted the company a label.