Classes of Pesticides Used in Landscape/Nursery Pest Management

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There are many considerations when using pesticides to manage insects and mites on nursery and landscape plants. Although efficacy is obviously central for any pesticide use, there are often special problems with development of pesticide resistance among certain pests (e.g., twospotted spider mite). Conservation of natural enemies of insect and mite pests is critical to optimizing pest management and there is very low tolerance of potential adverse effects to non-target organisms such as wildlife and pets. Perhaps most often of greatest concern is that pesticide applications often take place in areas of high human traffic and may be further complicated by special issues such as chemical trespass. Ideally, pesticides used in landscape/nursery pest management would: 1) be effective for the intended management purpose; 2) pose very low hazard to humans; 3) be compatible with natural enemies of pest insects and mites; 4) pose minimal hazard to birds, mammals and other non-target species; 5) be used in a manner that avoids drift and/or excessive environmental persistence. Pesticides that combine most of these feature are sometimes referred to as biorational pesticides.

Organophosphate Insecticides

The organophosphate insecticides have long predominated for insect control on lawns, shade trees and shrubs, and nurseries. Chlorpyrifos (Dursban), diazinon, malathion, acephate (Orthene), and dimethoate (Cygon) are common examples. Organophosphates have broad spectrum of activity against many insects, often including beneficial species. They have moderate to long environmental persistence and some have systemic activity, such as, dimethoate and acephate. All act as inhibitors of cholinesterase, used in nerve transmission of mammals as well as arthropods. Concerns about nervous system injury and, in some cases, non-target impacts on wildlife such as birds, has resulted in dramatic restriction in use of many organophosphate insecticides.

Carbamate Insecticides

Carbaryl (Sevin) is the carbamate insecticide most widely used in landscape/nursery pest management. It also has broad spectrum activity, particularly against chewing insects. Adverse effects on beneficial insects, such as, natural enemies and pollinators have been a concern. Carbamates also suppress cholinesterase in mammals, although effects are not as persistent as with organophosphates.

Pyrethroids

The pyrethroids have been the fastest growing class of insecticides over the past decade, largely supplanting organophosphates and carbamates. Pyrethroids, also known as synthetic pyrethrins, are synthetically derived. Natural pyrethrins are extracted from the pyrethrum daisy. However, synthetic pyrethroids are chemically modified to improve features, such as persistence. Examples of pyrethroids include bifenthrin (Talstar), cyfluthrin (Tempo), deltamethrin (Deltagard), fluvalinate (Mavrik), lambda-cyhalothrin (Scimitar), and permethrin (Astro). None are systemic in plants.

Pyrethroids are highly active as insecticides, typically used at rates of active ingredient a fraction of the organophosphates and carbamates. They also tend to have low toxicity to humans, other mammals and birds which further reduces many health hazards, particularly compared to organophosphates and carbamates. Environmental persistence is variable, some rapidly breaking down while others may persist for weeks or longer, particularly on protected sites such as bark. Pyrethroids tend to adhere strongly to organic matter.

Most pyrethroids have a broad spectrum of activity and are not compatible with biological controls. The extreme toxicity of many pyrethroids to fish and some aquatic organisms requires special precaution when used around water.

Neonicotinoids

The chloronicotinyls and thianicotinyls are a recently developed class that has been rapidly adopted for insect management. Like the pyrethroids, they are highly active against insects, so use rates are quite low, and mammalian toxicity is similarly low. However, perhaps their most useful feature is systemic activity, making them the first new systemic insecticides available for landscape/nursery plant protection in several decades. This property allows soil drench/injection use, a desirable application where drift is an important concern. Furthermore, persistence in plants is fairly long following soil application, considerably longer than when used as a foliar treatment. Imidacloprid (Merit, Marathon) is the first of these chloronicotinyls to be labelled; thiamethoxam (Flagship, Meridian) and acetamiprid are neonicotinyls in development.

The neonicotinoids are fairly broad spectrum, being particularly active on various Homoptera and leaf beetles. Most have little activity on caterpillars and mites and have been know to aggravate problems with the latter.

Microbial Insecticides

Some insecticides are formulations of microbes that kill insects by infection or toxic by-products. Most widely used is *Bacillus thuringiensis* (*Bt*), a naturally occurring bacterial, several strains of which have been isolated from soils in many parts of the world. Among the many different strains that have been identified, three are most widely used, each with a different specific effect. Most common is the *kurstaki* strain (Dipel, Thuricide, Foray, etc.) which affects most leaf and needle feeding caterpillars (Order: Lepidoptera). The *tenebrionis* (= *San Diego*) strain (Novodor) affects leaf beetles (Order: Coleoptera, Family: Chrysomelidae). The *israeliensis* strain (Gnatrol, Bactoimos, etc.) is used to control larval stages of mosquitoes, black flies, and fungus gnats.

Use of *Bt* has many advantages that recommend its use. Most important is that its effects are quite specific and limited to only certain susceptible insects. *Bt* is considered to be essentially non-toxic to humans, pets, and wildlife. The selectivity of *Bt* insecticides also extends to most beneficial insects, such as predators, parasites and pollinator species.

Bt insecticides act solely as stomach poisons that paralyze the insect gut. As such, they must be eaten to be effective. This limits their use against insects that tunnel into plant parts and feed little on treated surfaces. Also, younger insect stages are almost always far more susceptible to *Bt* than are older larvae and adults, so proper application timing is important. As *Bt* is quite susceptible to UV degradation, residues applied to plants often degrade within a couple of days.

Another microbe used for insect control is the fungus *Beauveria bassiana*. This fungus is widespread in nature and potentially infects many kinds of insects. Commercially available formulations (Mycotrol, Naturalis) are primarily sold for control of whiteflies and aphids. Successful infection is highly dependent on suitable environmental conditions, with sufficient moisture often being critical.

Microbial-derived Insecticides

Compounds derived from microbes, particularly various soil actinomycetes, have been recently been exploited for use as insecticides and miticides. Abamectin (Avid) was the first labelled for nursery/landscape use. Primarily developed as a miticide, abamectin also is effective against leafminers and leaf beetles. It has limited systemic activity when applied to foliage, but can act more generally through the plant as a soil or trunk injection. Toxicity to mammals is moderately high. Abamectin is potentially very hazardous to aquatic organisms.

More recently spinosad (Conserve) has been marketed. Spinosad has a somewhat different range of activity being most effective against most leaf chewing insects, flower thrips, and some gall makers. Effectiveness against spider mites is substantially less that with abamectin. However, spinosad has generally low hazard to humans and non-target organisms, including most natural enemies. Spinosad is generally considered to be a biorational pesticide.

Horticultural Oils

Certain highly refined specialty oils can be used to manage many insect pests found on trees and shrubs. Oils kill insects both by smothering (blocking their spiracles) or by some direct toxic action. They are typically applied as dilute sprays of from 1 to 4 percent concentration and must cover the insect or egg to which they are being applied. Most currently available horticultural oils have been sufficiently refined to allow use on most plants, even after leaves have emerged.

Advantages of oils are their effectiveness against many difficult to control insect pests, such as overwintering aphids on fruit trees and scale insects. Horticultural oils are low toxicity and have minimal effects on natural enemies.

Insecticidal Soaps

Recently, there has been increased interest and awareness of soaps for use as an insecticides and miticides. Control of most small, soft bodied insects and mites is possible with these treatments. This includes aphids, thrips (exposed on leaves), psyllids, scale crawlers, first instar scale nymphs, and some spider mites. Some larger insects such as plant bugs, sawfly larvae, and Japanese beetles have also been successfully controlled with these treatments.

Insecticidal soaps have several advantages for managing pests in landscapes, especailly for their safety and ease of use for an applicator. The insecticidal activity of soaps is generally specific enough so that most beneficial insects, such as parasites and predators of insects, are not adversely affected. (However, predatory mites are very susceptible to soaps.) Similarly, birds, pets, and wildlife are not injured by these procducts.

Conversely, insecticidal soaps have some important limitations that restrict their use. Several types of plants can be injured by soaps, some severely. If the safety of a soap treatment on a specific plant is not known, it should always be tested first. Soaps are also highly alkaline, so combinations with alkaline-sensitive chemicals should be avoided. Soap applications must be applied very thoroughly, since they act strictly as contact insecticides with no residual activity.

Botanical Insecticides

Plants have long been a source of insecticides and continue to be evaluated. Currently two plants in particular provide botanical products that can be useful for control of certain landscape plant pests—pyrethrum and neem.

Pyrethrum is an extract of the dried flowers of the pyrethrum daisy, *Chrysanthemum cinerarifolium*. The active ingredients contained in the plant are various compounds known as pyrethrins. Pyrethrins have a rapid “knock-down” effect on many insects and are irritating, which has caused them to be used for such purposes as wasp and hornet sprays, household aerosols or for flushing cockroaches.

Pyrethrins have very low toxicity to mammals and are rapidly broken down when exposured to light. As a result, certain pyrethrins are the only insecticides registered for use in food handling areas. Pyrethrins are widely labeled for use on most food crops as well.

Labels for pyrethrins list many insects. However, in regard to their use on shade trees and shrubs, they are probably most useful for control of exposed caterpillars, sawfly larvae, leaf beetles and leafhoppers. Their short persistence can limit effectiveness, yet it also helps minimize impacts on natural enemies.

Neem insecticides are extracted from the seeds of the neem tree, *Azadirachta indica*. This plant has long been used in Africa and southern Asia as a source of pharmaceuticals, such as wound dressings and toothpaste. More recently its ability to control insects has been developed. Products include Ornazin, AZA-Direct, and Azatin.

Neem seed extracts contain oils and a variety of compounds that can affect insect development. Most important is azadirachtin, which has various effects from inhibition of feeding, interference with molting or egg production, and disruption of hormones important in growth. Treated insects rarely show immediate symptoms, and death may be delayed a week or longer, usually occurring during a molt. Affected insects are often sluggish and feed little.

The very low toxicity and broad labelling of neem insecticides recommend its use. Furthermore, effects on beneficial species are minimal. Slow action and a limited range of susceptible insect species are the primary limitations of neem insecticides.

Insect Growth Regulators (IGR’s)

Pesticides that disrupt the growth of insects, instead of acting on insect nervous systems, are frequently discussed together as being insect growth regulators, or IGRs. Insect growth regulators affect different growth properties. For example, diflubenzuron (Dimilin) and fenoxycarb (Precision) interfere with synthesis of chitin, important in the production of the insect exoskeleton. Halofenzamide (MACH-2) and tebufenozide (Confirm) adversely accelerate insect molting. Kinoprene (Enstar II) mimics an important insect growth hormone.

Insect growth regulators tend to share many features. Most have very low hazard to vertebrates. They also tend to have selective activity among insects, often specific to one group, such as caterpillars, or one family of insects. As a result the use of insect growth regulators is often compatible with the activity of natural enemies of insect and mite pests.

Specific Miticides

Most insecticides have little or no effect on mites. Therefore specific insecticides and miticides are used for managing mites. New miticides coming to market vary greatly in chemistry and differently affect mite species. For example, bifenazate (Floramite), clofentezine (Ovation SC), and hexythiazox (Hexygon), are specific to spider mites and may have little effect on beneficial predatory mites. Other new miticides, such as pyridaben (Sanmite), are highly toxic to predatory mites. There is also a wide range in toxicity to vertebrates among the miticides.