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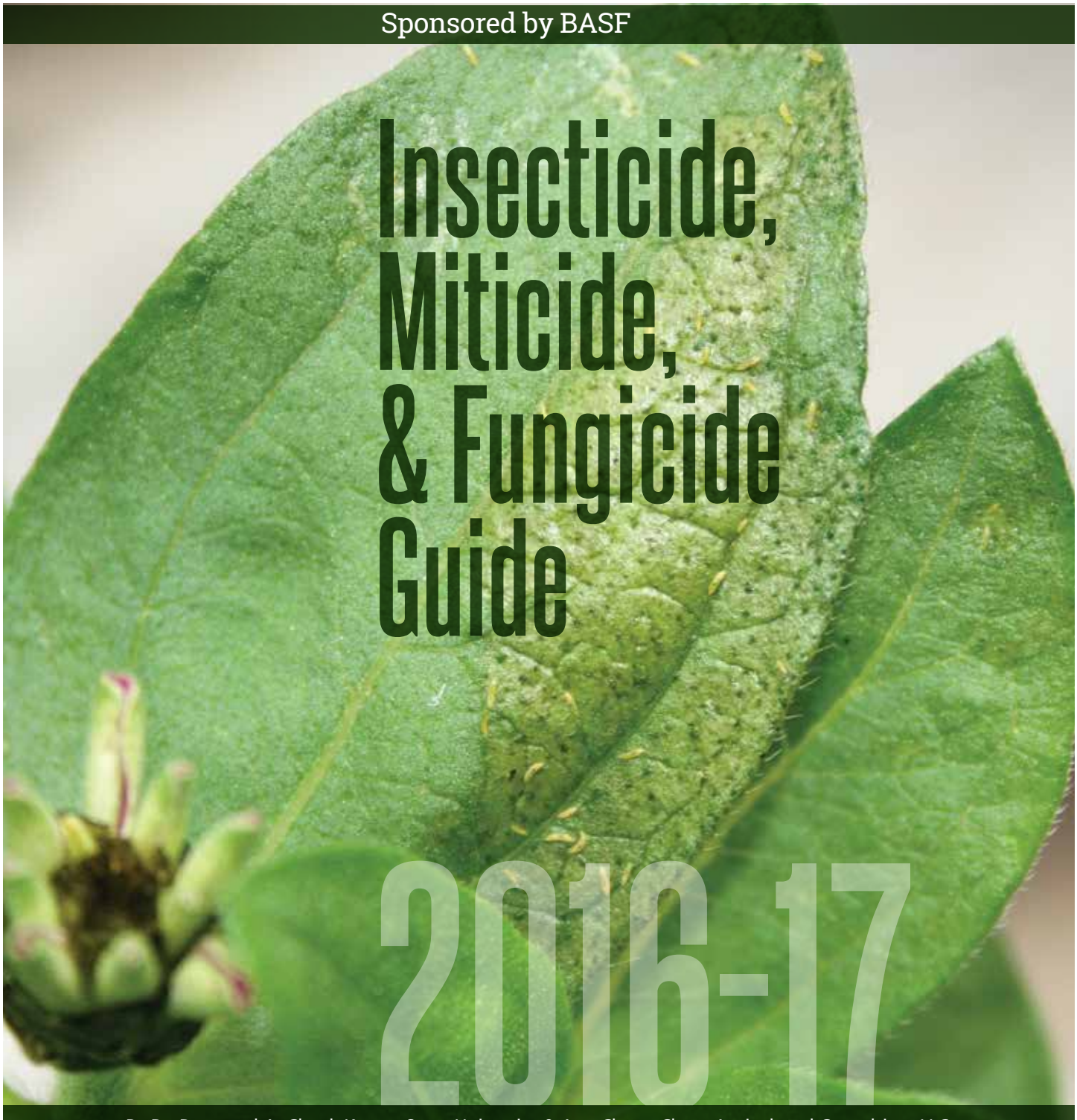

Insecticide, Miticide, & Fungicide Guide

2016-17

By Dr. Raymond A. Cloyd, Kansas State University & Ann Chase, Chase Agricultural Consulting, LLC

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GreenProfit Supplement Enclosed

Greetings!

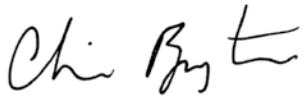
I've been in the industry since May of 1983, when my wife and I broke ground on our potted plant nursery, Indian River Ornamentals, in Merritt Island, Florida. And I've been in the publishing end of the business since 1993, when I joined Ball Publishing as managing editor of *GrowerTalks* magazine. I can assure you that, in those more than 33 years, I've never found a more popular topic among growers than pest management. Labor is big. Energy costs are big. New varieties are big. But nothing beats insects, mites, diseases and the best ways to eliminate them. That's why we invest so much time and energy into our biennial *GrowerTalks'* Insecticide, Miticide & Fungicide Guide.

But we're not the experts on the topic. That would be our co-authors, Dr. Raymond Cloyd of Kansas State University and Ann Chase of Chase Agricultural Consulting. They've put together a concise, but detailed, guide to using today's arsenal of insecticides and fungicides in your greenhouse or nursery.

Along with our comprehensive eight-page chart listing every labeled chemical for 18 of the most common insect and mite pests (page 8), our experts offer the latest on pesticide rotations (page 4), pesticide mixes (page 6), fungicide pre-mixes (page 16), a chemical class chart for ornamental fungicides (page 18) and a disease control guide for 18 tough diseases (page 22). We don't know of another place where you can have so much current pest management information at your fingertips.

We'd like to offer a special thanks to our partner, BASF, without whom guides like this wouldn't be possible. They help fund the work of researchers like Ray and Ann, and they help underwrite the publication and distribution costs of our guides, making it possible to keep you and your staff up to date and on top of your game.

May you have growing success for the rest of 2016 and beyond!



Chris Beytes, Editor
GrowerTalks/Green Profit/Acres Online

Disclaimer: These recommendations may not be appropriate for conditions in all states and may not comply with laws and regulations in every state. These recommendations were current as of September 2016. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before purchasing or applying any chemical. For assistance, contact your county Cooperative Extension Agent or pest control advisor. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by Ball Publishing.

Pesticide Rotation

Dr. Raymond A. Cloyd

Pesticide rotation is the temporal alternation of pesticides, such as insecticides and/or miticides that have different modes of action. One of the primary means of mitigating the potential for insect and mite pest populations from developing pesticide resistance, and extending the effectiveness of currently available pesticides, is to rotate pesticides with different modes of action. Mode of action or mode of activity refers to how a pesticide affects the metabolic or physiological processes in an insect or mite pest. Previously, the recommendation was to rotate pesticides based on chemical classes; however, some chemical classes have similar modes of activity, including organophosphates and carbamates. Examples of organophosphate and carbamate pesticides are acephate (Orthene) and chlorpyrifos (DuraGuard), and methiocarb (Mesurol). General recommendations include rotating different modes of action every two to three weeks or within an insect or mite pest generation in order to decrease selection pressure associated with the frequency of applying pesticides. The concept is to use one mode of action within a generation early in the crop production cycle and then switch to a different mode of action in subsequent generations.

However, the frequency of rotating pesticides with distinct modes of action may depend on the time of year and temperatures in the greenhouse because development of the life cycle (egg to adult) is contingent on temperature. In fact, higher temperatures can result in faster population growth, which can lead to simultaneous presence of overlapping generations at different life stages (eggs, larvae, nymphs, pupae and adults). The occurrence of overlapping generations can lead to increased pesticide applications, consequently, enhancing the frequency of resistance. Therefore, the ideal situation is to utilize a multitude of pesticides with different modes of action.

A potential problem associated with pesticide rotations is that insect or mite pest populations may evolve different ways to resist the same pesticide. Furthermore, if cross-resistance (which is associated with a single mechanism of resistance responsible for resistance to pesticides in similar chemical classes and/or with the same mode of action) occurs in a pest population, then rotating insecticides with different modes of action won't be effective in mitigating resistance.

The rotation of pesticides with distinct modes of action is based on the assumption that the frequency or proportion of individuals in a pest population resistant to one pesticide will be reduced when an alternative pesticide with a different mode of action is applied. Therefore, the frequency of resistant individuals declines in subsequent generations in which the initial pesticide was not applied. So, when the first pesticide is re-applied, there's a high frequency of susceptible individuals present. As such, the initial pesticide will provide effective suppression of a pest population when re-introduced into the rotation program.

Rotating pesticides with different modes of action will reduce selection pressure, as opposed to using only one pesticide, resulting in exposure of individual pests to only one mode of action during their lifetime. Moreover, rotating pesticides with different modes of action is important for preserving existing pesticide products, as well as for effectively managing insect and/or mite pest populations. However, a factor that may influence pesticide rotations is the stability of resistance, where resistance to certain pesticides may be retained in future generations despite rotating different modes of action. Therefore, rotation programs need to include a number of pesticides with different modes of action.

Another strategy is to rotate pesticides with specific modes of action with those having non-specific, multiple or broad modes of activity, such as insect growth regulators, insecticidal soaps, horticultural oils, selective feeding blockers, beneficial fungi and bacteria, and microorganisms. The use of pesticides with broad modes of activity may reduce the rate at which insect or mite pest populations develop resistance. However, be sure to rotate insect growth regulators with different modes of action since certain insect pests, including aphids and whiteflies, have developed resistance to a number of insect growth regulators.

In conclusion, always use pesticides judiciously to avoid problems with pesticide resistance by rotating pesticides with different modes of action, and more importantly, implement non-pesticidal strategies, including scouting, cultural control, sanitation, physical control and biological control.

When spraying pesticides (insecticides and miticides), be sure to rotate modes of action to avoid insect or mite pest populations developing resistance.

Use an insecticide or miticide with the same mode of action within an insect or mite pest generation before switching to another insecticide or miticide with a different mode of action.

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Always read and follow label directions.

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Pesticide Mixtures

Dr. Raymond A. Cloyd

Pesticide mixture involves combining an assortment of pesticides (in this case, insecticides and miticides) into a single spray solution. The mixture exposes individuals in a pest population to each pesticide simultaneously, which may improve pest suppression. Although there are benefits associated with pesticide mixtures, several issues should be considered in advance.

First, always read the pesticide label and understand why certain pesticides are being mixed together. Pesticide mixtures should be used that are appropriate based on the mode of action of each pesticide and developmental stage(s) of the target pest(s) for which the pesticide mixture is most effective.

For example, mixing two miticides that only have activity on the adult stage of the two-spotted spider mite *(Tetranychus urticae)* would not be appropriate because both miticides would only kill adults and have no activity on the eggs, larvae or nymphs. However, mixing a miticide with adult activity with another miticide that's active on eggs, larvae and nymphs would be better because the pesticide mixture targets all life stages of the pest.

The three factors to be aware of when mixing pesticides together are: 1) half-life; 2) persistence; and 3) mode of action. The half-life is associated with the pH of the spray solution in regards to how long it takes for the active ingredient to degrade. Always try to mix together pesticides with similar half-lives in order to avoid exposing pests to just one pesticide for any given time period.

Persistence refers to the residual activity of the pesticide following an application (e.g. short vs. long residual activity). Mix together pesticides that have similar residual activity so that pest populations are exposed to both pesticides for the same period of time.

The use of pesticide mixtures may result in synergism occurring when two different pesticides are mixed together.

Mode of action is how a pesticide affects the metabolic and/or physiological processes of an insect or mite pest. Always mix together pesticides with different modes of action in order to prevent pest populations from developing resistance to one mode of action.

One reason for mixing pesticides together is because it's less time consuming, costly and labor intensive to mix two or more pesticides and make one application as opposed to applying each pesticide separately. Another benefit of pesticide mixtures is the potential for improved pest suppression.

For instance, mixing two pesticides may result in greater kill than applying either pesticide separately, which is referred to as synergism or potentiation. Synergism is when the combined toxicity of two pesticides is greater than the sum of the toxicities of each individual pesticide. Another case is when one compound has pesticidal activity, but the other compound in the mixture has minimal, if any, activity when applied separately. Potentiation occurs when the activity of one pesticide enhances the activity of another pesticide. In this instance, both compounds have pesticidal activity and are toxic when applied separately.

Some compounds are synergists, which are adjuvants that enhance the effectiveness of the pesticide active ingredient. For example, piperonyl butoxide, or PBO, is not a pesticide, but is commonly mixed or formulated with pyrethrins [botanical pesticides derived from chrysanthemum *(Chrysanthemum cinerariaefolium)* flowers] and certain pyrethroid pesticides. Piperonyl butoxide works by blocking enzymes in the insect that detoxify the active ingredient so the pesticide still retains activity.

Furthermore, certain organophosphate pesticides (e.g. acephate and chlorpyrifos) are useful synergists for pyrethroid pesticides (e.g. bifenthrin and cyfluthrin) because they bind to particular enzymes responsible for detoxification or metabolism. This binding counteracts the ability of insect and mite pests to develop resistance, which may be the reason why pesticide manufacturers formulate pre-mixtures containing organophosphate and pyrethroid pesticides to manage insect and/or mite pests.

There are issues associated with pesticide mixtures. For instance, just as synergism improves the efficacy of pesticide mixtures, the opposite may occur when mixing two or more pesticides, consequently reducing the effectiveness of a pesticide mixture compared to separate applications of each pesticide. This is referred to as antagonism.

Moreover, applying pesticides together may not only reduce effectiveness, but may cause plant injury or phytotoxicity. Therefore, always read the labels of all pesticides that you want to mix together in order to determine if they should be mixed together. If you have any questions, then contact the pesticide manufacturer directly.

Another potential issue with pesticide mixtures is incompatibility, which is a physical condition that prevents pesticides from mixing properly in a spray solution, thus reducing effectiveness or increasing the potential for plant injury or phytotoxicity. Incompatibility may be due to a number of factors, including chemical or physical nature of the pesticide(s), water impurities, water temperature or formulation types mixed together.

In order to determine incompatibility between two (or more) pesticides, conduct a jar test that involves collecting a sample of the spray solution into a separate empty container and allowing the solution to remain still for about 15 minutes. If the pesticides are not compatible, there will be a noticeable separation, layering, or flakes or crystals will form. However, if the pesticides are compatible, then the solution will appear homogeneous or look like milk. Regardless, this procedure only assesses compatibility or incompatibility, not synergism or antagonism.

New plant varieties or cultivars are continually being introduced into the marketplace. Nonetheless, these new varieties or cultivars may differ in their response to pesticide mixtures. Therefore, in order to avoid problems associated with plant injury or phytotoxicity, always test a pesticide mixture by making applications to about 10 plants before exposing the entire crop to the pesticide mixture. If no plant injury or phytotoxicity is apparent, then the pesticide mixture can be applied to the whole crop.

Some commercially available pesticide products, like Sirocco, are formulated as pre-mixtures containing two different active ingredients with distinct modes of action, which provides broad-spectrum activity against many different insect and mite pests.

The issue regarding pesticide mixtures and resistance is still not well-understood, although applying two or more pesticides at different time intervals may offer similar advantages in pest suppression as a pesticide mixture. However, using pesticide mixtures to mitigate resistance development may not be appropriate because each individual pest in the population may not be exposed to a lethal dose of each pesticide.

The mixing of pesticides with different modes of action might delay resistance within a given pest population because individuals in the pest population are unable to develop resistance to several modes of action simultaneously. Furthermore, individuals in the pest population that are resistant to one or more pesticides would likely succumb to the other pesticide in the mixture. Nonetheless, using pesticide mixtures to mitigate resistance will only be effective if there's no cross resistance, which is based on a single mechanism of resistance responsible for resistance to pesticides in the same chemical class and/or with similar modes of action.

Some commercially available pesticide products are formulated as pre-mixtures, including Sirocco (bifenazate + abamectin), XXpire (spinetoram + sulfoxaflor) and Discus (cyfluthrin + imidacloprid). These products contain two different active ingredients with distinct modes of action and provide a broad-spectrum of activity against many different insect and mite pests.

Pesticide mixtures have advantages and limitations. Growers mix pesticides such as insecticides, miticides and fungicides together in order to reduce labor costs affiliated with multiple spray applications and to improve suppression of insect and mite pests. However, always exercise caution or avoid using pesticide mixtures altogether to prevent problems associated with antagonism, incompatibility, phytotoxicity and resistance. GT

2016 Pest Control Materials for Managing Insect and Mite Pests of Greenhouse-grown Horticultural Crops

Raymond A. Cloyd
Department of Entomology
Kansas State University

Greenhouse pest management/plant protection involves using a multitude of strategies in order to minimize the prospect of dealing with arthropod pest (insect and mite) populations. The use of pest control materials (insecticides and miticides) is one component of a pest management/plant protection program, which also includes pest identification and monitoring along with cultural, physical, and biological control. Proper stewardship of pest control materials involves resistance management by rotating products with different modes of action. The Insecticide Resistance Action Committee (IRAC) has developed a grouping, based on mode of action, to facilitate the implementation of appropriate rotation programs. Pest control materials have been assigned a designated number (sometimes number and letter combinations) associated with their mode of action. For more information, consult the IRAC website (www.irac.online.org). The information presented in this chart is not a substitute for the label. Always read and understand all information presented on the label before using any pest control material. Be sure to check county and state regulations to determine if there are any local restrictions associated with the use of specific pest control materials listed in this chart.

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
APHIDS	Abamectin	Avid	12 hours	GABA[1] chloride channel activator (6)
	Acephate	**Orthene**/Precise	24/12 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Beauveria bassiana	BotaniGard/Naturalis	4 hours	
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Isaria fumosoroseus	NoFly/Preferal	4 hours	
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Methiocarb	Mesurol	24 hours	Acetylcholine esterase inhibitor (1A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pymetrozine	Endeavor	12 hours	Selective feeding blocker (9B)
	Pyrethrins	**Pyreth-It/Pyrethrum**	12 hours	Prolong opening of sodium channels (3A)
	Pyrifluquinazon	Rycar	12 hours	Unknown mode of action
	Spinetoram + sulfoxaflor	XXpire	12 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator + nicotinic acetylcholine receptor disruptor (5 + 4C)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
BROAD MITE	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Fenpyroximate	Akari	12 hours	Mitochondria electron transport inhibitor (21A)
	Pyridaben	Sanmite	12 hours	Mitochondria electron transport inhibitor (21A)
	Spiromesifen	Judo	12 hours	Lipid biosynthesis inhibitor (23)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
CATERPILLARS	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Bacillus thuringiensis subsp. *kurstaki*	Dipel	4 hours	Midgut membrane disruptor (11)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyrethrins	**Pyreth-It/Pyrethrum**	12 hours	Prolong opening of sodium channels (3A)
	Pyridalyl	Overture	12 hours	Unknown mode of action
	Methoxyfenozide	Intrepid	4 hours	Ecdysone agonist: mimics action of molting hormone (18)
	Novaluron	Pedestal	12 hours	Chitin synthesis inhibitor (15)
	Spinetoram + sulfoxaflor	XXpire	12 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator + nicotinic acetylcholine receptor disruptor (5 + 4C)
	Spinosad	Conserve	4 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator (5)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)
CYCLAMEN MITE	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Fenpyroximate	Akari	12 hours	Mitochondria electron transport inhibitor (21A)
	Spiromesifen	Judo	12 hours	Lipid biosynthesis inhibitor (23)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
FUNGUS GNAT LARVAE	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
▼	*Bacillus thuringiensis* subsp. *israelensis*	Gnatrol	4 hours	Midgut membrane disruptor (11)

(Pest control materials in **bold typeface** are from BASF.)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
FUNGUS GNAT LARVAE continued	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Cyromazine	Citation	12 hours	Chitin synthesis inhibitor (17)
	Diflubenzuron	Adept	12 hours	Chitin synthesis inhibitor (15)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Pyriproxyfen	Distance/Fulcrum	12 hours	Juvenile hormone mimic (7C)
	Steinernema feltiae	**Nemasys**, NemaShield, Scanmask, and Entonem		
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
FUNGUS GNAT ADULTS	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
LEAFHOPPERS	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Beauveria bassiana	BotaniGard/Naturalis	4 hours	
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Buprofezin	Talus	12 hours	Chitin synthesis inhibitor (16)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Isaria fumosoroseus	NoFly	4 hours	
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyrethrins	**Pyreth-It/Pyrethrum**	12 hours	Prolong opening of sodium channels (3A)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
LEAFMINERS	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Acephate	**Orthene**/Precise	24 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin + Imidacloprid	Discus	4 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Cyromazine	Citation	12 hours	Chitin synthesis inhibitor (17)
	Diflubenzuron	Adept	12 hours	Chitin synthesis inhibitor (15)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Isaria fumosorosea	Preferal	4 hours	
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Novaluron	Pedestal	12 hours	Chitin synthesis inhibitor (15)
	Spinosad	Conserve	4 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator (5)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
MEALYBUGS	Acephate	**Orthene**/Precise	24/12 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Beauveria bassiana	BotaniGard/Naturalis	4 hours	
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Buprofezin	Talus	12 hours	Chitin synthesis inhibitor (16)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
▼	*Isaria fumosoroseus*	NoFly/Preferal	4 hours	

(Pest control materials in **bold typeface** are from BASF.)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
MEALYBUGS continued	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyrifluquinazon	Rycar	12 hours	Unknown mode of action
	Spineotram + sulfoxaflor	XXpire		Nicotinic acetylcholine receptor agonist and GABA chloride channel activator + nicotinic acetylcholine receptor disruptor (5 + 4C)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)
PLANT BUGS	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
SCALES (HARD AND SOFT)[a]	Acephate	**Orthene**/Precise	24/12 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (4A)
	Buprofezin	Talus	12 hours	Chitin synthesis inhibitor (16)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)
	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyriproxyfen	Distance/Fulcrum	12 hours	Juvenile hormone mimic (7C)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)
SHORE FLY LARVAE	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Cyromazine	Citation	12 hours	Chitin synthesis inhibitor (17)
	Diflubenzuron	Adept	12 hours	Chitin synthesis inhibitor (15)
	Pyriproxyfen	Distance/Fulcrum	12 hours	Juvenile hormone mimic (7C)
	Spinosad	Conserve	4 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator (5)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
SLUG AND SNAIL	Iron phosphate	Sluggo	0 hours	Inhibits calcium metabolism
	Metaldehyde	Deadline	Refer to Label	Central nervous system toxin
	Methiocarb	Mesurol	24 hours	Acetylcholine esterase inhibitor (1A)
SPIDER MITE (TWOSPOTTED)	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Acequinocyl	Shuttle	12 hours	Mitochondria electron transport inhibitor (20B)
	Bifenazate	Floramite	4 hours	Mitochondria electron transport inhibitor (20D)
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Clofentezine	Ovation	12 hours	Growth and embryogenesis inhibitor (10A)
	Cyflumetofen	**Sultan**	12 hours	Mitochondria electron transport inhibitor (25)
	Etoxazole	TetraSan	12 hours	Chitin synthesis inhibitor (10B)
	Fenazaquin	Magus	12 hours	Mitochondria electron transport inhibitor (21A)
	Fenbutatin-oxide (Hexakis)	ProMite	48 hours	Oxidative phosphorylation inhibitor (12B)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
	Fenpyroximate	Akari	12 hours	Mitochondria electron transport inhibitor (21A)
	Hexythiazox	Hexygon	12 hours	Growth and embryogenesis inhibitor (10A)
	Isaria fumosorosea	Preferal	4 hours	
	Metarhizium anisopliae	Met52	4 hours	
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyridaben	Sanmite	12 hours	Mitochondria electron transport inhibitor (21A)
	Spiromesifen	Judo	12 hours	Lipid biosynthesis inhibitor (23)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
THRIPS	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Acephate	**Orthene**/Precise	24/12 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Beauveria bassiana	BotaniGard/Naturalis	4 hours	
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Chlorfenapyr	**Pylon**	12 hours	Oxidative phosphorylation uncoupler (13)
	Chlorpyrifos	**DuraGuard**	24 hours	Acetylcholine esterase inhibitor (1B)
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
▼	Cyfluthrin + Imidacloprid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)

(Pest control materials in **bold typeface** are from BASF.)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
THRIPS continued	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)
	Isaria fumosoroseus	NoFly/Preferal	4 hours	
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Metarhizium anisopliae	Met52	4 hours	
	Methiocarb	Mesurol	24 hours	Acetylcholine esterase inhibitor (1A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Novaluron	Pedestal	12 hours	Chitin synthesis inhibitor (15)
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pyrethrins	**Pyreth-It/Pyrethrum**	12 hours	Prolong opening of sodium channels (3A)
	Pyridalyl	Overture	12 hours	Unknown mode of action
	Spinetoram + sulfoxaflor	XXpire	12 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator + nicotinic acetylcholine receptor disruptor (5 + 4C)
	Spinosad	Conserve	4 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator (5)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)
WHITEFLIES	Abamectin	Avid	12 hours	GABA chloride channel activator (6)
	Acephate	**Orthene**/Precise	24/12 hours	Acetylcholine esterase inhibitor (1B)
	Acetamiprid	TriStar	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Azadirachtin	Azatin/Ornazin/Molt-X/Azatrol[2]	4/12/4/4 hours	Ecdysone antagonist: inhibits action of molting hormone
	Beauveria bassiana	BotaniGard/Naturalis	4 hours	
	Bifenthrin	**Attain**/Talstar	12 hours	Prolong opening of sodium channels (3A)
	Bifenazate + Abamectin	Sirocco	12 hours	Mitochondria electron transport inhibitor + GABA chloride channel activator (20D + 6)
	Buprofezin	Talus	12 hours	Chitin synthesis inhibitor (16)
	Clarified hydrophobic extract of neem oil	Triact	4 hours	Suffocation or membrane disruptor
	Cyantraniliprole	Mainspring	4 hours	Selective activation of ryanodine receptors (28)
	Cyfluthrin	Decathlon	12 hours	Prolong opening of sodium channels (3A)
	Cyfluthrin + Imidaclorpid	Discus	12 hours	Prolong opening of sodium channels + nicotinic acetylcholine receptor disruptor (3A + 4A)
	Diflubenzuron	Adept	12 hours	Chitin synthesis inhibitor (15)
	Dinotefuran	Safari	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Fenazaquin	Magus	12 hours	Mitochondria electron transport inhibitor (21A)
	Fenoxycarb	**Preclude**	12 hours	Juvenile hormone mimic (7B)
	Fenpropathrin	**Tame**	24 hours	Prolong opening of sodium channels (3A)
▼	Flonicamid	Aria	12 hours	Selective feeding blocker/blocks action of potassium channels (9C)

Insect or Mite Pest	Pest Control Material Common Name	Pest Control Material Trade Name(s)	Restricted Entry Interval (REI)	Mode of Action (IRAC Mode of Action Classification)
WHITEFLIES continued	Imidacloprid	Marathon/Benefit/Mantra	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Isaria fumosoroseus	NoFly/Preferal	4 hours	
	Kinoprene	Enstar	4 hours	Juvenile hormone mimic (7A)
	Mineral oil	**Ultra-Pure Oil**/SuffOil-X	4 hours	Suffocation or membrane disruptor
	Novaluron	Pedestal	12 hours	Chitin synthesis inhibitor (15)
	Potassium salts of fatty acids	M-Pede	12 hours	Desiccation or membrane disruptor
	Pymetrozine	Endeavor	12 hours	Selective feeding blocker (9B)
	Pyrethrins	**Pyreth-It/Pyrethrum**	12 hours	Prolong opening of sodium channels (3A)
	Pyridaben	Sanmite	12 hours	Mitochondria electron transport inhibitor (21A)
	Pyrifluquinazon	Rycar	12 hours	Unknown mode of action
	Pyriproxyfen	Distance/Fulcrum	12 hours	Juvenile hormone mimic (7C)
	Spinetoram + sulfoxaflor	XXpire	12 hours	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator + nicotinic acetylcholine receptor disruptor (5 + 4C)
	Spiromesifen	Judo	12 hours	Lipid biosynthesis inhibitor (23)
	Spirotetramat	Kontos	24 hours	Lipid biosynthesis inhibitor (23)
	Tau-fluvalinate	Mavrik	12 hours	Prolong opening of sodium channels (3A)
	Thiamethoxam	Flagship	12 hours	Nicotinic acetylcholine receptor disruptor (4A)
	Tolfenpyrad	Hachi-Hachi	12 hours	Mitochondria electron transport inhibitor (21A)

[a] Refer to label for specific scale species.
[1] GABA=Gamma-aminobutyric acid.
[2] Additional azadirachtin products include the following: AzaGuard, Aza-Direct, and AzaSol.

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Why Tank-mix When You Can Pre-mix?

A. R. Chase

Since I started working at the University of Florida in 1979, tank-mixing has been a fact of life. I have a natural aversion to it because of being exposed to growers who mixed insecticides, miticides, fertilizer, minor elements, fungicides and bactericides (and adjuvants) all together to save labor costs. They sometimes got control, but other times had poor control or even phytotoxicity. Trying to figure out what went wrong when six or more products have been tank-mixed is a nightmare, to say the least.

Combining products for an application will continue to be common in ornamental production to save labor costs, meet REI concerns and especially to be able to cover your entire operation in a timely manner. For disease prevention and control, the choice of using pre-mixes (commercial blend of two active ingredients) versus creating your own through tank-mixing is a critical decision. Over the past 10 to 15 years, more pre-mixes have been introduced with a range of goals. Certainly, choosing a fungicide pre-mix to cover your bases has always been desirable as evidenced by early pre-mix products products like Banrot, which combined thiophanate methyl and etridiazole for control of most soil-borne fungi that caused root and crown rot.

Use of pre-mix fungicides can be driven by a variety of "efficacy" goals, including resistance management, ease of use, cost effectiveness and breadth of activity. Using a pre-mix will give you the security of knowing that the two products are chemically suited to work together, and in some cases, both are effective on the target disease.

Table 1 shows some of the pre-mixes available to ornamental producers. I've included the FRAC groups to demonstrate why some pre-mixes are additive and others aide in resistance management.

Positive aspects include:

1. Diagnosis is less critical
2. Mixed infections are covered
3. Plant safety is known
4. Resistance management
5. Improved efficacy
6. Fewer products on the shelf
7. Can be more cost effective

If you don't have time for a lab diagnosis of a problem (and most of you don't), use of a pre-mix that covers the most common disease possibilities would allow more timely control. This should be treated as the first step with sending an untreated sample to a lab of your choice. It's always better to obtain a diagnosis since not all problems are due to bacteria or fungi. Viruses, phytotoxicity, nutritional imbalance and temperature extremes will not be cured by a fungicide whether it's a pre-mix or not.

In the same vein, there are often mixed infections of two or more fungi causing a disease. This is especially common in root diseases, but sometimes leaf damage is caused by more than one fungus or bacterium. If you apply a pre-mix with the right combination of active ingredients, you'll control both problems with a single application.

After you obtain a diagnosis, you can fine tune your next application to target the culprit. Since application of more than one fungicide at a time is common, using a pre-mix will give you the security of knowing that the two products are

Table 1. Some pre-mix fungicides for ornamentals.

Fungicide	Manufacturer	Components (FRAC group)	Nature of pre-mix	Key targets
Banrot 40WP	Scotts Company	Thiophanate methyl (1) etridiazole (14)	additive	soil-borne pathogens
Clevis	Harrells	Myclobutanil (3) mancozeb (M3)	additive/resistance management	foliar diseases
Concert II	Syngenta	Chlorothalonil (M5) propiconazole (3)	additive/resistance management	foliar diseases (except bacteria and downy mildew)
Junction	SePRO	Copper hydroxide (M1) mancozeb (M3)	resistance management	fungal/bacterial foliar diseases
Mural	Syngenta	Azoxystrobin (11) benzouinidiflupyr (7)	additive/resistance management	foliar, crown and soil-borne fungal diseases
Orkestra Intrinsic	BASF Corp.	Pyraclostrobin (11) fluxapyroxad (7)	additive/resistance management	foliar, crown and soil-borne fungal diseases
Orvego	BASF Corp.	Dimethomorph (40) ametoctradin (45)	resistance management	downy mildew, Phytophthora
Pageant Intrinsic	BASF Corp.	Pyraclostrobin (11) boscalid (7)	additive/resistance management	foliar and crown fungal diseases
Palladium	Syngenta	Fludioxonil (12) cyprodinil (4)	additive/resistance management	foliar diseases (except bacteria and downy mildew)
RootShield Plus	BioWorks	*Trichoderma harzianum* T-22 (nc) *T. virens* G41 (nc)	additive	soil-borne fungal diseases
Spectro 90WDG	NuFarm	Chlorothalonil (M5) thiophanate methyl (1)	additive/resistance management	foliar fungal diseases
Strike Plus	OHP	Trifloxystrobin (11) triadimefon (3)	additive/resistance management	foliar and crown fungal diseases

chemically suited to work together. Making your own mixtures has the drawback of possible phytotoxicity and only your experience can determine safety of the mixture under your conditions.

One of the most important aspects of pre-mixes is that if the correct partners are chosen, they're excellent for resistance management. The only requirement is that both active ingredients target the pathogen. For instance, both copper and mancozeb in the pre-mix Junction work on bacteria like Pseudomonas and Xanthomonas. The newest premixes—Mural and Orkestra—can work to broaden the target list by being additive and controlling a wider range of pathogens. They also can work in resistance management since many of the listed on their labels can be controlled by both active ingredients. One thing to remember, however is that you cannot rotate between the two products since each one contains an active ingredient in FRAC 7 and one in FRAC 11. Thus, rotating between them would not be an effective practice for resistance management.

Finally, stocking pre-mixes is an attractive solution to the confusion that can occur by having every fungicide and bactericide that's labeled on ornamentals. It will, obviously, also be much more cost effective, especially for the smaller producer who might not use large quantities of these products.

Negative aspects include:

1. Specific ratio of the two active ingredients may not be ideal
2. Specific active ingredients may not be ideal
3. False sense of security—"covering all bases"
4. Cost may be higher (or lower sometimes)
5. REI is based on the longest time


Impatiens with downy mildew and pseudomonas.


Zinnia with Alternaria and Xanthomonas.

One of the concerns I heard in 1980 about Banrot was that the manufacturer had mixed them in the wrong ratio for the most common foliage plant diseases. This led to foliage growers making their own combinations, which is always an option … if you know what you're doing. In this case, expert advice was available from the University of Florida plant pathologist Dr. Jim Knauss, who'd researched the topic extensively and made the recommendation.

If what you really want is the best product for a specific combination of diseases, you may not be able to find a pre-mix already created. Once again, you'll be making your own tank-mix to do your best to manage disease losses and pesticide costs.

Over the years, I've often spoken to growers who use pre-mixes preventatively and then forget that they all run out eventually. With crops like bedding plants with a short production time, this may not be common. However, longer production times of herbaceous ornamentals, woody ornamentals, and cut foliage and flowers makes knowing what you're doing with re-treatment mandatory.

Finally, if you always use a pre-mix and you only need one of the active ingredients, you'll be wasting your money and sometimes subjecting yourself to a longer REI than a product with only one active ingredient might demand.

Conclusions

Pre-mixes save time and allow the user to be less involved in your disease management. In the case of pre-mixes, you're making use of outside expertise, and in the case of tank-mixing, you're becoming the expert. Both are valid and effective ways to approach disease management in ornamental production. GT

Chemical Class Chart for Ornamental Fungicides

FRAC group	Chemical Class	Active Ingredient common name	Trade Name
1	Methyl Benzimidazole Carbamates (Thiophanates)	thiophanate-methyl	AllBan Flo, Banrot*, 3336, ConSyst*, OHP 6672, Spectro 90*, SysTec 1998, T-Storm, TM 4.5, TM/C*, 26/36*, Zyban*
2	Dicarboximides	iprodione	Chipco 26019, Lesco 18 Plus, OHP 26GT-O, 26/36*
3	Demethylation Inhibitors (imidazole, pyrimidine, triazole)	fenarimol	Rubigan AS, Rubigan EC
		metconazole	Tourney
		myclobutanil	Clevis*, Eagle, MANhandle*, Systhane
		propiconazole	Banner MAXX, Concert II*
		tebuconazole	Torque
		triadimefon	Strike 50, Strike Plus
		triflumizole	Terraguard
		triticonazole	**Trinity**, **Trinity TR**
4	Phenylamides	mefenoxam	Subdue GR, Subdue MAXX
5	Amines "Morpholines" (Piperadines)	piperalin	Pipron
7	Succinate dehydrogenase inhibitors - SDHI (Pyridine carboxamides, phenyl-benzamides, pyrazole-4-carboxamides)	benzovindiflupyr	Mural*
		boscalid	**Pageant Intrinsic***
		flutolanil	Contrast 70WSP, ProStar 70WG
		fluxapyroxad	**Orkestra Intrinsic** *
9	Anilinopyrimidines	cyprodinil	Palladium*
11	QoI-fungicides (strobilurins)	azoxystrobin	Heritage, Mural*
		fluoxastrobin	Disarm
		pyraclostrobin	**Pageant Intrinsic***, **Empress**, **Orkestra Intrinsic***
		trifloxystrobin	Compass
	Imidazolinone	fenamidone	Fenstop
12	Phenylpyrroles	fludioxonil	Medallion WDG, Palladium*
14	Aromatic Hydrocarbons (chlorophenyl)	dicloran	Botran
		pentachloronitrobenzene (PCNB)	Terraclor
	Thiadiazole	etridiazole	Banrot*, Terrazole, Terrazole CA, Truban
17	Hydroxyanalide	fenhexamide	Decree
19	Polyoxins	polyoxin - D	Affirm WDG
21	Quinone inside inhibitors (Cyano-imidazole)	cyazofamid	Segway O
28	Carbamate	propamocarb	Banol
33	Phosphonates	fosetyl-Al	Aliette
		phosphorous acid, potassium phosphite	Alude, Biophos, Fosphite, Reliant, Vital
40	Carboxylic Acid Amines (cinnamic acid amides, mandelic acid amides)	dimethomorph	**Stature SC**, **Orvego***
		mandipropamid	Micora
43	Benzamides (Pyridinemethyl-benzamides)	fluopicolide	Adorn
44	Microbials	Bacillus amyloliquifaciens (D747)	Triathlon BA
44	Microbials	Bacillus subtilis (QST 713)	Cease, Companion
		Bacillus subtilis (MBI600)	Subtilex NG
45	Quinone x Inhibitor	ametoctradin	**Orvego***
M1 (multi-site)	Inorganics	copper salts	Camelot O, Champion, Copper-Count N, CuPro 5000, Cuproxat, Junction*, Nordox, Nu-Cop, Phyton 27, Phyton 35
M3 (multi-site)	Dithiocarbamate	mancozeb	Clevis*, Dithane, Fore, Junction*, Pentathlon, Protect, Zyban*

Chemical Class Chart for Ornamental Fungicides

FRAC group	Chemical Class	Active Ingredient common name	Trade Name
M5 (multi-site)	Chloronitriles	chlorothalonil	Clevis*, ConSyst*, Concert II*, Daconil Ultrex, Daconil
			Weatherstik, Echo, Exotherm Termil, Manicure 6FL, Spectro 90*, TM/C*
P5	plant extract	complex mixture, ethanol extract	Regalia
U15	piperidinyl-thiazole-isoxazolines	oxathiapiprolin	Segovis
Not Classified	Microbial/Biopesticides	Gliocladium catenulatum (J1446)	PreStop
		Streptomyces griseoviridis	Mycostop
		Streptomyces lydicus (strain WYEC 108)	Actinovate SP
		Trichoderma harzianum Rifai strain	Rootshield
		Trichoderma harzianum T22, Trichoderma virens G41	RootShield Plus*
Not Classified	Inorganic Protectants	botanical extract	Neem Oil
		hydrogen dioxide	Zerotol
		hydrogen peroxide	X3, Xeroton
		potassium bicarbonate	Armicarb 100, Kaligreen, MilStop
		quaternary ammoniums	KleenGrow

* Indicates a product that contains more than one active ingredient in a pre-pack mixture.

Rust and anthracnose on dianella.

(Pest control materials in **bold typeface** are from BASF.)

Fungicide Rotation Programs

A. R. Chase

Most of the time when we think about rotating fungicides, we're thinking resistance management. This is the main reason to do rotation most of the time, but it can also be a great tool to manage costs and minimize negative effects like residue, long re-entry intervals and phytotoxicity.

Many of our newest products are actually premixes. Two of the most recent are Orkestra (BASF) and Mural (Syngenta). Orkestra is a combination of two active ingredients in separate FRAC (mode of action groups; 11-pyraclostrobin and 7-fluxapyroxad) and Mural is a combination of the same two FRAC groups (11-azoxystrobin and 7-benzovindiflupyr).

Philosophically, I don't think broad scale spraying with tank mixes of everything but the kitchen sink is an acceptable means of producing a sustainable plant product. This approach inevitably stresses the plant, leaves a lot of residue, can be costly and, of course, doesn't target the real problem, except by accident. Not all crops need fungicides, especially if they're grown using at least some cultural tools to minimize disease. In this article, I'll cover a few issues that should be considered before addressing which products make good rotation partners for specific crops or diseases.

IPM comes first

The most important control method is to do everything in your power to reduce disease pressure—practice IPM. If you do nothing but spray fungicides, you're placing too much strain on them and they certainly are more likely to fail. Even the best fungicides work poorly if the cultural and environmental controls of IPM are ignored.

Diagnosis

Few growers (or even plant pathologists) accurately identify all diseases by sight. Guessing usually leads to crop damage due to use of ineffective products from either phytotoxicity or additional disease damage. You cannot simply pick a product and hope for the best … well, you can, but the results are usually pitiful. Choosing the most effective fungicide gives the best results with less cost in the long run since re-treatment is minimal.

Prevention

Downy mildew and some bacterial diseases aren't easily controlled unless preventative applications are made. Fungicide manufacturers really do know how to use their products effectively. Learn more about important diseases of your crops so you can find their Achilles heel. For example—Botrytis can be controlled without any fungicides if humidity and temperature are firmly under your control, which is possible in some greenhouses.

Fungicide resistance management

Most studies have shown that either tank-mixing and rotation are effective for resistance management in fungal pathogens. I prefer rotation over tank-mixing because it can be less costly, more effective and teach you to be a better grower. Using only two products (in different FRAC groups) in an alternating routine can go a long way to avoiding resistance development. Rotation also allows you to figure out what happened in case of failure or phytotoxicity. In tank-mix situations, one never really knows which product or even if the combination was responsible for the reaction.

Effective rotations

The first thing I consider in building an effective rotation is efficacy and the second is FRAC grouping. I also try not to include products that have significant residue and/or phytotoxicity concerns. I always consider the entire range of possibilities regardless of when they were introduced.

Alternaria Fungicide Rotation: Alternaria leaf spot can be controlled with many different fungicides. Some of the oldest fungicides, including chlorothalonil and mancozeb, can give excellent control of Alternaria leaf spot, but both leave residue that's unacceptable sometimes. The most effective products in our trials have been strobilurins (11 – like Heritage or Pageant Intrinsic), fludioxinil (12 - Palladium) and iprodione (2 – Chipco 26019). Thus, you could choose a rotation of Heritage and Palladium, or Chipco 26019 and Pageant Intrinsic.

Bacterial Leaf Spot Rotation: This is, unfortunately, a simple answer since very few products work well on bacterial diseases. If you have Xanthomonas or Pseudomonas, you can alternate a copper-containing product (M1 – like Camelot O or CuPro) with one containing streptomycin sulfate (antibiotic – like AgriStrep) or *Bacillus subtilis* (biological agent - Cease or Triathlon BA). You could also choose to add the quaternary ammonium product KleenGrow, which can give excellent bacterial leaf spot control alone or in combination with copper.

If you have Erwinia soft rot or fire blight *(Erwinia amylovora)*, streptomycin works best and can be alternated with a copper. Once again, KleenGrow has been very effective on Erwinia diseases (alone or with another bactericide). Triathlon BA and Cease are most effective on Pseudomonas and Xanthomonas, but shouldn't be mixed with KleenGrow, as it can kill these biofungicides in a tank-mix.

Botrytis Fungicide Rotation: Resistance is very common in Botrytis populations and has been reported to be with chlorothalonil (M5 – Daconil Ultrex), iprodione (2 – Chipco 26019) and, very recently, fenhexamid (17 - Decree). The most effective rotation would encompass as many FRAC groups as possible and, therefore, I suggest alternating Pageant Intrinsic or Orkestra (7 and 11) and Palladium (9 and 12). You can also successfully use any two of the following in rotation: chlorothalonil, iprodione, fenhexamid and fludioxinil (12 – Medallion).

Other fungicides may be helpful at times, but these are the best. Chlorothalonil does often cause slight damage to open flowers, so depending on the stage of the crop, you may want to phase it out near finishing.

Colletotrichum Fungicide Rotation: Anthracnose caused by *Colletotrichum* spp. can be controlled effectively with copper (M1-like Phyton 27), mancozeb (M3 – residue issues), chlorothalonil (M5 – residue issues) and, finally, Pageant Intrinsic (com-

bination of FRAC groups 7 and 11). Using a rotation of Phyton 27 (only when the sprays can dry quickly or copper burn can happen) with Pageant should give good control of anthracnose diseases without excessive residue.

Downy Mildew Fungicide Rotation: There are really quite a lot of very effective products for prevention of downy mildew and also some that are pretty effective in a curative manner. Three very effective newer products include Segovis (U15), Adorn (43 – must be tank-mixed according to label directions) and Segway O (21). Up until recently, the best curative effect has been with Subdue MAXX (4 – must be tank-mixed for this use), phosphonates (33 - like Aliette) and Micora, Orvego or Stature (40). With the introduction of Segovis, we're seeing excellent curative action, as well as very long-term prevention. Resist the temptation to rotate between more than three FRAC groups!

Fusarium or Cylindrocladium Fungicide Rotation: These are two of the toughest pathogen to control. I'm getting closer and closer to recommending a dumpster for plants infected with Fusarium or Cylindrocladium. However, the best products include strobilurins (11 - like Heritage), triflumizole (3 - Terraguard) and fludioxinil (12 - Medallion). Don't expect miracles with Fusarium control.

Phytophthora Fungicide Rotation: The best products for Phytophthora are roughly the same as the best ones for downy mildew. Segovis (U15), Stature, Orvego or Micora (40), Adorn (43 – must be tank-mixed according to label directions), FenStop (11 – not a strobilurin, but same FRAC grouping), Segway (21) and phosphonates (33 - like Aliette) are each very good. Pick any two (or three) of them in different FRAC groups and rotate, being sure to follow labels directions concerning rates, intervals and tank-mixing.

Powdery Mildew Fungicide Rotation: There's rather a long list of products for powdery mildew prevention and eradication. The best powdery mildew fungicides usually fall into the strobilurin (11) or sterol inhibitor (3) groups. Copper products (M1 – like Phyton 27 and Camelot) can be very effective with minimal residue. Myclobutanil (3 - Hoist) tends to have the lowest PGR activity of the sterol inhibitors. Some of the "green" products can be effective in powdery mildew rotations, including Triathlon BA and Cease (biological), MilStop (potassium bicarbonate – can leave objectionable residue) and oils (can be phytotoxic). If they were my plants, I would rotate a strobilurin and a sterol inhibitor for powdery mildew on ornamentals.

Pythium Fungicide Rotation: The products that work best for Pythium include Subdue MAXX (4 – resistance is a big concern), etridiazole (14 - like Terrazole) and Segway O (21). All of these are reasonably effective at "curing" Pythium root rot as long as you also improve the growing conditions a little—warmer, less water and less fertilizer help. Some of the other newer products are labeled for Pythium, but our trials haven't yielded enough control for me to include them in a rotation. Phosphonates have been used for Pythium control for many years, but our trials have shown efficacy against Pythium only


Xanthomonas leaf spot on ficus.

50% of the time. Finally, you should know that *Trichoderma harzianum* and *T. virens* (RootShield Plus) has been very good for Pythium in many of our trials, as long as they're used preventatively.

Rhizoctonia Fungicide Rotation: The single best product for Rhizoctonia in our trials in the past 25 years is fludioxinil (12 – Medallion). It can be rotated with a strobilurin (11 – like Pageant Intrinsic) or thiophanate methyl (3- like OHP-6672 or Cleary 3336). You can also very successfully use RootShield Plus for Rhizoctonia root rot, but it may be less effective for stem rot or aerial blight since it works best on roots.

Rust Fungicide Rotation: The best rust fungicides usually fall into the strobilurin (11) or sterol inhibitor (3) groups. Unfortunately, sterol inhibitors are sometimes effective as plant growth regulators, so rotation is especially important when trying to minimize PGR effects, as well as control disease. Many other products work—mancozeb (M3) and chlorothalonil (M1) are great preventers of rust infection and kill rust spores, but are less effective at stopping an ongoing problem. They can be rotated with a strobilurin (11-like Heritage) for excellent results.

Thielaviopsis Fungicide Rotation: Thiophanate methyl products like OHP-6672 and Cleary's 3336 can be rotated with Affirm (19). These have been the best in our trials. The new product Orkestra (11 and 7) appears to be effective as well. This disease really should be controlled through use of pathogen-free plugs or cuttings and maintaining the potting medium pH below 5.5. Growing plants under stressful conditions can make this disease worse.

Conclusions

There are probably as many effective rotation programs for diseases as there are successful growers. Remember that you need to know what you're trying to prevent, practice IPM and rotate. If you have a program that works for you, there's really no reason to change it. However, it never hurts to learn something new. Finally, be sure to do small tests for safety—at least when trying a new product—and always follow the label. GT

Important Disease Control Facts

Disease	Symptoms	Conditions that Promote Disease	Common Hosts
Anthracnose (Colletotrichum)	Anthracnose can cause discrete leaf spots, blight of stems and leaves. The fungus forms masses of pinkish-orange spores in the affected area. The spots are often round and the fruiting bodies form in concentric rings in the dead tissue. They are black and resemble pin cushions when viewed with a hand lens.	Warm, moist conditions with high humidity favor disease development. Avoid wounding and over-fertilization.	Cyclamen, many woody plants, mandevilla, sansevieria, palms, hosta, aglaonema, pansy, spathiphyllum, hydrangea, cordyline, ficus, anthurium
Bacterial Leaf Spot *(Pseudomonas, Xanthomonas)*	Small, angular, water-soaked lesions sometimes surrounded by a purple or yellow halo on leaves. Spots start yellow or light green, to dark brown or black. When conditions are unfavorable they may appear tan.	High humidity, wet leaf surfaces. Splashing water moves bacteria and allows infection of new leaves. Reducing nitrogen may reduce many bacterial diseases.	Zinnia, snapdragon, basil, ivy, begonia, poinsettia, impatiens, rosemary, lavender, hydrangea, diffenbachia, aglaonema, anthurium
Bacterial Soft Rot *(Pectobacterium =Erwinia)*	Watery decay of any plant tissue; rotten fish odor; rapid collapse of plant (meltdown).	Bacterium is ubiquitous in environment. Too much water or nitrogen promotes disease.	Poinsettia, orchids, many foliage plants – relatively rare on bedding or woody plants
Botrytis Blight (gray mold)	Symptoms vary with host and tissue invaded; leaf spots; bud rot; flower blight; cutting rot; stem canker, stem and crown rot; proliferation of fluffy, brown/gray fungal mycelium containing spores; damping-off.	High humidity more than 85%; poor air circulation; 70 to 77F optimum temp for spore germination; spores must have free moisture to germinate; old flowers and decaying vegetation source of spores; rapidly colonizes wounded tissue.	Nearly all plants – especially in propagation or when flowering
Downy Mildew	White/purple/gray fuzz (spores) on undersides of leaves. Yellowish or pale green mottling on upper leaf surface. On garden impatiens, foliage appears to have yellow stippling similar to spider mite injury. Downward curling of leaves. Emerging leaves may be small or discolored. Can become systemic in plants, resulting in stunting or distorted new growth.	Favored by high humidity, long durations of leaf wetness and cool weather (60 to 74F daytime). Can survive in plant debris in soil. Spores are spread by splashing water and air currents. Increasingly detected during warm months and in warmer regions.	Bracteantha, coleus, garden impatiens, snapdragon, veronica, pansy, agastache, rudbeckia, digitalis, hebe, galium, lamium, basil, rose, salvia
Fungal Leafspots *(Alternaria, Cercospora, Helminthosporium, Corynespora, Septoria, Phyllosticta)*	Round to irregular leaf spots; often with a border (red/purple/brown). Center of lesions becomes tan with age; size of lesion increases over time. Fruiting bodies may be present within lesion.	Prolonged leaf wetness, high humidity and warm temperatures favor most fungal leafspot diseases.	Nearly all plants get one or more fungal leaf spot diseases.
Foliar Nematodes	Pattern of damage is stripes or patchwork and easily confused with bacterial leaf spots. Leaves turns yellow and eventually brown and die.	Spread by vegetative propagation, splashing water, plant-to-plant contact, worker movement and tools.	Ferns, hosta, heuchera and many other herbaceous perennials
Fusarium Stem Rot or Wilt	Lower leaves yellow and dry; can be followed by rapid wilting of the one side of the plant is common. Vascular system has reddish-brown streaks. Yellowing and stunting of older plants. Crown rot may occur with reddish coloration at the rotted area.	Fungus may be present on seed coats or in stems of symptomless cuttings. Drought or flowering stress can result in rapid and severe symptoms. Can be spread by fungus gnats. Spores and fungal fragments move via irrigation water.	Chrysanthemum, cyclamen, gerbera, lisianthus, pansy, annual vinca, cacti and succulents
Myrothecium Crown Rot, Leaf Spot and Petiole Rot	Petioles rot at the soil line, leaf collapses. Circular leaf spots initially appear water-soaked, and eventually turn brown or light tan in color. Dark green-to-black masses of spores surrounded by a white fringe appear on upper surfaces within the dead tissue. They are often formed in a ring spot pattern.	Warm, moist, humid conditions favor infection and disease development. Wounds are quickly colonized by this soilborne fungus. It is often spread on symptomless infected cuttings.	New Guinea impatiens, pansy, syngonium, dieffenbachia, aglaonema, ferns, gardenia

Disease	Symptoms	Conditions that Promote Disease	Common Hosts
Phytophthora Root and Crown Rot	Mainly attacks crown and stems; roots are brown and disintegrate. Plant dies suddenly.	Generally the same as Pythium. Worst disease usually under high temperatures when plants are stressed.	Gerbera daisy, poinsettia, pansy, African violet, lavender, annual vinca, azalea, gardenia, liriope, petunia, spathiphyllum
Powdery Mildew	Fluffy white patches on upper leaf surface, turning gray with age. Can also infect stems and flower petals when severe.	Favored by warm days and cool, damp nights; free water inhibits spore germination. This fungus can infect at low relative humidity and is common in spring and fall.	Gerbera, petunia, rosemary, rose, verbena, poinsettia, begonia, hydrangea, dahlia, lonicera, sedum, kalanchoe, coreopsis, scabiosa
Pythium Root Rot	Damping off; lower leaves yellow and wilt; stunting; root rot with – outer cortex easily removed; irregular growth.	Over-watering and over-fertilization may predispose plants to infection. Can be spread by irrigation water especially when recycled or in ebb and flood. Poorly draining potting media and reuse of potting media or dirty containers.	Geranium, chrysanthemum, calibrachoa, all seed propagated bedding plants, ivy, pothos
Rhizoctonia Crown Rot and Aerial Blight	Damping off; infection starts at soil-line and can cause constriction (wire stem); rotted crown (shredded, dry-appearance); roots sometimes affected. Brown, irregular-shaped spots can develop on leaves and stems. Aerial web blight can develop when the fungus grows from the potting medium surface into the plant canopy.	Very wide host range and survives in plant debris and soil on benches, floors and pots. Web blight occurs often under high temperatures but decreases when they are over 95F. Plant crowding increases disease spread and severity.	Chrysanthemum, celosia, osteospermum, annual vinca, rosemary, garden and New Guinea impatiens, hydrangea, poinsettia and many foliage plants including ferns.
Rust	Chlorotic spots appear on tops of leaves. Yellow, orange or brown spore masses or pustules form on the underside of the leaf and erupt through the leaf tissue. On geranium and snapdragon, pustules can form in a bullseye pattern.	Infect under mild, moist conditions. Spores easily spread in air currents.	Dianthus, geranium, snapdragon, heuchera, daylily, grasses, rose, penstemon and other herbaceous perennials
Sclerotinia Blight (White Mold)	Water-soaked spots on the stems or leaves become covered in a white cottony mass of fungal mycelium. The plant rapidly becomes soft and slimy. Hard black structures (sclerotia) that resemble rat droppings develop usually at the edge of the dead zone.	Spread is primarily by airborne spores. High soil moisture, high humidity and cool temperatures favor disease development often as spring turns into summer.	Lobelia, marigold, petunia, zinnia (most bedding and flowering plants), osteospermum, lilies, iris, delphinium
Thielaviopsis Root Rot (Black Root Rot)	Yellow, stunted growth; black root rot; wilting.	Potting medium pH above 5.5 can be found in some peat mixes. Temperature stress.	Calibrachoa, pansy, petunia, annual vinca
Tospoviruses (INSV and TSWV)	Symptoms vary with host; yellow or necrotic spots on stems or leaves; leaf mosaic; black leaf spots; black ring spots; line patterns, overall yellowing; stunting. In some plants wilt occurs.	Transmission from infected to healthy plants via thrips; introduction into the greenhouse via infected plants or insect vector – several types of thrips including Western flower thrips.	Many plants including impatiens (common and New Guinea), cyclamen, gloxinia, aster, begonia, cineraria, dahlia, kalanchoe, lisianthus, lupine, nemesia, ranunculus, chrysanthemum, orchids
Tobacco Mosaic Virus (TMW)	Symptoms highly variable but include mosaic, stunting, distortion and tan spots. Symptoms may disappear but the plants remain infected.	Vegetative propagation and mechanical movement (on benches or cutting tools) most important means of spread. Can clean benches and tools with various disinfestants and nonfat dry milk.	Petunia, tomato, pepper, calibrachoa, phlox, orchids to name the most common

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