Missouri Environment & Garden

June 2015 **Volume 21, Number 6**

Biopesticides: Eco-Friendly Pest Control

by David Trinklein

Food security and environmental stewardship are two subjects on the minds of most individuals involved with agriculture. The misuse of conventional pesticides, in many cases, has led to pest resistance, population resurgence and pesticide residues. Once a novel idea with limited opportunities for use, biopesticides rapidly are becoming more widely available and represent an effective, environmental-friendly alternative method of pest control.

The term 'biopesticide' is a contraction of 'biological' (meaning living or involving life) and 'pesticide' (a substance or mixture of substances used to control pests). According to the Environmental Protection Agency (EPA), the term refers to "certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals." Biopesticides are considered to be forms of biological control. The latter includes the use of predators, parasitoides, pathogens and compounds of biological origin to control pests.

A familiar example of a biopesticide is the soil-derived bacterium Bacillus thuringiensis (or Bt). The latter frequently is used to control insect pests such as corn earworm and bagworm. Bt (e.g. Dipel®) is an effective insecticide because of a toxic crystal protein it produces. In the (alkaline) gut of an insect, the toxin is liberated from the crystals and paralyzes the digestive system of the insect. The end result is the insect stops eating and starves to death. Since the digestive system of mammals is acidic in nature, Bt is considered to be nontoxic to humans.

It must be emphasized that just because an organism or compound occurs in natures does not mean it is non-toxic. For example, nicotine sulfate (e.g. Black Leaf 40) is a derivative of tobacco that, for decades, was used as an insecticide to control pests such as aphids. Because of its high toxicity, it was removed from the market and is no longer available. Fortunately, a common denominator and attractive feature of most of today's biopesticides is their low mammalian toxicity.

Biopesticides are normally placed in one of three categories:

1. Biochemical pesticides are naturally occurring, non-toxic pest controllers. Biopesticides belonging to this category include insect pheromones, natural plant and insect regulators, enzymes and bio repellents or attractants.

As an example, neem (Azadirachta indica) is an evergreen tree native to India. An oil pressed from the fruits and seeds of this tree contains, in addition to other insecticidal and fungicidal compounds, azadirachtin. The latter acts as an antifeedant and growth disruptor for more than 200 species of insects. Examples of biopesticides containing azadirachtin include Azatin XL® and

(continued on pg. 4)

In This Issue

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Recovering Turf Density in Shaded Areas

by Brad Fresenberg

Trees and shade create a naturally pleasing environment in the landscape. However, it is difficult to grow grass under trees because not only the quantity but also the quality of the light changes in the shade. In full sun, light is in the "near red" range of wavelengths; in the shade it shifts to the "far red," which is less effective in photosynthesis. In addition, dense canopies, particularly those of conifers, filter out the blue component of sunlight, which is critical for plant growth. The result of these changes is a reduction in photosynthesis and its products, including carbohydrates needed for plant growth.

Leaves, leaf cuticles and stems of plants are thinner in shade. Shoot density decreases as well. Plant tissues are succulent and there is an increase in susceptibility to environmental stresses and disease. Transpired moisture from trees and grass, and moisture from dew forming under trees, take longer to dissipate, and the additional moisture may contribute to an increased potential in turf diseases.

Maintaining turfgrasses in shade is difficult. Turfgrass canopies can appear dense, but lack of light usually leads to a thinner stand of grass that does not compete well with weeds.

Shady conditions in combination with other plant stresses contribute to the difficulty of growing grasses under trees. For example, tree roots compete with turf for water and nutrients, and this competition can further weaken turf growing in shade. Allelopathic effects, such as the inhibitory effect of silver maple upon Kentucky bluegrass, are important between certain species of plants. Excessive organic matter from leaf litter will also inhibit grass. One or more of these factors make it particularly difficult to grow grass under sweet gum, maple and unpruned pin oak. On the other hand, grass is easier to grow under locust and poplar trees.

Areas of a landscape under full, dense shade throughout the day will not allow grass to grow and perhaps alternative ground covers should be considered. A weed like wild violets is also a great indicator weed for excess shade and may indicate a need for something like Vinca, Lirioipe or various ivy species.

Success with growing grass in shade can be increased if the tree canopy is thinned and branches from the lower third of the tree are selectively removed. Also, trees can sometimes be removed without disrupting the harmony and function of the landscape. This is something to look at and consider during the summer months in preparation for fall seeding.

Select and use grasses that have improved shade tolerance (Table 1). Most of the fine fescues (hard, sheep, spreading, slender creeping and Chewing's) have very good shade tolerance. Tall fescue has good shade tolerance, while Kentucky bluegrass is the least shade tolerant of the cool-season grasses. However, selected varieties of Kentucky bluegrass do have moderate tolerance to shade – Glade, Nuglade, Challenger, Midnight, Nassau. Bermudagrass, zoysiagrass and buffalograss should not be used in shady locations. In areas where shade-tolerant grasses fail, consider shade-tolerant groundcovers or mulched beds instead of grass.

Pruning trees to improve light penetration

Pruning trees with dense canopies, such as maples, will allow additional light to pass through to the turfgrass sward. Prune lower branches to a height of six feet. On large trees, branches should be removed all the way back to the trunk or a main leader so that the area under the canopy is clear. Thinning shrubs in the landscape will improve air circulation and lower humidity. Before planting grasses, remove shallow tree feeder roots that compete with the turf for nutrients and water.

(continued on pg. 3)

Lack of sunlight causes grass to look chlorotic (yellow) and thin. If soil can be seen through the turfgrass canopy, weeds will fill in.

Lawn management under trees

- Avoid excessive nitrogen fertilization, which promotes shoot growth at the expense of roots, lowers carbohydrates, and promotes soft, succulent tissue that is more susceptible to disease. Shade-tolerant grasses such as the fine fescues should receive no more than 2 pounds of nitrogen per 1,000 square feet per year. Apply fertilizer in shady areas in the fall just as leaves begin to drop. Rake and remove leaves before they accumulate to the point of covering grass. Leave can be mowed and mulched into the lawn canopy as they start to fall. However, as leaf drop accelerates and mulching becomes difficult, remove or blow leaves off of lawn. If fall fertilization was missed, fertilize in late winter or early spring, about a month before trees begin to leaf.
- Mow turf at 3 to 4 inches to allow maximum interception of reduced light by the thin turfgrass sward. Avoid scalping turf. Decline of turf in shade often begins after a single episode of scalping.
- Irrigate only enough to avoid droughty soil conditions in shady locations during summer months. When moisture is needed, water infrequently and deeply. Avoid frequent irrigation that will lead to increased humidity and disease. Irrigate in the early morning to allow maximum time for drying. Do not water in the evening; turf may remain wet and ambient humidity may remain high throughout the night, thus increasing the chance of disease. Above all, do not overwater turf in shade. Dry conditions are always preferable to wet conditions for fescues growing in shade.
- Limit traffic. Core aerify compacted areas that receive heavy traffic.
- Avoid using herbicides in shady areas if weed problems do not exist. Many weeds, especially crabgrass, will not grow in shade.

In Missouri, the hard, sheep, and Chewing's fescues are usually preferred over the other fine fescues when using a monoculture in shady locations. Turf-type tall fescues may also provide an acceptable turf in moderate shade caused by trees.

Another shade-tolerant grass is rough stalk bluegrass. This grass does well in cool, wet conditions found in some shady locations. It performs well in the spring and fall but will die in the summer if moisture is lacking. Rough stalk bluegrass should not be used in lawns where only one or two large trees cause thinning of turf. It is a spreading grass and may escape, causing unattractive patches in sunny areas. This grass should be used in lawns only where several trees exist and other grasses have been tried without success.

Recommended seed mixtures for shade

Light to moderately shady, dry areas

- 30 to 50 percent Kentucky bluegrass plus 50 to 70 percent fine fescue (blend two or three varieties of each species and mix). Use 3 to 4 pounds of seed per 1,000 square feet.
- 100 percent turf-type tall fescue (blend two or three varieties). Use 5 to 7 pounds of seed per 1,000 square feet.

Moderately shaded, dry areas

- 100 percent fine fescue (blend two or three varieties within a species or mix two or three species). Use 3 to 5 pounds of seed per 1,000 square feet.
- or 100 percent turf-type tall fescue (blend two or three varieties). Use 5 to 7 pounds of seed per 1,000 square feet.
- or 70 percent turf-type tall fescue (blend two or three varieties) plus 5 percent Kentucky bluegrass (blend two or three varieties – use rough stalk bluegrass in wet areas) plus 25 percent fine fescue (blend two or three varieties). Use 5 to 7 pounds of seed per 1,000 square feet.

Shady, wet areas

- 50 to 70 percent or more rough stalk bluegrass plus 30 to 50 percent perennial ryegrass (a blend of two or more varieties). Use 3 to 4 pounds of seed per 1,000 square feet.

Table 1. Species and cultivars for shaded areas.

Environment	Common name	Species	Selected cultivars
Light to moderate shade, dry	Hard fescue	Festuca longifolia	Aurora, Biljart, Discovery, Ecostar, Osprey, Reliant, Reliant II, Scaldis, Spartan, Waldina, Tournament
	Sheep fescue	Festuca ovina	Bighorn, Azay
	Spreading (strong creeping) fescue	Festuca rubra spp. rubra	Flyer, Flyer II, Fortress, Ensylva, Pennlawn, Rondo, Ruby, Shademaster II
	Slender creeping fescue	Festuca rubra spp. trichophylla	Dawson
	Chewing's fescue	Festuca rubra spp. commutata	Agram, Atlanta, Banner, Banner II, Brittany, Highlight, Jamestown, Jamestown II, Koket, Shadow, Shadow II, Tiffany, Victory, Victory II, Waldorf
	Turf-type tall fescue*	Festuca arundinacea	Adventure, Arid, Bonanza, Essential, Falcon, Falcon IV, Finelawn Petite, Houndog, Houndog V, Jaguar, Jaguar III, Jamboree, Rebel, Jr., Trident
Light shade, dry	Kentucky bluegrass*	Poa pratensis	Absolute, Adelphi, Allure, America, Bristol, Challenger, Chateau, Coventry, Enmundi, Estate, Georgetown, Glade, Huntsville, Midnight, Nassau, Nugget, Nuglade,
Light shade, wet	Perennial ryegrass*	Lolium perenne	All Star, Birdie II, Citation II, Cowboy, Elka, Fiesta II, Gator, Manhattan II, Palmer, Palmer III, Pennant, Pennant II, Regal, Repell
Light to moderate shade, wet	Rough stalk bluegrass	Poa trivialis	Colt, Laser, Laser II, Saber, Saber II

Note: This list is not comprehensive, and seed of listed cultivars may be unavailable in some localities.
*Some cultivars of turf-type tall fescue, Kentucky bluegrass and perennial ryegrass will adapt to moderate shade.

Azaguard®. Both carry EPA labels for the control of many insect pests but are relatively non-toxic to mammals.

Additional examples of biochemical pesticides include BacStop™ (a mixture of herbs and oils derived from herbs) broadly labeled for the control of bacterial and fungal diseases; Organocide™ (5% sesame oil) labeled for both fungal diseases and insect control; and Regalia® an extract of giant knotweed (Reynoutria sachalinensis) useful in helping to make treated plants more resistant to certain diseases.

2. Microbial pesticides contain a micro-organism (e.g. bacterium, fungus, virus or protozoa) or a product derived from micro-organisms that controls pests. Dipel® (mentioned above) is an example of a microbial pesticide as is Grandevo®. The latter is a microbial insecticide/miticide containing the bacterium Chromobacterium subtsugae and solids derived from its fermentation. It has multiple effects on pests, including fecundity reduction, serving to deter feeding and acting as a stomach poison. It is labelled for the control of a wide array of insects on many different food crops commonly grown in the garden.

Other examples of microbial pesticides include Actinovate AG® (Streptomyces lydicus) for suppressing several foliar and soil-borne diseases; Cease® and Senerade® (different strains of Bacillus subtilis) useful for the control of a number of different disease on vegetables; and NOLO Bait™ (Nomesa lacustae) a microsporidium protozoan labelled for the control of over 90 species of grasshoppers, crickets and locusts.

3. Plant-incorporated protectants are substances produced naturally by a plant. However, the gene(s) responsible for the production of these substances has been introduced to the genome of the plant via genetic engineering.

As an example, the gene in Bt responsible for the manufacture of the toxic crystal protein has been introduced into the genetic makeup of corn via genetic engineering. Bt corn, therefore, has the ability to make its own pesticidal protein, negating the need to apply the bacterium artificially. The EPA regulates the protein and the gene that produces it, but not the plant itself.

There are a number of advantages for using biopesticides. First, they usually are inherently less toxic to humans than conventional, synthetic pesticides. However, proper precautions still need to be taken when using them. Always read and follow label directions.

Secondly, biopesticides have a fairly narrow toxicity range. They tend to affect only the target pest and closely-related organisms. Contrast this with the broad-spectrum activity common to many conventional pesticides. Therefore, biopesticides pose little risk to mammals, birds and beneficial insects.

Third, biopesticides often are effective at (relatively) low concentrations and usually degrade rapidly. The latter helps to lower exposures and to avoid environmental problems caused by conventional pesticides. Since they pose less risk to the environment, the EPA usually requires much less data (and time) to register a biopesticide, compared to the registration process for a conventional pesticide.

Finally, biopesticides fit well into Integrated Pest Management (IPM) programs. Properly used, they can greatly reduce the use of conventional pesticides, while promoting high crop yields because of effective pest control.

On the negative side, biopesticides usually are more expensive than synthetic pesticides. It must be pointed out, however, that fewer applications normally are required. Additionally, in most cases pest control takes longer, given most biopesticides have little "knock down" activity. Therefore, preventative application is important.

"All the pests that out of earth arise, the earth itself the antidote supplies" is a poem dating back to 400 B.C. that summarizes nicely the concept of biopesticides. Today, there are more than 430 biological ingredients approved by the EPA for use in pesticides. With an annual market share approaching $1 billion, biopesticides now are attracting the research and development attention of large, well-known chemical companies. Without doubt, this will lead to the introduction of even more products that will make protecting plants in an environmentally manner easier to accomplish.

Disclaimer: Mention of registered or trademarked products does not constitute endorsement by the author.

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Wet Weather Woes

by David Trinklein

Photo from wikipedia.

"When you're up to your neck in alligators, it's hard to think about draining the swamp." So goes the wording of an old saying aimed at reminding people that certain dilemmas in life could have been prevented, had we thought about their cause earlier. It bodes well for those of us having plants that are suffering from the very wet spring we have experienced this year.

The first question to address is, "How does too much rainfall damage plants?" The answers lies in the fact that the cells of plants (including their roots) respire just as do the cells of animals. Since oxygen is needed for respiration, plant cells die without adequate oxygen. The oxygen content of the atmosphere is about 21 percent. The oxygen concentration in the soil atmosphere is significantly lower. Should it drop to less than 10 to 12 percent, plant roots suffocate and die.

When excessive rainfall occurs, soil pores that had been filled with air suddenly become filled with water. The latter forces oxygen-laden air from the soil fairly rapidly. The result is a sub-oxidized, or oxygen-deficient, soil atmosphere.

Plants in standing water or sub-oxidized soil first lose their lower roots where the oxygen concentration initially is lower. If the water persists in the soil for long periods, the roots will gradually die upward until only surface roots remain. The greater the number of roots that die, the less likely the plant will survive after the soil finally dries. Fortunately, not many gardens experience standing water for extended periods of time.

When the soil oxygen concentration drops below the above-mentioned critical level, water uptake decreases with an hour's time. The result is a phenomenon known as "water wilt" where plants show symptoms of wilting even though there is abundant water in the soil. Water wilt is more common among herbaceous plants (e.g. tomato) than on woody plants.

Another problem that tends to develop in wet soils is compaction. Driving equipment on or, to a lesser extent, walking on wet, saturated soil tends to reduce larger inter-particle pore spaces into smaller ones, resulting in soil compaction. The problem is more severe in clay soils than in sandy soils. Compaction not only reduces the amount of air in the soil while it is wet, it will continue (to a lesser extent) the problem after the soil dries.

When the soil warms during the early spring, woody ornamentals begin to develop new roots. When the soil is saturated, these roots become oxygen-starved and die nearly as quickly as they are formed. These "feeder roots" are very important for the well-being of the plant. Thus, trying to establish new trees and shrubs in the landscape when the soil continually is wet becomes a challenge.

(continued on pg. 6)

Additionally, plants that have lost roots during an extended wet period are ill-prepared to handle the rigors of a typical Missouri summer. If the summer remains cool and moist, few root-related problems would be expected. However, if the weather transitions from cool and wet to hot and dry, the reduced root area cannot keep up with the loss of water via transpiration. Leaf scorch, twig dieback, wilting or even death of the plant may result.

Because of heavy spring rains this year, garden plants should be monitored carefully during the next months. Water them regularly if we should experience dry periods. As a rule, most garden plants require about an inch of water per week during the summer. If this is not received as rainfall, supplemental irrigation should be practiced. When doing the latter, water well but avoid frequent, light watering. The latter tends to discourage plants from developing a deep, penetrating root system.

What about "draining the swamp?"

Other than not locating a garden in a flood plain, little can be done to prevent damage to plants growing in standing water. However, there are things that can be done to minimize the damage to garden plants during extended wet periods of weather. All involve working with the soil.

Plants growing in permeable, well-drained soil are less subject to wet-weather damage than those growing in "tight" soils. Permeable soils retain less of the rainfall they receive because of their large inter-particle pores. Thus, the pore spaces that held air before a rain event soon re-establish their air content, thanks largely to gravity.

Permeability is a function of soil structure. The latter describes the arrangement of soil particles (solids) and the pore spaces between them. When soil particles aggregate, they form "clumps" and have larger pores form between the solids. This promotes rapid infiltration of water and good drainage. Conversely, when soil particles are dispersed, pores become small and are more likely to retain water rather than air. Dispersed soils are notorious for being poorly drained.

Few things are better at building good soil structure than organic matter. As organic matter is broken down by soil microbes, the mineral components of soil (sand, silt and clay) tend to become coated. The latter facilitates the afore-mentioned aggregation, which provide large pores and that allow rainfall to pass through the soil

Soil organic matter is liable, meaning it is constantly undergoing chemical, physical and biological change. For this reason the incorporation of about four inches of well-decomposed organic matter on an annual basis is considered to be a "best management practice" for garden soils.

Gypsum (calcium sulfate) is a naturally-occurring substance that has been used for centuries to improve soil. Gypsum causes soil structure to be more sponge-like, causing water to infiltrate faster through the soil rather than "pond" or run-off. The end result is an increase in the amount of oxygen available to plants roots.

Another technique to cope with wet weather or poorly-drained soils is to plant on berms. A berm simply is a mound of soil with sloping sides. Since berms are sloped, rain is more likely to run off than to be absorbed by the soil. Properly designed, berms also tend to control erosion in gardens that are not level.

In closing, Charles Dudley Warner is credited with the saying, "Everybody talks about the weather, but no one does anything about it." Evidently, Mr. Warner was not a gardener.

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July Gardening Calendar

Category	Week				Activity
	1	2	3	4	
Ornamentals	x	x	x	x	Provide water in the garden for the birds, especially during dry weather.
	x	x	x	x	Remove infected leaves from roses. Pick up fallen leaves. Continue fungicidal sprays as needed.
	x	x	x	x	While spraying roses with fungicides, mix extra and spray hardy phlox to prevent powdery mildew.
	x	x	x	x	Newly planted trees and shrubs should continue to be watered thoroughly, once a week.
	x	x	x	x	Fertilize container plants every 2 weeks with a water soluble solution.
	x	x	x	x	Keep weeds from making seeds now. This will mean less weeding next year.
	x	x	x	x	Keep deadheading spent annual flowers for continued bloom.
	x	x	x	x	Perennials that have finished blooming should be deadheaded. Cut back the foliage some to encourage tidier appearance.
	x	x			Plant zinnia seed by July 4th for late bloom in annual border.
	x	x			Spray hollies for leaf miner control.
	x	x			Prune climbing roses and rambler roses after bloom.
	x	x			Apply final treatment for borers on hardwood trees.
	x				Apply no fertilizers to trees and shrubs after July 4th. Fertilizing late may cause lush growth that is apt to winter kill.
	x				Hot, dry weather is ideal for spider mite development. With spider mite damage, leaves may be speckled above and yellowed below. Evergreen needles appear dull gray-green to yellow or brown. Damage may be present even before webs are noticed.
		x	x		Fall webworms begin nest building near the ends of branches of infested trees. Prune off webs. Spray with Bt if defoliation becomes severe.
		x			Divide and reset oriental poppies after flowering as the foliage dies.
			x	x	Semi-hardwood cuttings of spring flowering shrubs can be made now.
			x	x	Summer pruning of shade trees can be done now.
			x		Powdery mildew is unsightly on lilacs, but rarely harmful. Shrubs grown in full sun are less prone to this disease.
				x	Divide bearded iris now.
		x			Don’t pinch mums after mid-July or you may delay flowering.

Gardening Calendar supplied by the staff of the William T. Kemper Center for Home Gardening located at the Missouri Botanical Garden in St. Louis, Missouri. (www.GardeningHelp.org)

(continued on pg. 8)

July Gardening Calendar

Category	Week				Activity
	1	2	3	4	
Lawns	x	x	x	x	Water frequently enough to prevent wilting. Early morning irrigation allows turf to dry before nightfall and will reduce the chance of disease.
			x	x	Monitor lawns for newly hatched white grubs. If damage is occurring, apply appropriate controls, following product label directions.
Vegetables	x	x	x	x	Blossom-end rot of tomato and peppers occurs when soil moisture is uneven. Water when soils begin to dry; maintain a 2-3 inch layer of mulch.
	x				To minimize insect damage to squash and cucumber plants, try covering them with lightweight floating row covers. Remove covers once plants flower.
		x			Dig potatoes when the tops die. Plant fall potatoes by the 15th.
			x	x	For the fall garden, sow seeds of collards, kale, sweet corn and summer squash as earlier crops are harvested.
			x	x	Set out broccoli, cabbage, and cauliflower transplants for the fall garden.
			x		Sweet corn is ripe when the silks turn brown.
			x		Keep cukes well watered. Drought conditions will cause bitter fruit.
			x		Harvest onions and garlic when the tops turn brown.
				x	Sow seeds of carrots, beets, turnips, and winter radish for fall harvest.
	x	x	x	x	Cover grape clusters loosely with paper sacks to provide some protection from marauding birds.
	x				Prune out and destroy old fruiting canes of raspberries after harvest is complete.
	x				Blackberries are ripening now.
		x	x		Apply second spray to trunks of peach trees for peach borers.
			x	x	Early peach varieties ripen now.
				x	Thornless blackberries ripen now.

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