TECH CENTER

Endophytes: insurance against insects

Though insect-resistant endophytes are not confined to perennial ryegrass cultivars any more, none have been found in bluegrass—yet.

by Richard Hurley, Ph.D.

■ Genetically-improved turfgrasses containing endophytes help us as landscape managers to enhance the environment, reduce maintenance costs, and conserve and improve soil and water resources.

Here are some advantages to turfgrass containing endophytes:

1) Frequent, dramatic enhanced resistance to many insect pests that feed on plant leaves.

2) Improvements in stress tolerance.

3) Superior performance of some turfgrasses during moisture deficits.

During 1990, an estimated 13 million pounds of elite, endophyte-containing perennial ryegrass seed was used throughout the world.

Efforts are being made to find or develop and use desirable endophytes in Kentucky bluegrass, strong creeping red fescue, blue fescue and various bentgrasses.

The discovery of a relationship between an endophytic fungus, *Acremonium lolii*, and resistance to the Argentine stem weevil has led to perennial ryegrass, tall fescue, chewings fescue and hard fescue with endophyte-enhanced insect resistance and improved stress tolerance.

No researchers have reported any adverse effects of endophytes on turf performance.

Endophytes might be considered similar to insurance: of little value when conditions are favorable, but of substantial value when turf is under certain biological or environmental stresses.

Endophytes enhance resistance to many insects, including sod webworms, billbugs and chinch bugs. Modest, but often meaningful, white grub resistance is being studied in Kentucky and Rhode

Table 1

ENDOPHYTE LEVELS FOR PERENNIAL RYEGRASS

% ENDOPHYTE CONTENT IN SEED*

Variety	Hi	Mod. Hi	Mod. Lo	Lo
Yorktown III	97			
Palmer II	97			
Gen-90	97			
Express	97			
Advent	97			
Seville	96			
Dandy	96			
Duet	93			
Manhattan II	93			
Prelude II	93			
Repell II	92			
Assure	92			
Pleasure	92			
Target	92			
Riviera	91			
Gettysburg	91			
Pennant	91			
Legacy	90			
4 Del. Dwarf	90			
Pinnacle	90			
Repell	89			
SR 4200	89			
Commander	88			
Regal	86			
Saturn	85			
Competitor		71		
Accolade		70		
Equal		68		
Calypso		66		
Citation II			59	
Stallion			58	
Caliente			54	
Premier			50	
Entrar			47	
Prestige			43	
Derby Supreme			38	
Lindsay			37	
Charger			34	
Envy			30	
Rodeo II			27	
Essence				20
Fiesta II				15
Cowboy II				12
Danilo				6
Ovation				5
Loretta				4
Allegro				1
Gator				1
Danaro				1
Pennfine				1

(Zero endophyte in other varieties)

** NOTE: This data from Rutgers University was obtained from seed lots submitted to the National Turfgrass Evaluation Program. Seed lots may contain lower percentages of seeds with viable endophytes because of loss of viability during seed storage.*

Source: Dr. Hurley

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Island. In addition, reduced numbers of spiral nematodes and stubby root nematodes were found on tall fescue containing an endophyte.

David Huff of Rutgers University is studying the mechanism, genetic or endophytic, of resistance to dollar spot observed in a strong creeping red fescue plant. But with this possible exception, we are not aware of convincing examples of successful disease suppression by endophytes under field conditions.

Acremonium endophytes can produce superior performance of some turfgrass genotypes. Instances of better summer survival, enhanced fall recovery and reduced weed invasion were observed in high-endophyte perennial ryegrass, tall fescue, hard fescue and chewings fescue.

We have observed larger, more competitive tall fescue plants infected by an Acremonium endophyte.

Perennial ryegrass—Dramatic progress has occurred in genetically improving perennial ryegrass for turf. Useful endophytes are being incorporated into many new perennial ryegrass cultivars. An estimated 13 million pounds of turf-type perennial ryegrass seed containing a high percentage of endophyte were harvested in 1990.

Turfgrass managers desiring the benefits of endophyte-enhanced performance must carefully select this seed. Endophyte viability declines during seed storage, especially under hot, humid conditions. Seed harvested in June or July should maintain a high level of viable endophyte if harvested properly, stored under cool, dry conditions and used before or during the following spring.

Table 2

ENDOPHYTE LEVELS FOR FINE FESCUE

Variety	% ENDOPHYTE CONTENT IN SEED* Hi	Mod. Hi	Mod. Lo	Lo
Jamestown II	100			
Reliant	100			
Warwick	96			
Southport	94			
SR 5000	92			
SR 3000		64		
Rainbow		63		
Valda		47		
Bridgeport		26		

(Zero endophyte in other varieties)

Table 3

ENDOPHYTE LEVELS FOR TALL FESCUE

Variety	% ENDOPHYTE CONTENT IN SEED* Hi	Mod. Hi	Mod. Lo	Lo
Titan	98			
Shenandoah	86			
Mesa		70		
Tribute		58		
Aguara		50		
Arid			48	
Normark 99			42	
Rebel Jr.			37	
Trident				28
Rebel II				28
Winchester				24
Taurus				18
Apache				18
Finelawn I				16
Sundance				14
Thoroughbred				14
Murietta				14
Bonanza				12
Chieftain				6
Hubbard 87				4
Finelawn 5GL				2

(Zero endophyte in other varieties)

** NOTE: This data from Rutgers University was obtained from seed lots submitted to the National Turfgrass Evaluation Program. Seed lots may contain lower percentages of seeds with viable endophytes because of loss of viability during seed storage.*

Source: Dr. Hurley

Tall fescue—Most, but not all, seed lots and plantings of Kentucky 31 tall fescue have a high percentage of seed or plants infected with an endophyte.

Beginning with the release of Rebel tall fescue in 1980, there has been continued, dramatic genetic improvements in tall fescue for turf use. However, only a few of the newer cultivars have high percentages of plants containing endophytes.

The limited use of endophytes in turf-type tall fescues is due to:

1) the potential misuse of cultivars for pastures, where they have deleterious effects on livestock;

2) concerns about grazing seed fields and use of forage produced as a by-product in seed production; and

3) lack of identification of the most desirable endophytes for use in best enhancing turf performance.

Fine fescue—Recent research indicates that endophyte infection in hard and chewings fescue is associated with resistance to chinch bugs. Further studies with three species of aphids and fall armyworms have confirmed this association with insect resistance.

Resistance levels in endophyte-enhanced fine fescues are dramatic. Endophyte infection in strong creeping red fescue, hard fescue, chewings fescue and blue fescue are associated with significant difference in insect survival and preference. No greenbugs survive after 72 hours on endophyte-enhanced hard, blue and chewings fescues. No fall armyworms survive to pupation when feeding on hard and chewings fescue that contain endophytes.

Bentgrass—Bentgrass plants collected from old turfs of the Mid-Atlantic region of the U.S. appear to be relatively free from endophytes, based on recent work at Rutgers University. No evidence of endophytes was found in more than 500 bentgrass samples examined.

It is likely that endophyte-containing bentgrasses would be more abundant in Europe, where bentgrass strains originated. Endophyte viability can be lost rather quickly in seed, especially when stored under warm, humid conditions. Therefore, many introduced seed lots would be expected to lose endophyte viability prior to planting.

Kentucky bluegrass—At Rutgers University, we have examined more than 800 plants of Kentucky bluegrass collected primarily from old turfs of the eastern U.S. without finding an endophyte.

We are unaware of a successful inoculation of an Acremonium endophyte from other grass genera into Kentucky bluegrass. We are currently attempting to transfer an endophyte (*A. typhinum*) from big bluegrass (*P. ampla Merr.*) into Kentucky bluegrass by hybridization and inoculation.

Other grasses—Endophytes have been discovered in many other grasses used for turf and soil protection. We examined more than 800 herbarium specimens in 93 grass genera: Agrostis, Bromus, Cinna, Elymus, Festuca, Lolium, Melica, Poa, Sitanion and Stripa. Many of these endophyte-containing species were native to the U.S., but much work is needed on the role of endophytes in these and many other grasses.

TALL FESCUE SEED CONTAINING VIABLE ENDOPHYTE AS RELATED TO STORAGE ENVIRONMENT AND DURATION OF STORAGE

STORAGE ENVIRONMENT	TEMP. F°	MONTHS IN STORAGE 3	7	11	15	19	27
FREEZER	-4	100	100	100	100	90	90
REFRIGERATOR	43	100	90	85	90	95	90
SEED STORAGE RM.	50	90	100	80	75	45	25
ROOM TEMP.	70	95	55	0	0	0	0
SEED WAREHOUSE	70-95	95	60	0	0	0	0

M.C. JOHNSON 1984

This article was developed by editing the following papers: "Importance of Acremonium Endophytes in Turfgrass Breeding and Management" by C.R. Funk and J.P. Breen of Rutgers University and R.H. White of Texas A&M University; "Endophyte Content of Cultivars and Selections in the 1990 National Perennial Ryegrass Test" by Suichang Sun, Nancy Januszka, Kelly Hollowood, Maribeth Wheeler, Carolyn Garvey and Jennifer M. Johnson-Cicalese, senior lab technician and lab assistant at Rutgers University and lab assistants and research associate at the University of Rhode Island.

—The author is director of research at Lofts Seed Inc. and an adjunct professor at Rutgers University.

Monitoring chlorine damage to plants

Even small emissions of chlorides can cause severe damage to plants near the leak, as observed in New York and Nevada.

by Dr. Robert Ll. Morris and Karen Lawson-Dyka, University of Nevada

■ Landscape managers should pay particular attention to any plant damage that may be caused by chlorine gas or hydrogen chloride. Such problems have been associated with the gases escaping from industrial sources during the manufacturing process or from accidental leaks.

(Chlorine and hydrogen chloride are used to produce pesticides and synthetic materials such as plastics and disinfectants. Emissions of chlorine have occurred around potash works, from pickling baths of hot-dip galvanizing plants, and in the combustion of PVC-containing wastes. Accidental emissions have occurred near swimming pools, sanitation plants and factories.)

Twice in Yonkers, N.Y., emissions have damaged 30 species of plants, including tree-of-heaven, apple, cherry, maple, basswood, dogwood, elm, ash, sweetgum, hemlock, oak and white pine. A more recent accident occurred in southern Nevada (see related story).

Chlorides have a herbicide-like effect on plants. Even small emissions can cause severe damage to plants near the leak. Plant damage is generally measured at about 4-1/2 feet above the ground, or at the upper limit of vegetation.

Table 1

TYPES OF DAMAGE FROM CHLORINE

Broadleaf plants

- leaf and flower drop
- bronzing
- chlorosis
- marginal and interveinal necrosis
- mottling and chlorotic flecking
- bleached tissue
- orange-brown necrosis
- dieback
- stem and leaf wilting
- blazing on leaf underside (not noted in Nevada, but reported in literature)

Conifers

- needle tip burn
- candle distortion (not in literature, but found in multiple Nevada locations)
- reddish-brown necrosis
- dieback

Grasses (and other monocots)

- leaf tip burn
- marginal leaf burn
- chlorosis
- twisted blades (not in literature, but found in multiple Nevada locations)

Source: The authors

Plant damage can be divided into four non-lethal categories:

(1) rapid leaf drop; **(2)** tissue chlorosis or discoloration; **(3)** tissue distortion and tip burn; and **(4)** marginal and interveinal necrosis.

The degree of plant damage depends on the amount of chlorine in the air, its duration of exposure, susceptibility of the plant to damage, and environmental conditions such as moisture content and temperature.

Lower concentrations of chlorine in the atmosphere will do more visible damage when humidity is high.

Under high humidity (more than 80 percent) or when fog or dew is present, chlorine combines with water vapor to form a hydrochloric acid aerosol mist on plant surfaces. Under these conditions, droplets may form on leaf surfaces, causing necrotic spots or burns to form.

Under low humidity, the chlorine gas forms an anhydrous hydrogen chloride which may cause less visual damage but has been speculated to cause more severe damage because of the dehydrating action on exposed tissue.

Acute damage happens so rapidly that chlorine is not assimilated by the plant and cannot be detected easily in tissue samples.

Table 2

SEVERITY OF DAMAGE TO PLANTS IN SOUTHERN NEVADA

NONE	SLIGHT	MODERATE	SEVERE
asparagus fern	Algerian ivy	agave dianthus	apricot
barrel cactus	ash	heavenly bamboo	bird of paradise
cholla cactus	canna	honeysuckle	chinaberry
dusty miller	bush morn. glory	stone pine	Chinese/Sib. elm
euonymus	English ivy	Jap. black pine	lilac
hesperaloe	fortnight lily	lavender	marigolds
ice plant	photinia	magnolia	nectarine
juniper	iris	Mexican primrose	olive
myrtle	pampasgrass	mulberry	peach
palms	pittosporum	mums	plum
pyracantha	salvia	oleander	poplars
rosemary	snapdragon	pansy	rose
santolina	verbena	pomegranate	
turfgrasses	Italian cypress	Idaho locust	
wisteria	heavenly bamboo	silk tree	
yucca	arborvitae	privet	
Texas ranger	almond		
athel	chrysanthemum		
star jasmine	Indian hawthorn		

Source: The authors

The Nevada burn

■ Early in the morning of May 6, 1991, a large blue-green cloud was released from a broken two-inch line that led to a 150-ton storage tank of liquid chlorine. An industrial plant in southern Nevada accidentally released 60 tons of chlorine that rapidly vaporized and caused the evacuation of 10,000 residents in a 20-square mile area. Nine people were hospitalized. In the affected area, landscape plants bathed in an unknown concentration of chlorine gas for several hours.

A team of commercial horticulture volunteers surveyed landscape plant damage in a neighborhood within 1/2 mile of the chlorine leak one week after the accident. Recorded plant damage is shown in Table 1. Table 2 lists the plants that were found to have probable chlorine emission damage.

Within 24 hours after emission, partial to total leaf drop occurred on elm, cottonwood, chinaberry, all stone fruits, some pome fruits, rose, olive, mulberry, pomegranate, Texas privet and Indian hawthorne.

Flowers were not affected and were more tolerant of exposure to chlorine with one exception: leaf and flower drop on Indian hawthorne. Chlorosis and necrosis occurred three to five days after emission. New growth began to cover damaged tissue, and refoliation occurrred in seven to 10 days.

All pines suffered some sort of damage, ranging from twisting and dieback of new growth (candles) to needle tip burn and needle drop.

Turfgrasses (tall fescue, bluegrass and bermuda) all tolerated the exposure with no visible damage. In some cases, chlorine damage was difficult to separate from previous winter damage.

—Dr. Morris, Ms. Lawson-Dyka

Treat now for pythium rots

This is the time of year to make sure pythium rots don't take away valuable turf areas.

■ Although this disease is most frequently associated with established bentgrass/annual bluegrass putting greens, it can also be a serious problem on highly managed home lawns and newly-seeded areas. It is particularly severe on ryegrasses, bentgrasses and bluegrasses.

To minimize turfgrass losses from pythium root rot (PRR), Dr.Eric Nelson of Cornell University says, manage to reduce plant stress or eliminate prolonged wet periods.

Early symptoms of PRR may be visible in the early spring immediately after snow melts, but are most common in the late spring. Symptoms may be evident any time during the growing season, and may continue into late autumn.

Symptoms:

- small diffuse yellow or reddish brown patches about two to three inches in diameter, often resembling early stages of pink snow mold;
- plants slow to come out of winter dormancy;
- less vigorous growth;

• during summer, small tan to brown or bronze patches similar to dollar spot patches;

• severe development may mean large yellow areas and a general weakened condition; and

• as season progresses, large areas may wilt, turn yellow to brown, and die.

Control:

1) Maintain extensive and vigorous plant root system.

2) Use management practices to reduce plant stress.

3) Eliminate prolonged wet periods.

4) Use broad-spectrum fungicides sparingly.

5) If necessary, use pythium-labelled fungicides and thoroughly water in. Areas with PPR history should be treated between October and November, followed up by another application in the spring. See chart for effective fungicides.

FUNGICIDES FOR ROOT-ROTTING PYTHIUM DISEASES

Fungicide	Trade Name	Formulation	Rate/1000 sq.ft.
ethazole	Koban	30W	7-9 oz.
		1.3G	8 lb.
	Terrazole	35W	8 oz.
metalaxyl	Subdue	2E	2 oz.
		2G	1.5 lb.
		5G	10 oz.
	Scott's Pythium Control	1.2G	2.5 lb.
phosetyl-al	Aliette	80W	4-8 oz.
proamocarb	Banol	65	2.4 oz

Source: Cornell University Turfgrass Times

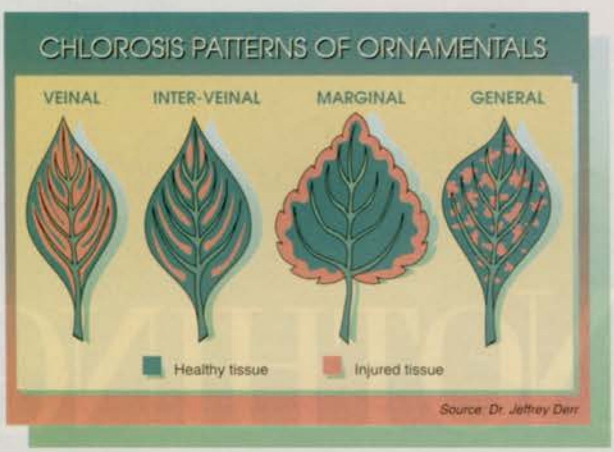
Recognizing herbicide injuries to ornamentals

Lawn/landscape herbicides can cause damage to non-target ornamentals.

■ Are the leaves of ornamentals under your care turning yellow and dying? Have you already ruled out disease and insects, and don't have another answer?

Perhaps you should consider herbicide injury as the culprit.

"A lot of other problems can mimic these herbicide injury symptoms," notes Dr. Jeff Derr of VPI-SU's Hampton Roads Ag Experiment Station. "However, there is no cure for herbicide injury. In most cases, the plant will outgrow it."



Some herbicide injury symptoms include chlorosis, bleaching, spotting and distorted growth. Each herbicide has a specific set of injury symptoms that it causes.

Chlorosis is a yellowing effect that can be either veinal, interveinal, marginal or general (see illustration). It is caused primarily by root-absorbed herbicides.

Bleaching occurs when some herbicides are taken up through the plant's roots or leaves. The plant's leaves turn white.

Spotting is a browning of leaves, while distorted growing patterns are generally the result of plant growth regulator injury.

The 2,4-D group of growth regulators produces a distorted appearance, twisting and downward bending. The Roundup group (Roundup, imidazolinone herbicides, sulfonylurea herbicides) of growth regulators produces tip chlorosis and distorted growth, but no twisting.

"Using Roundup in the fall, you may not see symptoms until budbreak next spring," Derr notes.

The dinitroanilines produce root inhibition and occasionally swelling and brittleness of the stem at the soil line.

Amides, anilides and thiocarbamates inhibit roots and shoots.

If you suspect herbicide damage, consult a reference text such as "Herbicide Injury to Trees and Shrubs: A Pictorial Guide to Symptom Diagnosis." (Available from Blue Crab Press, P.O. Box 5055, Virginia Beach, VA 23455-5055.)

Injuries produced by common herbicides

Here are some common herbicides and the types of injury they can produce:

CHLOROSIS: triazines (Atrazine, Simazine), ureas (Karmex, Spike), uracils (Hyvar, Sinbar), Casoron, Norosac, Basagran

BLEACHING: amitrole, Amazine

SPOTTING: diquat, paraquat (Gramoxone Extra), Goal, Ornamental Herbicide 2 (OH2), Rout, Ronstar

DISTORTION: 2,4-D group: 2,4-D, dicamba (Banvel), triclopyr (Garlon), picloram (Tordon), Weedone DPC, Trimec, Turflon
Roundup group: glyphosate (Roundup), Oust, Classic, Escort, Arsenal, Sceptor, Image

ROOT INHIBITION: dinitroanilines (Surflan, Treflan, Balan, XL, Team, Southern Weedgrass Control)

ROOT & SHOOT INHIBITION: amides (Devrinol), anilides (Lasso, Dual, Pennant), thiocarbamates (Eptam)

— Dr. Derr