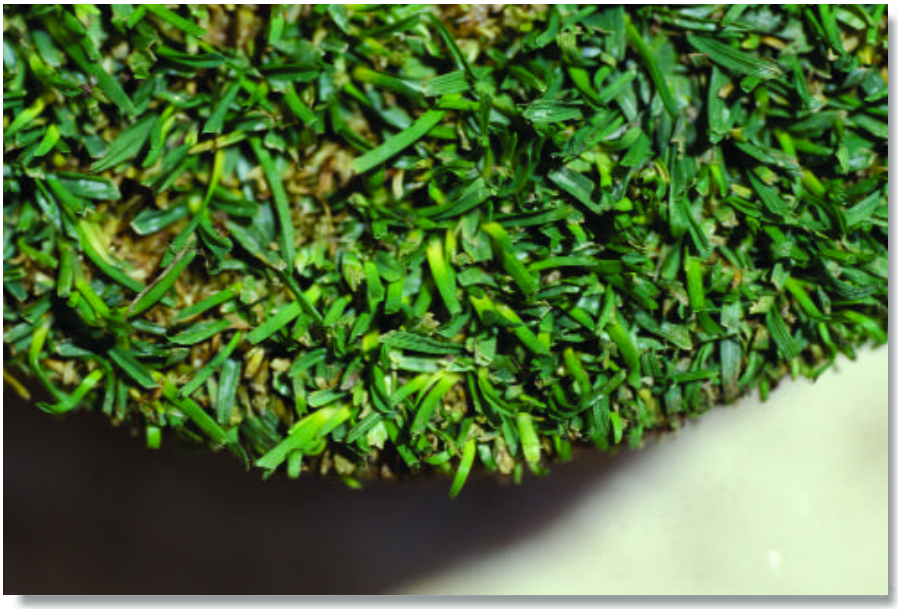
Bacterial wilt: An enigmatic annual bluegrass disease of putting greens

Bacterial wilt is difficult to identify and its causal organism is uncertain, but proper management practices can help prevent it and curtail its spread.

Peter H. Dernoeden, Ph.D.; Noel Jackson, Ph.D.; Nathaniel Mitkowski, Ph.D.; and John E. Kaminski, M.S.

Plant pathogenic bacteria are single-celled, usually rod-shaped organisms that reproduce at an extraordinarily high rate by binary fission. (In binary fission, the parent cell divides to form two similar daughter cells, which also divide to form two more cells each, and so on.) Most bacteria have rigid cell walls, and some are motile by means of flagella. Because bacteria have no means of penetrating cells, they must enter plants through natural openings such as stomata and hydathodes (apertures in plant surfaces, usually leaves, through which liquid is secreted) or through wounds. Once inside plants, bacteria cause damage by enzyme activity, toxin production and vascular plugging. By occluding xylem vessels, they interrupt water transport, causing plants to wilt and eventually die. Bacterial diseases are uncommon in turfgrasses. In fact, bacterial wilt of creeping bentgrass (*Agrostis stolonifera*) is the only recorded bacterial disease of turf in the United States. The reported casual agent is *Xanthomonas campestris*.



Photos courtesy of Peter Dernoeden

Early symptoms of bacterial wilt appear in annual bluegrass as yellow or lime green spots. Yellowing of leaf tips or the base of the lamina is symptomatic of the disease.

KEY points

More Info: www.gcsaa.org

- **Bacterial wilt in annual bluegrass** has been observed mainly in the Mid-Atlantic and northeastern United States.
- **The causal organism of bacterial wilt in annual bluegrass** has not yet been determined.
- **Bacterial wilt** often is very difficult to identify.
- **Because management practices** make annual bluegrass susceptible to bacterial wilt,they can also help control it.

Bacterial wilt in the United States was first recorded on Toronto (also known as C-15) creeping bentgrass. The cause of the disease was initially unknown, and the malady was referred to as "C-15 decline." Other vegetatively propagated cultivars of creeping bentgrass such as Cohansey and Nimislia also proved to be susceptible (10). Since the original report of C-15 decline in the early 1980s in the midwestern United States, no other cases of bacterial wilt have been authenticated in creeping bentgrass turf.

The causal organism

Xanthomonas campestris is the only xanthomonad known to cause bacterial wilt of grasses. Within this species, nine grass pathogens have been identified (commonly referred to as pathovars, abbreviated "pv."). These include *X. campestris* (*X.c.*) pv. *graminis*; pv. *phlei*; pv. *phleipratensis*; pv. *poae*; pv. *arrhenatheri*; pv. *undulosa*; pv. *secalis* and pv. *poaannua*. It is unclear how many of these organisms are currently present in the United States. Pathovars are usually specific to a particular host species. That is, the pathover that attacks creeping bentgrass is unlikely to attack annual bluegrass (*Poa annua*), and vice versa.

RESEARCH

In 1984 researchers at Michigan State University identified a strain of *X. campestris* that was pathogenic to annual bluegrass (7). The strain subsequently was named *X. c.* pv. *poaannua*, and a number of researchers have evaluated its potential as a biological control agent (4,9). EcoSoil Systems of California commercially developed an organism identified as *X. c.* pv. *poaannua* for the biological control of annual bluegrass. This name, however, has not been taxonomically recognized, and the true identity of this organism is still in doubt. In Japan, an organism identified as *X. c.* pv. *poae* has been identified as a pathogen of annual bluegrass on golf course putting greens (3,5). Research efforts to identify strains suitable for the biological control of annual bluegrass have been under way in Japan since 1995 (6).

Preliminary molecular characterization, undertaken at the University of Rhode Island, suggests that the organism responsible for bacterial wilt in annual bluegrass in the eastern United States is a pathovar of *X. translucens* (1). Bacterial taxonomy can be confusing. Although *X. translucens* and *X. campestris* are two different species of bacteria, these names also are synonymous for a number of pathovars, particularly those that attack grasses. Thus, it is not entirely surprising that at least one causal agent of bacterial wilt of annual bluegrass is *X. translucens*. Using both molecular techniques and fatty acid analysis, the URI research team has been able to conclude that the causal organism is definitely not *X. t.* pv. *graminis* (another name for *X. c.* pv. *graminis*). Work is under way to determine whether bacterial wilt is caused by pv. *poae*, pv. *poaannua* or another pathovar.

Symptoms on creeping bentgrass

Information about the nature of bacterial wilt was described from affected Toronto creeping bentgrass greens by researchers at Michigan State University (8). The bacteria were primarily limited to xylem vessels in roots, but could be detected in crown and leaf tissue. Once the xylem elements of a large number of roots became plugged with masses of bacterial cells, plants began to wilt, and leaves initially developed a blue green color. Subsequent to this short-lived stage, leaves turned brown rapidly and shriveled, and large areas succumbed within a few days. Adjacent Toronto turf in higher-cut collars or fairways displayed little or no damage. Periods of heavy rainfall followed by cool nights and warm sunny days in the spring and autumn appeared to favor the disease.

Symptoms on annual bluegrass

Bacterial wilt now is appearing with greater frequency on annual bluegrass putting greens and also may attack annual bluegrass in collars and approaches. Observations indicate that annual bluegrass turf is predisposed to bacterial wilt by various stresses such as intensive mowing and grooming, poor growing conditions (that is, shade, poor drainage, soil compaction, etc.) and perhaps other pathogens. The increased incidence of the disease appears to be related in large part to the trend for very low mowing heights, more-frequent mowing, lower nitrogen fertility and aggressive grooming practices (that is, topdressing, vertical cutting, brushing, grooved rollers, etc.) to increase green speed (2).

Bacterial wilt in annual bluegrass has been observed primarily in the Mid-Atlantic and northeastern regions of the United States. In annual bluegrass grown on greens in the eastern United States, the disease appears in late May or June generally but may remain active into September. Heavy rains and thunderstorm activity intensify the disease. Infected annual bluegrass plants may initially turn yellow, lime green or blue gray. Soon, individual infected plants turn reddish-brown and die, forming dime-sized (about 0.7 inch) white or tan-colored spots in the turf.

Diagnosis

No consistent leaf or sheath symptoms appear to be reliable for diagnosing bacterial wilt. When infected plants are incubated in a lab for about two days, the youngest leaf of some infected plants may become yellowed and elongated (etiolated). Infected, etiolated leaves sometimes are bent, but not twisted or otherwise distorted. Leaf etiolation, however, is not uncommon in apparently healthy turf. Older leaves of infected plants can appear darker green and stunted, but infected leaves are usually yellowed at the tip or the base of the lamina (leaf blade). The stem bases of infected plants may be variously discolored and water-soaked. Obviously, the variable leaf symptoms of bacterial wilt are not stable characteristics and are of little value in field diagnosis.

Bacterial wilt tends to develop first on pocketed or shaded greens. Damage appears in high and low areas, but tends to be most severe on the periphery or cleanup areas, walk-on and walk-off areas, and in impeded water drainage patterns that are subject to ice formation during the winter. Large areas of

Individual infected annual bluegrass plants die in whitish-tan colored spots about the size of a dime.

An annual bluegrass putting green is speckled with dead spots that disrupt playability of the putting surface.

the putting surface may become speckled with numerous pits, creating uneven putting conditions. In severe cases, whitish-tan dead spots ranging from ½ to 1 inch in diameter coalesce so that the pattern of injury no longer looks speckled but appears as a general blighting. The disease may abate during dry periods and flare up following rainfall.

Bacterial wilt symptoms can mimic active or residual anthracnose (*Colletotrichum graminicola*) or plants damaged by pythium-incited root diseases (*Pythium* spp). To add to the confusion, any two or all three of these diseases may occur simultaneously. It is unknown, however, whether infection by one of these pathogens predisposes plants to infection by the others.

Bacterial wilt often is very difficult to identify. In the laboratory, a diagnostician will place leaves or roots of plants suspected of being infected into a drop of water on a microscope slide, sever them with a razor blade and look for streaming of bacterial cells from vascular bundles. Slow oozes from senescent tissues are common, but rapid streaming of cells from vascular bundles of infected leaves or roots is the best indicator of bacterial wilt. Unfortunately, it is difficult and very time-consuming to isolate and positively identify *Xanthomonas* spp.

Management strategies

The bacteria seem to be spread by moving water and mowers. Obviously, mowing creates wounds, and contaminated equipment will distribute the bacteria onto wounded tissue. Mowing turf when leaves are dry later in the morning may therefore slow the progression of the disease. Increasing the mowing height reduces bacterial wilt severity, but this practice also slows the speed, decreasing playability of putting greens. It is very important to avoid mowing when greens are excessively wet and spongy and to mow every other day, particularly the cleanup lap. When the disease is restricted to one or a few greens, a mower, preferably a lightweight, walk-behind greensmower with solid rather than grooved rollers, should be dedicated to those greens. Dedicated mowers should be disinfected with a 10 percent sodium hypochlorite (Clorox) solution or similar disinfectant after use. Grooming, aerification and topdressing should be avoided when the disease is active because these practices abrade and wound tissue, creating openings for easy entry of the bacteria.

Antibiotics such as oxytetracycline (Mycoshield) may suppress bacteria wilt. Antibiotics, however, are very expensive, difficult to handle, may be phytotoxic and must be applied in high volumes of water (>50 gallons/1,000 square feet) at dusk every four to six weeks (10). Products containing copper hydroxide (Kocide, Junction) and copper oxychloride plus copper sulfate (COCS) may provide short-term disease suppression. Superintendents have observed

Dead annual bluegrass plants coalesce to form a pattern of general blighting. The disease is more severe in the "cleanup cut"and less severe in the higher-cut collar.

poor to good results with these copper-based products. There are, however, no research-based recommendations for using copper-based products for bacterial wilt control in turf. Anecdotal observations suggest that any of the aforementioned copper-based products can be effective and are safe for greens at rates in the range of ¾ to 2 ounces of product per 1,000 square feet, although some discoloration may occur. Applications of chelated iron or slow-release, liquid forms of nitrogen may help mask yellowing. Until research indicates otherwise, however, chelated iron or nitrogen should be applied separately rather than tank-mixed with copper-based products. Copper-based products should be applied in at least 5 gallons of water/1,000 square feet at 5- to 7-day intervals or following heavy rain as long as the disease is active. Using lower water dilutions or applying copper-based products on hot (>88 F) days could intensify chlorosis or injury in annual bluegrass. During summer stress periods, it may be necessary to apply copper-based products in the evening when temperatures are falling. Mature creeping bentgrass appears to be more tolerant of copper-based products than annual bluegrass, but creeping bentgrass seedlings are likely to be injured or killed. Copper may accumulate in soils and eventually cause toxicity to the turf. Currently, it is unknown how much copper can be applied to greens before turf decline occurs.

The most important cultural practices for managing bacterial wilt include: increase mowing height; reduce mowing frequency; replace grooved rollers with solid ones; avoid mowing when greens are wet and spongy; avoid use of plant growth regulators; and cease all grooming, aerification and topdressing practices when the disease is active. Weekly spray applications of 0.125 pound N/1,000 square feet from urea are recommended, particularly where annual bluegrass and creeping bentgrass are mixed. On greens where creeping bentgrass is the dominant species, the disease is best managed by employing cultural practices that promote creeping bentgrass growth.

Water management is also important. To prevent soils from becoming excessively wet, frequent syringing and hand watering is necessary in areas that are prone to rapid drying. Longer-range planning should include modifications to the growing environment such as tree and brush removal, use of fans to promote air circulation and improved water drainage. Where the disease is a chronic problem, greens composed primarily of annual bluegrass may have to be regrassed with creeping bentgrass.

Literature cited

1. Browning,M.,N.A.Mitkowski and N.Jackson. 2002. *Xanthomonas* spp.affecting golf course putting greens in the Northeast. *Phytopathology* 92:S10.Publication No.P-2002-0067-AMA.
2. Dernoeden, P.H.2000.Creeping bentgrass management,summer stresses,weeds and selected maladies.Ann Arbor Press,Chelsea,Mich.
3. Imaizumi,S.,and T. Fujimori.1999. Persistence of *Xanthomonas campestris* pv. *poae* (JT-P482) in annual bluegrass. *Annals of the Phytopathological Society of Japan* 65:52-56.
4. Johnson,B.1994.Biological control of annual bluegrass with *Xanthomonas campestris* pv. *poannua* in bermudagrass. *Hortscience* 29:659-662.
5. Nishino, T. 1998. Pathogenic diversity of *Xanthomonas campestris* pv. *poae* within the genus *Poa*. *Annals of the Phytopathological Society of Japan* 64:1-6.
6. Nishino, T.,S.Imaizumi,K.Miyabe,M. Yamada and M.Goto.1995. *Xanthomonas campestris* pv. *poae* as the causal agent of wilt symptoms on annual bluegrass in Japan. *Annals of the Phytopathological Society of Japan* 61:555-561.
7. Roberts,D.L.,J.M. Vargas and R.Detweiler. 1985.Occurrence of bacterial wilt on *Poa annua* and other turfgrasses. *Phytopathology* 75:1289 [Abstract].
8. Roberts,D.L.,J.M. Vargas,Jr.,R.Detweiler, K.K. Baker and G.R.Hooper. 1981.Association of a bacterium with a disease of Toronto creeping bentgrass. *Plant Disease* 65:1114-1116.
9. Savage,S.A.,R.A.Haygood and K.D.Mitchell. 1993.Evaluating the suitability of *Xanthomonas campestris* pv. *poannua* as a biocontrol agent for annual bluegrass (*Poa annua*). *Phytopathology* 83:1339 [Abstract].
10. Vargas,J.M.,Jr. 1994.Management of turfgrass diseases.Lewis Publishers,Boca Raton,Fla.

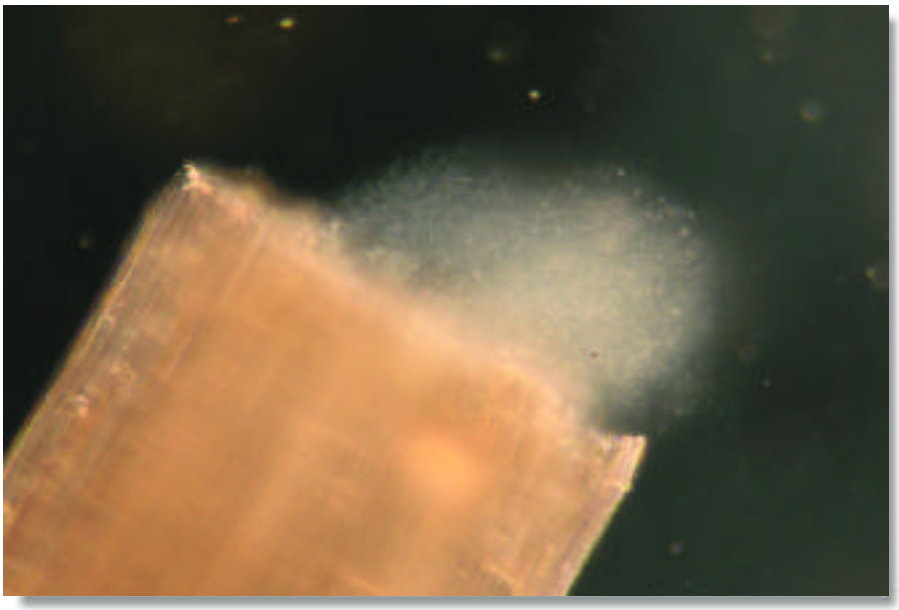


Photo by Nathaniel Mitkowski

A huge number of *Xanthomonas* cells streams from the vascular tissues of a cut annual bluegrass leaf.

Peter H.Dernoeden,Ph.D.(pd9@umail.umd.edu),is a professor and John E.Kaminski,M.S.,is a research assistant in the department of natural resource sciences and landscape architecture at the University of Maryland,College Park; Noel Jackson,Ph.D.,is a professor in the plant science department and Nathaniel Mitkowski,Ph.D.,is an assistant professor in the department of plant sciences at the University of Rhode Island,Kingston.