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PHYSIOLOGY

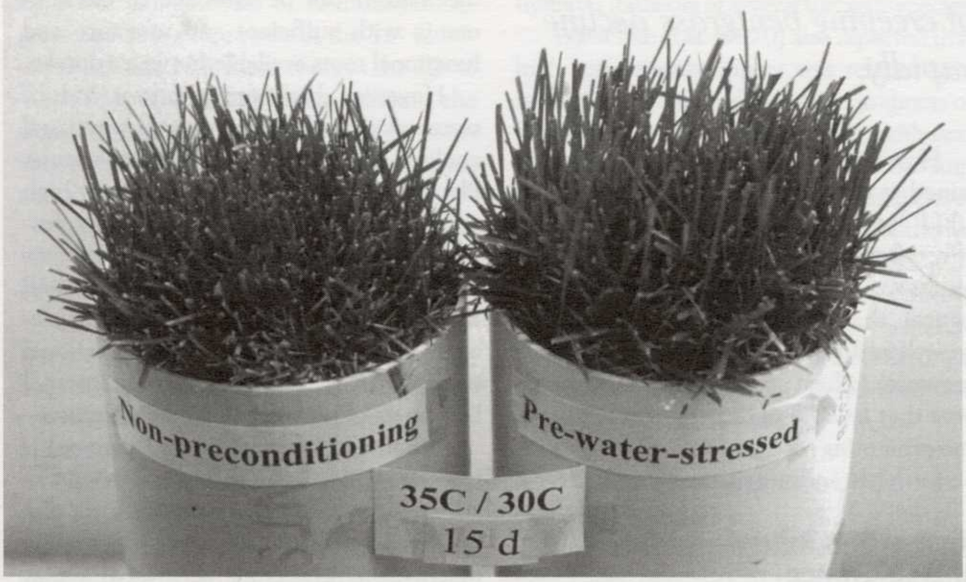
Summer Decline of Cool-season Turfgrasses:

Heat Stress and Cultural Management

Highly stressed turfgrass needs special consideration in managing irrigation and mowing, as well as a realization that the plants' mechanism for dealing with high temperatures can be rather complex

By Bingru Huang

Turf quality decline of cool-season grasses during summer is a major problem in turfgrass management in the transitional and warm climatic regions. The optimum temperatures for cool-season grasses are 60 to 75 F for shoot growth and 50 to 65 F for root growth (Beard, 1973). However, air temperature often approaches 95 F or higher during summer in those regions. Therefore, high temperature is a major stress-causing



Drought preconditioning facilitates water uptake during heat stress, as is evidenced by the Kentucky bluegrass on the right that has outgrown the grass on the left.

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summer quality decline.

It is important to understand the mechanisms by which cool-season grasses naturally tolerate high temperatures and how cultural practices affect grass tolerance to heat stress. This information can lead to efficient development of new grasses by breeding or genetic engineering for specific adaptive traits, as well as development of effective management practices to facilitate grass performance during summer.

Critical temperatures influencing turfgrass summer performance

Mid-day soil temperature is often as high as air temperature, and night soil temperature can be higher than air temperature, particularly in wet soils. Our work shows that soil temperature plays an important role in turf performance regardless of air temperature. If soil temperature is 100 F, and air temperature is 68 F, turf quality and root growth of creeping bentgrass decline rapidly. High soil temperature first causes injury to roots and then to shoots.

If soil temperature is 100 F, and air temperature is 68 F, turf quality and root growth of creeping bentgrass decline rapidly.

However, if soil temperature is maintained at 68 F, and shoots are exposed to 100 F, turf quality and root growth are not affected (Xu and Huang, 2000). Our results suggest that soil temperature is more critical than air temperature for plant growth and that roots may mediate shoot responses to heat stress. Any cultural practices that favor lowering soil temperatures and promoting root growth would help turf perform better during summer months.

Heat stress injury and tolerance

Heat injury in plants resulting from either high air temperature or soil temperature involves many physiological and morphological changes. The adverse effects of high temperatures on turf quality probably are due to direct inhibition of root growth and activity and, therefore, limitation of water and nutrient supplies to the shoot and disruption of carbohydrate metabolism.

Leaf water status of plants is controlled by three processes:

- transpiration,
- water transport and
- water uptake.

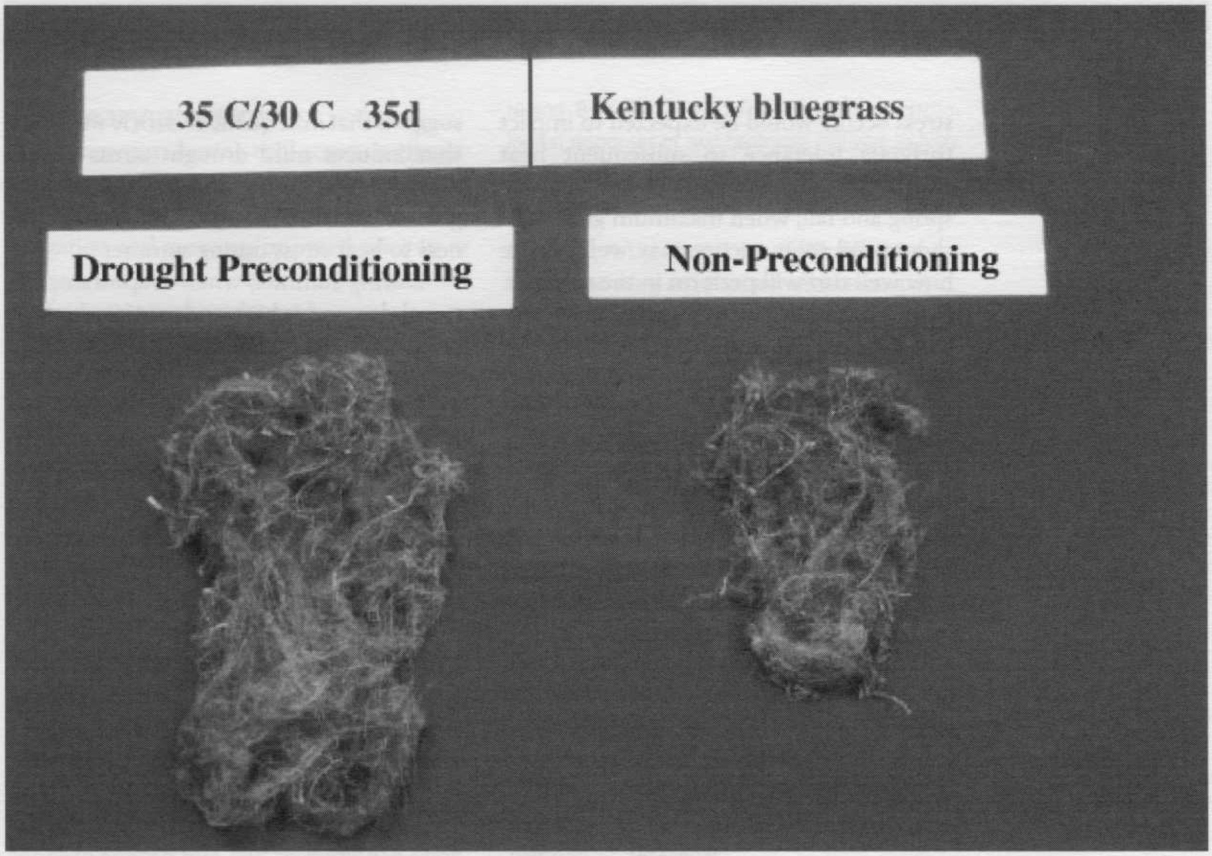
High temperature interrupts the water balance between shoots and roots by enhancing transpirational demand of leaves and inhibiting water uptake of roots. The results are leaf water deficits and a substantial increase in leaf temperature to potentially lethal levels. Jiang and Huang (2000) reported severe leaf water deficit in heat-stressed Kentucky bluegrass.

Lehman and Engelke (1993) found that turf quality of creeping bentgrass was correlated significantly with shoot water content under elevated soil temperatures ranging from 29 to 34°C. Various studies suggest that maintaining a favorable water status plays an important role in plant tolerance to heat stress.

One of the main mechanisms plants can utilize to cope with high temperatures is heat dissipation through transpiration. This mechanism can be effective in environments with sufficient soil moisture and functional roots available for water uptake.

However, high temperatures induce stomatal closure, reducing transpirational cooling and increasing leaf temperature. Plants that can survive at a relatively high temperature have significantly higher stomatal conductance and transpiration rates than plants that fail to survive (Kolb and Robberecht, 1996). Therefore, maintenance of water uptake and transpirational cooling can protect plants from internal heat stress at relatively high temperatures.

When evapotranspirational demand is high under high temperatures, water uptake and transport place a constraint on the potential use of transpiration as a cooling mechanism. Therefore, any factors that affect water uptake capacity of the root system could influence plant performance



The Kentucky bluegrass roots on the left were preconditioned for drought conditions and therefore grew more extensively than the non-preconditioned roots on the right.

under high temperature conditions. An extensive, deep, root system contributes positively to water uptake and maintenance of favorable leaf water status, which has been identified as an important characteristic of heat-resistant plants.

Bonos and Murphy (1999) found that heat-tolerant cultivars of Kentucky bluegrass had 19% more roots at the 15- to 30-cm depth and 65% more roots at the 30- to 40-cm depth than intolerant cultivars; the extensive root system of the tolerant cultivars resulted in lower stomatal resistance and a cooler canopy.

Lehman and Engelke (1987) indicated that selection for heat tolerance indirectly selected a population with increased rooting area.

Indirect heat stress may be related largely to levels of carbohydrate accumulation, because carbohydrates serve as energy reserves and provide structural materials for maintaining cell functions.

High temperature reduces photosynthesis (food production) but increases respiration (food consumption), leading to an imbalance between the two processes (Carrow, 1996; Huang and Gao, 1999; Huang et al., 1998a). Youngner and Nudge (1976) reported a negative relationship between temperature and total nonstructural carbohydrates in shoots of several turfgrass species.

Watschke et al. (1970) also reported that high temperature injury was related to a reduction in sugar concentration in shoots of Kentucky bluegrass. Our research with several cultivars of creeping bentgrass has suggested that heat stress injury is related closely to declines in carbohydrate availability in shoots and roots (Liu and Huang, 2000).

Any factors that enhance carbohydrate production or limit carbohydrate consumption would be beneficial for carbohydrate accumulation and, thus, could facilitate plant tolerance to heat stress.

Irrigation management and heat tolerance

Given the close association of water and heat stress, exposure of grasses to periodic drought stress by infrequent or deficit irrigation (drought preconditioing) before heat stress occurs would be expected to impact turfgrass tolerance to subsequent heat stress. Irrigation practices performed in the spring and fall, when maximum growth of shoots and roots occurs, may well dictate how well turf will perform in the summer.

Several studies have reported that prior exposure of plants to water deficit at low temperatures (drought preconditioning) increases their resistance to subsequent heat stress (Wehner and Watschke, 1981; Martin and Wehner, 1987; Jiang and Huang, 2000).

In our studies with Kentucky bluegrass, enhancement of turf quality (Fig. 1) during subsequent heat stress by drought preconditioning was associated with improved root growth and water relations.

Drought-preconditioned plants developed more extensive root systems deeper in the soil profile than non-preconditioned plants (Fig. 2), which facilitateed water uptake under heat stress. Drought-preconditioned plants had higher leaf water content, stomatal conductance, and transpiration rate than non-preconditioned plants under heat stress, which could lead to greater cooling ability.

Several studies have reported that prior exposure of plants to water deficit at low temperatures (drought preconditioning) increases their resistance to subsequent heat stress.

Our results also have demonstrated that leaves of drought-preconditioned grasses were more turgid than those of non-preconditioned plants during subsequent heat stress (Fig. 1). This response was related to the accumulation of solutes in leaves during drought, particularly potassium and soluble sugars.

However, Becwar et al. (1983) found that drought preconditioning did not increase heat tolerance in four turfgrass species tested in a laboratory. Nevertheless, in cases where turf managers irrigate to excess during spring, reducing irrigation frequency prior to periods of anticipated high temperature stress may well have practical appreciation for improving heat tolerance. Improved heat tolerance of cool-season grasses by drought preconditioning suggests that infrequent or deficit irrigation that induces mild drought stress during spring could be used to encourage root growth and enhance physiological hardiness to heat stress during summer.

During summer, when evapotranspirational demand is high and rooting depth is reduced, frequent, light irrigation should be applied as needed. However, it is very important to avoid over-irrigation, especially on poorly drained soils. Excessive irrigation under high temperatures can cause more damage to turf than high temperature alone, because wet soils retain heat for long periods and are associated with lack of oxygen (Huang et al., 1998a, b).

Mowing and heat tolerance

For sustaining growth and heat tolerance, it is essential that plants maintain a level of photosynthesis that is equal to or greater than the level of respiration. When food consumption exceeds production, carbohydrate depletion occurs, and decline of shoot and root growth is inevitable.

In our field studies with creeping bentgrass, mowing at 1/8 inch reduced the canopy photosynthesis rate by removing a larger amount of leaf surface area compared to grasses mowed at 5/32 inch (Huang et al., 2000).

However, low mowing caused an increase in the whole-plant respiration rate, and, thus, resulted in an imbalance between photosynthesis and respiration. The increase in respiration rate may have been related to increases in soil temperature at low mowing. The temperature within the top 2 inches of soil is 2 to 3 C higher at 1/8 inch mowing than that at 5/32 inch mowing.

Creeping bentgrass mowed at 5/32 inch maintain a higher rate of photosynthesis than respiration, even during the hottest periods. This could result in production of additional carbohydrates, which would prevent grass starvation and allow maintenance of shoot and root growth. Our research shows that raising the mowing height by only 1/32 inch during summer can have a significant, positive effect on bentgrass quality by altering physiological activities and soil temperatures.

Summary practices

In summary, managing cool-season turfgrasses during summer remains a challenge to turfgrass managers. Cultural practices, including irrigation and mowing, imposed prior to or during the summer stress period influence turf summer performance.

Infrequent irrigation during spring and fall promotes deep rooting and physiologically prepares plants to go through the summer by maintaining transpirational cooling. Light, frequent irrigation, however, is necessary when evapotranspirational demand is high and roots are shortening during summer. But over-irrigation should be avoided as much as possible.

Mowing at the highest acceptable height in midsummer will maintain the needed balance between food production and consumption and, thus, promote healthy, vigorous turf.

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Bringing scale problems down to size

By Cliff Sadof

Scale insects, those obscure little bumps on twigs, branches and leaves, are among the most problematic, and poorly understood insect pests encountered on woody plants. They damage trees by sucking plant juices and often are ignored until tree limbs leaf out late in spring, or mysteriously start to die. This is probably because during most of its life, a scale doesn't look anything at all like an insect. To make matters even worse, each scale spends most of its life, immobile and hidden from view under a tough skin, or waxy armor that is impenetrable by insecticides.

While the work-a-day world is focused on grass, groundskeepers need to know how to identify scale insects and should have a good idea of how to control them.

The first question typically asked is, How do I know if the bumps I am seeing on twigs and leaves are scales?

If you can flip the bump off with your thumbnail without disturbing the tissue below, then the bump is a scale. Other bumps that are not normally present on your tree or shrub may be galls, or the fruiting bodies of fungal diseases. Galls are abnormal growths of plant tissue often containing, mites, wasps, flies, or aphids, and some of their relatives. Fruiting bodies are part of a fungal pathogen that bursts through the plant tissue.

What are scales?

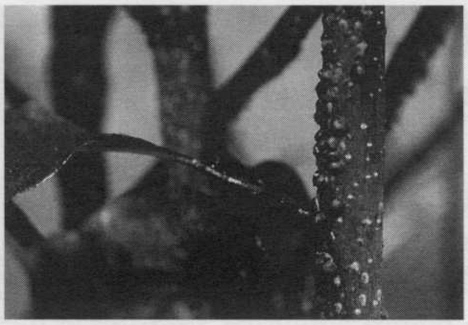
Scales are insects closely related to aphids. From a damage perspective there are two types, those that excrete a sugary liquid excrement called honeydew and those that do not. Honeydew producers can create both a public nuisance and a threat to plant health. Parked cars, walks, and benches beneath infested trees often become a sticky mess. The sugary liquid attracts ants, flies and stinging wasps. Plants become unsightly when a black fungus called sooty mold grows on honeydew. Sooty mold will shade leaves and reduce plant growth. Scales that do not produce honeydew may simply cause dieback and make the plant appear unthrifty.

Soft, kermes, and bark scales, mealybugs, margarodids, and ensign scales produce honeydew. These scales suck fluids from the plant vascular system. They only produce honeydew when they are actively feeding. Typically honeydew production will fall off between molts and when scales are producing eggs.

In contrast, armored scales and pit scales do not produce honeydew and are less mobile and less closely related to aphids. The wiry mouthparts of armored scales move like a plumber's snake to burst plant cells and feed on their contents. Pit scales are likely to do the same to the raised gall tissue that surrounds them.

Euonymus scale on Japanese euonymus.

Scales spend most of their lives immobile, with their tubular mouthparts anchored to the plant tissue on which they feed. After the eggs hatch beneath females the young scales are called crawlers. Crawlers are small (<1/32") and flattened, looking like dust on the plant surface. Since crawlers lack chewing mouthparts they must leave the scale by crawling out from



Tuliptree scale on Magnolia. Note black sooty mold on leaves and stems from honeydew secretion of this soft scale.

beneath the adult female body. Scale infestations spread within a plant as crawlers walk to the site where they settle and feed. They move to new plants when they are blown by the wind to nearby plants or plant parts. In the landscape, scale infestations can also be brought in on nursery stock. Adult males of all scales are winged and because they have no functioning mouthparts are rather short-lived.

After an armored scale crawler begins to feed, it becomes very flat and covered with a clear wax shell. As it continues to grow, it remains beneath its waxy armor. At each of the three successive molts, it produces a new shell that expands beneath the old armor. This waxy covering is difficult to penetrate with insecticides. Winged males crawl out from beneath their cover and mate with covered females who produce eggs. Females can produce about 100 eggs each.

Soft scales are not covered by a waxy shell and excrete large amounts of honeydew. Crawlers hatch from eggs in mid-summer. In most species, crawlers go directly to leaves where they spend most of the summer. They return to the twigs and bark where they spend the winter as settled second stage scales. They continue to grow on twigs in the spring until winged males mate with wingless females, who swell with up to 1,000 eggs.

Where are scale problems usually found?

Scales are mostly found on plants in disturbed areas. This includes areas near pavement, highly managed turf, or plantings that regularly receive insecticide applications.

These areas are prone to scale problems because they create conditions unfavorable for the natural enemies of scales that usually keep them under control in undisturbed sites.

These natural enemies include predatory lady beetles that consume many scales and parasitic wasps that consume individual scales. Furthermore, plants on many of these sites suffer from water stress that can contribute to the growth of scale populations.

What can I do to reduce my problems with scales?

• Minimize stress.

Scales will thrive on trees that are under stress. Keep trees mulched and watered. Do not over-fertilize. Slower growing trees, including those planted in a high-stress site or with variegated leaves can require more care.

• Prune out heavily infested limbs.

Scale infestations are rarely, if ever uniformly distributed on a tree because they move around by either walking or being blown to new limbs. Consequently, trees are usually killed limb by limb. You can exploit this habit to your advantage by pruning out some of the more heavily infested limbs before scales crawlers emerge. Consider radical pruning for rapidly growing woody plants like yellowtwig dogwood , or eounymus that are heavily infested. For mature trees, whose growth is slowed, this option is less desirable.

If you can flip the bump off with your thumbnail without disturbing the tissue below, then the bump is a scale.

• Use dormant season oil sprays for armored scales.

When trees are dormant and scales and natural enemies are less active spray trees with a 3% spray of superior oil (e.g. Sunspray Volk, Scalecide) or a 4% rate of Ultrafine oil (Ultrafine, Sunspray 6E-Plus, Rockland and others) to kill scales. These materials work by smothering scales and disrupting their membranes.

Parasitized scales and those that winter in the egg stage (e.g. pine needle scale, oystershell scale, and winged euonymus scale) are generally not killed by this method. Many of the important scale pests, however do not winter in the egg stage. Scale predators winter in the leaf litter and are not killed by this spray. Be sure to follow label restrictions about sensitive plants. Applying oil on blue needled conifers may turn them green.

Coverage is essential to effective control with oil. When spraying scale-infested ground covers with oil use adequate pressure to cover the scales that lie deep in the ground cover. Studies that applied 4% Ultrafine oil at 250 psi with a Greenarde JD-9 handgun to Pachysandra achieved a 66% reduction numbers of euonymus scale.

• Use summer oil sprays for all scales and mealybugs.

Ultrafine oil, can be applied at the 2% rate in the summer when leaves are present to kill scales. This material will kill any crawlers and scales that have recently settled. It is not effective against armored scales after the clear scale body starts becoming covered with opaque waxy armor. It is also less effective against soft scales and mealybugs with each successive molt.

The wiry mouthparts of armored scales move like a plumber's snake to burst plant cells and feed on their contents.

Treating pachysandra ground cover in both the dormant season and when crawlers were active reduced euonymus scale populations by 99% .

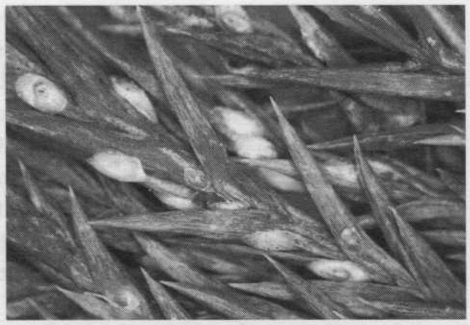
Oil spray will also kill natural enemies flying and walking on the tree at the time of application. Like the dormant spray, it does not kill parasitoids developing within scales. Natural enemies on nearby trees and unsprayed tree portions will suffer no ill effects when they fly back to sprayed areas after the oil has dried.

• Use systemic soil, applied insecticide for honeydew producing scales.

Soil applied insecticides (e.g. Merit 75 WSP) can also kill honeydew producing scales when they are actively feeding on leaves and twigs. Although it can take several weeks to get enough material into the tree canopy, materials like Merit are long lasting and have a long window of activity.

Ironically, armored scales are not controlled by Merit because they do not ingest enough of the plant sap to receive a toxic dose of this insecticide. These materials are likely to kill all natural enemies feeding on honeydew producing insects located on treated trees.

Cottony camellia scale on Holly. Note black sooty mold on leaves and stems from honeydew secretion of this soft scale.



Juniper scale on Juniper.

• Reserve summer conventional sprays for emergencies only.

Conventional pesticides (e.g. diazinon, maltahion, acephate, chlopyriphos, biphenthrin, and cyfluthrin) only kill the crawling stage of scales since they cannot penetrate a scale's tough skin or waxy cover. These materials work best when applied at the begining of the crawler period.

Crawlers are killed by direct spray contact or as they walk along treated surfaces for days or even weeks after spraying.

The long -lasting killing power of these insecticides can work against you when you are trying to manage scales because of their negative impact on natural enemies. When natural enemies are greatly lowered live scales remaining on the tree are free to increase their numbers after the insecticide loses its effectiveness. With each female scale having between 100 and 1000 eggs each, leaving a couple of dozen scales on a tree can cause a big problem.

*— **Cliff Sadof** is an associate professor of entomology at Purdue University.*

Weeds as Indicators of Environmental Conditions

The presence of certain weeds isn't accidental.
Good weed management depends on understanding the underlying conditions that allow weeds to flourish. That may mean investigating soil conditions, mowing, moisture or shade conditions first

By Jeffrey F. Derr

Turfgrass managers know that turfgrass species are adapted to certain soil and light conditions. Bermudagrass grows best in full sun and creeping red fescue is adapted to shady conditions.

Weed species, just like our cultivated turfgrasses, are also often associated with certain environmental conditions. Understanding the association of weed species to the soil environment could help you identify an underlying soil problem. You can then correct the soil problem and the result will be enhanced turf growth. A more competitive turf will reduce weed density.

The presence of a specific weed species is not proof, however, that the associated soil condition exists at that site. Weeds are generally adapted to a range of growing conditions. They may even grow better in areas other than specific environments with which they are associated.

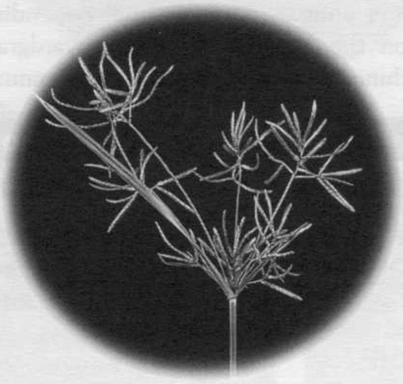
Prostrate knotweed (Polygonum aviculare) is often found in compacted soils such as paths worn in turf areas. This does not mean that prostrate knotweed only grows in compacted soil — in fact, it grows well under more favorable conditions. Turfgrass, however, may not survive under the stress of soil compaction, so prostrate knotweed is taking advantage of an ecological niche that cannot be exploited by our desirable lawn species.

The appearance of a given weed species, such as height or color, can vary, depending upon the environment at that site. In compacted areas such as footpaths, prostrate knotweed is a small, prostrate, dark-green colored plant. When growing in undisturbed sites, it can have a lighter green color, larger leaves, and a more upright growth habit.

Weeds common in wet sites

Certain weed species can thrive under wet soil conditions. Such areas may include land near ponds or streams, drainage ditches, poorly drained soils or sites that are frequently irrigated. Members of the sedge and rush families are commonly found in wet sites. Slender (path) rush (Juncus tenuis) is an example of a perennial weed in the rush family. More commonly, one finds members of the sedge family in wet turf sites.

Important turf weeds in the sedge family include yellow and purple nutsedge (Cyperus exculentus and Cypcrus rotundus), both perennial weeds that spread by rhizomes and tubers. Green kyllinga (kyllinga brevifolia) is another perennial sedge that spreads by rhizomes.



Yellow or purple nutsedge

Certain annual weeds in the sedge family, such as annual sedge (Cyperus compres-

Annual bluegrass

sus), can infest turf areas. The annual sedges spread strictly by seed, making them somewhat easier to control than the perennial sedges, which spread vegetatively and by seed.

Two more grasses associated with wet sites are annual bluegrass (Poo annua), a winter annual or a perennial depending upon the subspecies; and barnyardgrass (Echinochloa crus-galli), a summer annual.

Certain perennial broadleaves can be found in wetter locations. They include:
• alligatorweed (Alternanthera philoxeroides),
• a pennywort (Hydrocotyle spp.),
• Virginia buttonweed (Diodia virginiana),
• pearlwort (Sagina procumbens), and
• moneywort (Lysimachia nummularia).

Pennywort is also referred to as dollarweed. Mosses and liverworts can grow under higher soil moisture as well. Cool, moist environments are conductive to growth of bittercress species (Cardamine spp.).

Certain types of these weeds, like compressed sedge, are probably not that competitive with turfgrass. I visited a site once, however, where the turf had been damaged by an herbicide application. The damage thinned the turf considerably, allowing for the germination and growth of annual sedge. Although this was a wet site due to the proximity to a lake and the soil type, the invasion by the sedge was probably due more to the turf injury caused by the herbicide.

Weeds common in compacted soils

As mentioned earlier, certain weed species can grow in compacted soil such as paths in parks, school grounds and other areas that receive heavy foot traffic. Weeds in this category include:

TABLE 1. WEEDS COMMON IN WET SITES
Alligatorweed
Annual bluegrass
Annual sedge
Barnyardgrass
Bittercress
Green kyllinga
Liverworts
Moneywort
Mosses
Pearlwort
Pennywort
Purple nutsedge
Slender (path) rush
Virginia buttonweed
Yellow nutsedge

TABLE 2. WEEDS COMMON IN COMPACTED SOIL
Annual bluegrass
Annual sedge
Broadleaf plantain
Corn speedwell
Goosegrass
Lespedeza
Prostrate knotweed
Slender rush
Spotted (prostrate) spurge

TABLE 1. WEEDS COMMON IN DROUGHT PRONE SITES
Bitter sneezeweed
Black medic
Broomsedge
Goosegrass
Lespedeza
Prostrate knotweed
Spotted knapweed
Spotted spurge
Yellow woodsorrel

- goosegrass (Eleusine indica),
- annual bluegrass,
- prostrate knotweed,
- spotted (prostrate) spurge (Euphorbia maculata),
- corn speedwell (Veronica arvensis),
- broadleaf plantain (Plantago major), and
- various lespedesa species.

Goosegrass is a summer annual grass.

Although this was a wet site due to the proximity to a lake and the soil type, the invasion by the sedge was probably due more to the turf injury caused by the herbicide.

Spotted spurge and prostrate knotweed are summer annual broadleaves. Corn speedwell is a winter annual, while broadleaf plantain is perennial. There are both annual and perennial lespedeza species.

Compacted soil could also be associated with poorly drained, wet sites, favoring the growth of species such as annual sedge and slender rush.

Keep in mind that these species can also grow in soil that is not compacted. Goosegrass, for example, is a common weed in cultivated soil. These species can survive under compacted soil conditions, although their growth may not be as robust compared to situations where they are growing under more favorable soil conditions.

Species in drought-prone sites

Some species can tolerate dry soil environments. Certain types of these species were listed earlier in the compacted soil section, such as spotted spurge, prostrate knotweed, lespedesa and goosegrass. Others that can grow under drier soil conditions include:

- yellow woodsorrel (Oxalis stricta),
- broomsedge (Andropogon virginicus),
- spotted knapweed (centaurea maculosa),
- bitter sneezeweed (Helenium amarum), and
- black medic (Medicago lupulina).

Yellow woodsorrel and spotted knapweed are perennial broadleaves. Broomsedge is a perennial grass while bitter sneezeweed and black medic are annual broadleaves. Species like yellow woodsorrel can grow in irrigated sites but may have a competitive advantage over turfgrass under dry soil conditions.

Weeds and mowing

Mowing height and mowing frequency both have a dramatic effect on weed species composition. Some weed species are most commonly found in specific types of sites:

Sites infrequently mowed — Chicory (Cichorium intybus), a perennial broadleaf, is found under such conditions, making it common in turf maintained along highways.

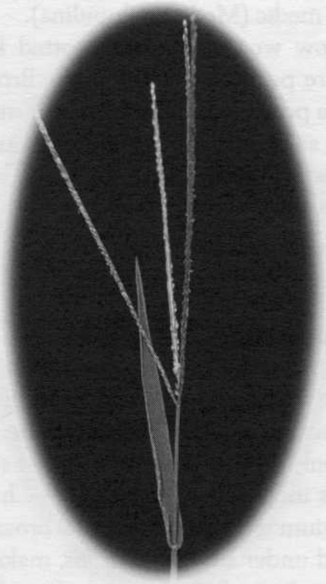
Broomsedge

Wild carrot (Daucus carota), teasel (Dipsacus fullonum), burdock (Arctium minus) and yellow sweetclover (Melilotus officinalis) all biennial broadleaves — will also grow in areas that are not mowed on a regular basis.

Sites frequently and closely mowed — A golf course green would be one example of this condition. Weeds found in this environment include annual bluegrass, goosegrass, smooth crabgrass (Digitaria ischaemum), common chickweed (Stellaria media), mosses and pearlwort.

Smooth crabgrass is a sum-

Species like yellow woodsorrel can grow in irrigated sites but may have a competitive advantage over turfgrass under dry soil conditions.



Smooth crabgrass

mer annual grass while common chickweed is a winter annual broadleaf. Pearlwort is a perennial broadleaf.

Weeds found in turf areas, such as home lawns, obviously can tolerate frequent mowing. For an annual weed to persist in turf, it must be able to produce seed below the mowing height or flower between mowings. Upright pigweed (Amaranthus hybridus) do not persist in frequently mowed turfgrass, although they may be found after the area has been tilled in a lawn renovation project.

Frequent mowing also is conducive to perennials with a prostrate growth habit, such as white cover or ground ivy (Glechoma hederacca).

Soil nitrogen and pH effects

Soil fertility may impact weed species composition. Soils high in nitrogen favor growth of plants such annual bluegrass and common chickweed.

Weeds adapted to low nitrogen conditions include:

• black medic,
• birdsfoot trefoil (Lotus corniculatus),
• white clover (Trifolium repens),
• corn speedweel, hawkweed (Hieracium spp.), and
• broomsedge.

Certain weeds can grow in acid soils. Reed sorrel (Rumex acetosella), a creeping perennial, is one example. Mosses can grow under low pH conditions. Broomsedge, a perennial grass, also grows in acidic, low nitrogen soils.

One may think that correcting a soil fertility of pH problem by liming or nitrogen application would cause these weeds to disappear. These weeds can grow under more favorable soil conditions, so additional inputs such as herbicide application may be required to remove theses species from a site. Fertilization should make the turf more competitive, helping to limit re-invasion by these plants.

How sunlight affects weeds

The amount of sunlight reaching the soil surface can impact weed species composi-

TABLE 4. WEEDS FOUND IN SITES INFREQUENTLY MOWED
Burdock
Chicory
Teasel
Wild carrot
Yellow sweetclover

TABLE 5. WEEDS ADAPTED TO CLOSE, FREQUENT MOWING
Annual bluegrass
Common chickweed
Goosegrass
Mosses
Pearlwort
Smooth crabgrasss

TABLE 6. WEEDS COMMON TO SITES WITH HIGH SOIL NITROGEN
Annual bluegrass
Common chickweed

TABLE 7. WEEDS COMMON TO SITES WITH LOW SOIL NITROGEN
Birdsfoot trefoil
Black medic
Broomsedge
Corn speedwell
Hawkweed
White clover

TABLE 8. WEEDS FOUND IN ACIDIC SOILS
Broomsdege
Mosses
Red sorrel

TABLE 9. WEEDS COMMON TO SHADY AREAS
Ground ivy
Japanese stiltgrass
Poison ivy
Violets
Virginia creeper

tion. Some weeds are more commonly found in partial shade. Japanese stiltgrass (Microstegium vimineum) is a summer annual grass that is found in moist, shady conditions. The perennial broadleaf weeds ground ivy, violets, poison ivy (Toxicodendron radicans) and Virginia creeper (Parthenocissus quinquefolia) are also associated with shady conditions. They also can be found growing in areas receiving little shade. However, they may establish better under cool, moist, shady conditions.

Most weed species grow well under full sun. Frequently, weeds that are troublesome in full sun are not that aggressive under shady conditions.

Yellow nutsedge and Bermudagrass (Cynodeon dactylon) would be examples of weeds that are less of a problem when growing turf in shade. I was reminded of this issue when visiting a research site with one of our graduate students. He had difficulty establishing yellow nutsedge in his turf plots. Where the turf was killed by a herbicide application to make alleyways between different plots in the study, yellow nutsedge grew vigorously. A thick, healthy turf will shade the soil, limiting the availability of light for growth of a full-sun species like yellow nutsedge.

Integrated pest management

Weeds are generally more adapted to adverse growing conditions than our desirable turfgrass species.

By correcting a soil problem, such as low pH, compacted soil or low nitrogen, we enhance the conditions for turf growth. Any factor that improves the competitiveness of turf will reduce weed populations at that site. Correcting the site problem may not eliminate the weeds currently present, especially for perennial species.

If we do not address the soil condition, however, and instead only apply a herbicide to the site, we can temporarily solve the weed problem. That weed will probably return to the sprayed area, however, if the site is not conducive to turf growth.

Soil fertility impacts weed species' composition. Soils high in nitrogen favor growth of plants such as annual bluegrass and common chickweed.

Weed scouting can be part of an integrated program to manage turf areas. Scout for winter weeds in spring when these species are in bloom and thus easier to identify.

Scout for summer annual and most perennials in late summer or fall when these species are in flowers. See if any of the weed species present at each site match any specific soil condition. Besides applying a chemical to control those weeds, also check soil pH, drainage, irrigation scheduling and other factors. Addressing these soil problems through actions such as liming, aeration and pruning trees to increase sun penetration can lead to an improved weed management plan.

*— **Jeffrey F. Derr** is a weed scientist at Virginia Tech University, Virginia Beach, VA.*

Dan Dinelli Earns Excellence Award

Dan Dinelli (left) receives congratulations from The Scotts Company's former vice president of sales, John Johnson.

Dan Dinelli, CGCS, of the North Shore Country Club, in Glenview, IL, north of Chicago, had a well-deserved star turn on television recently during the Senior Tour. Dan was on camera, accepting the 2000 Scotts Tradition of Excellence Award from Scott Todd of the Scotts Co., Marysville, OH.

The award was presented officially at GCSAA's 71st International Golf Course Conference and Show in New Orleans in February.

Dan, of course, is one of the field advisors to TurfGrass TRENDS. The Tradition of Excellence Award recognizes outstanding achievements among golf course superintendents who are dedicated to advancing the science of course maintenance and making golf the best it can be. Dinelli is the seventh recipient of the annual peer-nominated award.

IPM (integrated pest management) and biological pest management are Dinelliís strong points. As a result of his efforts, the North Shore Country Club was certified in the Audubon Cooperative Sanctuary Program in 1998.

Dinelli also mentors and teaches techniques. In 1997, a putting green was built at North Shore to evaluate bentgrass varieties for sponsors GCSAA, USGA and NTEP. The green is still used today. Dinelli has worked with the University of Illinois on use of various composts on turfgrasses. He also serves on the state Turfgrass Research Review Committee. He teaches a seminar on golf course management at Harper College and has served on the collegeís Park Management and Horticulture Advisory Committee for 15 years.

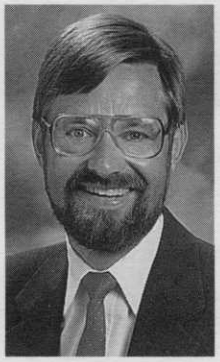
Selection for the Tradition of Excellence Award is based on several criteria: teaching and mentoring, leadership, environmental responsibility, research and innovation in cultural or management practices, and professional involvement.

In Future Issues

- Herbicide control based on soil temperature degree days
- N and turf, reconsidered
- Disease control today, outlook for tomorrow
- Reducing crabgrass germination

Start to Cultivate Yourself

As a reader of TurfGrass TRENDS, you are among the elite in the industry. While many of you have advanced degrees in ag chemistry or agronomics, it is unlikely that you've studied much public relations.



Curt Harler
Managing Editor

But it is time you began a soft-sell campaign with management, pointing out the good things that you and your staff accomplished over the past couple of months.

It's a pretty safe bet that most of your face-time with the boss falls into one of two categories: either there have been some complaints about the quality of the greens on 16 and 17 or you are asking for five-grand for a new self-propelled mower. Neither is exactly the kind of positive meeting that endears you to the powers-that-be.

Yet, there are many opportunities each week to spend some time with the head honcho and push what a good job you or your crew is doing. It can be small things, like Fred's willingness to show up early and work on an irrigation pump (demonstrating worker loyalty). Or, asking the boss to share an "attaboy" with the two new workers who are starting to show some promise on the job.

Never miss an opportunity to point out how you or your crew saved the organization money. If you've made an adjustment in spray schedules that will save one or two sprays per season, figure out what that means in dollar terms. Forget the chemical-speak. Tell the boss how many dollars you saved. Or, dig out some machinery maintenance figures from a few years ago and compare them to today's numbers, showing how well the in-house mechanic is doing.

At the end of each meeting with your boss, there should be at least one thing that leaves the impression, "Those people are doing a good job."

We know you'll do the best you can at keeping the grass green. Be sure to do just as good a job highlighting the positive things you and your team are doing on the job. Otherwise, someone new will be brought in next year and get the credit for all your hard work.

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