from the infected roots and grow on the culture medium, enabling a more detailed study of the organism. Once potential pathogens have been recovered from infected roots, attempts can be made to complete Koch's postulates.

Most of the techniques used to diagnose root and crown diseases require specialized equipment and considerable expertise. Even experienced turfgrass pathologists have difficulties diagnosing some root and crown diseases on turfgrasses. As we learn more about the biology of root-infecting turfgrass pathogens, however, and as more sophisticated techniques for their detection and identification are developed, root disease diagnosis will become more accurate.

Not to be overlooked

Abiotic factors can also contribute to root dysfunction and decline, in particular high concentrations of soluble salts, root zone oxygen depletion and excessive soil temperatures. The natural senescence of turfgrass roots, particularly during the summer months, further complicates the picture. These factors must always be taken into account when contemplating, or conducting, root disease diagnosis, and should be included in any routine diagnostic procedure.

Terms to Know

Rhizome - a plant stem, usually horizontal, usually under the soil surface, with leaves or shoots above and roots below the nodes

Pre-/Post-emergent - before/after the emergence (of a weedy plant, for instance)

Surfactant - surface active agent; when added to liquids, surface active agents reduce surface tension, increasing the liquid's spreading and wetting properties

Tuber - a short, thickened, fleshy part of an underground stem; contains nodes and buds

Yellow Nutsedge: Biology and Control In Cool-Season Turf

by Joseph C. Neal

About the weed

Yellow nutsedge (*Cyperus esculentus*), often referred to as "nutgrass," is a tough-to-control perennial weed that infests most crops and turfgrass areas throughout most of the United States. Although grasslike in many ways, yellow nutsedge is not a grass; it is a sedge.

Sedges are easily distinguished from grasses by their leafy shoots, which are triangular in cross section. Shoots of grasses, on the other hand, are either flat or round. Distinguishing between grasses and sedges is very important, as most herbicides for grass control do not control sedges.

Yellow nutsedge emerges between late spring and midsummer, producing leafy clumps of long, narrow, light green and glossy, grasslike foliage. Yellow nutsedge spreads by rhizomes (underground stems), which produce "daughter" plants. Starting in late June, when days begin to get shorter, small, egg-shaped tubers begin to form at the tips of the rhizomes. Tubers mature in late July to mid-August. Under optimum conditions, a single plant can produce up to 7,000 tubers!

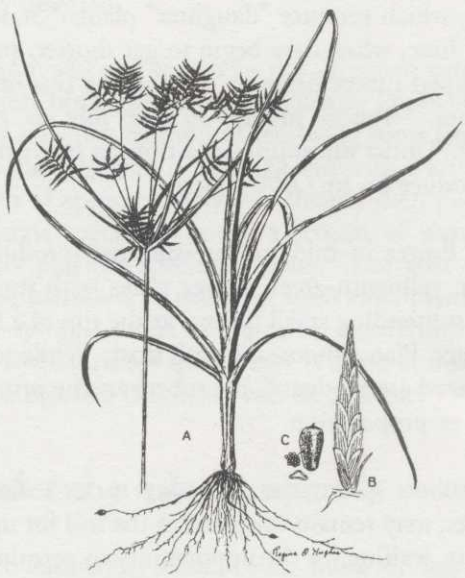
Plants flower in mid- to late-summer, producing slender, yellowish-green flower stalks with leaflike bracts subtending small flowers at the top of a leafless stem. Plants shoots die with frost. While some viable seed are produced, the tubers are the primary means of propagation.

Most tubers sprout the following spring. Some, however, may remain dormant in the soil for up to 10 years, waiting for the opportunity to germinate. Consequently, nutsedge control strategies must include a long-term commitment to preventing new tuber formation.

Where did it come from?

Yellow nutsedge is a native of North America. Although originally found primarily in poorly drained or wet areas, it now infests millions of acres of cultivated land and turf. Mindful of its past, many still consider the presence of yellow nutsedge a suggestion of drainage problems. On the contrary, yellow nutsedge is well adapted to growing in wet soils; dry, sandy soils; and everything in between. It tolerates close mowing, high or infrequent mowing and most herbicides labeled for use in turfgrass weed management. The primary reason for its spread appears to be the elimination of competition from other weeds. As we controlled other weed species, we eliminated the competition that previously restricted the distribution of nutsedge; in effect, we "released" nutsedge to become the major weed pest it is today.

Another factor contributing to the spread of yellow nutsedge is the resiliency of the tubers. Nutsedge tubers can remain dormant in the soil for up to 10 years. Control procedures may be effective within a season, but dormant tubers will remain to reinfest in following years. Additionally, tubers that have not yet sprouted are almost impervious to herbicides or cultivation. In conventionally tilled crops, tubers are spread by cultivation. As urban sprawl reaches farming communities, the top soil, much of it containing nutsedge tubers, is often sold and used for landscaping. Nutsedge tubers are also often introduced in root balls of field-grown trees and shrubs, from which rhizomes spread into adjacent turf.



Yellow nutsedge. Line drawing by Regina O. Hughes, from Selected Weeds of the United States, Washington, DC: USDA, 1970.

Why is yellow nutsedge so difficult to control?

Several herbicides are registered for yellow nutsedge control in turf; so, why is it considered to be so hard to manage? The answer requires a consideration of the biology of nutsedge growth and reproduction, as well as the situations where it is a pest. Yellow nutsedge reproduces primarily by tubers, then spreads by rhizomes. The tubers begin sprouting in the spring when soil temperatures reach about 65° F, but continue to emerge through late June. Since no pre-emergent herbicide labeled for use in cool-season turf is effective against nutsedge, post-emergent strategies are the only option available. Post-emergent herbicides are most effective on young nutsedge plants; but with no residual activity, and new plants emerging over an extended period, multiple applications are often necessary to achieve adequate control. Additionally, the extended dormancy of some tubers results in plant emergence and reinfestation of the site for years to come, even if effective control is obtained in a single season.

How to control yellow nutsedge

Herbicides registered for the post-emergent control of yellow nutsedge include the methane arsenates, MSMA and DSMA, and bentazon (Basagran T/O). With each product, multiple applications and treatments during warm weather are often necessary to obtain satisfactory control, but these same conditions can result in unacceptable turfgrass injury.

MSMA and DSMA are organic arsenicals that can be used for post-emergent control of crabgrass and nutsedge. Both are essentially contact-type herbicides; that is, they provide top kill and do not translocate to the rhizomes.

MSMA, available under numerous trade names, is used more commonly. It is generally available in

two formulations: 6 lb. ai per gal. or 6.6 lb. ai per gal. Besides the difference in ai per gal., the two formulations differ in surfactant recommendations. With the 6 lb. ai per gal. formulation, the surfactant is included in the product, and no additional surfactant is recommended. The 6.6 lb. ai per gal. formulation, on the other hand, contains no surfactant, and the addition of a nonionic surfactant at 2 to 3 oz. per 1000 ft.^{2} is recommended. The recommended rate of application for both formulations is 1 oz. per 1000 ft.^{2}. This is equivalent to 2 to 2.2 lb. ai/A (depending on the formulation).

Complete control is usually not achieved with a single application. Two to three applications at 14-day intervals are suggested. Since it is a contact-type herbicide, thorough spray coverage is essential for good control. Use a calibrated boom sprayer, not a hose-end applicator. The label suggests a spray volume of 2.5 gal. per 1000 ft.^{2} (about 110 gal. per acre); however, with flat fan nozzles operating at about 40 psi, excellent results can be obtained with as little as 0.7 gal. per 1000 ft.^{2} (30 gal. per acre).

Most turfgrass species are injured to some extent by MSMA; the extent of injury depends on the species, rate of application and environmental conditions at the time of treatment. Established Kentucky bluegrass, perennial ryegrass and tall fescue are tolerant, but may exhibit undesirable injury when treated during hot, dry weather. Bentgrasses and fine-leaved fescues are sensitive. Injury symptoms, which include yellowing, foliar burn and increased leaf spot disease, can persist for three to five weeks. Reducing the application rate limits the turfgrass injury but also results in diminished control, necessitating several applications.

The label suggests treating weeds during warm weather, when daytime temperatures are between 80° and 90° F. While this will provide rapid control of the weeds, high temperatures increase the severity of turf injury. In my research, I have found MSMA to work very well under cooler conditions. In fact, under cool, moist conditions, I have obtained better nutsedge and crabgrass control than when applications were made during hot, dry weather.

Bentazon also controls yellow nutsedge and annual sedges after they emerge. Unlike MSMA, bentazon does not control crabgrass. Bentazon is translocated to some extent in treated plants, but is still considered to have contact-type action on yellow nutsedge. Consequently, like MSMA, thorough coverage of the weeds is essential for control. Applications in water at a minimum of 1 gal. per

New Help Against an Old Pest

by Joseph C. Neal

Monsanto recently introduced a new product for nutsedge control with the trade name "Manage," the proposed common name halosulfuron and the research code number MON12000.

In trials across the country, this compound has controlled yellow and purple nutsedge as well as or better than industry standards, with reduced turfgrass injury. The active ingredient is a member of the sulfonylurea class of herbicides and, like other members of this herbicide class, will be used at low application rates—probably between 0.03 and 0.06 lb. ai per acre. Manage has been released for distribution and is already available from some distributors and suppliers in some states.

From our research at Cornell University, it appears that sequential applications will provide more consistent control than single treatments. In 1993, treatments applied at the three-to-five leaf stage controlled nutsedge at 0.03 lb. ai per acre. However, in 1994, the same treatment only suppressed nutsedge for about six weeks in our Long Island experiments and provided about 70% control in an up-state New York trial. In the up-state trial, 0.03 lb. ai per acre applied at the three-to-five leaf stage, followed by a second application six weeks later, increased control to 85%. These results mirror those obtained by other researchers in other regions. The variability between years may be attributed to drier weather during the 1994 trials. Research continues to refine the best rates of application and intervals for sequential treatments.

TGT view—Dr. Neal's promising results with Manage notwithstanding, turfgrass managers should keep in mind that nutsedge is one of the most difficult turfgrass weeds to control. Prudence suggests managers remain flexible when deciding on a control strategy based on new product. If experience is any guide, different strategies will be required to deal with nutsedge at different sites.

1000 ft.^{2} (about 40 gal. per acre) are recommended, using a calibrated boom sprayer.

Bentazon is available in a 4 lb. ai per gal. formulation. The recommended application rate for yellow nutsedge control is 2 to 4 pt. per acre (0.75 to 1.5 oz. per 1000 ft.^{2}, or 1 to 2 lb. ai per acre). The higher rate provides more effective nutsedge control, yet repeat applications at 10- to 14-day intervals are often necessary. With the lower rates, a 10-day period between applications (rather than 14 days) is recommended. The addition of a non-phytotoxic crop oil concentrate at a rate of 2 pt. per acre (0.75 oz. per 1000 ft.^{2}) greatly improves yellow nutsedge control but may increase the potential for turf discoloration.

Tolerant turfgrasses include established bluegrass, ryegrass, fescue and bentgrass (not collars or greens). While I have personally seen no turfgrass injury from bentazon, many turfgrass managers in warmer climates have observed injury on perennial ryegrass when applications were made during warm weather. Consequently, to avoid unacceptable turf injury, many superintendents with perennial ryegrass fairways reduce the application rate to 0.75 lb. ai per acre and/or omit the crop oil concentrate. Also, a longer interval between applications, 21 days, is suggested on the label. As you might expect, these actions will reduce nutsedge control.

Maximizing yellow nutsedge control while minimizing turf injury

While bentazon and MSMA differ in many respects, the following guidelines are useful for both herbicides.

- Know where the nutsedge is located. Map the infestations in late summer and scout these areas the following spring. This knowledge will enable you to be ready with the proper herbicides in adequate amounts and to treat the nutsedge when it is young and more easily controlled.

- Begin treatments when weeds are young. Young plants are more easily controlled, and cooler, moister conditions in the early season will reduce the potential for turfgrass injury. With early treatment, lower rates will be effective, but follow-up applications 10 to 14 days later will be necessary to control later-emerging weeds and plants that survive the first treatments.

- Continue these treatments at the appropriate intervals until control is achieved and no more yellow nutsedge emergence is observed.

- Avoid applications during hot, dry weather. Weed control is reduced and the likelihood of turfgrass injury is increased. Irrigation the day before treatment will help, but is no substitute for natural rainfall and cooler weather.

- Calibrate the sprayer. Both herbicides require thorough coverage for maximum control. Overdosing will increase turf injury; underdosing will decrease effectiveness. Also, watch your overlaps; too much overlap effectively doubles your application rate!

- Keep after it. Due to long-term tuber viability, it may take five years or more to get this weed under control.

- Remember that tubers may be brought to the surface or introduced in top soil when you do repair work.

With careful attention to the timing, dose, application method and retreatment intervals of herbicide applications, and with a long-term commitment, this weed can be controlled in cool-season turf. But then, no one ever said this job would be easy!

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