Golf's Most Common Weed-Control Challenges

Golf course superintendents face an array of weeds in putting greens, tees, fairways, and roughs.

BY JIM BROSNAN, PH.D.

There are many answers to the question "What is a weed?" but perhaps the most specific was offered by Aldrich: "A weed is a plant that originated in a natural environment and, in response to imposed or natural environments, evolved, and continues to do so, as an interfering associate with our crops and activities" (R. J. Aldrich, 1984, "Weed Crop Ecology: Principles in Weed Management"). When applied to golf courses, the definition offered by Aldrich communicates that weeds not only hamper aesthetic and functional turfgrass quality, but also that they are a product of both the natural growing environment and imposed maintenance practices. Successful weed-control strategies need to address both of these parameters to be effective for a sustained period of time.

BUILDING A SUCCESSFUL WEED-MANAGEMENT PROGRAM

Proper weed identification is critically important in building a successful weed-management program. Superintendents must be able to determine the weed species they are attempting to control in order to select an appropriate management strategy. For example, smooth crabgrass (*Digitaria ischaemum*) and tropical signalgrass (*Urochloa subquadripara*) can look similar when subjected to mowing at fairway heights (Figure 1). However, while numerous herbicides can control smooth crabgrass in fairways post-emergence, the choices to control tropical signalgrass are quite limited. Often, it requires more than just selective herbicides to eradicate tropical signalgrass infestations. Superintendents should become familiar with online weed-identification resources available through many land-grant universities like North Carolina State University and the University of Tennessee.

*Figure 1. Smooth crabgrass (*Digitaria ischaemum*) (top) and tropical signalgrass (*Urochloa subquadripara*) (bottom) infestations in golf course turf.*

Knowledge of weed life cycles also can aid in optimizing control strategies on golf courses. Weed life cycles are directly affected by both temperature increases during spring and decreasing temperatures during fall. Growing degree days (GDD) and cooling degree days can be used to track weed development and identify periods when herbicides will optimally perform (Elmore et al., 2014; Fidanza et al., 1996).

Implementing control programs before weeds set seed also is an important component of a successful weed-management strategy, particularly in high-traffic areas. Many problematic golf course weeds can produce large amounts of seed that can be deposited back into the soil. For example, annual bluegrass (*Poa annua*) can produce 2,577 viable seeds per square meter in the upper 2.5 centimeters of soil (Watschke et al., 1979).

*Figure 2. Annual bluegrass (*Poa annua*) seed on the sole of a golfer's shoe. Photo courtesy of Robert Raley, M.S.*

If left uncontrolled, weed seeds can be tracked to other portions of a course by golfers, equipment tires, or other means and result in situations where control becomes more challenging — i.e., tracking from roughs onto putting greens (Figure 2). Moreover, letting weeds deposit seed back into the soil will ensure that problems occur annually. As a result, preemergence herbicides that remain active in the soil are often the most effective annual weed controls, as they act on many weed seeds in soil rather than just the weeds that emerge and become established in turf.

A new challenge facing many golf course superintendents is the evolution of weed biotypes with resistance to pre- and postemergence herbicides (Table 1). Since 2008, reports have steadily increased of annual bluegrass and goosegrass (*Eleusine indica*) evolving herbicide resistance. In 2015, cases of multiple resistance — i.e., survival after being treated with two different herbicides — surfaced in both annual bluegrass and goosegrass populations (Heap, 2015). In nearly all instances, herbicide resistance developed when the same herbicide was applied over consecutive years without rotating to products with different mechanisms of action or implementing alternatives to herbicide treatment. Applying the same herbicide without rotation simply selects for weeds that are genetically capable of surviving that herbicide. Initially, the number of individuals genetically capable of surviving a herbicide treatment is quite small, but every year the same herbicide is applied, the worse the problem becomes until the majority of the remaining weed population consists of individuals genetically capable of surviving herbicide treatment.

Resistance poses many challenges to effectively managing golf course weeds. First, when a weed population evolves resistance to a particular herbicide, all other herbicides employing the same mechanism of action are no longer effective. Take the acetolactate synthase (ALS) inhibitors, for example. If annual bluegrass evolves resistance to foramsulfuron (Revolver), none of the other ALS-inhibiting herbicides labeled for annual bluegrass control — e.g., Monument®, TranXit®, Katana®, Velocity®, Certainty®, etc. — will be effective. In many cases, resistance to one herbicide mechanism of action necessitates the use of a different herbicide class that is more expensive or more prone to injuring desirable turf than the mechanism of action originally used. Knowledge of herbicide mechanisms of action is critical in building weed-management programs that rotate herbicides to manage resistance. The University of Tennessee (UT) has compiled several online reference materials to help superintendents improve their understanding of herbicide mechanisms of action. Also, UT

Table 1

Weeds known to evolve herbicide resistance that can occur in turfgrass situations. Currently, most cases of herbicide resistance are in localized areas, but resistant biotypes are becoming more common.

Weed*	Herbicide Resistance
Annual bluegrass	dinitroanilines, sulfonylureas, glyphosate, triazines
Spurges	sulfonylureas
Nutsedges/kyllinga	sulfonylureas
Crabgrass	fenoxaprop
Goosegrass	dinitroanilines, oxadiazon, sulfonylureas, triazines, diclofop, glyphosate
Broadleaf weeds (Lawn burweed, Buckhorn plantain, etc.)	auxins

*Some weed species that can persist in managed turf have evolved herbicide resistance in row crops, including Johnsongrass, ryegrass, and horseweed. Others are suspected.

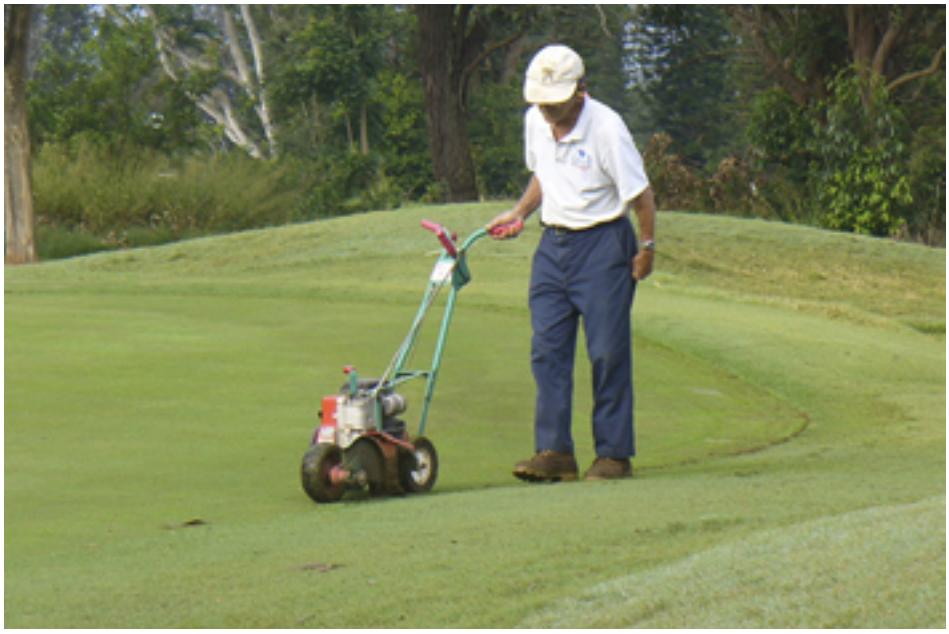

*Figure 3. Mechanically edging bermudagrass (*Cynodon *spp.) collar encroachment.*

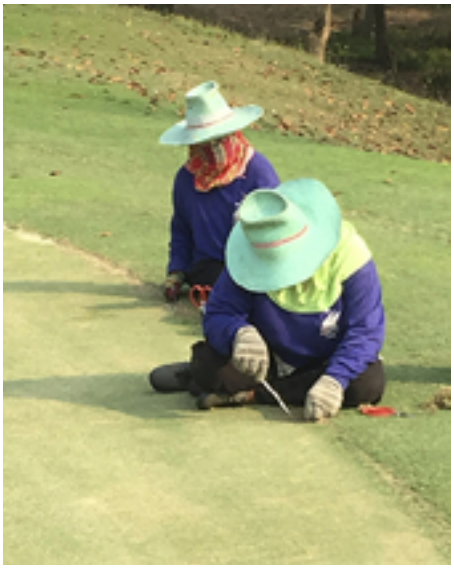

*Figure 4. Manually removing bermudagrass (*Cynodon *spp.) encroachment from an ultradwarf bermudagrass green.*

has developed an online tool to help superintendents develop herbicide programs that rotate mechanisms of action to manage resistance when controlling annual bluegrass. Simply input the herbicide last applied to control annual bluegrass and this online tool will offer options for pre- and postemergence herbicides that employ different mechanisms of action from what was last applied.

Proper identification, knowledge of weed life cycles, and understanding the threat of resistance are important components of weed-management programs. The aim of this article is to provide insight into weed-management programs that target some of the most difficult-to-control weeds on golf courses today.

WEED-MANAGEMENT CHALLENGES ON PUTTING GREENS

BERMUDAGRASS ENCROACHMENT

A common question from golf course superintendents is how to control hybrid bermudagrass encroachment from collars into creeping bentgrass (*Agrostis stolonifera*) or ultradwarf bermudagrass greens. Unfortunately, there is no simple solution to this problem.

Realistically, bermudagrass encroachment is managed over time using several practices rather than completely eradicated or controlled with a single technique. On creeping bentgrass greens, siduron (Tupersan®) is labeled for bermudagrass encroachment at rates up to 1 pound per 1,000 square feet. Usually, siduron is applied as an 8- to 12-inch band from the edge of the collar into the putting surface. Sequential applications are required on four- to five-week intervals for long-term success. Best results occur when bermudagrass is green but not aggressively growing — i.e., spring and fall for most areas. On warm-season putting surfaces, many choose to physically edge the interface between the putting surface and collar using a mechanical edger or have maintenance staff remove encroaching stolons by hand (Figures 3 and 4).

GOOSEGRASS CONTROL

In the transition zone and southern United States, goosegrass infestations on both cool- and warm-season putting greens have become increasingly problematic. Bunch-type growth causes goosegrass infestations on putting greens to reduce both aesthetics and putting quality (Figure 5).

*Figure 5. Goosegrass (*Eleusine indica*) infesting a Tifdwarf putting green in Puerto Rico.*

The only option for effective preemergence control of goosegrass on putting greens is bensulide + oxadiazon (Anderson's Goosegrass/Crabgrass Control). The combination of bensulide and oxadiazon is labeled for creeping bentgrass and non-overseeded bermudagrass greens but not mixed stands of creeping bentgrass and annual bluegrass. Turf must be dry at the time of application and the herbicide should be watered in immediately following treatment. Minimizing application overlap and treating when air temperatures are below 80 degrees Fahrenheit also are helpful tips.

On bermudagrass greens, the only labeled option for selective-herbicide control of goosegrass is foramsulfuron (Revolver®). Diclofop (Illoxan®) had been an option to control nontillering goosegrass plants on bermudagrass greens, but it is no longer being manufactured. Superintendents attempting to control goosegrass with either foramsulfuron or diclofop should be aware that resistance to both mechanisms of action has been observed following the repeated use of either product without rotation. Topramezone (Pylex™) is labeled for goosegrass control in creeping bentgrass at 0.25 fluid ounce per acre with a methylated seed oil surfactant. However, applying topramezone to putting greens is not recommended due to the potential for undesirable injury to creeping bentgrass.

The best option for goosegrass control on either bermudagrass or creeping bentgrass putting greens is to diligently scout for infestations and mechanically remove goosegrass before weed populations become problematic. Maintenance teams can scout for newly germinated goosegrass seedlings when mowing putting surfaces or fixing ball marks.

GREEN KYLLINGA CONTROL

Another weed that has become increasingly problematic in bermudagrass putting greens is green — aka perennial — kyllinga (*Kyllinga brevifolia*). Green kyllinga has a similar appearance to yellow and purple nutsedge, but it can persist and produce flowers at mowing heights less than 0.25 inch. Green kyllinga spreads through rhizomes and can form dense mats in turf.

Trifloxysulfuron (Monument®) is an effective option for controlling kyllinga species in bermudagrass turf, and the label neither allows nor restricts applications to putting greens. However, superintendents should be advised that removing a mat of green kyllinga with a herbicide application likely will require that the treated area be reestablished using plugs from a nursery. In the transition zone, green kyllinga also can be problematic in bermudagrass collars surrounding creeping bentgrass greens. Trifloxysulfuron cannot be applied in these scenarios due to the potential for nontarget movement onto creeping bentgrass.

ANNUAL BLUEGRASS CONTROL

Controlling annual bluegrass in putting greens has been a challenge for decades (Yelverton, 2015). Annual bluegrass infestations in both creeping bentgrass and bermudagrass putting surfaces negatively affect aesthetics and ball roll. Additionally, the presence of different species within a turf canopy complicates cultural management. Preemergence herbicides rarely are used on putting greens due to concerns about hampering root growth, so most superintendents focus on managing annual bluegrass problems postemergence with herbicides or plant growth regulators.

On non-overseeded bermudagrass greens, there are several options for postemergence annual bluegrass control, including trifloxysulfuron (Monument®), foramsulfuron (Revolver®), rimsulfuron (TranXit®), and pronamide (Kerb®). Effective herbicide programs require rotation to manage the potential for annual bluegrass to develop resistance to herbicides like trifloxysulfuron, foramsulfuron, and rimsulfuron, all of which employ the same mechanism of action (ALS inhibition). Populations of annual bluegrass resistant to ALS-inhibiting herbicides have been identified at several golf courses throughout the southern United States since 2013 (Heap, 2015).

Annual bluegrass management on creeping bentgrass greens is centered on the use of plant growth regulators, which not only can shift the competitive balance in favor of creeping bentgrass rather than annual bluegrass but also can be used to minimize annual bluegrass seedhead formation, a problematic issue for many superintendents dealing with mixed stands of creeping bentgrass and annual bluegrass. A review of plant growth-regulator and seedhead-suppression programs was presented by Yelverton (2015).

CRABGRASS CONTROL

Crabgrass (*Digitaria* spp.) infestations can be problematic in putting greens, particularly those established to creeping bentgrass and/or annual bluegrass (Figure 6). At present, there are no

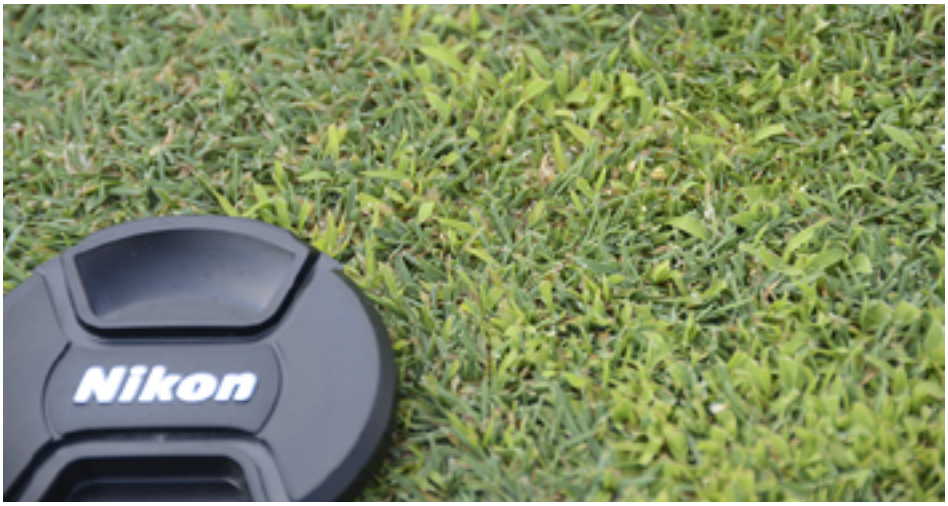

*Figure 6. Smooth crabgrass (*Digitaria ischaemum*) in a creeping bentgrass (*Agrostis stolonifera*) putting green.*

labeled options for selective postemergence control of crabgrass in creeping bentgrass/annual bluegrass putting greens. Superintendents must rely on preemergence chemistry to manage crabgrass infestations in creeping bentgrass/annual bluegrass putting greens. Bensulide (Bensumec™) is labeled for preemergence crabgrass control on creeping bentgrass putting greens, as are mixtures of bensulide + oxadiazon (Anderson's Goosegrass/Crabgrass Control) and several granular formulations of dithiopyr. However, there are no preemergence options labeled for use on mixed stands of creeping bentgrass and annual bluegrass.

Given the lack of herbicide technology available, diligence must be taken to manually remove newly germinated crabgrass seedlings after emergence. Similar to goosegrass, maintenance teams can scout for newly germinated crabgrass seedlings when mowing putting surfaces or fixing ball marks and remove them with a pocket knife or similar instrument. Additionally, ensuring crabgrass is thoroughly controlled in rough areas surrounding green complexes will minimize the threat of seed being moved onto putting surfaces, where control options are limited.

WEED-MANAGEMENT CHALLENGES ON TEES AND FAIRWAYS

PURPLE NUTSEDGE CONTROL

Throughout much of the southern United States, purple nutsedge (*Cyperus rotundus*) is a problematic weed of golf course tees and fairways (Figure 7). Perhaps the biggest key to controlling purple nutsedge is proper identification. Under mowed conditions, yellow nutsedge (*Cyperus esculentus*) is very similar in appearance to purple nutsedge. There are many effective postemergence control options for yellow nutsedge, but few herbicides provide long-term control of purple nutsedge. The difference in herbicide efficacy is related to plant morphology. When applied to purple nutsedge, herbicides must move through a vast underground network of rhizomes connecting tubers to one another. Yellow nutsedge tubers are not connected to one another and are therefore easier to control with postemergence herbicides.

*Figure 7. Purple nutsedge (*Cyperus rotundus*) connected via underground rhizomes. Photo courtesy of Joseph DeFrank, Ph.D.*

Research trials conducted at Clemson University have found trifloxysulfuron (Monument®), sulfentrazone + imazethapyr (Dismiss® South), and sulfosulfuron (Certainty®) to be the best options for controlling purple nutsedge when applied sequentially, controlling more than 90 percent of purple nutsedge infestations in bermudagrass for a period of more than 70 days (Blanton et al., 2010). Despite high levels of efficacy, sequential applications likely will be required for complete eradication, as purple nutsedge plants can produce thousands of new tubers each year. Each purple nutsedge tuber can remain viable for three years when supplied with adequate soil moisture. In renovation scenarios, turning soil to expose tubers to sunlight before establishing new turf can be helpful, as the viability of purple nutsedge tubers is dramatically reduced under dry conditions (Stoller and Sweet, 1987).

PERENNIAL RYEGRASS CONTROL

Another issue for superintendents managing creeping bentgrass and annual bluegrass fairways is perennial ryegrass (*Lolium perenne*) contamination. Although results from several experimental materials have been promising, currently no products to selectively control perennial ryegrass in creeping bentgrass and annual bluegrass have been commercialized. Currently, physically removing and replacing perennial ryegrass with sod or plugs of desirable turf is the only effective control option.

BERMUDAGRASS CONTROL

Bermudagrass contamination of tees and fairways is a problem for many golf courses throughout the transition and warm-season growing environments. Similar to dealing with bermudagrass encroachment into putting surfaces, infestations are managed with an array of techniques rather than eradicated with a single herbicide application. Regardless of whether bermudagrass is contaminating zoysiagrass (*Zoysia* spp.), seashore paspalum (*Paspalum vaginatum*), or creeping bentgrass/annual bluegrass fairways, the goal of any herbicide application is to hamper bermudagrass growth such that the desirable turf gains a competitive advantage.

Nearly all herbicide programs for bermudagrass management require sequential applications over multiple years. In zoysiagrass fairways, applications of fluazifop (Fusilade® II) or fenoxaprop (Acclaim® Extra) mixed with triclopyr (Turflon® Ester) are quite common (Lewis et al., 2010). In seashore paspalum fairways, researchers have experimented with applications of ethofumesate (Prograss®) and flurprimidol (Cutless™) for selectively managing bermudagrass (Johnson and Duncan, 2000). In general, herbicide applications halt bermudagrass growth for a period of three to five weeks, depending on application rate and timing, in order to give desirable turf an opportunity to become established in the voids created while bermudagrass is suppressed. Given the patience required to make several

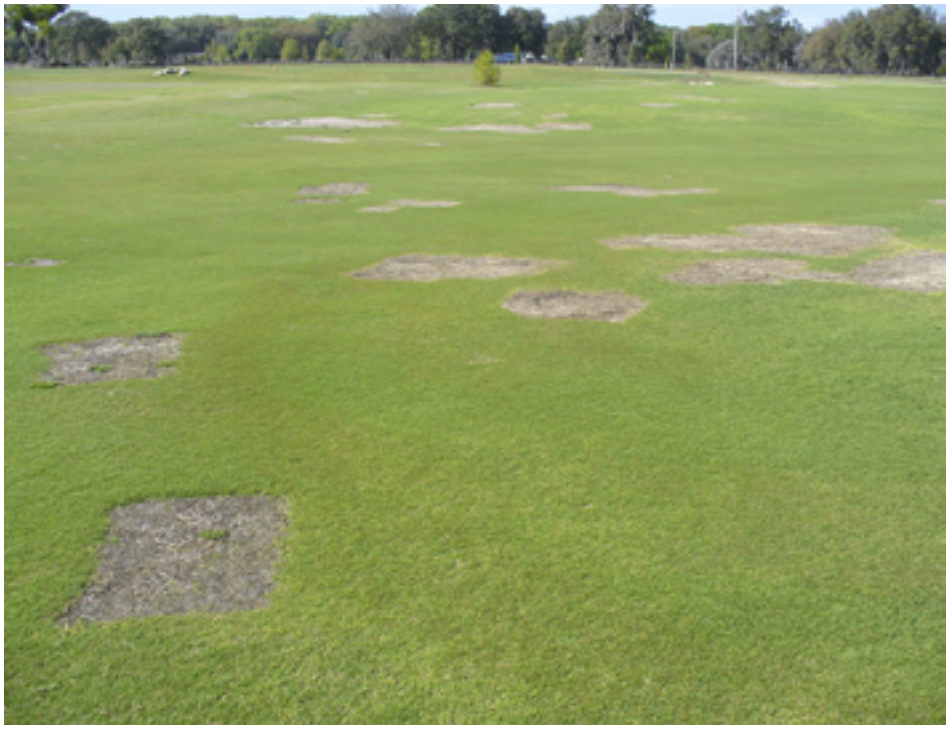

*Figure 8. Removal of bermudagrass (*Cynodon *spp.) contamination in seashore paspalum (*Paspalum vaginatum*) turf.*

applications over multiple years, many simply choose to identify areas infested with bermudagrass and resod with desirable zoysiagrass or seashore paspalum (Figure 8).

TROPICAL SIGNALGRASS CONTROL

Tropical signalgrass is a perennial, warm-season weed that has become problematic in fairways, particularly in Florida. where the use of monosodium methanearsonate (MSMA) for post-emergence control is prohibited. Recent research by Dr. Bert McCarty at Clemson University has explored options for effective postemergence tropical signalgrass control in place of MSMA. McCarty's research found that fall is the best time to treat tropical signalgrass infestations, and that sequential applications (two weeks apart) of amicarbazone (Xonerate®), sulfentrazone + imazethapyr (Dismiss® South), and thiencarbazone + foramsulfuron + halosulfuron (Tribute® Total), both alone and in mixtures with one another, are most effective (McCarty and Estes, 2014). Additionally, researchers found that including a preemergence herbicide like indaziflam (Specticle® Flo) or prodiamine (Barricade®) can lengthen the period of tropical signalgrass control.

WEED-MANAGEMENT CHALLENGES IN ROUGHS

DALLISGRASS CONTROL

One of the most difficult-to-control weeds in golf course roughs is dallisgrass (*Paspalum dilatatum*). A bunch-type perennial, dallisgrass is common in bermudagrass roughs throughout the south and has been found with increasing regularity in tall fescue (*Festuca arundinacea*) roughs throughout the northern transition zone (Figure 9).

As is the case with most perennial weeds, dallisgrass infestations are managed over time rather than controlled with a single herbicide application. Many ALS-inhibiting herbicides can be used for dallisgrass management in bermudagrass, particularly thiencarbazone + foramsulfuron + halosulfuron (Tribute® Total) and trifloxysulfuron (Monument®). Until 2019, MSMA can be used as a spot treatment — i.e., less than 100 square feet — for dallisgrass on golf courses (EPA, 2015). In tall fescue, several researchers have found that fluazifop (Fusilade® II) can be an effective tool to manage dallisgrass (Elmore et al., 2013). Depending on the level of infestation, herbicides can be applied as broadcast sprays or as spot treatments.

The key to maximizing the efficacy of herbicide applications is to apply treatments when target plants are most sensitive. For dallisgrass, the best timing for herbicide applications tends to be fall, when plants begin the process of transitioning into winter dormancy. Research has shown that dallisgrass-management programs perform optimally once average daily air temperatures continually remain below 72 degrees Fahrenheit (Elmore

*Figure 9. Dallisgrass (*Paspalum dilatatum*) in a bermudagrass (*Cynodon *spp.) rough.*

et al., 2013). Herbicide applications also can be made under similar temperature conditions during spring, using a target growing degree-day value of 300 GDD50F. However, spring treatments can be less effective if dallisgrass has not produced enough green tissue to be easily visible when the growing degree-day threshold is reached. Furthermore, herbicide applications made in late spring/early summer after the growing degree-day threshold is reached — i.e., greater than 360 GDD50F — tend to be largely ineffective and, in the case of fluazifop, can be injurious to desirable turf.

Even when the best herbicide is selected and applied at the optimal time, multiple applications will be required over several years to reduce dallisgrass populations. Superintendents struggling with dallisgrass infestations in roughs should determine if the infestation warrants the cost of implementing selective weed-control programs. In cases where dallisgrass populations are high, applying a nonselective herbicide — e.g., glyphosate — and reestablishing desirable turf might be the best choice.

BERMUDAGRASS CONTROL

Bermudagrass contamination is another problematic issue for many golf course superintendents managing cool-season roughs throughout the transition zone. Programs to manage bermudagrass contamination in cool-season roughs look very similar to those used for dallisgrass management, as both weeds are perennial species that persist each year from underground rhizomes.

In cool-season turfgrass, there are several herbicides that can provide selective bermudagrass suppression, including fenoxaprop (Acclaim® Extra), fluazifop (Fusilade® II), mesotrione (Tenacity®) and topramezone (Pylex®). Combining triclopyr (Turflon® Ester) with these herbicides at 32 fluid ounces per acre can improve both the degree and length of time that bermudagrass is suppressed without causing any harm to desirable cool-season turfgrass (Brosnan et al., 2013). Much like dallisgrass, bermudagrass-control herbicides need to be applied sequentially during fall once air temperatures begin to decrease for the season (Brosnan et al., 2011). Interseeding desirable cool-season turf into the voids remaining after bermudagrass has been suppressed can improve success over the long term. Researchers at the University of Tennessee conducted a two-year study during which herbicides were applied three times in the fall and subjected to tall fescue interseeding at 0 or 10 pounds per 1,000 square feet. At the end of the experiment, topramezone + triclopyr controlled about 90 percent of the bermudagrass when combined with interseeding compared to only 50 percent bermudagrass control when only herbicides were applied (Brosnan et al., 2013).

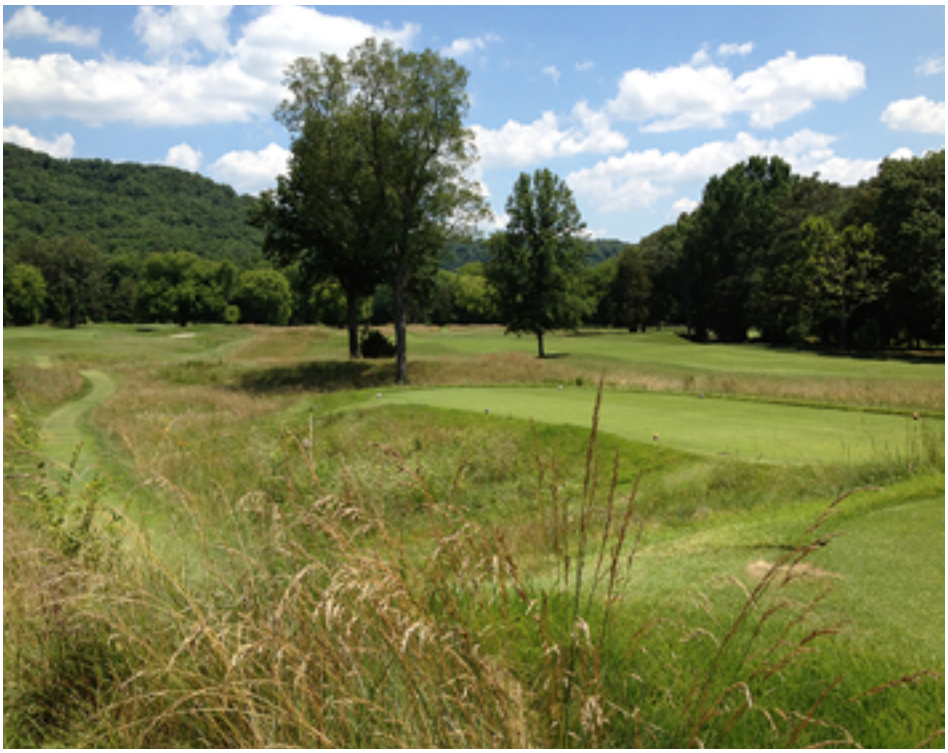

Figure 10. Naturalized areas established to warm-season species.

NATURALIZED AREAS

A trend throughout the golf industry is to replace acres of regularly mowed turf with naturalized areas comprised of either warm- or cool-season species that are sparingly mowed (Figure 10). Common choices for naturalized areas on golf courses include fine fescues (*Festuca* spp.) or warm-season species like broomsedge (*Andropogon virginicus*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloë dactyloides*), and weeping lovegrass (*Eragrostis curvula*).

There are many options for pre- and postemergence control of grass, sedge, and broadleaf weeds in established fine fescue natural areas, including prodiamine (Barricade®), pendimethalin (Pendulum® AquaCap), quinclorac (Drive® XLR8), sethoxydim (Segment®), fenoxaprop (Acclaim® Extra), halosulfuron (SedgeHammer®), mesotrione (Tenacity®), and topramezone (Pylex®). Many products containing 2,4-D also are labeled for use in fine fescue. However, postemergence herbicide applications are only recommended during mild conditions in spring and fall.

Weed control in naturalized areas established with warm-season grasses can be more difficult as few herbicides are labeled for pre- or postemergence weed control in these systems. Exceptions to this include imazapic (Plateau®) and sulfosulfuron (Certainty®).

Imazapic has specific label directions for use on big bluestem, little bluestem,

bushy bluestem (*Andropogon glomeratus*), blue grama, sideoats grama, buffalograss, Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Imazapic controls a wide range of grasses, sedges, and broadleaf weeds and also can be used to suppress dallisgrass. Sulfosulfuron can complement imazapic in a weed-management program as it is labeled on similar species and is a better option for controlling yellow nutsedge, purple nutsedge, and annual bluegrass. However, it should be noted that imazapic and sulfosulfuron use the same mechanism of action — ALS inhibition. Continued use of only imazapic and sulfosulfuron will select for ALS-inhibitor-resistant weeds. Alternative weed-control methods — i.e., mechanical removal, burning, etc. — can be incorporated in rotation with imazapic or sulfosulfuron to manage resistance. Additionally, superintendents can experiment with herbicides that neither allow nor restrict applications to warm-season naturalized areas. Treating a small test area will determine whether a particular product causes undesirable injury to desirable species or if it could help provide alternative herbicide options to help build rotational programs to manage herbicide resistance.

CONCLUSION

Golf course superintendents face an array of weed-management challenges in putting greens, tees, fairways, and roughs. Many weed-management challenges have no simple solutions, particularly those pertaining to perennial weeds like bermudagrass. Weed-management plans incorporating proper identification, knowledge of weed life cycle, and herbicide selection to manage the evolution of resistance can considerably help improve weed-management efforts. However, in some cases the level of weed infestation may not warrant the resources required for selective herbicide removal and physical removal or renovation may be the best option.

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