CONTROLLING CRABGRASS and GOOSEGRASS

with Resistance to Sethoxydim and Other ACCase-Inhibitors in Georgia Turf

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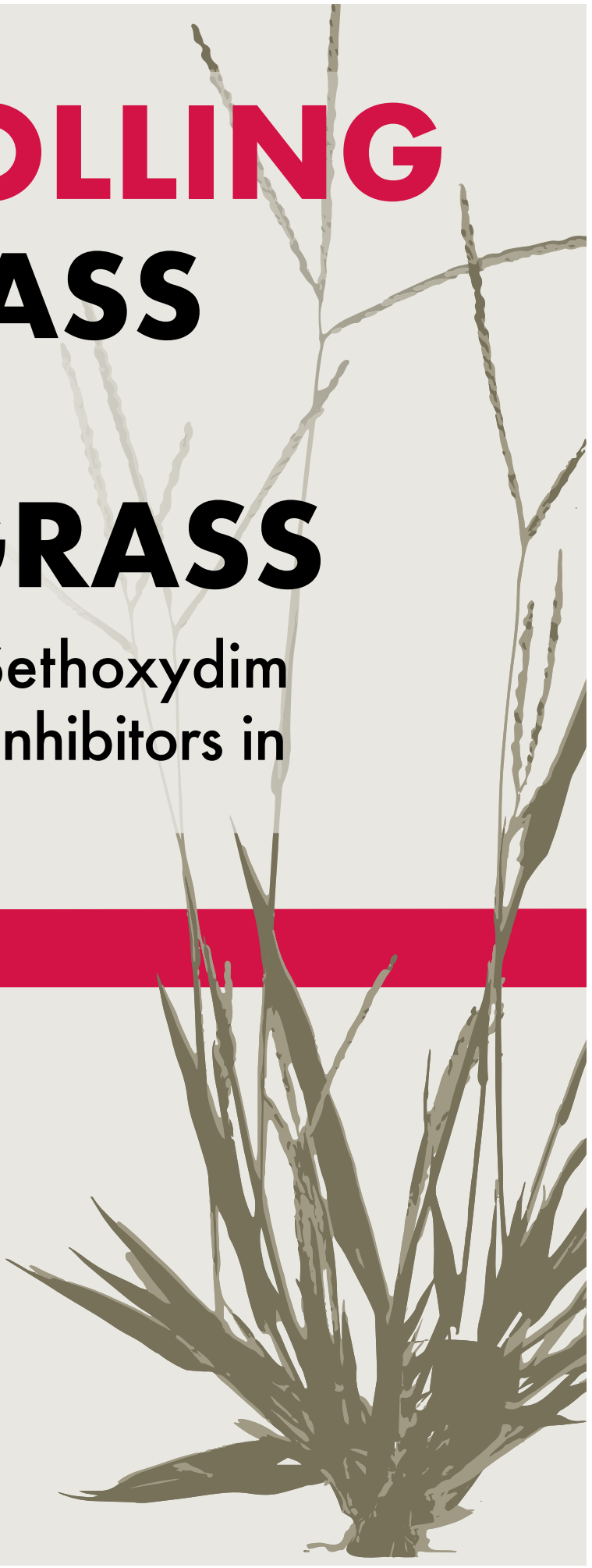
EXTENSION



Herbicide resistance is an emerging issue that affects lawns, golf courses, sod farms, and other turf areas in Georgia. Resistance develops from selection pressure by repeated use of the same herbicide or mode of action over time. The most common mechanisms for resistance are through an altered target-site or enhanced herbicide metabolism (DePrado et al. 2005; Osuna et al. 2012). Other resistance mechanisms may include reduced absorption, herbicide sequestration, or overproduction of the target site enzyme (Petit et al. 2010). As susceptible biotypes are controlled from herbicide use, the resistant plants spread and become the predominant biotype in the field. This type of selection pressure shifts weed populations from susceptible to resistant biotypes over time.

We have identified sethoxydim (Segment) resistant southern crabgrass (*Digitaria ciliaris*) and goosegrass (*Eleusine indica*) in Georgia turf. These biotypes are also cross-resistant to other herbicides that inhibit the acetyl Co-A carboxylase (ACCase) enzyme in fatty acid biosynthesis (Cronan and Waldrop 2002). The aryloxyphenoxypropionate (AOPP) herbicides fenoxaprop (Acclaim) and fluazifop (Fusilade) are used in cool-season turfgrasses and zoysiagrass for postemergence goosegrass control. Diclofop (Illoxan) is an AOPP herbicide used in bermudagrass for selective control of goosegrass, ryegrass (*Lolium* spp.), and other grassy weeds. Sethoxydim is a cyclohexanedione herbicide that selectively controls grassy weeds in centipedegrass and fine fescues.

Sethoxydim has been widely used in Georgia for grassy weed control in centipedegrass lawns, roadsides, and sod farms. Decades of exclusive sethoxydim use in certain areas have led to the emergence of ACCase-resistant goosegrass and southern crabgrass (Figures 1 and 2). Turf managers must have an appreciation for management programs that delay resistance development in weed populations for long-term successful control. Alternative herbicides to ACCase-inhibitors have significant limitations on efficacy and selectivity in certain turfgrass species. As more resistant weeds are identified, turf managers will need to incorporate cultural, mechanical, and alternative chemical control strategies to optimize the potential for controlling ACCase-resistant biotypes of crabgrass and goosegrass after emergence.

Figure 1. ACCase-resistant (left) and susceptible (right) biotypes of goosegrass at three weeks after a sethoxydim application.

Figure 2. ACCase-resistant and susceptible southern crabgrass at three weeks after a sethoxydim application.

Recommendations for postemergence control of ACCase-resistant crabgrass

Most herbicide alternatives to ACCase-inhibitors control crabgrass prior to tillering and require sequential applications. Mesotrione (Tenacity) and topramezone (Pylex) inhibit carotenoid biosynthesis (HPPD-inhibitors) in susceptible grassy weeds. Injury symptoms include foliar bleaching (whitening) that may persist for approximately two weeks after treatments (Figure 3), followed by necrosis in susceptible weeds. Tenacity and Pylex may be used for crabgrass control in centipedegrass, Kentucky bluegrass, and tall fescue.

Figure 3. Control of sethoxydim-resistant southern crabgrass with topramezone (Pylex) in centipedegrass.

The initial Tenacity application should be made at 8 fl oz of product per acre with a non-ionic surfactant at 0.25 percent vol/vol (Table 1). Tenacity must be applied twice to control tillered crabgrass plants in summer. The second treatment may be applied using 5 to 8 fl oz of product per acre approximately 3 weeks after the initial treatment. Pylex should be applied from 1 to 1.5 fl oz of product per acre with a crop oil concentrate at 0.5 to 1 percent vol/vol. Sequential applications after three weeks may be required to control mature crabgrass.

Quinclorac is the active ingredient in Drive and numerous combination products (such as Q4 Plus, One Time, and Solitare) that provides postemergence control of crabgrass. Established Kentucky bluegrass, tall fescue, and zoysiagrass are tolerant to quinclorac applications, and should be considered if resistance to ACCase-inhibitors, such as fenoxaprop, is suspected. Quinclorac should be applied at 0.75 lb of active ingredient per acre with crop oil or methylated seed oil adjuvant. Quinclorac is most efficacious on crabgrass that is 1- to 2-tiller or younger, and repeated applications will be required to control multi-tiller crabgrass in summer. Quinclorac also controls broadleaf weeds, such as white clover (*Trifolium repens*), but it does not control goosegrass.

Monosodium methanearsonate (MSMA) is an organic arsenical that may be applied at 1 to 2 lb of active ingredient per acre to Kentucky bluegrass, tall fescue, and zoysiagrass as an alternative to ACCase-inhibitors for crabgrass control. Similar to quinclorac, single applications may effectively control immature crabgrass, but sequential applications will be required to control multi-tiller plants. Turf managers need to apply MSMA with a non-ionic surfactant at 0.25 percent vol/vol if the formulated product does not contain an adjuvant (see product label). In the U.S., MSMA has restricted uses in golf courses, highway rights-of-way, and sod farms (U.S. EPA 2013). One spot application of MSMA, not to exceed 25 percent of the total area per year, is allowed on golf courses, while two applications are allowed on sod farms and roadsides. Residential lawns and athletic fields have lost all uses of MSMA. The potential loss of MSMA in the future could limit the modes of action available to end-users for resistant management.

Table 1. Herbicide alternatives to ACCase-inhibitors for postemergence control of crabgrass and goosegrass in turf.

Turfgrass	WSSA group[1]	Herbicide (trade name)	Rate	Applications needed	Sequential timing	Rating[3]
Crabgrass Control						
Centipedegrass	3	dithiopyr (Dimension 2EW)[2]	1 qt/acre	1		F-G
	27	mesotrione (Tenacity 4SC)	5 to 8 fl oz/acre	2	3 WAIT	G
	27	topramezone (Pylex 2.8SC)	1 to 1.5 fl oz/acre	1 or 2	3 WAIT	G-E
Kentucky bluegrass and tall fescue	3	dithiopyr (Dimension 2EW)[2]	1 qt/acre	1		F-G
	4	quinclorac (Drive, others)	0.75 lb ai/acre	2	2 to 3 WAIT	G
	17	MSMA (Target 6, others)	1 to 2 lb ai/acre	2	2 to 3 WAIT	G
	27	mesotrione (Tenacity 4SC)	5 to 8 fl oz/acre	2	3 WAIT	G
	27	topramezone (Pylex 2.8SC)	1 to 1.5 fl oz/acre	1 or 2	3 WAIT	G-E
Zoysiagrass	3	dithiopyr (Dimension 2EW)[2]	1 qt/acre			F-G
	4	quinclorac (Drive, others)	0.75 lb ai/acre	2	2 to 3 WAIT	G
	17	MSMA (Target 6, others)	1 to 2 lb ai/acre	2	2 to 3 WAIT	G
Goosegrass Control						
Bermudagrass and zoysiagrass	2	foramsulfuron (Revolver 0.19SC)	17 to 26 fl oz/acre	2	2 to 3 WAIT	F-G
	2	foramsulfuron + thiencarbazone + halosulfuron (Tribute Total 60.5WDG)	3.2 oz/acre	2	2 to 3 WAIT	G
	17	MSMA (Target 6, others)	1 to 2 lb ai/acre	2	2 WAIT	F-G
Centipedegrass	27	topramezone (Pylex 2.8SC)	1 to 1.5 fl oz/acre	1 or 2	2 to 3 WAIT	G-E
Kentucky bluegrass and tall fescue	17	MSMA (Target 6, others)	1 to 2 lb ai/acre	2	2 WAIT	F-G
	27	topramezone (Pylex 2.8SC)	1 to 1.5 fl oz/acre	1 or 2	2 to 3 WAIT	G-E

[1]WSSA group numbers: 2 = acetolactate synthase inhibitors, 3 = mitotic inhibitor, 4 = synthetic auxins, 17 = cell division inhibition, 27 = carotenoid biosynthesis (HPPD) inhibitors.

[2]Dithiopyr is a preemergence herbicide that provides postemergence control of crabgrass up to a 1-tiller growth stage in early spring.

[3]Efficacy ratings: Excellent (E) = 90 to 100 percent, Good (G) = 80 to 89 percent, Fair (F) 70 to 79 percent control.

Dithiopyr (Dimension 2EW) may also provide an alternative to ACCase-inhibitors for postemergence crabgrass control in warm- and cool-season grasses. Turfgrass managers primarily use Dimension for preemergence crabgrass control, but applications have potential to provide early-postemergence control in spring. Dimension must be applied to seedling crabgrass for best results. Applications to tillered crabgrass provide erratic levels of postemergence control in early summer. Areas treated with Dimension should receive irrigation within 24 hours to minimize losses through volatilization in late spring or summer.

Recommendations for postemergence control of ACCase-resistant goosegrass

In Georgia, sethoxydim-resistant goosegrass has been identified in centipedegrass (McCullough et al. 2016). This biotype is also cross-resistant to the ACCase-inhibitors diclofop (Illoxan), fenoxaprop (Acclaim), and fluazifop (Fusilade). Therefore, rotating herbicide modes of action may be critical for managing ACCase-resistant goosegrass in bermudagrass, tall fescue, and zoysiagrass.

Topramezone (Pylex) provides excellent postemergence control of goosegrass in centipedegrass, tall fescue, and other tolerant species (Table 1). Applications of Pylex at 1.5 fl oz per acre in field experiments have effectively controlled (more than 90 percent) ACCase-resistant goosegrass in Georgia. End users should include a crop oil adjuvant with treatments, and monitor areas for regrowth after approximately three weeks to determine if a sequential application is needed. Mesotrione (Tenacity) may control seedling goosegrass plants but does not control mature goosegrass. Therefore, to treat postemergence goosegrass in lawns and sod farms, Pylex is the best alternative to sethoxydim in centipedegrass and the best alternative to Acclaim or Fusilade in tall fescue.

The recent discontinuation of diclofop (Illoxan) by Bayer will limit options for postemergence goosegrass control on golf courses. Illoxan is an ACCase-inhibitor that controls goosegrass in bermudagrass, but is ineffective on biotypes with resistance to ACCase-inhibitors found in Georgia (McCullough et al. 2016). MSMA controls goosegrass at an early stage (prior to tillering) in tolerant turfgrass species, including bermudagrass. The addition of metribuzin (Sencor 75) with MSMA treatments enhances postemergence control of mature goosegrass in bermudagrass turf. These treatments often require repeat applications for acceptable control and are injurious to bermudagrass in summer. The MSMA plus Sencor combination is not recommended on any other turfgrass species due to the excessive potential for injury.

Foramsulfuron (Revolver) and foramsulfuron + thiencarbazone + halosulfuron (Tribute Total) may be used in bermudagrass and zoysiagrass as alternatives to ACCase-inhibitors. These products contain acetolactate synthase (ALS) inhibitors used for controlling other grassy weeds including annual bluegrass (*Poa annua*). Two applications of these herbicides are required for effective postemergence control of established goosegrass populations. Due to potential antagonism, do not apply Revolver with a non-ionic surfactant or crop oil concentrate. Sulfentrazone is an active ingredient found in Dismiss, Blindside, Solitare, and other combination products. Sulfentrazone is a chlorophyll synthesis inhibitor that provides early-postemergence control of seedling goosegrass, but because it provides erratic control of established goosegrass, tank-mix partners are recommended to improve efficacy.

Enhancing the efficacy of herbicide alternatives to ACCase-inhibitors

For intensively managed tall fescue lawns, foliar bleaching of grassy weeds from Pylex and Tenacity is sometimes considered objectionable. Sequential applications of these herbicides are often required to control multi-tiller plants, which may extend the duration of foliar bleaching associated with crabgrass or goosegrass control. These effects could preclude use by end users who are concerned about turf aesthetics. The addition of triclopyr (Turflon Ester) at 1 to 2 pints per acre enhances the efficacy of Tenacity for controlling multi-tiller crabgrass in tall fescue. Smooth crabgrass (*Digitaria ischaemum)* bleaching can be almost completely eliminated when Turflon Ester is included with Tenacity at 4 or 8 fl oz per acre (Yu and McCullough 2016). Smooth crabgrass control was also improved from around 65 percent by Tenacity alone to greater than 90 percent when Turflon Ester was applied in tank mixtures. Enhanced control from the tank mixture is associated

with faster foliar uptake of Tenacity when applied with Turflon Ester (Yu and McCullough 2016). Bleaching of crabgrass may also be minimized by reductions in translocation of mesotrione or derivatives by triclopyr.

Centipedegrass managers can also enhance the efficacy of the bleaching herbicides, Pylex and Tenacity, by using a triazine herbicide with applications. The addition of atrazine and simazine at 0.5 to 1 lb active ingredient per acre can be applied with standard use rates of Pylex and Tenacity. The synergistic effects occur from enhanced levels of free radical damage to susceptible weeds caused by the inhibition of photosynthesis and carotenoid biosynthesis. These physiological effects enhance phytotoxicity from Pylex or Tenacity alone, and have shown to improve efficacy on weeds like goosegrass. These combinations are recommended for centipedegrass only.

Tank-mixing two herbicides with different modes of action will enhance the potential to control ACCase-resistant crabgrass and goosegrass. For example, a superintendent that needs to control goosegrass with suspected resistance to ACCase-inhibitors in centipedegrass could apply sethoxydim (Segment) with Pylex. The additional mode of action in tank mixtures increases the potential to control resistant biotypes that may be present in the population. Incorporating other modes of action in sequential programs would delay the onset of resistance to multiple modes of action as well.

Turf managers should have an appreciation for the herbicide mode of action when selecting products for controlling crabgrass and goosegrass. Most labels have the herbicide group classification on the front page to identify the mode of action. The group classification and modes of action are listed for herbicides discussed in Table 1. Although product rotation is strongly recommended, costs, efficacy, and turf injury potential may be significant limitations to using various modes of action in many turfgrass species.

Preventing the establishment of herbicide-resistant crabgrass and goosegrass

Integrated management programs consisting of sound cultural practices and preemergence herbicides can help control crabgrass and goosegrass in turf. Hand pulling or digging plants can help control populations, especially in turfgrass species that are susceptible to herbicide injury. However, this may be ineffective under severe weed infestations or in large fields. Modifying cultural practices to promote turfgrass competition with crabgrass and goosegrass may reduce herbicide use for long-term management. For example, withholding water until desirable turfgrasses exhibit initial symptoms of drought stress can reduce the establishment of annual grassy weeds. Regular mowing or adjusting the height of the cut may help reduce scalping if weather precludes mowing operations in summer. Raising the mowing height for tall fescue to three inches or higher will help promote turfgrass competition with crabgrass and goosegrass seedlings to reduce populations in spring and summer. While returning clippings is recommended to recycle nutrients to the soil, removal of clippings may reduce the spread of viable seed of crabgrass and goosegrass in late summer and fall.

Goosegrass is often found in areas with heavy soil compaction and limited turfgrass competition. Core aerification in heavily trafficked areas could alleviate turfgrass growth limitations and promote competition with goosegrass. Aerifications should be conducted during active turfgrass growth and favorable periods for quick recovery. Voids left in turf with exposed soil following aerifications may permit weed invasion during periods of peak germination. Warm-season grasses should have enough time to recover from summer aerifications to promote turf density to reduce crabgrass and goosegrass establishment.

Preemergence herbicides are critical for controlling crabgrass and goosegrass in turfgrass systems. Dinitroaniline (DNA) herbicides and dithiopyr (Dimension) are widely used for preemergence control of crabgrass in turfgrass, but often provide erratic levels of goosegrass control. Furthermore, we have identified DNA-resistant goosegrass in Georgia that is not controlled by prodiamine (Barricade, others), pendimethalin (Pendulum), or other mitotic inhibitors. Indaziflam (Specticle) and oxadiazon (Ronstar) effectively control crabgrass and goosegrass, but have significant limitations for use in turfgrass. Specticle is only labeled for use in warm-season species and may cause excessive turf injury when applied at high rates on soils with low (less than 1 percent) organic matter. Ronstar may be applied to most major warm- and cool-season turfgrasses, except centipedegrass. It must be made in a granular formulation during active growth due to excessive injury

potential from sprayable applications. Flumioxazin (Sureguard) has the same mode of action as Ronstar and is labeled for dormant bermudagrass. It provides effective preemergence crabgrass control but results have been erratic for controlling goosegrass in the southern United States. Applications of Sureguard are also injurious to bermudagrass after greenup in spring. These limitations, along with herbicide costs, may present challenges to controlling goosegrass with preemergence herbicides in turfgrass.

As the identification of herbicide-resistance increases in turfgrass weeds, there will be an emphasis on incorporating cultural, mechanical, and alternative chemical control strategies in management programs. It is critical that turf managers routinely scout their fields to identify biotypes of weeds that exhibit population segregation after herbicide applications. Early detection of resistance is critical to prevent the spread and growth of these biotypes in turf. There are currently no new herbicides under development that offer alternative mechanisms of action to products currently available in turfgrass. Practitioners must plan management programs that emphasize the rotation of herbicides with various modes of action that will delay the further spread of resistant biotypes in new turf areas.

References

Cronan, J.E., & Waldrop, G.L. (2002). Multi-subunit acetyl-CoA carboxylases. *Progress in Lipid Res, 41*, 407–435.

DePrado, J.L., Osuna, M.D., Heredia, A., & DePrado, R. (2005). *Lolium rigidum*, a pool of resistance mechanisms to ACCase inhibitor herbicides. *J Agric Food Chem, 53*, 2185–2191.

McCullough, P.E., Yu, J., Raymer, P., Chen, Z. (2016). First report of ACCase-resistant goosegrass in the United States. *Weed Sci, 64*(3), 399–408.

Osuna, M.D., Goulart, I.C.G.R., Vidal, R.A., Kalsing, A., Ruiz, Santella JP, DePrado R (2012) Resistance to ACCase inhibitors in *Eleusine indica* from Brazil involves a target site mutation. *Planta daninha, 30*(3), 678–681.

Petit C, Bay G, Pernin F, Delye C (2010) Prevalence of cross- or multiple resistance to the acetyl-coenzyme A carboxylase inhibitors fenoxaprop, clodinafop, and pinoxaden in black-grass (*Alopecurus myosuroides* Huds.) in France. *Pest Manag Sci, 66*,168–177.

U.S. Environmental Protection Agency (2013) Pesticide Reregistration: Organic Arsenicals. U.S. Environmental Protection Agency. 2013. Pesticide Reregistration: Organic Arsenicals. http://www2.epa.gov/ingredients-used-pesticide-products/monosodium-methanearsonate-msma-organic-arsenical

Yu J, McCullough PE (2016) Triclopyr reduces foliar bleaching from mesotrione and enhances efficacy for smooth crabgrass by altering uptake and translocation. *Weed Technology, 30*(2), 516–523.

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