Post-emergence herbicides provide the turfgrass manager with viable options to control weeds during the entire year.

by Tim R. Murphy, Ph.D., University of Georgia

Weed control is the process of limiting a weed infestation so that a turfgrass can properly grow, develop and be aesthetically appealing.

A balanced turfgrass weed control program uses a combination of cultural, mechanical and chemical weed control practices. When properly maintained, warm-season turfgrasses are highly competitive with weeds. Adherence to recommended fertility programs, water requirements, mowing heights and schedules and controlling diseases and insects will dramatically improve the success of the chemical weed control program.

The use of herbicides, in the absence of approved cultural and mechanical practices, will not result in a high quality, warm-season turfgrass.

Turfgrass managers can choose from two types of herbicides to control weeds in warm-season turfgrasses. Pre-emergence herbicides form the base of the chemical weed control program. They are primarily used for the control of crabgrass, goosegrass, annual bluegrass and certain annual broadleaf weeds. Post-emergence herbicides are generally used to control weeds that are not controlled by pre-emergence herbicides, or in the event of a pre-emergence weed failure, as a reliable backup.

Post-emergence herbicides offer several advantages over pre-emergences.

**Spot treat, or as needed**

Post-emergence herbicides can be applied on a "spot treatment" or "as-needed" basis, directly to a weed infestation; pre-emergence herbicides are usually applied to the entire turfgrass area.

Spot treatments of post-emergence herbicides are less expensive than blanket applications of pre-emergence herbicides. Post-emergence herbicides will control many problem annual and perennial weeds not controlled by pre-emergence herbicides. Low rates of most post-emergence herbicides may be used on newly-sprigged or sodded warm-season turfgrasses.

In areas that are scheduled to be overseeded or renovated, the majority of post-emergence herbicides can be used up to one month before renovation. The time interval from application to seeding, sprigging or sodding operations for pre-emerg-
Herbicide selection

Many post-emergence herbicides are available to control weeds in warm-season turfgrasses (Table 1). They all have different qualities.

Turfgrass tolerance. The warm-season turfgrasses dramatically vary in their tolerance to post-emergence herbicides (Table 2). Bermudagrass has good tolerance to MSMA and DSMA; however, carpetgrass, centipedegrass and St. Augustinegrass are severely injured by these herbicides. With the exception of bahiagrass and carpetgrass, warm-season turfgrasses have excellent tolerance to Image.

Additionally, cultivars within a species may respond differently to the same herbicide. For example, Meyer zoysiagrass has better tolerance to MSMA than Emerald or Matrella.

The most important factor in selecting a post-emergence herbicide is the tolerance of the turfgrass to the herbicide. Refer to the specific label to determine if the herbicide may be used on a particular turfgrass species.

Weed species. Similar to turfgrasses, weed species vary in their susceptibility to herbicides. Correct weed identification is a prerequisite for selecting an appropriate herbicide. Weed identification manuals and identification assistance is available at many county extension service offices. Several chemical companies also distribute excellent weed identification guides.

Time of application. The time of year that a herbicide is applied can influence turfgrass tolerance. For example, dormant bahiagrass and bermudagrass have excellent tolerance to Roundup. However, severe injury will occur if this herbicide is applied to semi-dormant or actively growing bahiagrass or bermudagrass.

The risk of injury from post-emergence herbicides is also greater during the spring green-up process (transition from winter dormancy to active growth) than when the turfgrass is fully dormant or actively growing.

Post-emergence herbicides such as 2,4-D + mecoprop + dicamba (Trex-sam, Trimec Classic, Three-Way and others) have been shown to slightly decrease the quality of Tifway bermudagrass when applications were made three weeks before or during spring green-up. Image can also cause slight to moderate delays in green-up if applications are made during spring transition.

Research has shown that the decrease in turfgrass quality that may result from using post-emergence herbicides...
during green-up persists for two to six weeks after application. Also, in turfgrasses that are severely infested with weeds, better turfgrass growth eventually results due to the elimination of the thick cover of weeds.

In the event that a dense weed population necessitates using a post-emergence herbicide during green-up, use only the lowest recommended or one-half the recommended rate. Low or one-half rates will minimize herbicide injury to the turfgrass.

**Problem weed management**

**Bahiagrass**: Repeat applications of MSMA or DSMA at 7- to 10-day intervals will control bahiagrass in MSMA/DSMA tolerant turfgrasses. In bermudagrass and St. Augustinegrass, DMC will effectively control bahiagrass. In centipedegrass, repeat application of Vantage (formerly Poast) at 10- to 14-day intervals will suppress bahiagrass growth and seedhead development.

**Dallisgrass**: It is believed that most pre-emergence herbicides will control dallisgrass that arises from seed. Established dallisgrass can be controlled in bermudagrass or zoysiagrass with repeat applications of MSMA or DSMA. Applications should be made to actively-growing dallisgrass. Also, a non-ionic surfactant at 0.25 percent v/v is recommended with MSMA or DSMA for dallisgrass control. Staying on the application schedule (2 to 4 applications, each at a 7- to 10-day interval) will be required to control dallisgrass. Shortening the application interval to five days may help on sites where dallisgrass has been difficult to control with MSMA or DSMA.

**Nutsedge**: Basagran will provide good control of yellow nutsedge, but not of the purple variety. Monthly applications of MSMA or DSMA in tolerant turfgrasses during the late spring and summer months can be used to suppress the growth of both species. With the exception of bahiagrass and carpetgrass, Image can be used in warm-season turfgrasses for yellow and purple nutsedge control. The addition of MSMA to Image generally improves nutsedge control in MSMA tolerant turfgrasses. A repeat application, six to eight weeks after the first application, of Image or Image + MSMA will be required to control nutsedge during the summer months.

**Prostrate spurge**: Control requires repeat applications of two-way or three-way broadleaf herbicides. In bermudagrass, low rates of Sencor (0.125 to 0.25 lb. AI/acre) will effectively control emerged prostrate spurge.

**Virginia buttonweed**: Rapidly becoming the number one problem broadleaf weed in southern turfgrass. A repeat application, of Image + Sencor, at a 7- to 10-day interval, is necessary to control Virginia buttonweed. Research conducted in Mississippi has shown that applications of Ronstar or Princep at the time of the 2,4-D + dichlorprop application increased the control of Virginia buttonweed.

The increase in control with Ronstar and Princep is believed to be the control of Virginia buttonweed plants that arise from seed. Turfgrass managers should be aware that Princep is not labeled on southern turfgrasses in the months of June, July, and August. However, depending upon the geographical location, a mid-April or May application of Princep may assist in the control of Virginia buttonweed.

**Wild garlic**: A perennial that appears in turfgrasses in the mid- to late-fall months. Fall (November) and winter (January-February) applications of 2,4-D or two-way or three-way products that contain a phenoxy herbicide or dicamba will control wild garlic. The fall plus early winter treatment program will need to be repeated for two to three consecutive years to effectively eliminate this weed from turfgrasses. Late fall to early winter applications of Image has provided good control of wild garlic and treated plants will remain visible in the turfgrass for an extended time after application. Mowing one to two weeks after the Image application will remove a significant portion of the wild garlic foliage and improve the overall appearance of the turfgrass. Image should be applied to emerged wild garlic in the late fall or early winter after the first killing frost or the onset of winter dormancy of the warm-season turfgrass.

In St. Augustinegrass and bermudagrass, DMC will also effectively control wild garlic.

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**Application frequency.** For some weed species, a repeat application is necessary to effectively control the weed. For example, two applications of MSMA + Sencor, at a 7- to 10-day interval, are necessary to control goosegrass. In contrast, small crabgrass can often be controlled with a single application of MSMA. However, large, well-tillered crabgrass usually requires two applications of MSMA or DSMA, each at a 7- to 10-day interval.

**Ornamental tolerance.** Turfgrass herbicides are commonly applied to sites containing ornamental plantings. Ornamentals may be injured by spray or vapor drift or by root absorption of the herbicide. Vapor drift is the movement of herbicide vapors from the intended site of application.

Ester formulations of the phenoxy herbicides (2,4-D, dichlorprop) easily volatize during warm temperatures and can injure sensitive ornamentals by vapor drift. Ester formulations of the phenoxy herbicides (2,4-D, dichlorprop) easily volatize during warm temperatures and can injure sensitive ornamentals by vapor drift. Ester formulations...
Suggestions for use

Post-emergence herbicides are applied after annual weeds emerge or when new growth of perennial weeds appear in the turfgrass. Follow these guidelines for better weed control and improved turfgrass tolerance.

1. Small, actively-growing weeds.

Perennial and annual weeds that are growing under good soil moisture conditions at moderate air temperatures are easier to control with post-emergence herbicides than weeds that are stressed due to adverse environmental conditions. Target the application to coincide with good soil moisture conditions at air temperatures of 60 to 90°F. Applications on cold, wintry days, or to drought-stressed weeds will result in poor weed control.

2. Do not apply post-emergence herbicides to turfgrasses and weeds that are stressed due to high air temperatures or drought.

The tolerance of warm-season turfgrasses to post-emergence herbicides decreases at air temperatures greater than 90°F, and when turfgrasses are drought-stressed. Additionally, turfgrasses growing under high soil moisture, high relative humidity and high air temperatures, (less than 90°F) have a lower level of tolerance to post-emergence herbicides than turfgrasses growing under similar moisture and humidity conditions but at cooler temperatures.

Herbicides that contain 2,4-D; dicamba; mecoprop; dichlorprop; MSMA and DSMA should not be applied at high air temperatures since there is a high risk of increased turfgrass injury.

Follow label guidelines.

3. Repeated applications at low rates will generally improve weed control and turfgrass tolerance.

Single applications at high rates generally cause more turfgrass injury than repeat applications at low rates. Additionally, single, high rate applications often do not control the weed, particularly perennial weeds. The repeat application is usually made at intervals of 7 to 14 days after the first application, or when regrowth of the weed is noted. Refer to the label for information regarding repeat treatments.

4. Coordinate mowing schedules.

A general recommendation is to delay mowing three to four days before or after a post-emergence herbicide application. The delay prior to application will increase the leaf surface area of the weed and result in better spray coverage and control. The delay after application is necessary to allow adequate time for herbicide absorption and translocation in the target weed species.

5. Do not apply post-emergence herbicides immediately before rainfall or irrigation.

The effectiveness of most post-emergence herbicides is better when rainfall or irrigation does not occur for 6 to 24 hours after application. Rainfall or irrigation immediately after application can wash the herbicide from the treated weed foliage and decrease control.

6. Use surfactants and crop oil concentrates according to label directions.

The effectiveness of many post-emergence herbicides is enhanced by the addition of a crop oil concentrate or surfactant to the spray mixture, particularly under less than ideal spray conditions. However, indiscriminate use of surfactants or crop oil concentrates can increase the risk of turfgrass injury. Check the label for crop oil guidelines.

7. Calibrate spray equipment, train operators.

Weed control failure can be linked to improper calibration of spray equipment.

The tolerance of warm-season turfgrasses rapidly decreases at elevated or higher-than-recommended rates of post-emergence herbicides. Training assistance is available through most county extension service offices and spray equipment company representatives.

—Dr. Murphy

Agronomist Tim R. Murphy specializes in weed science at the University of Georgia Cooperative Extension Service.
The effectiveness of soon-to-be-released post-emergence control products depends largely on an understanding of the plant's physiology.

by Bruce Branham, Ph.D., Michigan State University

Weed control is the cornerstone of most landscape management. In golf course operations, knowledge of weed control is important; however, disease management often requires more time and money for the average golf course superintendent than does weed control.

Regardless of the type of turf you manage, it is important to understand weed control principles, so that the decisions you make are economical, environmentally sound and produce good results.

No new products for post-emergence weed control in cool-season grasses have been introduced in the past year, although we are still waiting on the EPA to approve three turf herbicides. Two of those products are pre-emergence herbicides (di-thiopyr/Dimension and prodiamine/Blockade) while the other is a post-emergence grass and broadleaf herbicide (quinclorac/Impact) from BASF Ag products.

Impact of Impact
Impact is an excellent post-emergence grass herbicide with good activity on a number of broadleaf weeds as well. Data in Table 1 shows the effectiveness of this product when compared to other commonly used post-emergence grass herbicides. Impact controls crabgrass effectively at all growth stages and quickly by providing rapid initial burndown of the crabgrass. Impact also has some pre-emergence activity as demonstrated by the date from the two- to three-leaf application.

The Impact treatments provided excellent control (99 to 100 percent) at eight weeks after treatment (WAT), while the Acclaim treatment provided good initial control—87 percent at four weeks after treatment, which fell to only 51 percent by eight WAT.

This loss of control with Acclaim indicates that new germination of crabgrass had occurred to reinfest the treated area which occurs because Acclaim does not have pre-emergence activity.

Evidently, Impact had enough pre-emergence activity to provide control for the rest of the growing season. However, applications of Impact applied at the normal time for a pre-
emergence herbicide have not given season-long crabgrass control. Impact has also been shown to provide effective control of broadleaf weed species such as white clover, black medic, field bindweed, spurge, and some Veronica (speedwell) species.

Currently available herbicides for post-emergence control are shown in Table 2. Impact is not expected to be available until at least 1992.

**Dimension’s residual**

Dimension is an excellent pre-emergence herbicide. But as the data in Table 1 shows, it also has excellent early post-emergence crabgrass activity. However, Dimension’s ability to control crabgrass falls off rapidly after crabgrass starts producing tillers.

Formulations of MSMA provide effective weed control if two applications spaced 10 to 14 days apart are made. This product has fallen out of favor with lawn care operators because of the necessity to make repeat applications and because the potential for turf injury is high.

**Acclaim: the standard**

Acclaim is still the standard to which other post-emergence crabgrass herbicides are compared. This product will provide very effective crabgrass control when applied on crabgrass with four tillers or less. As crabgrass grows beyond four tillers, control declines. In addition, crabgrass that is drought stressed is also more difficult to control with Acclaim, although this is generally true of all herbicides.

### TABLE 1. Effect of Impact on post-emergence crabgrass control in Kentucky bluegrass turf.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (lbs AI/A)</th>
<th>% Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Stage: 2-3 tillers</td>
<td>4 WAT</td>
<td>8 WAT</td>
</tr>
<tr>
<td>Appl. date: 6-14-90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact + BAS 090</td>
<td>0.75 + 1qt/A</td>
<td>100 a</td>
</tr>
<tr>
<td>Impact + BAS 090</td>
<td>1.0 + 1qt/A</td>
<td>100 a</td>
</tr>
<tr>
<td>Dimension</td>
<td>0.38</td>
<td>90 a-d</td>
</tr>
<tr>
<td>Acclaim</td>
<td>0.18</td>
<td>87 a-e</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Few non-selectives**

The list of herbicides available for non-selective weed control is a short one. Non-selective herbicides are used to control all vegetation and therefore are not normally used in a turf weed control program. These are, however, useful in a variety of situations.

Non-selective herbicides such as Roundup are used to renovate poor quality turf areas. In this situation, Roundup would be applied to the entire area; a seven-day waiting period should be sufficient to kill all vegetation. The area can then be re-established to a more desirable turf species. Non-selective herbicides are useful for edging around trees to prevent mower damage to the trees and for controlling weeds in the cracks of sidewalks, where it is often combined with a pre-emergence herbicide such as Surflan to provide long-term residual weed control. Non-selective herbicides can also be used to control weeds in mulched planting beds or gardens by directing the spray only on the weeds present.

Paraquat, a non-selective contact post-emergence herbicide, does not translocate. It kills only vegetation that it comes in contact with. Thorough spray coverage is required to achieve good control, but because the herbicide does not translocate, it will only kill the green vegetation of the plant. Some plant species can regenerate from the surviving roots and meristems. In addition, paraquat is moderately toxic, with an LD₉₀ of 120 mg/kg.

Roundup is translocated throughout the plant. The LD₉₀ of Roundup is 7200 mg/kg and is classified as almost non-toxic. Both Roundup and paraquat are inactivated once they contact the soil surface, so reseeding operations can begin very shortly after application.

### TABLE 2. Post-emergence broadleaf weed control herbicides used in turf.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Active Ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCPA</td>
<td>2-(2,4-dichlorophenyl)acetic acid</td>
</tr>
<tr>
<td>MCPP</td>
<td>2-(2,4-dichlorophenyl)propionic acid</td>
</tr>
<tr>
<td>dicamba</td>
<td>3,6-dichloro-o-anisic acid</td>
</tr>
<tr>
<td>triclopyr</td>
<td>3,5,6-trichloro-2-pyridinonic acid</td>
</tr>
<tr>
<td>clopyralid</td>
<td>3,6-dichloro-2-pyridine carboxylic acid</td>
</tr>
</tbody>
</table>

Some commonly used broadleaf herbicide mixtures and the ratio of each product in the mix:

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Active Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>2-(4-chloroanilino)acetic acid</td>
</tr>
<tr>
<td>2,4-DP</td>
<td>2-(4-chloroanilino)propionic acid</td>
</tr>
<tr>
<td>MCPA</td>
<td>2-methyl-4-chlorophenylpropionic acid</td>
</tr>
<tr>
<td>MCPP</td>
<td>2-(2-methyl-4-chlorophenyl)propionic acid</td>
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**Broadleaf options**

The list of currently available post-emergent broadleaf herbicide combinations has not changed appreciably from last year. In post-emergent broadleaf weed control, manufacturers tend to sell mixtures of two to three herbicides. Thus, when you are applying an herbicide for post-emergence broadleaf weed control, you are usually using at least two different herbicide products.

The only single herbicide product currently sold is MCPA, which has excellent safety on bentgrass and for that reason is used by many golf courses.
Esters and amines

Ester and amine control products have different herbicidal properties which are important to know. Amines are soluble in water; esters are oil-soluble. Esters are generally better herbicides than the corresponding amine product. Esters tend to penetrate into the leaf more effectively than do amines.

The reason that esters are not used exclusively is that they are slightly volatile. This volatility can result in non-target injury to susceptible plants in the landscape. Amines, on the other hand, are non-volatile but not as good as herbicides as the esters.

Thus, you use an amine to avoid the risk of injury that comes when you use an ester. Amines should always be used in the spring when plant material is breaking dormancy, actively growing, and very susceptible to these broadleaf herbicides. Esters can and should be used in the summer when weeds are hardening off for the winter and are much less susceptible to injury from volatile broadleaf herbicides.

Effectiveness principles

The factors affecting post-emergence weed control are:

- Spray deposition;
- Absorption;
- Translocation;

Spray deposition and retention are very important factors in getting good post-emergence weed control. Several factors are important in deter mining spray intention, including spray volume, surface tension of the spray solution, the angle of the leaf and the composition of the cuticle.

Higher spray volumes tend to generate larger spray droplets which often may not be retained on leaves. Low spray volumes produce smaller droplets which are more readily retained by plant leaves. However, production of smaller droplets increases the likelihood of the spray drifting onto non-target plants.

Spray solutions with high surface tensions, such as water, may bounce off the leaf surface at impact. Spray solutions that have very low surface tensions may run off the leaf surface and result in little spray retention. Thus, an intermediate surface tension is desirable.

Leaf movement

Nyctinasty is the folding movement of leaves with decreasing light intensity and unfolding with increasing light intensity. Nyctinasty could result in decreased weed control from early morning or late evening applications due to a decrease in spray retention by weed species showing this kind of leaf movement.

Another factor which affects spray retention is the composition of the cuticle. The cuticle refers to a layer of wax, cutin and pectin deposited on the leaf surface. The more lipophilic (i.e., waxier) the leaf surface, the more difficult it is to retain water droplets.

Caution with surfactants

Some applicators always add a wetting agent to a herbicide to improve performance. However, this practice is not advised since unexpected results often occur. For starters, most herbicide manufacturers have some kind of wetting agent in their formulation and you don’t need to add one. The label will tell you under what conditions to add a surfactant. For instance, the Acclaim label suggests adding a wetting agent when the crabgrass is under drought stress. Based on the above discussion, one can see that always adding a wetting agent to Acclaim could result in unacceptable injury to the turf by increasing the absorption of the herbicide to phytotoxic levels under non-drought conditions. Thus, always follow label recommendations.

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