W 294

TURFGRASS SCIENCE
at the UT Institute of Agriculture

# Using Growing and Cooling Degree-day Accumulations to Maximize Herbicide Efficacy

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## Introduction

Dallisgrass (*Paspalum dilatatum*) and bermudagrass (*Cynodon* spp.) are extremely prevalent and difficult to control in warm- and cool-season turfs throughout Tennessee. These perennial grassy weeds disrupt the turfs' aesthetic and functional quality. Herbicide programs are often ineffective in providing long-term control of these troublesome weeds. Researchers at the University of Tennessee found that dallisgrass and bermudagrass sensitivity to postemergence herbicides can vary throughout the growing season. Weather data can be used to determine when dallisgrass and bermudagrass are most sensitive to herbicide application, and properly timed treatments offer increased control. This fact sheet provides an overview on practices for using weather data to time herbicide applications for selective control of bermudagrass and dallisgrass in warm- and cool-season turf.

*Figure 1: Dallisgrass (Paspalum dilatatum)*

*Figure 2: Dallisgrass (Paspalum dilatatum) rhizomes*

## Life Cycle and Growth Habit in Tennessee

### *Dallisgrass*

Dallisgrass (Figure 1) is a bunch-type, perennial warm-season grass native to South America. First reported in the United States in the late 1800s, it has spread throughout the Southeast. The short, thick rhizomes (Figure 2) likely contribute to its ability to recover from

*Figure 3: Dormant bermudagrass (Cynodon spp.) in tall fescue (Festuca arundinacea) turf*

*Figure 4: Bermudagrass (Cynodon spp.) in zoysiagrass (Zoysia spp.) turf*

herbicide applications. For more information on dallisgrass growth and identification, see UT Extension Publication "**SP 642 Dallisgrass**."

### *Bermudagrass*

Bermudagrass is a warm-season turfgrass often used on athletic fields, golf courses and home lawns. This species provides excellent aesthetic and functional quality at several different mowing heights. However, when bermudagrass invades other desirable turfgrass stands, such as tall fescue (*Festuca arundinacea*) and zoysiagrass (*Zoysia* spp.) (Figures 3 and 4), it is considered a problematic weed. Bermudagrass often spreads by way of long stolons and rhizomes, which, like dallisgrass, contribute to its ability to recover from herbicide applications. For more information on bermudagrass identification and growth characteristics, see the UT Extension publication "**W237 Bermudagrass Control in Tall Fescue and Zoysiagrass Turf**."

## Growing Degree-days

Growing degree-day (GDD) accumulation is commonly used in row crop agriculture to predict important events in plant development such as flowering or crop maturity. In turfgrass management, GDDs are used in northern climates to predict annual bluegrass (*Poa annua*) seedhead emergence, crabgrass (*Digitaria* spp.) germination and the emergence of insect pests from dormancy. GDDs help determine the proper timing of management practices for controlling crabgrass with pre-emergence herbicides, suppressing annual bluegrass seedheads, and maximizing insect control. The accuracy of these GDD-accumulation models in Tennessee turfgrass systems has not been evaluated.

GDDs measure atmospheric heat accumulation in the growing environment that above a given base temperature threshold during a 24-hour period. For warm-season weeds, a good default base temperature is 50 degrees F. GDDs for control of warm-season weeds can be calculated using the following equation.

$$\text{Daily GDD}_{50F} = [(\text{Daily high air temp} + \text{Daily low air temp})/2] - 50F$$

Each daily GDD value is added to the yearly total beginning Jan. 1. Negative GDD values are disregarded (not added to or subtracted from the total). An example is provided in Figure 5.

### *Example 1 — Calculating GDDs using a Fahrenheit scale*

If the high temperature during the 24 hour period was 70 F and the low temperature was 45 F, 7.5 $GDD_{50F}$ would be added to the yearly total, as shown in the equation below.

$$\text{Daily GDD}_{50F} = [(70 + 45)/2] - 50\ F = 7.5\ \text{GDD}_{50F}$$

| Date | Daily GDD | Accumulated GDD |
|---|---|---|
| January 1 | 4 | 4 |
| January 2 | 6 | 10 |
| January 3 | 5 | 15 |
| January 4 | 2 | 17 |
| January 5 | 0 | 17 |
| January 6 | -3 | 17 |
| January 7 | 3 | 20 |

*Figure 5: A hypothetical example calculating growing degree-day (GDD) accumulation from daily GDD values. Note that when daily GDDs are negative, nothing is added to or subtracted from the total.*

### *Example 2 — Calculating GDDs using a Celsius scale*

For example, if the high air temperature for the day measured 21 C and the low air temperature measured 7 C, based on the equation below, the daily GDD accumulation would be 4.

Daily $GDD_{10C}$ = [(21 + 7)/2] – 10 degrees C = 4 $GDD_{10C}$

**Note that the same air temperatures were used in both examples, but different GDD values were produced.** These equations and the values they produce are not interchangeable! When using a Celsius temperature scale to calculate GDDs, you must always input Celsius temperatures into the equation and ensure the target GDD values were also calculated on the Celsius temperature scale.

### *Tracking GDD accumulation*

Several free software programs can be used to determine GDDs that have accumulated across a specific geographic area. Growing Degree Days is a free mobile application for both Apple and Android operating systems that provides a user-friendly interface for tracking GDD accumulation. The Weather Channel website also provides a GDD calculator. The University of Tennessee does not guarantee the accuracy of these services when calculating GDDs. These software programs will not calculate cooling degree-days.

## Cooling Degree-days

Late-season herbicide applications are also effective in controlling dallisgrass and bermudagrass. However, using GDD accumulation to time late-season applications is not optimal. Instead, timing of late-season herbicide applications can be determined using cooling degree-days. CDDs measure the accumulation of cooling below an optimal air temperature threshold. For warm-season weeds this temperature is 72 F (22 C). CDD accumulation begins on Aug. 1, where Aug. 1 equals 0. In the same manner as described earlier for GDDs, these daily CDD values are added to the total. Daily CDD values below 0 are disregarded, and do not affect the yearly total. An example is provided in Figure 6.

For example, if the high and low daily air temperatures measured 70 F and 45 F, respectively, the following equation is used to determine that 8 $CDD_{22C}$ were accumulated.

| Date | Daily CDD | Accumulated CDD |
|---|---|---|
| August 1 | -3 | 0 |
| August 2 | 2 | 2 |
| August 3 | 0 | 2 |
| August 4 | 5 | 7 |
| August 5 | 3 | 10 |
| August 6 | 4 | 14 |
| August 7 | 1 | 15 |

*Figure 6: A hypothetical example calculating cooling degree-day (CDD) accumulation from daily CDD values. Note that when daily CDDs are negative, nothing is added to or subtracted from the total.*

Daily $CDD_{72F}$ = 72 - [(70 + 45)/2] = 14.5 $CDD_{72F}$

Research at the University of Tennessee evaluated efficacy of several herbicide products applied at different GDD- and CDD-based timings for control of dallisgrass and bermudagrass in warm- and cool-season turfgrass. The objective of these research efforts was to identify the timings at which dallisgrass and bermudagrass were most sensitive to herbicide application, potentially providing the option for chemical control programs with fewer herbicide applications to be implemented.

## GDDs and CDDs in Practice: Management Trials in Tennessee Turf

### *Selective Control of Dallisgrass in Tall Fescue*

The active ingredient fluazifop-p-butyl (fluazifop) is registered for use in tall fescue under the trade names Fusilade II and Ornamec. Two different formulations of Ornamec are available: one blended with surfactant designed for spot treatments and another without a surfactant and higher fluazifop concentration designed for broadcast applications. Fusilade II is not registered for use on home lawns and must be applied by a certified professional applicator. Both the Fusilade II and Ornamec labels recommend application with a nonionic surfactant at 0.25 percent v/v. To avoid tall fescue injury, do not apply fluazifop during the summer or during high temperatures. Seeding tall fescue to promote turfgrass stand density may increase long-term dallisgrass control provided by Fusilade II and Ornamec. Tall fescue cannot be seeded for two weeks after Fusilade II or Ornamec application. See the University

of Tennessee turfgrass website (**tennesseeturf.utk.edu**) for more information on turfgrass establishment.

Research results demonstrated that a single application of Fusilade II applied in the spring at 270-360 $GDD_{50F}$ (175-200 $GDD_{10C}$) provided better dallisgrass control than other spring and summer GDD timings. A single late-season application at 10-225 $CDD_{72F}$ (5-125 $CDD_{22C}$) of Fusilade II provided dallisgrass control similar to that obtained at 270-360 $GDD_{50F}$. These findings illustrate that dallisgrass is most susceptible to fluazifop applications at 270-360 $GDD_{50F}$ and 10-225 $CDD_{72F}$. Multiple applications of Fusilade II may be required for long-term dallisgrass control in tall fescue. If multiple applications are required, we suggest making an application at both 270-360 $GDD_{50F}$ and 10-225 $CDD_{72F}$. This process may need to be repeated for several years to achieve complete dallisgrass eradication. See Figure 7 for a complete diagram of GDD-based timings that can be used to schedule herbicide applications for dallisgrass control.

### *Selective Suppression of Dallisgrass in Bermudagrass and Zoysiagrass*

Complete, long-term dallisgrass control in bermudagrass and zoysiagrass turf will likely require several herbicide applications for multiple growing seasons. To provide the best dallisgrass control using the herbicides listed below, University of Tennessee data suggest making late-season applications (about 10 $CDD_{72F}$) followed by a sequential applications four weeks later and an additional application at 270-360 $GDD_{50F}$ the following spring. This process may need to be repeated for several years to achieve complete eradication.

** None of the herbicides listed below should be applied to desirable tall fescue.

**Tribute Total – 3.2 oz/A**

Tribute Total is registered for use in bermudagrass turf and zoysiagrass only. For dallisgrass suppression, the Tribute Total label recommends including methylated seed oil (MSO) at 0.5 to 1 percent v/v and ammonium sulfate at 1.5 to 3 pounds per acre or urea ammonium nitrate (UAN) at 1.5 to 2 quarts per acre acre to the spray solution. The yearly maximum application rate is 6.4 ounces per acre.

**Revolver – 26.2 oz/A**

Revolver is registered for use in bermudagrass, zoysiagrass and buffalograss (*Buchloë dactyloides*) for use by professional applicators only. The yearly maximum application rate of Revolver is 54 fluid ounces per acre. Adjuvants are recommended for difficult-to-control weeds. For information on adjuvants, see the Revolver herbicide label.

**Monument – 0.53 oz/A**

Monument is registered for use in bermudagrass and zoysiagrass. The label recommends adding NIS up to 0.5 percent v/v. The yearly maximum application rate is 1.7 ounces per acre.

**Monosodium Methanearsonate (MSMA)**

The active ingredient MSMA is sold under many trade names. Consult the label for information on the proper application rate. MSMA is currently labeled for use on golf courses, sod farms and highway rights-of-way under modified use restrictions announced by the EPA in 2009. For more information regarding these restrictions, see the University of Tennessee Extension publication "W 243 The Turfgrass Industry Officially Loses MSMA."

### *Selective Suppression of Bermudagrass in Tall Fescue and Zoysiagrass*

Both Fusilade II and Ornamec are also registered for selective bermudagrass suppression in tall fescue and zoysiagrass turf. Application rates of these herbicides vary depending on the time of year that they are applied. Fusilade II and Ornamec applications for bermudagrass suppression may cause zoysiagrass discoloration. University of Tennessee research results indicate that Fusilade II (6 fluid ounces per acre) in combination with Turflon Ester (32 fluid ounces per acre) reduced zoysiagrass discoloration and increased bermudagrass control in the Zoysia japonica varieties 'Palisades' and 'Zenith.' The Zoysia matrella variety 'Diamond' was not tolerant to Fusilade II alone or in combination with Turflon Ester. Neither Fusilade II or Ornamec should be applied to any *Zoysia matrella* species. As discussed earlier, applying Turflon Ester in combination with Fusilade II or Ornamec reduces dallisgrass suppression.

Research from the University of Tennessee found that a single application of Fusilade II + Turflon Ester applied in the spring at 300 $GDD_{50F}$ provided better bermudagrass suppression than applications made at other timings throughout spring and summer. A single

late-season application of Fusilade II + Turflon Ester at approximately 10 $CDD_{72F}$ also provided excellent bermudagrass suppression. Results indicate that bermudagrass is most sensitive to herbicide applications at about 300 $GDD_{50F}$ and 10 $CDD_{72F}$. Multiple applications of Fusilade II + Turflon Ester may be required for long-term bermudagrass control. If multiple applications are required, we suggest making an application at 270-360 $GDD_{50F}$ and another at approximately10 $CDD_{72F}$. See Figure 7 for a complete diagram of GDD-based timings than can be used to schedule herbicide applications for bermudagrass control.

### *Non-chemical control*

Hand-removal of dallisgrass and bermudagrass from turf may be difficult due the large amount of underground perennial biomass these weeds produce. It is important to completely remove this biomass or the plant will survive. Hand-removal of bermudagrass is more difficult than dallisgrass as plants establish an extensive network of underground rhizomes and aboveground stolons. If stolons and rhizomes are not completely removed, dallisgrass and bermudagrass will recover.

## Final Thoughts

Controlling dallisgrass and bermudagrass in turf can be difficult. Herbicides are an effective tool for control if used in conjunction with proper turfgrass management practices to maintain a healthy, dense turfgrass stand. Maintaining a healthy, dense turf will improve long-term bermudagrass and dallisgrass control provided by a herbicide application.

This publication contains herbicide recommendations that are subject to change at any time. The recommendations in this publication are provided only as a guide. It is always the herbicide applicator's responsibility, by law, to read and follow all current label directions for the specific herbicide being used. The label always takes precedence over recommendations in this publication.

Always refer to the product label for specific information on proper use, tank-mix compatibility and turfgrass tolerance. For more information on turfgrass weed control, visit the University of Tennessee's turfgrass weed science website at **www.tennesseeturfgrassweeds.org**.

Herbicides listed in this publication have provided good to excellent control in research trials conducted at the University of Tennessee; however, other herbicides may also have activity on this weed. For more information on herbicide selection, please visit The University of Tennessee Mobile Weed Manual (MWM) at **mobileweedmanual.com**. MWM was developed by UT Extension professionals to assist green industry professionals in selecting herbicides for use in turf and ornamentals. MWM is a web-based platform optimized for use on mobile devices such as smartphones and tablets but it will function on desktop and laptop computers as well. The site provides users with weed control efficacy information for 90 different herbicides, tolerance information for over 2300 turf and ornamental species, as well as direct links to label and material safety data sheet information on herbicides used for turf and ornamental weed management.

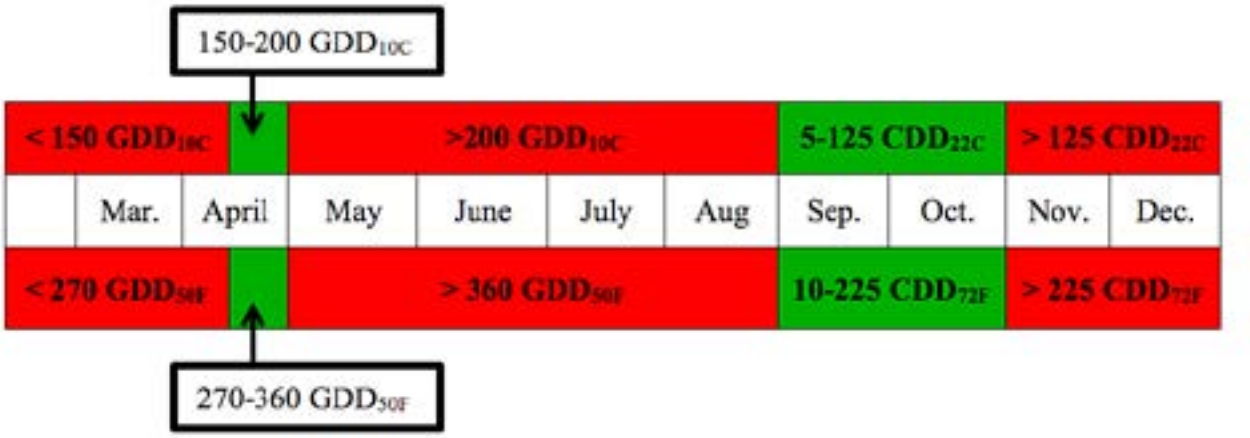


*Figure 7: Growing (GDD) and cooling degree-day (CDD) herbicide application intervals for dallisgrass and bermudagrass control. Green areas indicate optimum application timings and red areas indicate suboptimal application timings. Months are hypothetical and based on historical weather data and should be used only as an approximation for when a particular GDD or GDD threshold might be reached. Degree-day values based on Celsius and Fahrenheit temperature are presented with base temperatures subscripted.*




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