1

2

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4

Weeds Influence Field Playability

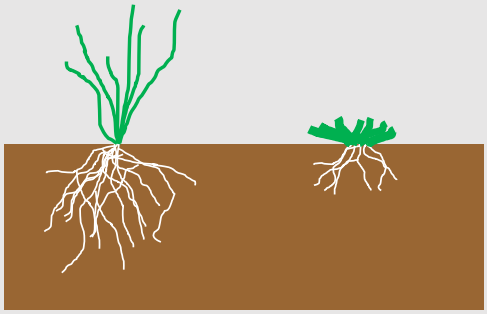
5

Weeds Influence Field Playability

- Differences in canopy height and architecture
  - Tripping hazard
- Often shallow rooted species
  - Easily uprooted
  - Less wear tolerance

6

Rooting Depth



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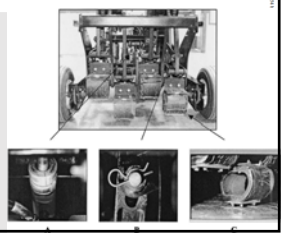
Published April 28, 2015

RESEARCH

Large Crabgrass, White Clover, and Hybrid Bermudagrass Athletic Field Playing Quality in Response to Simulated Traffic

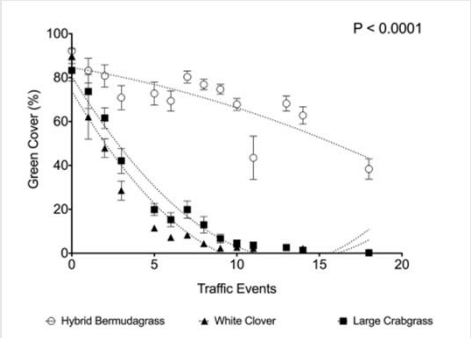
J.T. Brosnan,* K.H. Dickson, J.C. Sorochan, A.W. Thoms, and J.C. Stier

- Traffic imposed using Cady traffic simulator
- Evaluated green cover, surface hardness, and rotational resistance



8

Surface Response to Wear/Traffic



9

Canopy Resilience of Turfgrass

- Most utilized turfgrass playing surfaces
  - Kentucky bluegrass and hybrid bermudagrass
- Rhizomes sustain less injury from wear and traffic
  - Protected within the soil profile
- Most common athletic field weeds are annuals
  - Lower canopy resistance; less dense
  - No rhizomes or stolons
  - Fleshier foliage

10

Surface Response to Wear/Traffic

Surface hardness[1,2]

Surface type	2012 0 events[§]	2012 6 events	2012 12 events	2012 18 events
	Gmax			
Hybrid bermudagrass	48	69	61	68
White clover	97	134	120	134
Large crabgrass	92	121	120	130
$LSD_{0.05}$[¶]	4	8	8	8

11

Increased Surface Hardness

- Perennial turfgrass species often exhibit dense and deep root systems
- Prolific root systems and the presence of stolons and rhizomes fracture soil and help reduce the accumulation of surface hardness

12

Surface Response to Wear/Traffic

Surface type	Rotational resistance† 2012 0 events‡	2012 9 events	2012 18 events	2013 0 events	2013 9 events	2013 18 events
	Nm					
Hybrid bermudagrass	53	49	64	46	52	52
White clover	34	35	35	40	50	40
Large crabgrass	34	33	40	40	50	42
$LSD_{0.05}$§	4	4	4	3	NS	4

13

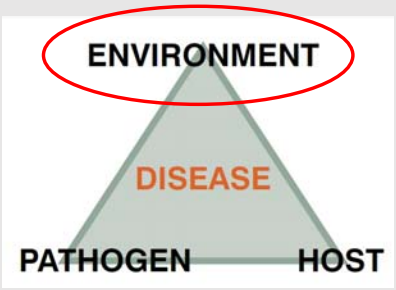
14

Weed Ecology

- Most weeds have preferred environments
  - May indicate underlying agronomic problems
- Changes to cultural practices or agronomic conditions can reduce weed pressure
- Further emphasizes use of IPM strategies

15

Disease Triangle



16

High Soil Moisture/Poor Drainage

- Moss
- Virginia buttonweed
- Purple and yellow nutsedge
- Buckhorn plantain

Virginia buttonweed (*Diodia virginiana*)

17

18

19

20

Soil Compaction

- Common chickweed
- Goosegrass
- Prostrate knotweed
- Buckhorn plantain
- Pineappleweed

pineappleweed
(*Matricaria discoidea*)

21

22

European Journal of Sport Science

ISSN: 1746-1391 (Print) 1536-7290 (Online) Journal homepage: http://www.tandfonline.com/loi/tejs20

Does variability within natural turfgrass sports fields influence ground-derived injuries?

Chase M. Straw, Christine O. Samson, Gerald M. Henry & Cathleen N. Brown

- Collaboration with UGA Biomechanics Lab and Rec Sports
- Men's and Women's Rugby, Ultimate Frisbee, Soccer, and Lacrosse

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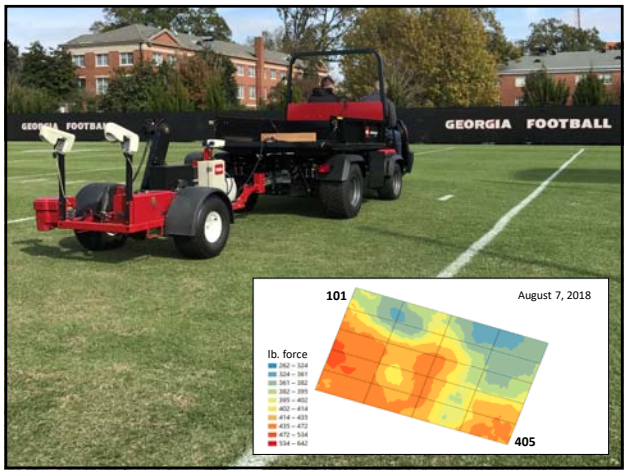
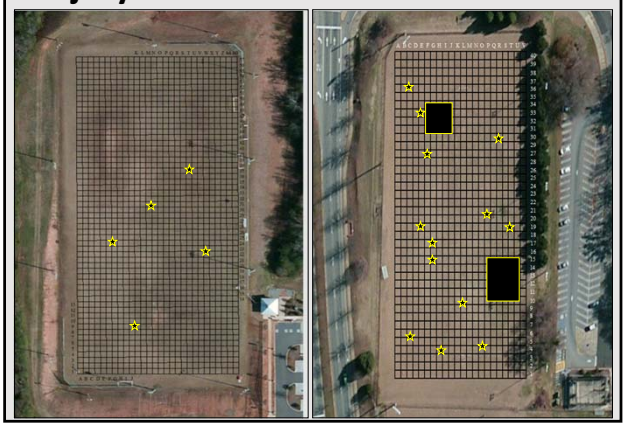


24

Injury Locations



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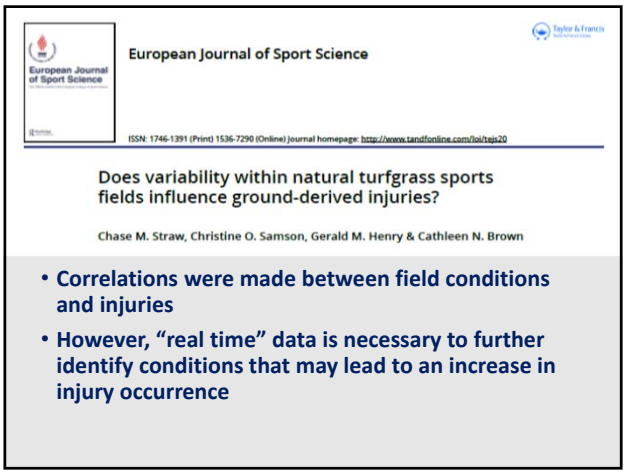
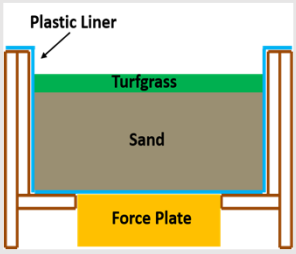


26

Ground Reaction Platforms



Determine the impact of field surfaces and the underlying soil profile on athletes

27

28

Ground Reaction Platforms

Potential use:

- Compare natural turfgrass vs. synthetic turf
- Evaluate impact of surface hardness, soil compaction, soil moisture, etc.
- Evaluate profile materials – sand, soil, etc.
- Compare turfgrass species and cultivars
- Determine impact of weeds

29

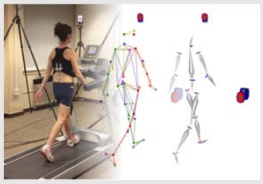
Ground Reaction Platforms

- Collaboration with UGA Biomechanics Lab
- University-level male and female athletes will be recruited to perform maneuvers on the platforms, such as:
  - Walking
  - Running
  - Jumping
  - Cutting

30

Data Collection

- The force plate will be used in conjunction with an eight-camera motion capture system to collect kinetic and kinematic data
- Reflective markers are attached to the lower limbs of participants conducting maneuvers



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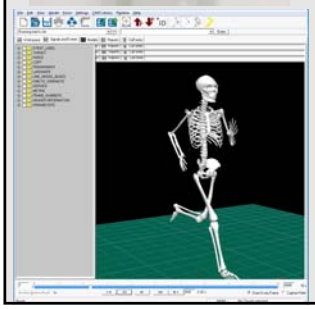


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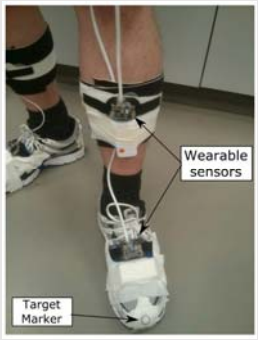
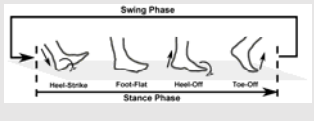
Influence of Species Composition

- Evaluate the impact of weed pressure on player safety and field playability
- Examine the influence of weed species composition on field longevity and performance
- Ground reaction platform and field trials

33

Inertial Sensor-Based Slip Detection





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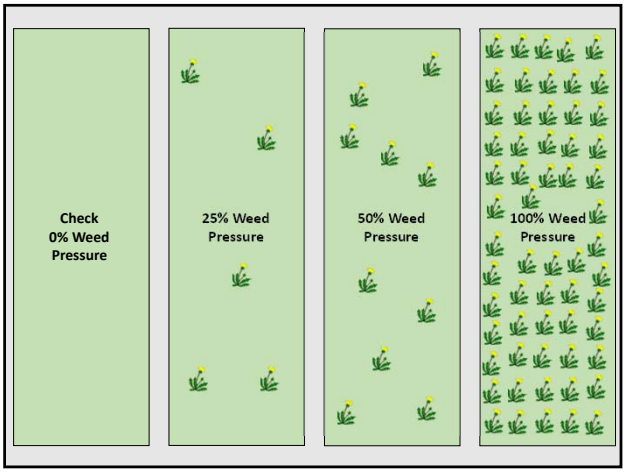


35

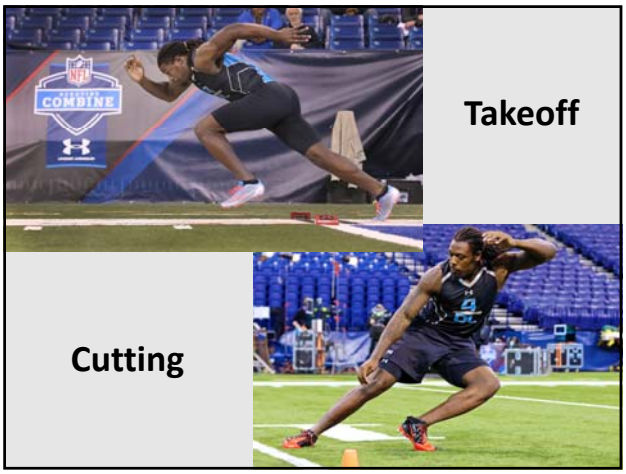
Common Weed Species


Annual Bluegrass


White Clover


Large Crabgrass

36



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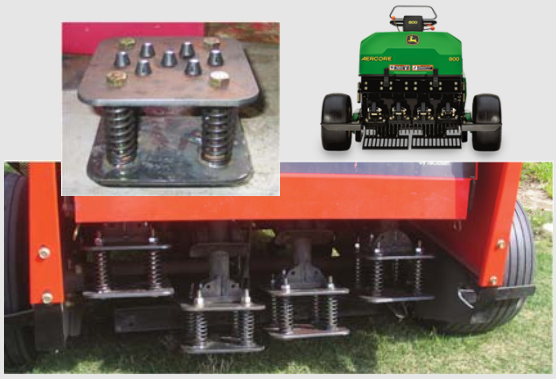
Wear and Traffic Simulator



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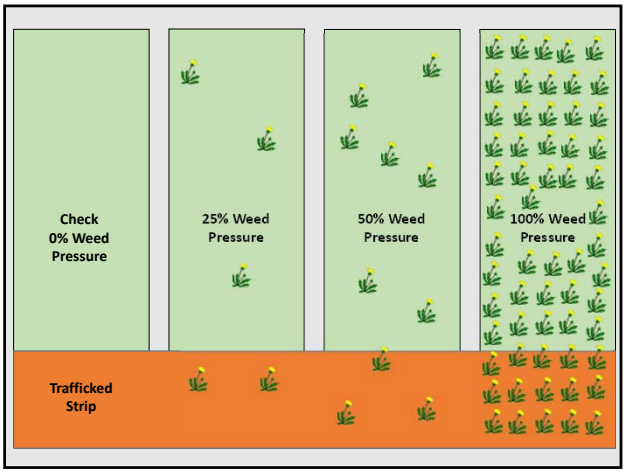


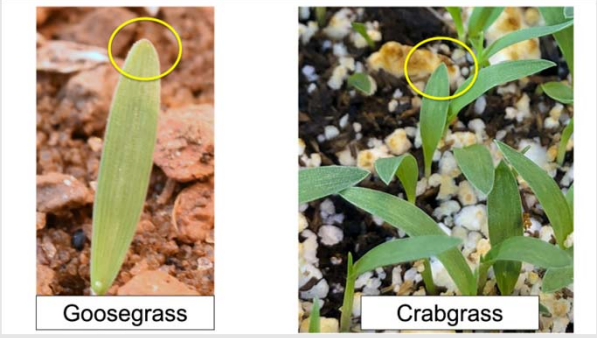
39

Keys to Successful Weed Control

- Correct weed ID
- Knowledge of weed biology
  - Annual vs perennial
- Use of cultural practices to reduce weed populations
- Proper herbicide selection, timing, and application

40

Know What to Look For…..



Slide by: M. Elmore, Rutgers Univ

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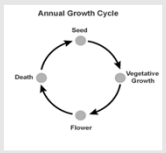
Weed Lifecycles



- Summer annuals
  - Germinate in spring; grow in summer; die in fall
- Winter annuals
  - Germinate in fall; grow in spring; die in summer
- Perennials
  - Ability to overwinter; resume growth year to year

42

Annual Weeds

- Most common
  - Annual bluegrass
  - Crabgrass spp.
  - Goosegrass
- Other grass weeds
- Broadleaf weeds

43

Annual Weeds

- Establishment through seeds
- Cultural practices
  - Reduce weed seed bank
    - Collect clippings during seed set
  - Decrease germination
    - Adjustments in mowing height

44

45

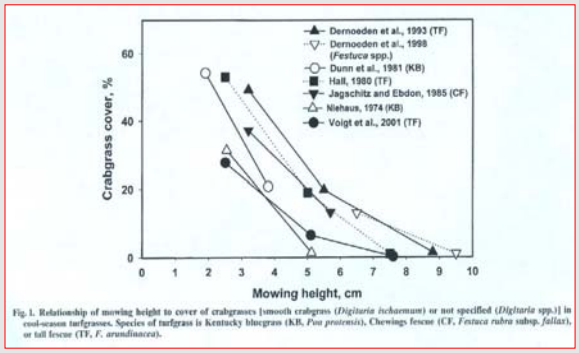
46

Fraise Mowing

- Remove aboveground biomass to a depth of 2 inches
- Turfgrass reestablishes from belowground rhizomes
- UT research observed a 26% reduction in Spring *Poa annua* cover following a mid-summer fraise mowing in Zoysiagrass
  - Responses in bermudagrass more pronounced in both TN and FL

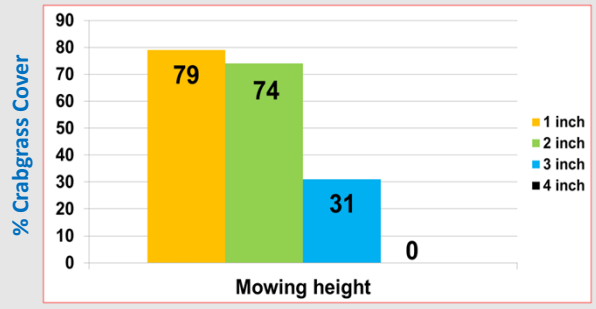
47

Effect of Mowing Height on Crabgrass



48

Effect of Mowing Height on Crabgrass Incidence in Tall Fescue



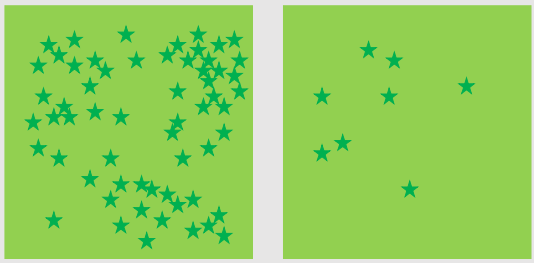
Hoyle et al. 2009

49

50

Density Effect

- **Which population is easier to control with a POST herbicide?**



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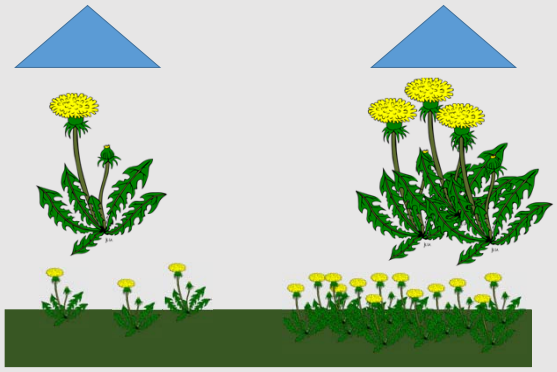
Density Effect



52

Preemergence Herbicides

- **Target species: annual grasses; annual and some perennial broadleaf weeds**
- **Spring applications**
  - **Initial app. late February to mid-March**
  - **Sequential app. approx. 60 days later**
- **Fall applications**
  - **Mid to late September**

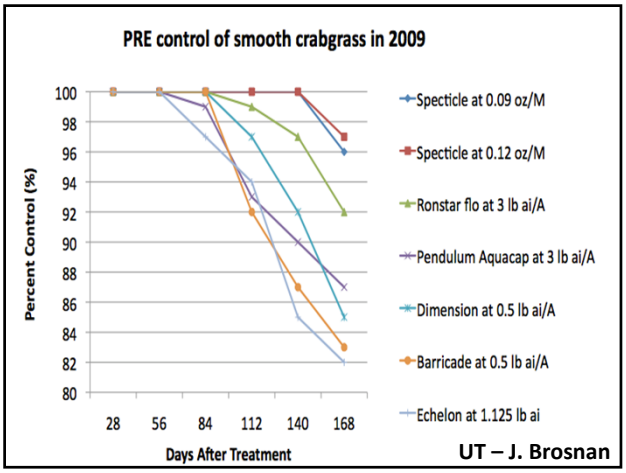
53

Preemergence Herbicides

- **Dimethenamid (Tower)**
- **Dithiopyr (Dimension)**
- **Indaziflam (Specticle)**
- **Metolachlor (Pennant)**
- **Oryzalin (Surflan)**
- **Oxadiazon (Ronstar)**
- **Pendimethalin (Pendulum)**
- **Prodiamine (Barricade)**
- **Imazaquin + Prodiamine + Simazine (Coastal)**

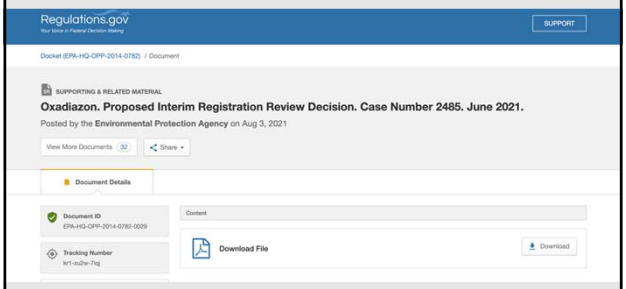
Safety varies among turfgrass species

54



55

Emerging Regulatory Issues



Oxadiazon Re-registration with EPA

56

EPA Decision – March 2022

- Continued registration on golf courses, sports fields, sod production, and parks
- Restrictions:
  - Apps require same day post-app irrigation
  - Products containing oxadiazon will become restricted use

Granular formulation
- Single max app = 3 lb ai A^{-1}; Max annual app = 6 lb ai A^{-1}

Liquid formulation
- Single app per year of max app = 3 lb ai A^{-1}

- Apps require 10-ft wide buffer from any surface water

https://www.regulations.gov/document/EPA-HQ-OPP-2014-0782-0151

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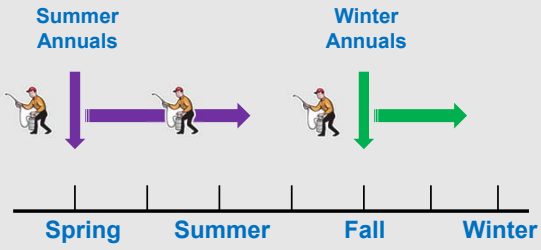
Application Timing



58

Doveweed

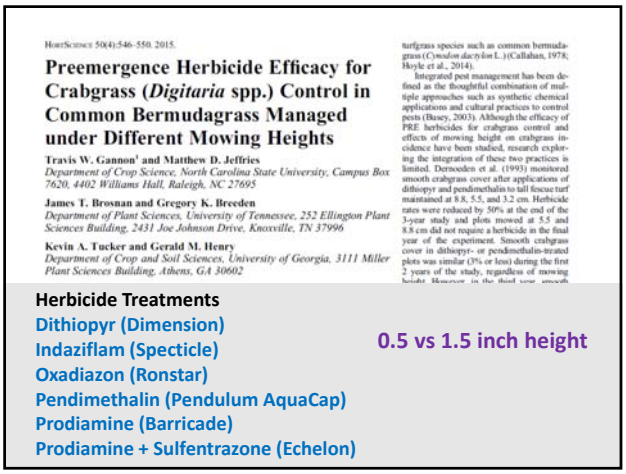
- Summer annual
- Favored by low, frequent mowing
- Increases horizontal growth and often spreads creeping stems to other locations

59

Game Changer - Doveweed

- Germinates when soil temps approach 70 F
- Typical PRE application timings may be ineffective due to reduced soil residual activity
- Specticle, Tower, Ronstar, and Pennant are most effective
- Split apps most effective:
  - Initial app March
  - Sequential 4 weeks after

60



HortScience 50(4):546–550. 2015.

Preemergence Herbicide Efficacy for Crabgrass (*Digitaria* spp.) Control in Common Bermudagrass Managed under Different Mowing Heights

Travis W. Gannon[1] and Matthew D. Jeffries
Department of Crop Science, North Carolina State University, Campus Box 7620, 4402 Williams Hall, Raleigh, NC 27695
James T. Brosnan and Gregory K. Breeden
Department of Plant Sciences, University of Tennessee, 252 Ellington Plant Sciences Building, 2431 Joe Johnson Drive, Knoxville, TN 37996
Kevin A. Tucker and Gerald M. Henry
Department of Crop and Soil Sciences, University of Georgia, 3111 Miller Plant Sciences Building, Athens, GA 30602

turfgrass species such as common bermudagrass (*Cynodon dactylon* L.)(Callahan, 1978; Hoyle et al., 2014).

Integrated pest management has been defined as the thoughtful combination of multiple approaches such as synthetic chemical applications and cultural practices to control pests (Busey, 2003). Although the efficacy of PRE herbicides for crabgrass control and effects of mowing height on crabgrass incidence have been studied, research exploring the integration of these two practices is limited. Dernoeden et al. (1993) monitored smooth crabgrass cover after applications of dithiopyr and pendimethalin to tall fescue turf maintained at 8.8, 5.5, and 3.2 cm. Herbicide rates were reduced by 50% at the end of the 3-year study and plots mowed at 5.5 and 8.8 cm did not require a herbicide in the final year of the experiment. Smooth crabgrass cover in dithiopyr- or pendimethalin-treated plots was similar (3% or less) during the first 2 years of the study, regardless of mowing

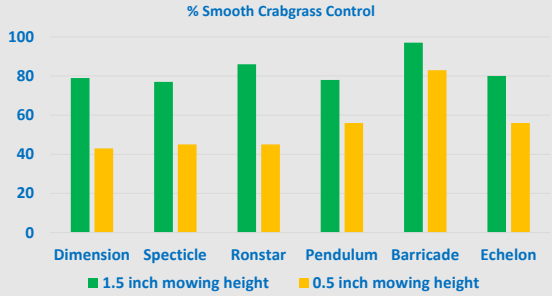
Herbicide Treatments

Dithiopyr (Dimension)
Indaziflam (Specticle)
Oxadiazon (Ronstar)
Pendimethalin (Pendulum AquaCap)
Prodiamine (Barricade)
Prodiamine + Sulfentrazone (Echelon)

0.5 vs 1.5 inch height

61

Crabgrass Control in Response to Mowing Height



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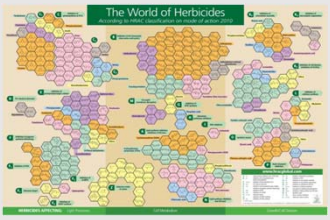
Crabgrass Control in Response to Mowing Height

- **Analysis of soil samples for residual herbicide activity revealed that mowing height had no influence**
- **Therefore, differences in control may be the result of plant growth, soil surface light, etc. and not differential degradation of applied herbicides at the two mowing heights**

63

Herbicide Resistance Management

- **Apply labelled rates**
- **Rotate modes of action**
- **Tank mix different MOA**



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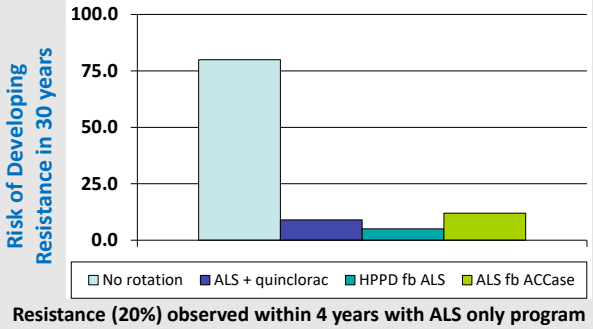
Modeled Effects of Rotation/Mixtures on ALS Resistance

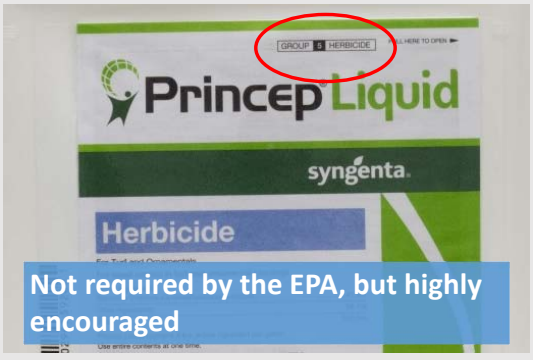


Resistance (20%) observed within 4 years with ALS only program

Bagavathiannan et al. 2014. Weed Tech. 28:89-103

65

Herbicide Classification System



Not required by the EPA, but highly encouraged

66

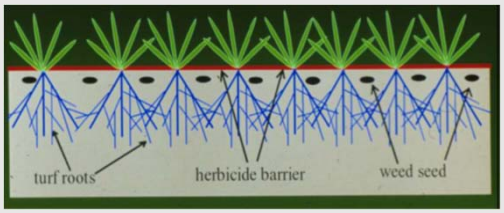
Preemergence Herbicides

- Dimethenamid (Tower) 15
- Dithiopyr (Dimension) 3
- Indaziflam (Specticle) 29
- Metolachlor (Pennant) 15
- Oryzalin (Surflan) 3
- Oxadiazon (Ronstar) 14
- Pendimethalin (Pendulum) 3
- Prodiamine (Barricade) 3
- Imazaquin + Prodiamine + Simazine (Coastal) 2, 3, 5

Safety varies among turfgrass species

67

Preemergence Herbicides



Herbicides do not prevent weeds from germinating, they control weeds as they grow through the herbicide treated zone

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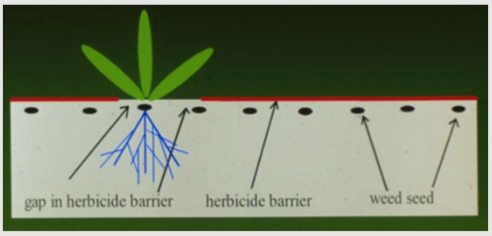
Preemergence Herbicides



Large gaps in herbicide barriers result in weed escapes

70

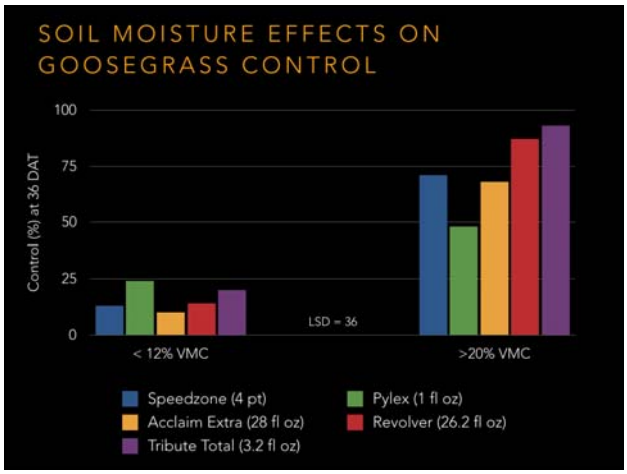
Postemergence Herbicides

- **Annual Weeds**
  - Target small weeds
  - Apply prior to seed production
  - Addition of surfactants
  - Sequential applications may be necessary

71

Goosegrass Control

72



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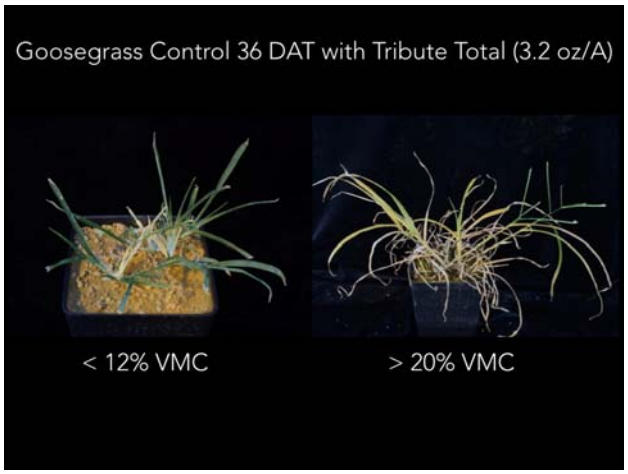
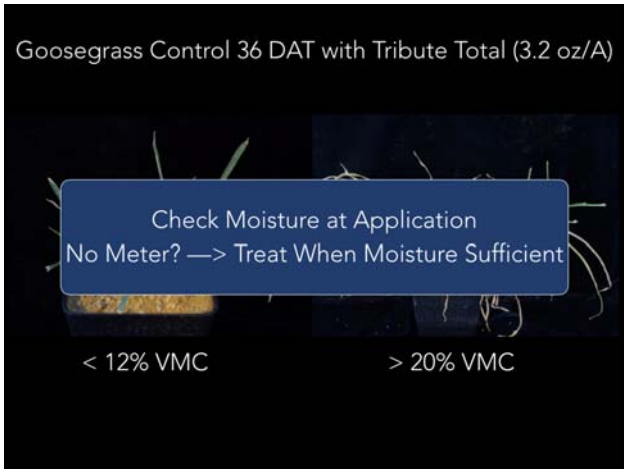


74



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Manuscript

Manuscript® Herbicide

- **Active Ingredient:**
  - **Pinoxaden**
- **MOA: ACCase Inhibitor 1**
- **Rate: 9.6 to 19.2 fl oz/A**
- **Tolerant Turf Species: bermudagrass, zoysiagrass, and St. Augustinegrass (sod farm only)**
- **Target Weeds: POST grass weeds**

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Perennial Weeds

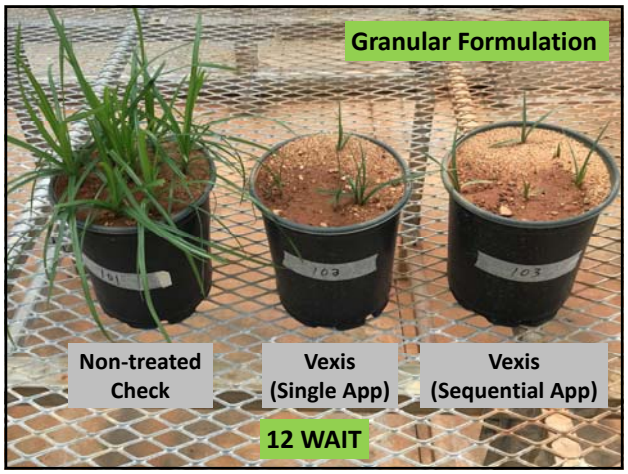
- **Vegetative and seed reproduction**
- **Herbicides alone will not provide adequate control**
- **Minimal control with PRE herbicides**
- **Accurate POST herbicide selection and timing**

78

PRE Purple Nutsedge Control

- Vexis (granular formulation)
  - pyrimisulfan (1 or 2x)
- Vexis (liquid formulation) (1 or 2x)

79



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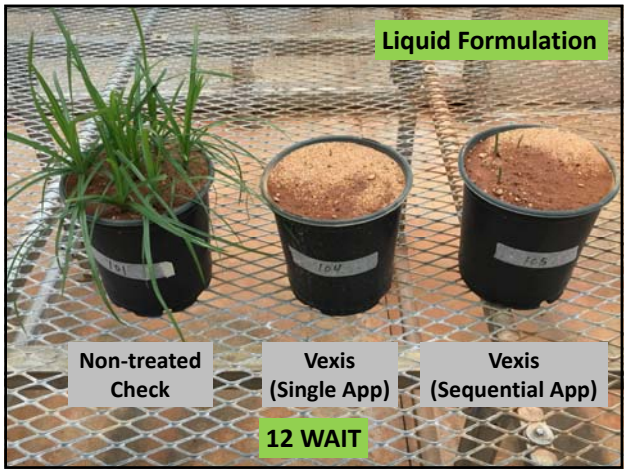

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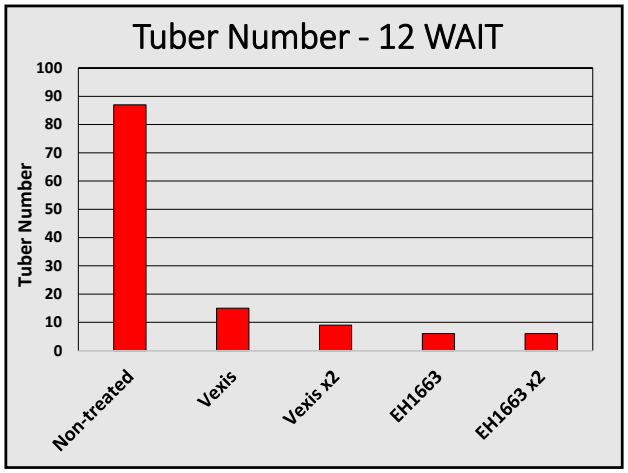

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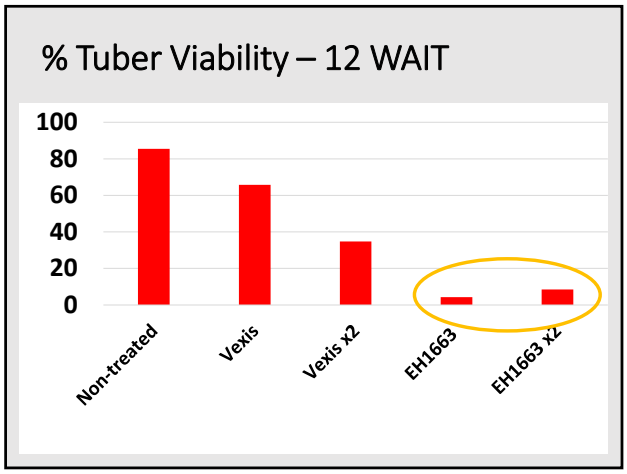

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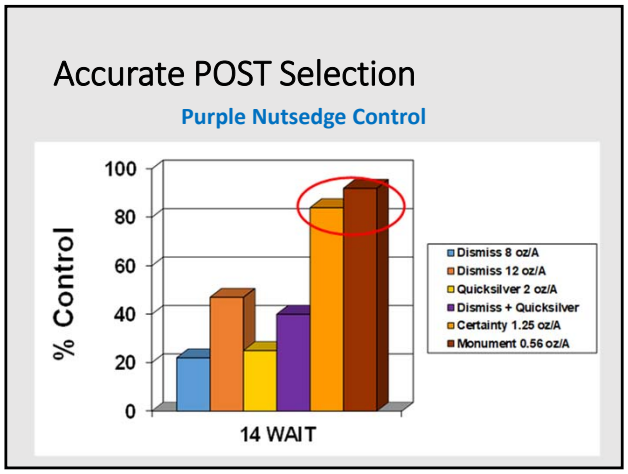
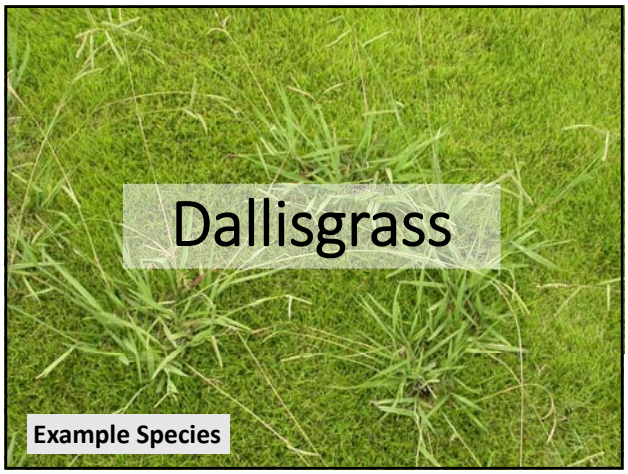


84

Accurate POST Selection

85



86

Dallisgrass

- Abundance of rhizome production

87

Mowing to Reduce Weed Colonization

- Mowing depletes carbohydrate reserves through biomass reduction

Bahiagrass & Dallisgrass

Mowing Heights (in.)
0.5, 2, 3, and non-mowed

88

Weed Science 2007 55:486–490

Effect of Mowing on Lateral Spread and Rhizome Growth of Troublesome *Paspalum* Species

Gerald M. Henry, Michael G. Burton, and Fred H. Yelverton*

The effect of mowing regime on lateral spread and rhizome growth of dallisgrass and bahiagrass was determined in field studies conducted in 2003 and 2004 in North Carolina over 5 mo. Treatments were selected to simulate mowing regimes common to intensively managed common bermudagrass turfgrass and include 1.3-, 5.2-, and 7.6-cm heights at frequencies of three, two, and two times per week, respectively. A nonmowed check was included for comparison. Lateral spread of dallisgrass was reduced 38 to 47% regardless of mowing regime when compared with the nonmowed check. Rhizome fresh weight of dallisgrass was reduced 49% in 2003 and 30% in 2004 when mowed at the 7.6-cm regime after 5 mo, whereas the 5.2-cm mowing regime caused a reduction of 31%. Rhizome fresh weight of dallisgrass was most negatively affected by the 1.3-cm regime, which caused reductions of 57% in 2003 and 37% in 2004. Lateral spread of bahiagrass was more strongly affected by mowing height and frequency than dallisgrass, with reductions of 21 to 27%, 40%, and 44 to 62% when mowed at 7.6, 5.2, and 1.3-cm regimes, respectively. Rhizome fresh weight of bahiagrass was reduced 24 to 33%, 55%, and 70 to 73% when mowed at 7.6, 5.2, and 1.3 cm, respectively. Based upon these results, areas mowed at a golf course rough height (≥ 5.2 cm) may be more conducive to bahiagrass spread, whereas dallisgrass may tolerate areas mowed at a fairway height (1.3 cm). Mowing at the shorter heights examined in this study clearly reduced the potential of *Paspalum* spp. vegetative spread and may help to explain observed distributions of *Paspalum* spp. infestations in bermudagrass turfgrass.

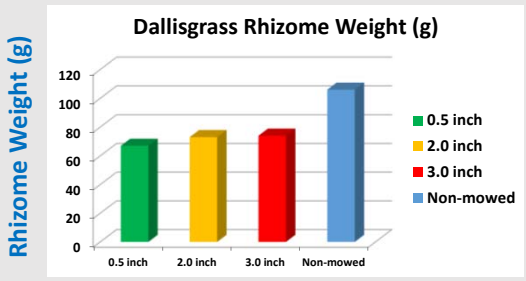
Nomenclature: Bahiagrass, *Paspalum notatum* Flueggé PASNO; bermudagrass, *Cynodon dactylon* (L.) Pers.; dallisgrass, *Paspalum dilatatum* Poir. PASDI.
Key words: Golf course weeds, rhizome production, turfgrass.

"Mowing height and frequency had a greater impact on bahiagrass growth and reproduction then dallisgrass."

89

Mowing to Reduce Weed Colonization

- Mowing depletes carbohydrate reserves through biomass reduction



90

Effect of Soil Moisture

- Dallisgrass, bahiagrass, and each in competition with bermudagrass
- Sand and sandy loam soil types
- Monitored vegetative growth and survival

91

RESEARCH

Asymmetric Responses of *Paspalum* Species to a Soil Moisture Gradient

Gerald M. Henry,* Fred H. Yelverton, and Michael G. Burton

"Dallisgrass may be more competitive with bermudagrass when soil moisture is high, while bahiagrass may be more competitive when soil moisture is low."

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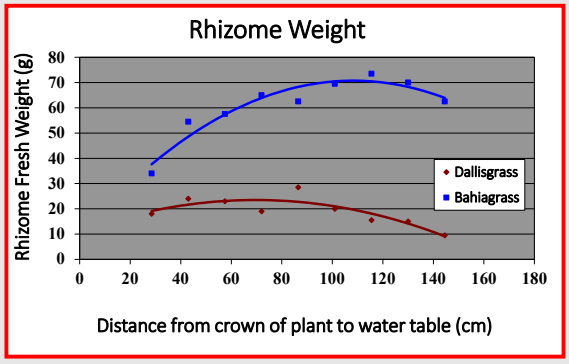
Paspalum spp. Response to Soil Moisture



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Journal of Soil and Water Conservation 2018

Uniformity and spatial variability of soil moisture and irrigation distribution on natural turfgrass sports fields

C.M. Straw, R.N. Carrow, W.J. Bowling, K.A. Tucker, and G.M. Henry

Abstract: Emerging technology that couples spatial irrigation distribution data with spatial plant and soil property data may provide a more robust assessment of irrigation system performance than conventional methods. Research was conducted on native soil and sand capped

Irrigation Association suggests the target catch can DU_{lq} for turfgrass and landscape areas be between 65% and 75% for rotary irrigation heads (Irrigation Association 2010).

The catch can DU_{lq} method provides insight on distribution uniformity of an irrigation system, but it does not indicate water infiltration or redistribution (Li and Rao 2000; Dukes et al. 2006; Kiefer and Heck 2008). Devices that measure soil moisture (volumetric water content [VWC]) are becoming more readily available to turfgrass managers (Mecham 2001; Dukes et al. 2006; Kieffer and O'Connor 2007; Vis et al. 2007; Straw et al. 2016). It is not uncommon to determine VWC DU_{lq} of irrigated areas using the same sample locations as catch can

Improving the efficiency of your irrigation system

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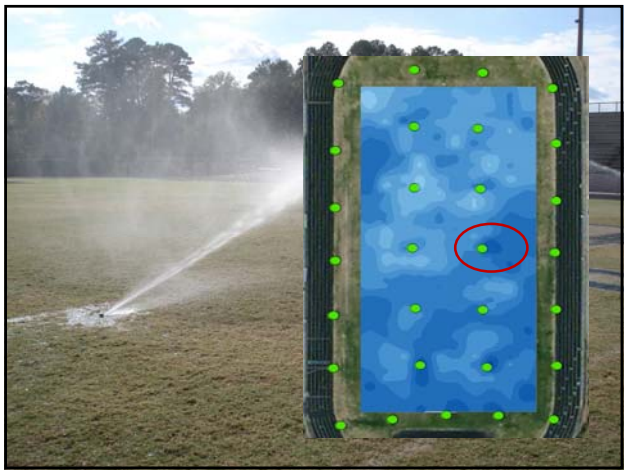

95

96

HortScience 51(6):754–756. 2016.

Dallisgrass (*Paspalum dilatatum*) Control with Thiencarbazone-methyl, Foramsulfuron, and Halosulfuron-methyl in Bermudagrass Turf

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Additional index words. Cynodon dactylon, turfgrass, weed, iodosulfuron-methyl-sodium, dicamba, dormancy, phytotoxicity, perennial grass

availability and continued use of MSMA has been uncertain following the 2009 decision by the Environmental Protection Agency, which eliminated the use of MSMA on home lawns and athletic fields, while restricting use on sod farms, golf courses, and highway rights of way and prohibiting use in all turfgrass environments after 31 Dec. 2013 (United States Environmental Protection Agency (EPA), 2009). The 2009 EPA decision on MSMA prohibition was recently delayed, pending a registration review that began in 2013 and is scheduled for completion in 2019 (United States Environmental Protection Agency, 2015).

Limitations on the efficacy of other herbicides for dallisgrass control have also been reported. Henry et al. (2007b) observed

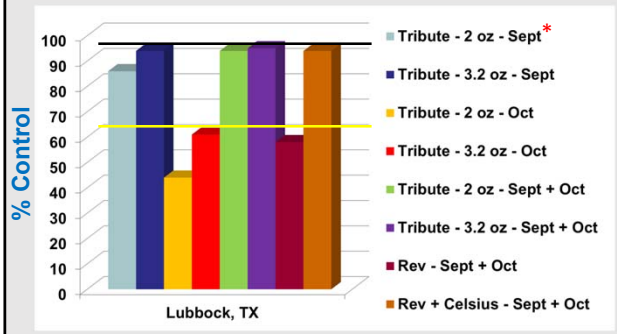
Evaluate rates and timings of Tribute Total

Rates – 2 or 3.2 oz/A
Application timings – Sept., Oct., or Sept. fb Oct.

+ MSO – 0.5% v/v and AMS – 2% w/v

97

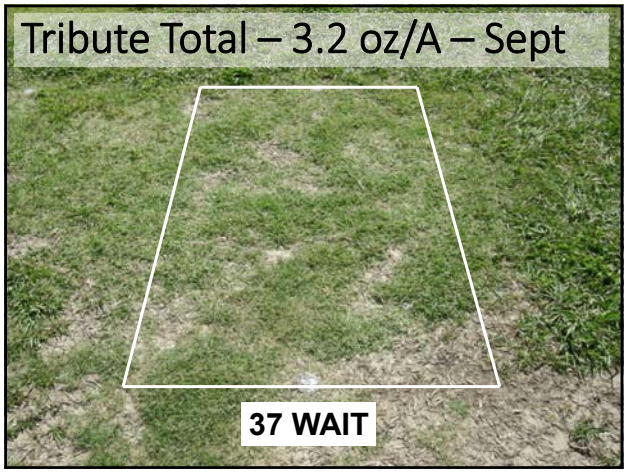
Dallisgrass Control – 37 WAIT



***+ MSO – 0.5% v/v and AMS – 2% w/v**

98

Tribute Total – 3.2 oz/A – Sept



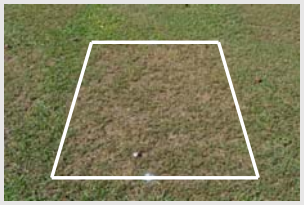
99

3 Years After Application

100

Dallisgrass Control

- **Current Tribute Total program employs late summer and/or fall applications**
- **Is spring or summer control still feasible?**
- **Enhancing herbicide translocation may be key!**



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HortScience 57(2):290–296. 2022. https://doi.org/10.21273/HORTSCI16209-21

Impact of Verticutting on the Efficacy and Soil Activity of ALS-inhibiting Herbicides for Dallisgrass Control

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lawns, golf courses, and athletic fields (McCarty, 2008).

Current chemical control options for dallisgrass in managed turfgrass systems are neither efficient nor consistent from year to year. Monosodium methanearsonate (MSMA) is a contact herbicide that results in significant canopy loss following sequential applications, but regrowth can occur throughout summer from rhizome carbohydrate reserves and concerns exist regarding phytotoxicity to desirable warm-season turfgrass species (Henry et al., 2007b, 2008; McCarty et al., 1991; Smith et al., 1974). Furthermore, numerous restrictions were placed on MSMA by an Environmental Protection Agency (EPA) ruling in 2009 that significantly limits its use for turfgrass applications (U.S. Environmental Protection Agency, 2009). Brosnan et al., (2010) reported 90% control of dallisgrass 76 d after treatment (DAT) with single, spring applications of fluazifop, but significant bermudagrass (*Cynodon* spp.) injury in response to this chemistry has also been reported (Bryson and Wills, 1985; Johnson, 1992; McElroy and Breeden, 2006). Greater than 95% dallisgrass control was observed when pinoxaden, an acetyl coenzyme A carboxylase (ACCase) inhibitor, was applied at ≥10 g·ha^{-1} a.i.; however, control was only

- **Examine Summer application timings (June)**
- **Cultural Practices**
  - **Mowed day of herbicide application**
  - **Mowed + verticut day of herbicide application**

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Deer Trail CC – 17 WAIT

	% Dallisgrass Control	
Herbicide Treatment	Mowed	Mowed + Verticut
Non-treated Check	0	5
MSMA	52	63
Tribute Total	55	86
Monument 40 GPA	8	27
Monument 120 GPA	61	85

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VEXIS

- Pyrimisulfan 2
- Granular formulation with activity on sedge, kyllinga, and some grasses
- Root absorption allows applications to dry turf —> no need for dew
- **Use sites**: Residential and commercial lawns, golf courses, sports fields, sod farms, parks, and many more.
- Sequential applications on harder to control perennial weeds
- Mixtures will be coming
  - Warm-season turfgrass = Aethon (Vexis + penoxsulam) 2 + 2
  - Cool-season turfgrass = TBD (Vexis + ???)

105

Dismiss NXT Herbicide

- Carfentrazone (3.5%) + sulfentrazone (32%) 14 + 14
  - 1:9 ratio of carfentrazone to sulfentrazone
- 3.5 lb active/gallon formulation
- All cool-season grasses: CBG, PR, KBG, RBG, FF, TF
- Rates of 5.1 to 10.2 fl oz/A
- Residential & Commercial Lawns, Golf (Fairway and Rough), Sod Farms, Rights-of-Way, Other Non-Crop Areas

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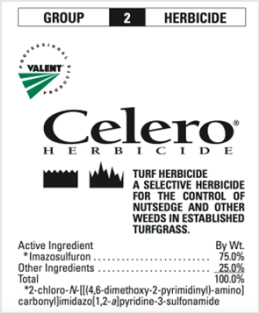
Celero

- New product from NuFarm
- Imazosulfuron - 2
- Labeled for CBG, FF, KBG, PR, TF, B, C, Z, St. A
- 8 - 14 oz/A
- Sedge and Kyllinga control via ALS inhibition



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Coastal Herbicide

- Three active ingredients
  - prodiamine 3
  - simazine 5
  - imazaquin 2
- Rates of 32 fl oz (applied 2x) or 64 fl oz
- Activity for EPOST Poa control in warm-season turf
- Mixtures with metsulfuron to expand BLW spectrum

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Halauxifen-methyl

Relzar™ Arylex™ active SPECIALTY HERBICIDE

- Synthetic auxin herbicide 4
  - Similar to fluroxypyr and triclopyr in structure, different binding site
- Potential tool to replace 2,4-D in synthetic auxin herbicide mixtures
  - Need for this as public pressure against 2,4-D use increases
- Foliar and root absorption, moves through xylem and phloem
- No drip line issues on trees —> rapidly degrades in soil and plant tissue

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Crew™ SPECIALTY HERBICIDE

- New PRE option in 2019
- AI - dithiopyr + isoxaben
  - 3 + 29
- Golf course (non-greens), sports turf, lawns, sod, etc
- 200 lb/A application max, 600 lb/A yearly cap
- Smooth crabgrass control in 2019 TN trials > FreeHand, Specticle G
- Split program effective versus Poa in 2020-2021 trials

110

Quintessential HERBICIDE HValue Technology

- New POST option for 2021
- AI - quinclorac 4
  - Enhanced formulation —> Improved control at intermediate growth stages, enhanced rain fastness
- Lawns, grounds, parks, schools, athletic fields, golf courses, cemeteries, sod farms, etc.
- Turf tolerance identical to Drive XLR8

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Questions?

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