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Continued from page 60

Insecticidal soap, lemon dishwashing soap and the label rate of permethrin killed nematodes, but none of the treatments affected nematode infectivity. Only the insecticidal soap and label rate of permethrin flushed more infected mole crickets than the standard lemon dish soap in the field.

Thus, to determine the effectiveness of a nematode application, a dilute permethrin drench can flush mole crickets from the soil and provide accurate infection results.

Compatibility with insecticides

Combinations of insecticides and insect parasitic nematodes may have a synergistic effect on nematode infection rates against white grubs (Koppenhöffer and Kaya 1998, Koppenhöffer et al. 2000).

Grubs treated with imidacloprid became sluggish and could not move normally, which allowed cruiser nematodes to invade the grubs' bodies. We wanted to determine if this could also occur for fast-moving mole crickets and an ambush nematode.

The half and full label rates of five insecticides used to control mole crickets were evaluated in the laboratory, including acephate (Orthene Turf, Tree and Ornamental Spray), bifenthrin (Talstar GC Flowable), deltamethrin (DeltaGard T&O), fipronil (Chipco Choice) and imidacloprid (Merit 75 WP). Submerging nematodes in these solutions for 24 hours did not harm nematode health or ability to infect mole crickets. More than 95 percent of the nematodes survived.

Mole crickets exposed to acephate, bifenthrin, deltamethrin or fipronil died within two days, and most of those exposed to imidacloprid died within 26 days. Nematodes infected nearly half or more of the treated crickets (range: 40 percent to 100 percent). Thus, tank-mixing nematodes and insecti-

Continued on page 64

Impact of insecticides on nematode survival and subsequent infectivity of tawny mole crickets in laboratory assays.

Trade name	Rate	Percent survival of nematodes held in insecticide solutions for 24 hrs (n=5)	Avg. no. days until mole cricket death, after a 24-hr exposure to insecticide-treated nematodes (n=5)	Avg. no. days until mole cricket death after insecticide treatment, then 24-hr exposure to nematodes (n=5)
Orthene TT&O	1 kg Al/ha	96.3 a	1.4 b	1.0 b
	2 kg Al/ha	97.5 a	1.4 b	1.0 b
Talstar GC Flowable	112 g Al/ha	95.9 a	2.8 b	1.0 b
	224 g Al/ha	95.6 a	1.6 b	1.0 b
DeltaGard T&O	73 g Al/ha	--	--	1.0 b
	146 g Al/ha	--	--	1.0 b
Chipco Choice	140 g Al/ha	--	--	1.0 b
	280 g Al/ha	--	--	1.4 b
Merit 75 WP	275 g Al/ha	100.0 a	23.2 a	25.6 a
	451 g Al/ha	98.2 a	22.2 a	17.4 a
Untreated control	N/A	99.8 a	17.0 ab	39.6 a

Mean ± standard error of the mean (SEM), means within columns followed by different letters are significantly different at _ = 0.05 using Tukey's honestly significant difference means separation test.

Editor's note: g = gram, kg = kilogram, ha = hectare, AI = active ingredient

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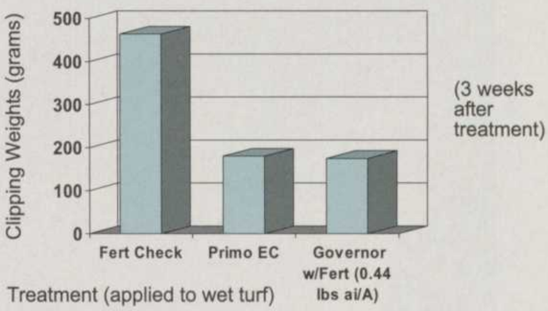
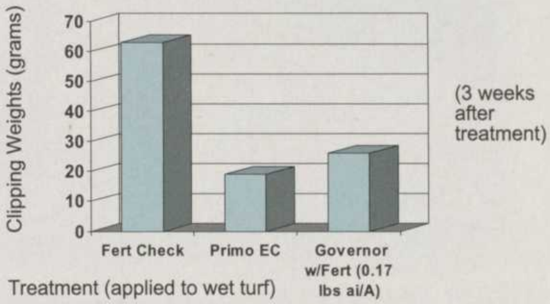
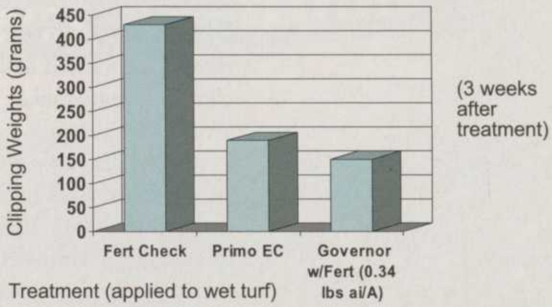


Efficacy on Perennial Ryegrass
Dr. Mahady, Pebble Beach, CA



Efficacy on Tifway Bermudagrass
Dr. Bert McCarty, Clemson University



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A tawny mole cricket infected with nematodes.

infected mole crickets.

When placed into arenas with half of the sand treated with nematodes and the other half left untreated, mole crickets tunneled normally and equally in both halves, indicating that the nematodes were nonrepellent. When allowed to choose between nematodes or insecticides in lab assays, acephate, bifenthrin, imidacloprid and deltamethrin repelled mole crickets, but crickets seemed to prefer fipronil over *S. scapterisci*.

Egg chamber depth and the number of eggs laid was similar among healthy and nematode-infected female mole crickets. Thus, healthy females could become infected while laying eggs or infected females could still oviposit before dying, and offspring would escape immediate infection because nematodes cannot penetrate their bodies.

As a result, Nematac S may provide greater control when applied during the fall adult activity period because mole crickets are not laying eggs, and nematode populations could increase during the winter before mole cricket mating flights and egg-laying occur.

Continued from page 62

cides may be possible for a quick knockdown and long-term suppression.

Behavioral effects of infection

Finally, we wanted to see if nematode infection changed mole cricket tunneling, egg laying or avoidance behavior.

Tunnel distances and depths began decreasing after six days in mole crickets that were exposed to 500 or 10,000 *S. scapterisci*, but the total distance tunneled in 10 days and tunnel dimensions were consistent among healthy and

Eileen A. Buss is the landscape entomology extension specialist at the University of Florida. Her research and extension programs focus on the biology and integrated pest management of white grubs, billbugs, southern chinch bugs and mole crickets in Florida turfgrass.

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Cutless, Primo MAXX Regulate Tifway Bermudagrass Growth

By F.W. Totten, J.E. Toler and L.B. McCarty

Tifway bermudagrass (*Cynodon dactylon* x *transvalensis* Tifway) is a popular turfgrass utilized on golf course fairways and athletic fields. Aggressive summer growth habit, fine leaf texture and dark green color attribute to its popularity.

However, if mowed infrequently, excessive scalping and clipping production combine to decrease its appearance and aesthetic quality.

Plant growth regulators (PGRs) were introduced into the turf industry in the 1950s and since have been used on bermudagrass to reduce mowing requirements (Fagerness and Yelverton, 2000), enhance color (Waltz, 1997), reduce nitrogen allocation to foliage (Fagerness *et al.*, 2004) and reduce sensitivity to shade (Bunnell, 2003). However, much of the improvements have been concentrated on hybrid bermudagrass putting green surfaces with only limited information for higher mowed turf such as fairways.

PGRs are classified as Type I or Type II based on their mode of action. Type I PGRs, maleic hydrazide (SloGro) or mefluidide (Embark), for example, inhibit cell division. Since being introduced in the 1950s, their use has become limited due to observed reductions in root quality and turf injury (Watschke *et al.*, 1992). Type II PGRs were discovered by Japanese scientists working in rice (*Oryza sativa* L.). Type II mode of action involves inhibition of gibberellic acid (GA) biosynthesis, the hormone responsible for cell elongation.

Cutless 50WP (flurprimidol) is a Type II PGR that inhibits GA biosynthesis. Cutless interrupts this biosynthesis early in the GA biosynthetic pathway via the cytochrome p450 monooxygenase enzyme. Blocking this enzyme inhibits the formation of ent-kaurenoic acid, a precursor to active GAs. The result is shorter internode length; that is, plant cells developed but at a reduced size. Cutless is predominantly root absorbed and exhibits excellent soil residual, implying that growth regulation could be provided over time with this product. The rate of Cutless typically used on fairway-grown Tifway bermudagrass ranges from 8 ounces (oz) to 16 oz of product per acre (0.56 kilogram [kg] to 1.12 kg product per hectare [ha]). These applications are generally every four to six weeks. The cost of Cutless, at 8 oz of product per acre and based on six applications per season, is approximately $287 per acre annually (SePRO, 2005). Benefits from use of Cutless on warm- and cool-season turfgrasses include: an increase in turf color and density, mowing can be reduced up to 50 percent, and water use by the plant can be reduced (SePRO, 2005).

Like Cutless, Primo MAXX 1L (trinexapac-ethyl) is a Type II PGR that inhibits GA biosynthesis. However, Primo interrupts biosynthesis late in the pathway via the 3β-*hydroxylase* enzyme. Blocking this enzyme inhibits formation of active GAs. Unlike Cutless, Primo is foliar absorbed, thus, irrigation should be delayed for at least one hour following application. This should be done to ensure adequate foliar penetration. The rate of Primo typically used on Tifway bermudagrass maintained at fairway height ranges from 6 oz to 12 oz of product per acre (0.42 kg to 0.84 kg product per ha). Periods of rapid growth and/or excessive rainfall could require use of higher rates or shorter application intervals. The cost of Primo, at 12.8 oz of product per acre and based on seven applications per season, is approximately $245 per acre annually (SePRO, 2004). Benefits of Primo use include: increases in turf color, promotes lateral stem and root mass development and reduces vertical growth (SePRO, 2005).

Currently, much attention surrounds Cutless and Primo tank mix programs. Superintendents have raised questions such as: Is a Cutless and Primo tank mix more cost effective than applying either product alone? And is a Cutless and Primo tank mix more effective in terms of growth regulation?

Bunnell (2003) reported that a Cutless plus Primo combination, at 4 oz plus 6 oz of product per acre respectively, provided Tifway bermudagrass turf quality and growth regulation comparable to Primo used exclusively at 12 oz of product per acre. Also, 4 plus 6, 8 plus 6 and 12 plus

6 oz product per acre combinations of Cutless plus Primo tank mix provided approximately 70 percent *Poa annua* control and 18 percent seedhead suppression in perennial ryegrass/Kentucky bluegrass fairways, which was comparable to Cutless used exclusively at 8 oz or 12 oz of product per acre (Bunnell, 2003).

Cooper (2003) reported that a 4 + 6 ounces product per acre Cutless + Primo tank mix produced less injury and greater turf color and density on Tifway bermudagrass throughout the season, compared to Primo alone at 12 oz product per acre and Cutless alone at 8 ounces product per acre. He also noted that an 8 plus 6 ounces product per acre Cutless plus Primo tank mix was comparable to Cutless alone at 24 ounces product per acre which provided greater than 90 percent control of *Poa annua* populations.

The use of a Cutless plus Primo tank mix provides the applicator with several potential benefits. This combination provides growth regulation in both early and late stages of gibberellic acid synthesis, and provides both foliar and root absorption of PGRs. From an economic standpoint, the applicator uses approximately half the rate of product of either PGR when used alone.

Combining Cutless and Primo could potentially provide longer residual growth regulation, thus reducing the number of applications required over a season. The objective of this research was to evaluate Tifway bermudagrass injury, regrowth and growth regulation in response to various rates of Cutless and Primo, alone and in combination.

Materials and methods

The study was conducted during the summer of 2003 and '04 at the registered Tifway bermudagrass research site at Clemson University. Experimental design was a randomized complete block with three replications and treatments were arranged as a 3-foot by 3-foot factorial design. Plot size was 36 square feet.

During both summers, turf was mowed six days a week at 0.56 inches (1.4 centimeters [cm]) and irrigated to maintain a well-watered status. Cutless and Primo were applied exclusively and in combination at the following rates:

Cutless 50WP (flurprimidol)

1. 0 oz product per acre
2. 4 oz product per acre (0.28 kg per ha)
3. 8 oz product per acre (0.56 kg per ha)

Primo MAXX 1L (trinexapac-ethyl)

1. 0 oz product per acre
2. 6 oz product per acre (0.42 kg per ha)
3. 12 oz product per acre (0.84 kg per ha)

Treatments were applied with a carbon dioxide (CO_2) backpack sprayer, calibrated at 20 gallons per acre (GPA) (187 liters [L] per ha). After the initial treatment, three sequential applications were made at three-week intervals.

During both years, turf injury was measured weekly on a scale of 0 to 100 percent with more than 30 percent being unacceptable. Percent lateral regrowth was measured using methods described by Bunnell (2003).

A 4-inch (10.4-cm) Tifway bermudagrass plug was removed at the initiation of the study from each replicate. The holes were backfilled with an 85 to 15 sand/peat mix. A wire mesh grid containing 230 uniform squares was constructed in equal dimension to the original hole. A green shoot present in one 0.062 square-inch square denoted one point.

Percent lateral regrowth was calculated by taking the number of squares green shoot points divided by total points (230), times 100.

Clippings were harvested from all treatments for all three replicates at four, eight and 12 weeks after the initial application and analyzed for dry weight. Data was analyzed using analysis of variation (ANOVA), and means were compared using least significant difference (LSD=0.05).

Results and discussion

2003 — All injury observed during the 2003 season was acceptable, thus not exceeding the 30 percent threshold. No Primo x Cutless interaction was observed for bermudagrass injury one week after initial treatment (WAIT), indicating the two products were acting independently.

Greatest but still acceptable turfgrass injury was with Primo at 12 oz product per acre every three weeks (about 18 percent) and Cutless at 8 oz product per acre every three weeks (about 14 percent), as compared to the untreated. A Primo x Cutless interaction was observed two WAIT, indicating a synergistic response. Bermudagrass injury increased linearly as rate of Cutless increased. The greatest injury was with Cutless plus Primo tank mixed at 8 plus 12 oz product per acre every three weeks (about 25 percent), respectively, but again was deemed acceptable.

Continued on page 68

Continued from page 67

No Primo x Cutless interaction was observed for bermudagrass clipping reductions during the 2003 season. A linear reduction in clippings was observed as rate of Primo increased four WAIT. Clippings were reduced 43 percent by Primo 12 oz product per acre every three weeks (Table 1).

Cutless alone did not produce a significant response in clipping yield.

A reduction in lateral regrowth occurred two WAIT as rate of Primo increased. Lateral regrowth was reduced 26 percent with Primo at 6 oz product per acre every three weeks and 41 percent with Primo at 12 oz product per acre every three weeks (Table 2). At four WAIT, a reduction in lateral regrowth was also observed as the rates of Primo and Cutless increased. Lat-

Continued on page 70

TABLES 1-6

Table 1. **Effect of Primo on Tifway bermudagrass clipping yield 4 WAIT during the summer of 2003.**

Product	Rate (oz/acre/3 wk)	Clipping Yield (grams)	Clipping Reduction (%)
Primo	0	5	0
Primo	6	4	22
Primo	12	3	43
$LSD_{0.05}$	-	1.8	-

Table 2. **Effect of Primo on Tifway bermudagrass lateral regrowth 2 WAIT during the summer of 2003.**

Product	Rate (oz/acre/3 wk)	Lateral Regrowth (%)	Reduction (%)
Primo	0	59	0
Primo	6	44	26
Primo	12	35	41
$LSD_{0.05}$	-	9.9	-

Table 3. **Effects of Primo and Cutless on Tifway bermudagrass lateral regrowth 4 WAIT during the summer of 2003.**

Product	Rate (oz/acre/3 wk)	Lateral Regrowth (%)	Reduction (%)
Primo	0	91	0
Primo	6	77	16
Primo	12	71	22
Cutless	0	83	0
Cutless	4	82	1
Cutless	8	74	11
$LSD_{0.05}$	-	7.6	-

Table 4. **Effect of Primo on Tifway bermudagrass lateral regrowth 6 WAIT during the summer of 2003.**

Product	Rate (oz/acre/3 wk)	Lateral Regrowth (%)	Reduction (%)
Primo	0	98	0
Primo	6	94	4
Primo	12	90	8
$LSD_{0.05}$		2.6	

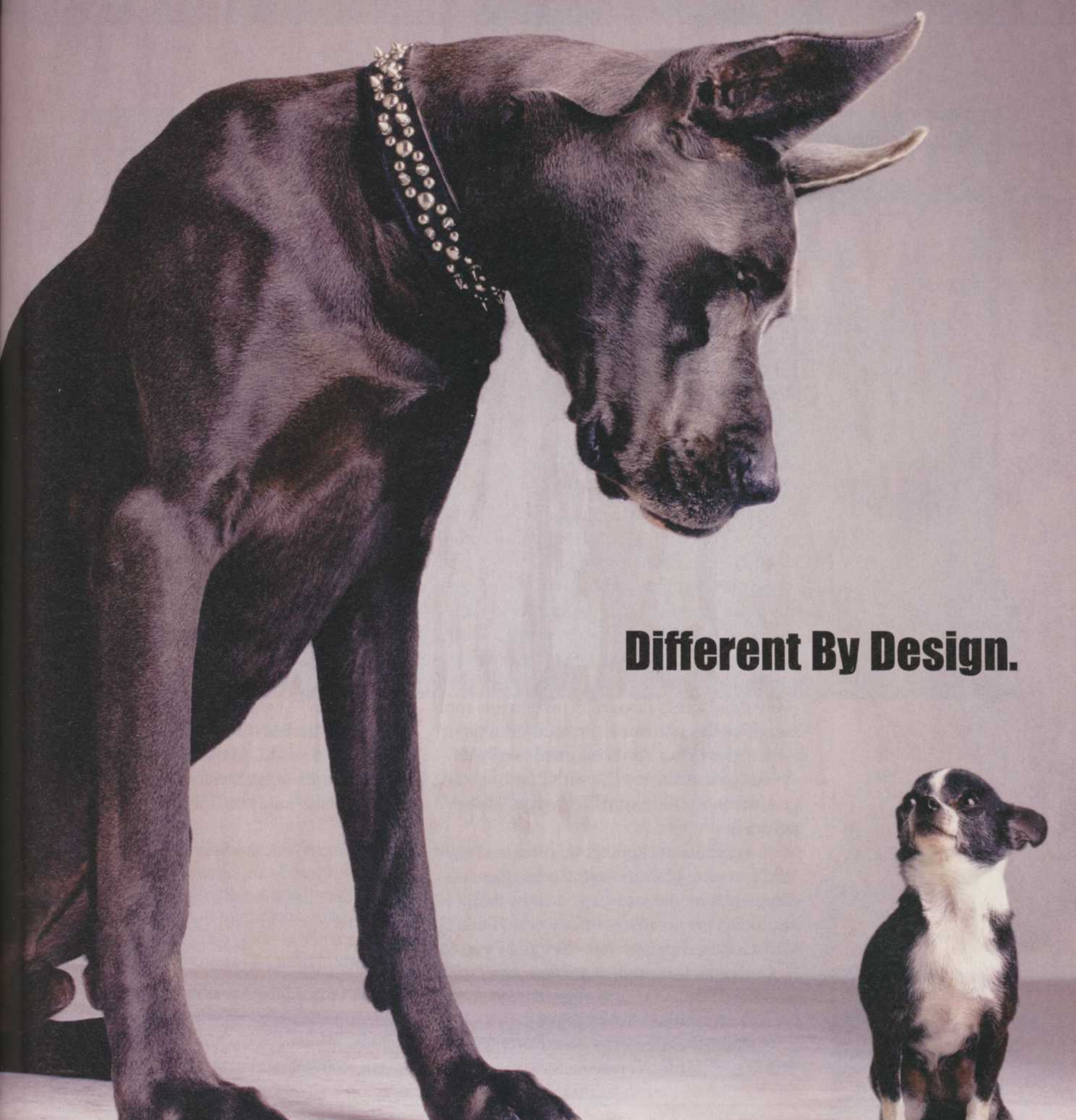
Table 5. **Effects of Primo and Cutless on Tifway bermudagrass clipping yield 8 WAIT during the summer of 2004.**

Product	Rate (oz/acre/3 wk)	Clipping Yield (grams)	Clipping Reduction (%)
Primo	0	4	0
Primo	6	3	20
Primo	12	2	49
Cutless	0	5	0
Cutless	4	2	57
Cutless	8	2	59
$LSD_{0.05}$	-	1.3	-

Table 6. **Effect of Cutless on Tifway bermudagrass lateral regrowth 2 WAIT during the summer of 2004.**

Product	Rate (oz/acre/3 wk)	Lateral Regrowth (%)	Reduction (%)
Cutless	0	51	0
Cutless	4	44	13
Cutless	8	38	26
$LSD_{0.05}$	-	12.2	-

Editor's note: WAIT is "Week After Initial Treatment"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eral regrowth was reduced 16 percent with Primo at 6 oz product per acre every three weeks and 22 percent with Primo at 12 oz product per acre every three weeks (Table 3). With Cutless, lateral regrowth was reduced 11 percent at 8 oz product per acre every three weeks (Table 3).

At six WAIT, again, as rate of Primo increased, a decrease in regrowth occurred. Lateral regrowth was reduced 4 percent with Primo at 6 oz product per acre every three weeks and 8 percent with Primo at 12 oz product per acre every three weeks (Table 4).

2004. A Primo x Cutless interaction was not observed for any parameter measured, suggesting the two products acted independently. Therefore, the 2004 data indicated a Primo plus Cutless tank mix did not offer superior growth regulation compared to either individual product.

At one WAIT, an increase in bermudagrass injury was observed as rates of Primo and Cutless increased. The greatest injury was with Primo at 12 oz product per acre every three weeks (about 8 percent) and Cutless at 8 oz product per acre every three weeks (about 7.5 percent), as compared to the untreated. Bermudagrass injury increased as rate of Primo increased two WAIT.

The greatest injury was with Primo at 12 oz product per acre every three weeks (about 3 percent).

A reduction in clippings was observed eight WAIT as rates of Primo and Cutless increased. Clippings were reduced 49 percent by Primo 12 oz product per acre every three weeks (Table 5). With Cutless, clippings were reduced 57 percent by Cutless at 4 oz product per acre every three weeks and 59 percent by Cutless at 8 oz product per acre every three weeks (Table 5).

Cutless reduced lateral regrowth at two WAIT. This was reduced 26 percent at 8 oz product per acre every three weeks (Table 6).

In conclusion, during the 2003, season-long Primo plus Cutless tank mixed at 12 plus 8 oz product per acre every three weeks produced the greatest Tifway bermudagrass injury, while in 2004, Primo at 12 oz product per acre every three weeks and Cutless at 8 oz product per acre every three weeks had the greatest injury. All injury, however, was deemed minor and acceptable.

Clippings were reduced up to 43 percent four WAIT by Primo at 12 oz product per acre every three weeks in year one.

During year two, clippings were reduced up to 49 percent and 59 percent eight WAIT by Primo at 12 oz product per acre every three weeks and Cutless at 8 oz product per acre every three weeks, respectively.

In 2003, Primo at 12 oz product per acre every three weeks reduced lateral regrowth 41 percent, 22 percent and 8 percent at two, four and six WAIT, respectively. Therefore, these data indicate that a Primo plus Cutless tank mix does not offer superior growth regulation compared to individual product use.

Primo at 12 oz product per acre every three weeks and Cutless at 8 oz product per acre every three weeks produced the greatest reduction in clippings and percent lateral regrowth, while causing acceptable injury to Tifway bermudagrass.

Wesley Totten has a bachelor of science degree in agronomy and soils (concentration in turfgrass management) and a master's of science degree in horticulture, both from Auburn University. He is currently pursuing a doctorate at Clemson University in plant and environmental sciences.

Bert McCarty is professor of turfgrass/weed science at Clemson University.

Joe Toler is a professor of applied economics and statistics at Clemson University.

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