Weed Technology. 2006. Volume 20:682–687

Using Preemergence Herbicides to Improve Establishment of Centipedegrass (*Eremochloa ophiuroides*) from Seed[1]

JASON A. FERRELL, TIM R. MURPHY, and THEODORE M. WEBSTER[2]

Abstract: Centipedegrass is a warm-season turf grass that has increased in popularity in recent years. However, more information is needed on the use of herbicides during centipedegrass establishment from seed, particularly in seed and sod production systems. The intent of this study was to evaluate turf-grass injury and weed control when atrazine, imazapic, imazethapyr, and simazine are applied immediately after seeding centipedegrass. Atrazine and simazine (applied at 1.1, 2.2, and 4.4 kg ai/ha) injured centipedegrass less than 15% at 5 wk after treatment (WAT) in 2001. Imazethapyr and imazapic (applied at 0.04, 0.07, and 0.1 kg ai/ha) injured centipedegrass between 7 and 13%, 5 WAT, in 2001 and from 30 to 77% in 2002. Herbicide and application rate also affected centipedegrass cover. At 3 WAT, cover decreased with all herbicides as application rate increased. At 12 WAT in both years, centipedegrass cover increased as atrazine application rate increased and imazethapyr application rate decreased. Imazapic and simazine were less consistent, causing increases in cover one year and decreases, or no change, the next. Imazapic controlled Texas panicum 80 to 89% and was more effective than any other herbicide. Atrazine and simazine controlled crowfootgrass better than any other herbicide. Imazethapyr often injured centipedegrass and failed to control weeds. Atrazine effectively controlled grass and broadleaf weeds with minimal centipedegrass injury. Imazethapyr and imazapic were too injurious to permit usage during centipedegrass establishment from seed.

Nomenclature: Atrazine; imazapic; imazethapyr; simazine; centipedegrass, *Eremochloa ophiuroides* Munro., 'Tifblair' #[3] ERLOP; crowfootgrass, *Dactyloctenium aegyptium* (L.) Willd., # DTTAE; Texas panicum, *Panicum texanum* Buckl., # PANTE.

Additional index words: Turf cover.

Abbreviation: DAT, days after treatment.

INTRODUCTION

Centipedegrass is a warm-season turf grass that is adapted to southern regions of the United States. Low fertility and maintenance requirements have made this turf attractive to homeowners and planted hectarage of centipedegrass continues to increase (Waltz and Landry 2003). Centipedegrass is established by sodding, sprigging, plugging, or seeding (Beard 1973). Sodding, which ensures establishment in the shortest possible time, is often the most desirable approach on home and commercial properties. However, cost can be prohibitive if large areas are to be established by sodding, sprigging, or plugging. In commercial seed or sod farms, centipedegrass is usually established by seeding. This method is lower in cost than sprigging; however, weeds can be a severe problem during establishment. Methyl bromide has been commonly used to control weeds in areas prior to establishment of turfgrass for seed or sod production. However, the use of methyl bromide is becoming cost prohibitive and may be eliminated altogether. Alternatives for weed control prior to turfgrass establishment have been investigated (Bingham and Hall 1985; Fishel and Coats 1994; Unruh et al. 2002). However, these studies have mainly focused on sprigged bermudagrass and have not evaluated the effect of herbicides on seeded centipedegrass.

Centipedegrass seed often require 10 to 14 d to germinate (Brede 2000). The characteristic slow germination and subsequent vegetative growth of centipedegrass prolongs its establishment period. Additionally, depending upon seeding rate, several months to 1 yr are often

[1] Received for publication November 7, 2003, and in revised form January 11, 2006.

[2] Assistant Professor, Agronomy Department, University of Florida, Gainesville, FL 32611; Professor, Department of Crop and Soil Sciences, University of Georgia, Griffin, GA 30223; and Research Agronomist, Crop Protection and Management Research Unit, USDA-ARS, Tifton, GA 31794. Corresponding author's E-mail: jferrell@ufl.edu.

[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

required before seed can be harvested or sod cut. It is during this prolonged period of slow growth and lateral spread that interference by weeds is most likely to occur.

Previous research by Johnson (1973, 1976b) has shown that using atrazine and simazine for weed control during establishment of centipedegrass sprigs can be problematic. Multiple atrazine and simazine applications, three to four per season, resulting in as much as 6 kg ai/ha, often controlled large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and goosegrass [*Eleusine indica* (L.) Gaertn.] greater than 90%. However, centipedegrass injury increased with increasing herbicide rate. Increased injury resulted in less than 50% centipedegrass ground coverage within a growing season for all atrazine and simazine treatments (Johnson 1973, 1976b). Pronamide applications (0.84 to 3.3 kg ai/ha) resulted in less than 66% centipedegrass ground cover after 1 yr (Johnson 1974). For seeded centipedegrass, atrazine and simazine applied at 1.1 kg/ha often resulted in less than 66% ground cover at 22 weeks after seeding (Johnson 1985). Therefore, providing acceptable weed control during establishment of centipedegrass without excessive herbicide injury is difficult.

In an attempt to increase weed control and minimize turf injury, centipedegrass sprigs have been coated with activated charcoal prior to planting and herbicide application (Johnson 1976a). Activated charcoal served as a protectant and allowed the use of higher herbicide application rates for greater weed control and less herbicide injury. Charcoal has been used previously with a number of herbicides to increase crop tolerance (Burr et al. 1972; Kratky et al. 1970; Lee 1973). Charcoal and simazine at the time of sprigging did improve centipedegrass cover to 85% by seasons end and provided greater than 85% weed control (Johnson 1976a). However, charcoal may be impractical for large-scale centipedegrass establishment.

Since the mid-1970's few research studies have been conducted to explore the use of herbicides during seeded centipedegrass establishment. Since this time, atrazine has been the most commonly used herbicide during establishment. Although atrazine controls many weeds, certain species, particularly sedges (*Cyperus* spp.), are not controlled. However, a number of new herbicides have since been developed with differing chemistries and have been used for PRE and POST weed control in turfgrass and other crops. The imidazolinone herbicides have been shown to control many broadleaf and sedge weeds (Vencill 2002). Our objective was to compare the effect of two imidazolinone herbicides to atrazine and simazine for weed control and centipedegrass tolerance during establishment from seed.

MATERIALS AND METHODS

Field studies were conducted in Tifton, GA, in 2001 and 2002. The soil type was a Tifton sandy loam (fine–loamy, kaolinitic, thermic Plinthic Kandiudults; 84% sand, 9% silt, and 7% clay) with pH 6.5 and 1.0% organic matter. The site was prepared with a disk followed by a roller to firm the seedbed both before and following centipedegrass seeding. Experimental areas were planted with 'TifBlair' centipedegrass at a rate of 24 kg/ha to a depth of 0.6 cm in rows spaced 18 cm apart on May 21, 2001 and May 22, 2002. Overhead irrigation was used to supplement rainfall as needed throughout the season for optimum crop growth.

Treatments included PRE applications of imazapic and imazethapyr at 0.035, 0.07, and 0.1 kg ai/ha, as well as atrazine and simazine at 1.1, 2.2, and 4.4 kg/ha. Herbicides were applied immediately after planting and seedbed firming using a CO_2-pressurized plot sprayer. The sprayer was calibrated to deliver 190 L/ha with the use of XR8003[4] nozzles at 206 kPa.

Centipedegrass injury was estimated visually on a percent scale of 0 = no injury to 100 = plant death. Centipedegrass cover was visually estimated on a scale of 0 = no turfgrass ground cover to 100 = turfgrass completely covers the ground. Weed control was estimated visually on a scale of 0 = no weed control to 100 = total weed control. All visual ratings occurred at 3, 5, and 12 WAT. Only the 3 and 5 WAT ratings are reported for weed control as maximum differences among herbicides were apparent. Control of Texas panicum and crowfootgrass was evaluated in both years of the study. The experiment was arranged in a randomized complete block design with four replications. Treatments were arranged in a factorial of four herbicides each applied at 0.5, 1.0, and 2.0 times the recommended rate as expressed on the herbicide registration. Specific rates are noted with Figures 1 and 2. Data were subjected to ANOVA to test for year, herbicide, and rate effects. If significant interactions occurred, data were presented separately; if not, data were pooled. Appropriate main effects and interactions were separated with the use of Fisher's protected LSD at P = 0.05. Significant effects of herbicide rate were explained with linear regressions,

[4] XR8003 Teejet spray nozzles, Spraying Systems Co., North Avenue, Wheaton, IL 60189.

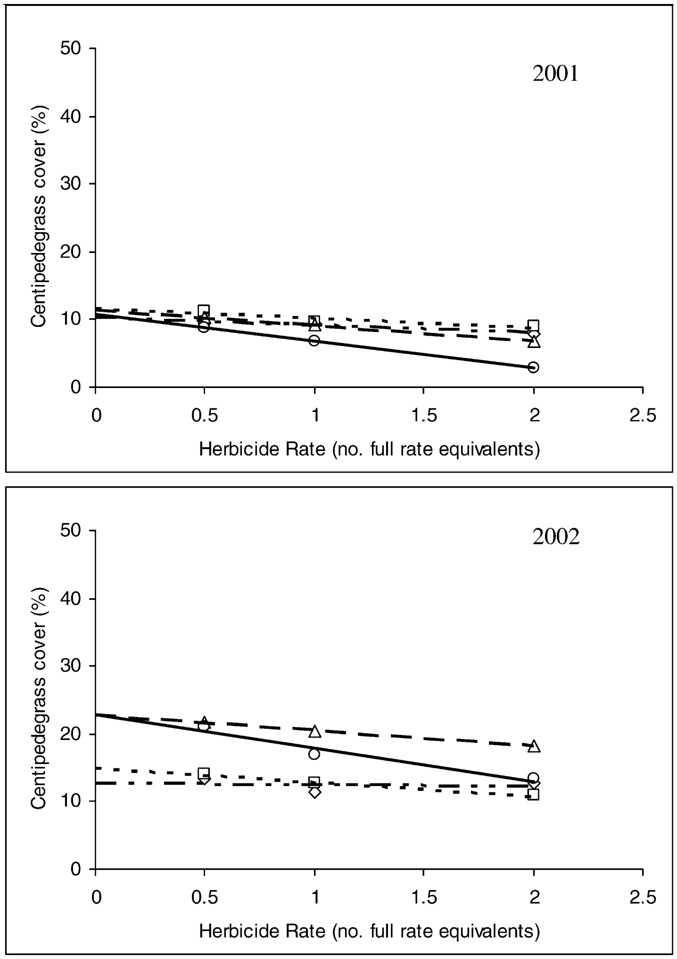

Figure 1. Effect of herbicide and application rate on centipedegrass cover 3 wk after treatment in 2001 and 2002. Herbicide rates were 0.5, 1.0, and 2.0 times the label-recommended application rate for each herbicide. These levels correspond to 0.04, 0.07, and 0.1 kg/ha for imazapic (◇) and imazethapyr (□), and 1.1, 2.2, and 4.4, kg/ha for atrazine (Δ) and simazine (◦). See Table 2 for regression parameters.

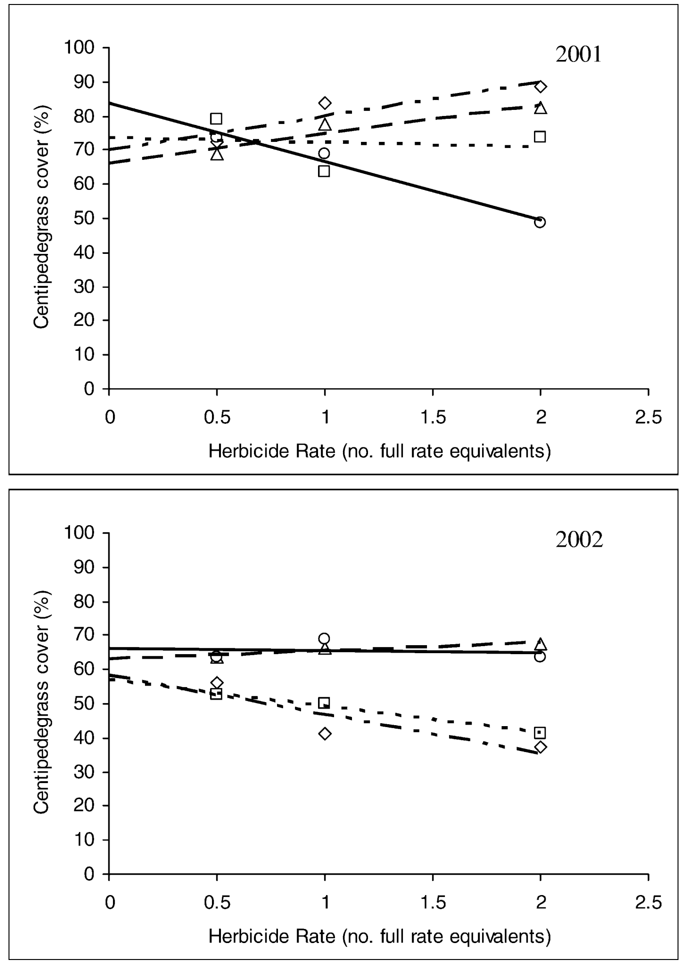

Figure 2. Effect of herbicide and application rate on centipedegrass cover 12 wk after treatment in 2001 and 2002. Herbicide rates were 0.5, 1.0, and 2.0 times the label-recommended application rate for each herbicide. These levels correspond to 0.04, 0.07, and 0.1 kg/ha for imazapic (◇) and imazethapyr (□), and 1.1, 2.2, and 4.4, kg/ha for atrazine (Δ) and simazine (◦). See Table 2 for regression parameters.

and corresponding slopes, intercepts, and correlation coefficients were tabulated for reference and comparison.

RESULTS AND DISCUSSION

Centipedegrass Injury. Significant treatment by year interactions were observed and centipedegrass injury data were presented by year. Additionally, the herbicide by application rate interaction was not significant for injury data. These data were pooled and analyzed without regard to application rate (Table 1).

In 2001, imazapic injured centipedegrass 13% 3 WAT and more than imazethapyr, atrazine, and simazine, which injured centipedegrass between 8 and 9% (Table 1). In 2002, injury from all herbicide applications resulted in greater centipedegrass injury at 3 WAT. Imazapic and imazethapyr injured centipedegrass greater than 76% at 3 WAT and atrazine and simazine caused 18 and 34% injury, respectively. By 5 WAT, centipedegrass injury for atrazine, imazethapyr, and imazapic decreased to between 5 and 8%, and simazine injury in-

Table 1. Centipedegrass injury (%) from preemergence herbicides pooled over three application rates.

	3 WAT[b]		5 WAT	
Herbicide[a]	2001	2002	2001	2002
Imazapic	13	77	8	37
Imazethapyr	8	76	7	30
Atrazine	8	18	5	3
Simazine	9	34	15	2
$LSD_{0.05}$	3	9	9	10

[a] Herbicides were applied immediately after seedbed preparation on May 21, 2001 and May 22, 2002. Imazapic and imazethapyr were applied at 0.04, 0.07, and 0.1 kg/ha. Atrazine and simazine were applied 1.1, 2.2, and 4.4 kg/ha.

[b] WAT, weeks after treatment.

creased to 15% in 2001. Imazapic and imazethapyr injured centipedegrass 37 and 30%, respectively, 5 WAT. For atrazine and simazine, significant recovery occurred by 5 WAT, and injury declined to equal or less than 3%.

Previous research has shown that atrazine and simazine, each applied at 3.3 kg/ha, reduced centipedegrass sprig survival greater than 50% (Johnson 1973) and reduced turf quality ratings 41% at 3 WAT (Johnson 1976b). However, atrazine and simazine injury on centipedegrass sprigs was shown to be transient, and recovery generally occurred before the end of the season (Johnson 1976b). We observed a similar response in this study in that atrazine and simazine usually injured centipedegrass less at 5 than at 3 WAT.

Increased herbicide injury in 2002 may have been due to increased irrigation and rainfall. Irrigation and rainfall for the first 9 d after seeding was 5 cm in 2001 and 11 cm in 2002 (data not shown). The higher amount of precipitation following seeding in 2002 may have increased herbicide uptake by centipedegrass seedling roots. All herbicides in the present study can be root absorbed (Vencill 2002). An increase in precipitation may have increased herbicide concentration in the seed germination zone, similar to herbicide incorporation with irrigation. Previous research has shown that irrigation is an effective method of incorporation of herbicides into the soil (Liu and O'Connell 2002) and imidazolinone herbicides are mobile and weakly adsorbed to soil at pH 6.5 (Mangels 1991). It is possible that increased precipitation in 2002 moved an intolerable quantity of herbicide into the germination zone, which resulted in increased herbicide injury. Compared to atrazine and simazine, imazethapyr and imazapic applied PRE may pose a greater risk of severe injury to newly seeded centipedegrass, if high amounts of rainfall or irrigation occur within 1 wk of seeding and herbicide application.

Centipedegrass Cover. A significant rate and rate by herbicide interaction was observed during analysis of centipedegrass cover data. Centipedegrass cover decreased as application rate of all herbicides increased 3 WAT in 2001 and 2002 (Figure 1). The response of centipedegrass cover to herbicide application rate was similar for atrazine, imazapic, and imazethapyr and statistical differences were not detected among these treatments (Table 2). Conversely, simazine applications were the most injurious at 3 WAT in 2001 and 2002. Therefore, centipedegrass cover was most responsive to elevated rates of simazine.

By 12 WAT centipedegrass cover increased with increasing atrazine application rates in both years (Figure

Table 2. Intercept, slope, and correlation coefficients for Figures 1 and 2.

Herbicide	3 WAT[a]						12 WAT					
	2001			2002			2001			2002		
	Intercept	Slope[b]	r^2	Intercept	Slope	r^2	Intercept	Slope	r^2	Intercept	Slope	r^2
Imazapic	10.2	−1.1 b	0.75	12.8	−0.2 b	0.20	70.0	10.0 a	0.95	58.1	−11.2 b	0.89
Imazethapyr	11.6	−1.3 b	0.96	14.9	−2.0 b	0.99	73.7	−1.40 b	0.10	56.8	−7.70 b	0.90
Atrazine	11.5	−2.3 b	0.94	22.8	−2.3 b	0.98	66.2	8.50 a	0.97	63.1	2.30 a	0.96
Simazine	10.7	−4.0 a	0.96	22.8	−4.9 a	0.99	83.7	−17.1 b	0.89	66.2	−0.70 a	0.94

[a] Abbreviations: WAT, weeks after treatment.

[b] Based on linear regression from visually estimated percent centipedegrass cover as affected by herbicide rate, expressed as units of the recommended application rates. For example, a slope of −0.75 indicates that centipedegrass cover decreases 0.75% for each full recommended rate applied. See Figures 1 and 2 for regression lines and specific herbicide rates.

2). In 2001, centipedegass cover increased from 68 to 80% as atrazine rate increased from 1.1 to 4.4 kg/ha 12 WAT, which was a reverse of the trend shown at 3 WAT. The positive response to atrazine rate at 12 WAT was likely due to increased weed control and minimal injury from atrazine. Therefore, the lack of weed interference and centipedegrass injury resulted in an increase in overall stand establishment. Conversely, centipedegrass cover decreased as imazethapyr application rate increased in 2001 and 2002 (Figure 2). In 2002, centipedegrass cover decreased 7.7% for each 0.04 kg/ha increase in imazethapyr rate (Table 2).

The response of centipedegrass cover to imazapic and simazine was not consistent between years at 12 WAT. In 2001, centipedegrass cover increased 10% with each full rate equivalent of imazapic, and ranged from 72 to 88% at the rates tested (Figure 2). However, in 2002 imazapic was highly injurious to centipedegrass and cover decreased 11% with each full rate increase of imazapic. In 2002, centipedegrass response to imazapic was not statistically different from imazethapyr. Simazine also provided differing trends between 2001 and 2002. In 2001, centipedegrass cover decreased from 75 to 50% as simazine rate increased from 1.1 to 4.4 kg/ha. However, in 2002 centipedegrass cover did not respond positively or negatively to simazine application rate.

To better understand the differences in stand establishment between 2001 and 2002, weed density ratings were examined. The differences in centipedegrass stand cover was likely due to an increase in weed pressure in 2002. In 2002, Texas panicum was twice as dense (3.2 plants/m^2) than in 2001, whereas crowfootgrass was six times more dense (9.5 plants/m^2) than in 2001. Because percent cover is affected by both weed competition and herbicide injury, increases in weed populations can negatively impact density. Only atrazine consistently improved stand cover, at all application rates, in both years tested.

The effect of atrazine on centipedegrass cover during establishment can be somewhat difficult to interpret. In our experiments, atrazine decreased centipedegrass cover at 3 WAT, but actually improved cover at 12 WAT. This increase in cover at 12 WAT is attributed to the partial control of crowfootgrass and Texas panicum with atrazine (Table 3). Previous research has shown that atrazine applied at 3.4 kg/ha initially reduced sprig survival by 46%, whereas centipedegrass cover at the conclusion of the growing season was increased by 11%, relative to nontreated controls (Johnson 1973). These previous findings support our data, as initial injury from atrazine was as high as 18%, but by 12 WAT cover slightly improved with an increase in atrazine application rate.

Table 3. Crowfootgrass and Texas panicum control (%) with PRE applied herbicides.[a]

	Crowfootgrass				Texas panicum			
	4 WAT[c]		12 WAT		4 WAT		12 WAT	
Herbicide[b]	2001	2002	2001	2002	2001	2002	2001	2002
Imazapic	43	98	46	75	89	80	64	81
Imazethapyr	20	91	14	81	68	85	32	72
Atrazine	66	98	76	79	54	71	18	55
Simazine	85	99	84	56	55	63	30	49
$LSD_{0.05}$	18	NS	20	18	20	20	23	22

[a] Weed density in nontreated control: Texas panicum 1.5 and 3.2 plants/m^2 in 2001 and 2002, respectively, crowfootgrass 1.5 and 9.5 plants/m^2 in 2001 and 2002, respectively.

[b] Herbicides were applied immediately after seedbed preparation on May 21, 2001 and May 22, 2002. Imazapic and imazethapyr were applied at 0.04, 0.07, and 0.1 kg/ha. Atrazine and simazine were applied 1.1, 2.2, and 4.4 kg/ha.

[c] WAT, weeks after treatment.

Weed Control. Significant treatment by year interactions were observed and data are presented by year. Additionally, the herbicide by application rate interaction was not significant for weed control data. These data were pooled and analyzed without regard to application rate (Table 3).

Crowfootgrass control differed between 2001 and 2002 for all herbicides. Atrazine and simazine controlled crowfootgrass 66 and 85%, respectively, 4 WAT in 2001. In 2002, control with both atrazine and simazine was ≥98% at 4 WAT. Imazapic and imazethapyr controlled crowfootgrass 43 and 20%, respectively, in 2001. By 12 WAT, crowfootgrass was controlled less than 46% regardless of herbicide. In 2002, crowfootgrass control with these herbicides was greater than 91% 4 WAT. In 2002, control at 12 WAT had decreased substantially and was not greater than 81%. Although it is unknown why large differences between years was observed, it is likely due to the same factors that influenced centipedegrass injury during these same times. It is suggested that increased rainfall/irrigation the week after seeding in 2002 may be responsible for the increased control of this weed, as was previously discussed with centipedegrass injury.

Atrazine and simazine controlled Texas panicum less than 55 and less than 63% in 2001 and 2002, respectively, at 4 WAT (Table 3). Imazapic controlled Texas panicum greater than 80% in both years. Control of Texas panicum with imazethapyr was variable between years. Control was higher in 2002 (85%) relative to 2001 (68%) for imazethapyr. By 12 WAT, no herbicide provided greater than 81% control of Texas panicum in either year and control with simazine was less than 49%.

Research conducted by Johnson (1973, 1974) concluded that atrazine and simazine could effectively be used during centipedegrass establishment from sprigs. Of the herbicides evaluated in this study, atrazine was the most effective and consistent herbicide for use during centipedegrass establishment from seed. Although Texas panicum was only partially controlled with atrazine, this weed can be controlled POST with sethoxydim (McCarty et al. 1986).

Imazapic provided effective weed control; however, excessive centipedegrass injury (77% in 2002) occurred in 1 of the 2 years of this study. Similarly, imazethapyr, which generally provided less weed control than imazapic at equivalent rates, was also highly injurious to centipedegrass in 1 of 2 years. Imazapic and imazethapyr would not be effective replacements for methyl bromide applied in advance of seeding or atrazine applied PRE immediately after centipedegrass seeding. Research to investigate the effect of precipitation on the response of seeded centipedegrass to PRE applications of imazapic and imazethapyr needs to be conducted. Additionally, the tolerance of seedling centipedegrass to these imidazolinone and triazine herbicides also needs to be investigated.

LITERATURE CITED

Beard, J. B. 1973. Centipedegrass. *In* J. B. Beard, ed. Turfgrass: Science and Culture. Englewood Cliffs, NJ: Prentice-Hall. Pp. 151–153.

Bingham, S. W. and J. R. Hall. 1985. Effects of herbicides in bermudagrass (*Cynodon* ssp.) sprig establishment. Weed Sci. 33:253–257.

Brede, D. 2000. Grasses that demand less maintenance. *In* D. Brede, ed. Turfgrass Maintenance Reduction Handbook: Sports, Lawns, and Golf. Ann Arbor, MI: Ann Arbor Press. Pp. 67–69.

Burr, R. J., W. O. Lee, and A. P. Appleby. 1972. Factors affecting use of activated carbon to improve selectivity. Weed Sci. 20:180–183.

Fishel, F. M. and G. E. Coats. 1994. Bermudagrass (*Cynodon dactylon*) sod rooting as influenced by preemergence herbicides. Weed Technol. 8:46–49.

Johnson, B. J. 1973. Establishment of centipedegrass and St. Augustine grass with the aid of chemicals. Agron. J. 65:959–962.

Johnson, B. J. 1974. Effects of pronamide treatments on the establishment of centipedegrass. Weed Sci. 22:508–511.

Johnson, B. J. 1976a. Effect of activated charcoal on herbicide injury during establishment of centipedegrass. Agron. J. 68:802–805.

Johnson, B. J. 1976b. Effects of herbicides on establishment of centipedegrass. Agron. J. 68:852–855.

Johnson, B. J. 1985. Herbicide tolerance of seeded centipedegrass during establishment. Univ. Ga. Dept. Agric. Exp. Stn. Res. Rep. 482:1–8.

Kratky, B. A., D. L. Coffey, and G. F. Warren. 1970. Activated carbon root dips on transplanted strawberries. Weed Sci. 18:577–580.

Lee, W. D. 1973. Clean grass seed crops established with activated carbon bands and herbicides. Weed Sci. 21:537–541.

Liu, F. and N. V. O'Connell. 2002. Off-site movement of surface-applied simazine from a citrus orchard as affected by irrigation incorporation. Weed Sci. 50:672–676.

Mangels, G. 1991. Behavior of imidazolinone herbicides in soil—a review of the literature. *In* D. L. Shaner and S. L. O'Conner, eds. The Imidazolinone Herbicides. Boca Raton, FL: CRC Press. Pp. 192–208.

McCarty, L. B., J. M. Higgins, L. C. Miller, and T. Whitwell. 1986. Centipedegrass tolerance to postemergence grass herbicides. Hortscience 21: 1405–1407.

Unruh, J. B., B. J. Brecke, J. A. Dusky, and J. S. Godbehere. 2002. Fumigant alternatives for methyl bromide prior to turfgrass establishment. Weed Technol. 16:379–387.

Vencill, W. K. 2002. Herbicide Handbook. 8th ed. Lawrence, KS: Weed Science Society of America. Pp. 27, 249, 256, 397.

Waltz, C. and G. Landry. 2003. Annual Georgia sod producers inventory survey. Georgia Sod Prod. Assoc. News. 13:3–4.