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Note

Reduction of Torpedograss (*Panicum repens*) Canopy and Rhizomes by Quinclorac Split Applications[1]

PHILIP BUSEY[2]

Abstract: Two field experiments were conducted to evaluate the reduction of torpedograss canopy by multiple split applications of quinclorac applied postemergence (POST) to bermudagrass golf course roughs in Florida. In one experiment, quinclorac treatments were reapplied for a second year to the same plots, followed by biomass harvest, to evaluate the reduction of torpedograss rhizomes. Quinclorac sprayed at 1.68 kg/ha/yr visually reduced torpedograss canopy to a varying extent, depending on the number of split applications. The most effective treatment, 0.42 kg/ha quinclorac applied four times each year for 2 yr, reduced torpedograss canopy to 10% compared with 86% torpedograss canopy in the untreated plots, and reduced torpedograss dry weight to 1,570 kg/ha compared with 8,010 kg/ha in the untreated plots. After reapplication for 2 yr with the commercially labeled treatment, quinclorac at 0.84 kg/ha applied twice per year, torpedograss canopy was reduced to 45% and dry weight to 4,640 kg/ha. Visual evaluation of canopy was too optimistic in representing the herbicidal control of torpedograss by quinclorac because torpedograss regrew from rhizomes, and canopy was a relatively small part of the plant. In plots not chemically treated, pachymorph rhizomes were 63%, leptomorph rhizomes were 24%, and leaves were only 13% of the total dry weight of torpedograss.

Nomenclature: Quinclorac; hybrid bermudagrass, *Cynodon transvaalensis* × *C. dactylon*; torpedograss, *Panicum repens* L. #[3] PANRE.
Additional index words: Golf course, turf.
Abbreviations: MSO, methylated seed oil; OM, organic matter; POST, postemergence; TPC, Tournament Players Club; WAIT, weeks after initial treatment.

INTRODUCTION

Torpedograss is a persistent, rhizomatous weed in turfgrass and many other crops around the world (Holm et al. 1977). In Florida, torpedograss grows along lake margins and advances by vegetative spread or is spread by movement of soil, infesting bermudagrass golf course turf. Torpedograss is not known to propagate by seed in the United States (Wilcut et al. 1988). It may therefore be possible to eradicate torpedograss by using postemergence (POST) herbicides.

Selective suppression of torpedograss in bermudagrass (*Cynodon* spp.) turf is accomplished using quinclorac. A split application of 2.2 kg/ha quinclorac, followed by two applications at 1.1 kg/ha, effectively reduces torpedograss canopy up to 89% through 10 wk after initial treatment (WAIT) and reduces torpedograss canopy up to 53% through 19 WAIT (McCarty et al. 1993). Quinclorac was first sold as the turf herbicide 'Drive 75DF'[4] in 1998, after registration the same year by the US Environmental Protection Agency for use as a split application of 0.84 + 0.84 kg/ha, which was much lower than the aforementioned effective rate. In comparison, split application of 1.1 + 1.1 kg/ha quinclorac reduces torpedograss canopy by only 16% when evaluated 19 WAIT (McCarty et al. 1993).

The recovery of torpedograss from quinclorac applications suggests that quinclorac mainly defoliates the plant, which then regrows using rhizome reserves. Tor-

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[2] Associate Professor of Environmental Horticulture, Institute of Food and Agricultural Sciences, University of Florida, Fort Lauderdale Research and Education Center, 3205 College Avenue, Fort Lauderdale, FL 33314. Corresponding author's E-mail: turf@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.

[4] Drive 75DF is a registered trademark of BASF Corporation, Research Triangle Park, NC.

pedograss may be eradicated by a gradual and long-term quinclorac application strategy, even through defoliation, if the plant is caused to deplete rhizome reserves and if photosynthetic replacement of reserves is hampered. A three-way split application of 0.6 + 0.6 + 0.6 kg/ha quinclorac reduces torpedograss canopy by 88% when evaluated 12 WAIT, whereas a two-way split application of 0.8 + 0.8 kg/ha reduces torpedograss canopy by only 69% (Brecke et al. 2001). At one location, reapplication of the three-way split application treatments to the same plots in the second year resulted in 92% reduction of torpedograss canopy compared with 74% reduction after the first year (Brecke et al. 2001). The objective of this study was to evaluate the reduction of torpedograss canopy and rhizomes in subtropical South Florida golf courses after single and multiple split applications of quinclorac and after 1 and 2 yr of application.

MATERIALS AND METHODS

Two experiments were conducted in golf course roughs, one at Tournament Players Club (TPC) at Eagle Trace, Coral Springs (''Eagle Trace'') and the other at Palm Aire Country Club and Resort, Pompano Beach (''Palm Aire''), both at Broward County, FL. Soil at Eagle Trace was 92% sand, pH 7.7, and 3.5% organic matter (OM); soil at Palm Aire was 82% sand, pH 6.6, and 6.4% OM. Both experimental areas overlaid rock. Neither area was shaded. Irrigation, mowing, and fertilization practices were performed to maintain a dense stand of 'Tifway' (T-419) hybrid bermudagrass turf, mown twice weekly at 32-mm cutting height and fertilized with approximately 240 kg N/ha/yr. Mowing was not performed within 2 d before or after herbicide treatments. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 289 L/ha spray solution at 276 kPa, using 11002 flat-fan nozzle tips. All herbicide treatments involved quinclorac applied at a total of 1.68 kg/ha/yr, either as a single application or divided among multiple applications at an interval between 21 and 34 d. Treatment interval varied because of weather disturbances. According to the manufacturer's recommendations to mix in a methylated seed oil (MSO), all quinclorac treatments contained Meth Oil,[5] a methylated soybean oil mixture, as an adjuvant at 1% by volume.

At TPC at Eagle Trace, quinclorac was applied on August 2, August 25, and September 15, 1999. The three-way split application of 0.56 + 0.56 + 0.56 kg/ha quinclorac was applied on all three dates; the two-way split of 0.84 + 0.84 kg/ha quinclorac was applied on August 2 and 25, and the single application of 1.68 kg/ha quinclorac was applied on August 2. There was also an ''MSO control'' treatment containing only water and MSO, and there was a ''water control'' treatment. There was no rain or irrigation for 24 h after treatment, except for 4 mm rainfall during 1 h after treatment on August 2, 1999. The experimental design was a randomized complete block with four replications. Plots (2.4 by 1.8 m) were assigned to blocks to provide similar initial canopy densities of torpedograss and Tifway bermudagrass. Plots were evaluated visually for percent live torpedograss canopy coverage (0 = no live torpedograss canopy, and 100 = solid, living torpedograss canopy) before the first treatment and on August 16 and 23, September 1, 10, and 15, October 6 and 22, and November 24, 1999.

At Palm Aire, quinclorac was applied on September 2 and 23, October 27, and November 22, 1999. The four-way split application of 0.42 + 0.42 + 0.42 + 0.42 kg/ha quinclorac was applied on all four dates. Other split applications (three-way, two-way, and single, as in the experiment at Eagle Trace) also started on the initial date of September 2, 1999. There was no rain or irrigation for 24 h after treatment. There was also an MSO control treatment containing only water and MSO. Experimental design was a randomized complete block with eight replications. Plots (2.4 by 2.4 m) were assigned to the replicated coterminous blocks to provide similar initial weed densities of torpedograss and Tifway bermudagrass. Plots were evaluated visually for percent surviving torpedograss canopy coverage immediately before the first treatment and on September 17 and 23, October 6 and 22, November 4 and 17, and December 20, 1999, and January 25 and June 2, 2000. A second annual series of the same split applications of quinclorac was applied to the same plots on June 7, July 6, August 1 and 31, 2000, and plots were evaluated for percent torpedograss canopy on July 5, August 1 and 31, September 20 and 29, November 2, and December 11, 2000.

To estimate torpedograss biomass, soil cores of 10-cm diameter were collected at Palm Aire on November 7 and 13, 2000, with two subsamples per plot, to a depth of 15 cm or shallower, depending on the closeness to rock. Samples were combined as repeated measures and washed to remove all soil and dead vegetation. Torpedograss and bermudagrass plant parts were separated, blotted dry, and oven-dried separately at 60 C for 48 h and weighed. Before drying, torpedograss plant parts

[5] Meth Oil is a registered trademark of Terra International, Inc., Sioux City, IA.

were also separated into leaves and rhizomes. In addition, rhizomes were separated into two highly distinctive types. Adopting terminology from bamboo (McClure 1966), leptomorph rhizomes of torpedograss were slender, cylindrical, and whitish, with extended and smooth internodes and distinctive nodes producing a scale. Pachymorph rhizomes were thickened, knotted, and brown, with scaleless nodes that were clustered and indistinct. Torpedograss roots, which were a minimal biomass component, were included with leptomorph rhizomes.

Torpedograss canopy coverage on the last dates of evaluation (after the last quinclorac treatment) was analyzed as repeated measures. Thus for Eagle Trace, these represented from 9 to 16 WAIT. For the first year at Palm Aire, the pooled evaluation dates represented from 16 to 21 WAIT. For the second year at Palm Aire the pooled evaluation dates represented from 16 to 27 WAIT, counting from the initiation of the second annual series, or from 55 to 66 WAIT, counting from the initiation of the first annual series. Data were analyzed by ANOVA, using treatment by block interaction for comparison of treatment means, and means were separated by the Waller–Duncan Bayesian *k*-ratio *t* test, $k = 100$, $P \approx 0.05$ (Sokal and Rohlf 1981). In discussing the relative reduction of torpedograss, canopy coverage was transformed for each quinclorac treatment and variable (date of visual canopy evaluation or fresh or dry weight component) as the percent reduction of each treatment relative to the water control treatment (Eagle Trace) or the MSO control treatment (Palm Aire) evaluated on the same date. The MSO control and the water control treatments, which received no quinclorac, varied only slightly seasonally in torpedograss canopy.

RESULTS AND DISCUSSION

Canopy Reduction. Initial torpedograss canopy coverage before herbicide application averaged 55 and 86% at Eagle Trace and Palm Aire, respectively, with no difference among treatments (Table 1). Torpedograss canopy differences ($P < 0.001$) were observed after quinclorac treatment. The most effective treatment, the four-way split application, resulted in 17% torpedograss canopy after the first year at Palm Aire and 10% torpedograss after the second year. The second most effective treatment was the three-way split application of quinclorac, which resulted in 16% torpedograss canopy at Eagle Trace and 25% torpedograss after the second year at Palm Aire.

Relative to control treatments (water only or MSO), torpedograss was reduced during a single year to as little as 22% using two applications of quinclorac at Palm Aire and as much as 76% using four applications of quinclorac in the first year at Palm Aire, averaged across evaluation dates 16 to 21 WAIT. This was comparable to the 88% torpedograss reduction observed by Brecke et al. (2001) evaluated 12 WAIT, considering the difference in evaluation dates. Torpedograss canopy generally increased after initial reduction by quinclorac. Some of the canopy increase occurred while treatment series were ongoing (data not shown) and progressed as long as evaluations continued. For example, the most effective treatment, the four-way split application of quinclorac, increased from 17% torpedograss canopy after the first year at Palm Aire to 36% torpedograss canopy 18 wk later (‘‘Before year 2,’’ June 2, 2000, or 39 WAIT, Table 1). Relative to untreated control plots, these values represent 76% torpedograss reduction relative to plots not chemically treated, averaged for the period 16 to 21 WAIT, compared with only 56% reduction by 39 WAIT. These results were less effective than the 74% torpedograss reduction observed for the most effective single-year treatment at one location, evaluated 64 WAIT (Brecke et al. 2001), although the latter report was accompanied with the comment that ‘‘some torpedograss reinfestation occurred.’’ McCarty et al. (1993) observed 89% torpedograss reduction from the most effective treatment, 10 WAIT, but only 53% by 19 WAIT, which shows that considerable torpedograss reinfestation sometimes occurs after quinclorac application. Other treatments were considerably less effective by 19 WAIT.

Rhizome Dry Weights. After 2 yr of successive applications to the same plots, the most effective quinclorac treatment (0.42 kg/ha applied four times each year) reduced torpedograss dry weight from 8,010 to 1,570 kg/ha. The commercially labeled treatment (0.84 kg/ha applied two times) reduced torpedograss dry weight to 4,640 kg/ha.

The vast majority of torpedograss biomass was belowground, and this may explain the regrowth. Averaged across all treatments, the distribution of torpedograss dry weight was 63% pachymorph rhizomes, 24% leptomorph rhizomes (with roots included), and only 13% leaves. Pachymorph rhizomes (Figure 1) were brown, knotted, up to 1 cm thick, and harder and less succulent than the leptomorph rhizomes. They have also been described as ‘‘ginger-like rhizomes,’’ which can emerge from burial depths of up to 20 cm (Hossain et al. 1999). Holtermann (1907) illustrated the same thick rhizomes that I have described, and suggested that they may explain the ability of torpedograss to persist in dry and

Table 1. Effect of quinclorac spilt application treatments on torpedograss canopy at Eagle Trace and Palm Aire Golf Courses, Broward County, FL, and on bermudagrass and torpedograss harvest weight at Palm Aire.[a,b]

	Eagle Trace		Palm Aire								
	Torpedograss canopy		Torpedograss canopy				Harvest wt (after year 2)				
								Torpedograss			
Treatment, quinclorac rate, and no. of applications	Before treatment	After year 1	Before treatment	After year 1	Before year 2	After year 2	Bermudagrass Dry wt	Total dry wt	Leaf dry wt	Leptomorph rhizome dry wt	Pachymorph rhizome dry wt
	%						kg/ha				
1.68 kg/ha × 1 app	53	32	80	39	45	40	5,660	3,720	500	950	2,270
0.84 kg/ha × 2 app	54	33	87	56	51	45	4,950	4,640	620	1,040	2,980
0.56 kg/ha × 3 app	49	16	84	29	40	25	5,690	2,710	260	750	1,690
0.42 kg/ha × 4 app	—	—	89	17	36	10	5,700	1,570	70	310	1,180
Water control	58	57	—	—	—	—	—	—	—	—	—
MSO control	60	50	89	72	82	86	4,370	8,010	1,000	1,940	5,070
MSD	NS	13	NS	11	11	10	1,080	1,720	230	530	1,100
P	0.13	< 0.001	0.10	< 0.001	< 0.001	< 0.001	0.031	< 0.001	< 0.001	< 0.001	< 0.001

[a] Means of four replications (Eagle Trace) and eight replications (Palm Aire). Canopy percent is pooled across several evaluations after the last split application; at Eagle Trace ''After year 1'' represents 9 to 16 WAIT; at Palm Aire ''After year 1'' represents 16 to 21 WAIT, and ''After year 2'' represents 16 to 27 WAIT.

[b] Abbreviations: app, applications; MSD, minimum significant difference ($P \approx 0.05$); MSO, methylated seed oil; NS, not significant; wt, weight; WAIT, weeks after initial treatment.

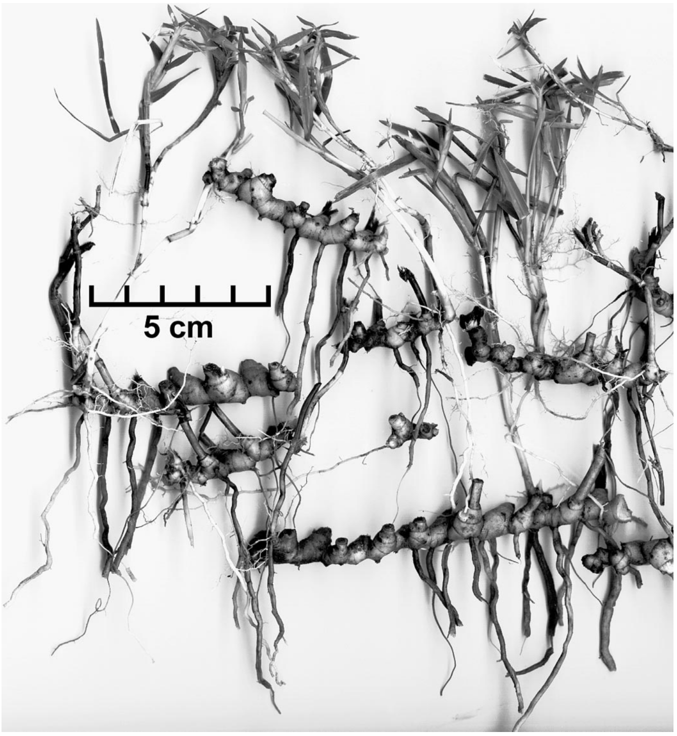

Figure 1. Torpedograss plant parts separated from a 10-cm-diam soil core showing the difference between the dark, thickened, knotty pachymorph rhizomes and the whitish, slender, cylindrical leptomorph rhizomes.

sandy soil. On the basis of the rapid reproduction of torpedograss from rhizomes, Sutton (1996) concluded that herbicide treatments must kill all the rhizomes to be effective.

In the present study, removal of torpedograss using quinclorac would require at least several years of split-application treatments, based on the 80% reduction of total dry weight observed after 2 yr of the 0.42 kg/ha four-way split application (Table 1). The benefit from multiple split applications is probably due to starving the underground storage of new photosynthate; thus the greater the number of weeks that canopy is suppressed, the less new underground storage occurs. Early visual observation of torpedograss canopy reduction is too optimistic in representing the reduction of torpedograss by quinclorac, because canopy is a relatively small part of the plant and subsequent regrowth appears to be from rhizomes.

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LITERATURE CITED

Brecke, B. J., J. B. Unruh, and J. A. Dusky. 2001. Torpedograss (*Panicum repens*) control with quinclorac in bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) turf. Weed Technol. 15:732–756.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Hersberger. 1977. The World's Worst Weeds: Distribution and Biology. Honolulu, HI: University Press of Hawaii.

Holtermann, C. 1907. Einfluss des klimas auf den bau der pflanzengwebe. Leipzig, Germany: Verlag von Wilhelm Engelmann.

Hossain, M. A., Y. Ishimine, H. Akamine, S. Murayama, S.M.M. Uddin, and K. Kuniyoshi. 1999. Effect of burial depth on emergence of *Panicum repens*. Weed Sci. 47:651–656.

McCarty, L. B., J. M. Higgins, and D. L. Colvin. 1993. Selective torpedograss (*Panicum repens*) control in bermudagrass (*Cynodon* spp.) turf. Weed Technol. 7:911–915.

McClure, F. A. 1966. The Bamboos: A Fresh Perspective. Cambridge, MA: Harvard University.

Sokal, R. R. and F. J. Rohlf. 1981. Biometry. 2nd ed. San Francisco, CA: W. H. Freeman.

Sutton, D. L. 1996. Growth of torpedograss from rhizomes planted under flooded conditions. J. Aquat. Plant Manag. 34:50–53.

Wilcut, J. W., R. R. Dute, B. Truelove, and D. E. Davis. 1988. Factors limiting the distribution of cogongrass, *Imperata cylindrica*, and torpedograss, *Panicum repens*. Weed Sci. 36:577–582.