J. Aquat. Plant Manage. 58: 36–40

Evaluation of fluazifop-P-butyl for para grass and torpedograss control in aquatic and wetland sites

STEPHEN F. ENLOE, KAITLYN H. QUINCY, MICHAEL D. NETHERLAND, AND DWIGHT K. LAUER*

ABSTRACT

Invasive grasses continue to be problematic for aquatic managers in a wide variety of managed systems, and a lack of selective options has hindered restoration efforts. Recent work with the graminicide sethoxydim in aquatic systems in Florida has prompted the examination of a second active ingredient, fluazifop-P-butyl, which is known to be effective on many weedy grasses. Studies were conducted in south Florida to assess fluazifop-P-butyl efficacy on para grass and torpedograss, two of the most difficult to manage species in aquatic systems. Aerial and airboat application studies were conducted from 2016 to 2018 to compare fluazifop-P-butyl with glyphosate and imazapyr tank mixes. Single fall aerial treatments of fluazifop-P-butyl at 0.42 kg ai ha^{-1} reduced torpedograss and para grass cover to 19% and 6%, respectively, by early spring at 4 mo after treatment (MAT). However, both species recovered by the onset of the summer wet season the following year. Sequential applications 14 days apart reduced torpedograss and para grass cover to 6 and 4%, respectively, but did not increase the longevity of control. Airboat application studies also found good short-term control ($\leq$ 3% cover) of both species at 2 MAT with fall treatments and reduced longer-term control ($\geq$ 31% cover) with the onset of the following summer wet season at 8 MAT. Glyphosate and imazapyr provided better control of both species in all studies compared to the fluazifop-P-butyl. These studies indicate fluazifop-P-butyl may be a useful tool for torpedograss and para grass management in Florida, especially where a high degree of selectivity is needed. However, further studies are needed to establish optimal retreatment timings for longer-term control of both species.

Key words: aerial application, fluazifop-P-butyl, glyphosate, imazapyr, *Panicum repens* L., sequential treatments, *Urochloa mutica* (Forsk.) Nguyen.

INTRODUCTION

Para grass [*Urochloa mutica* (Forsk.) Nguyen] and torpedograss (*Panicum repens* L.) are two of the most widespread aquatic invasive grasses in south and central Florida. Native to Africa, para grass was historically introduced throughout the tropics and subtropics as a potential forage grass due to its aggressive growth, high productivity, and tolerance to considerable hydrologic fluctuation (Rojas-Sandoval and Acevedo Rodríguez 2014). In Florida, it is found primarily in the southern and central regions of the peninsula, with limited infestations in the northeastern peninsular and western panhandle region (Wunderlin et al. 2019). Para grass primarily spreads by stolons and stem fragments; historical research suggests it produces very little viable seed (Thompson 1919). Para grass is robust in its growth habit, may reach heights of 3 m, and forms very dense stands. It becomes problematic in and along canals, marshes, the margins along many lakes and rivers, and disturbed, wet areas in general. Para grass is listed as a category one species by the Florida Exotic Pest Plant Council (FLEPPC 2019), which indicates documented ecological damage within the state. However, it is not a regulated species in Florida or other parts of the United States.

Torpedograss is an Old World species that has also been widely distributed as a forage species in tropical and subtropical regions of the world (Langeland et al. 1998). In the United States, it extends throughout Florida and the southeastern region, with additional infestations in California and Hawaii. Torpedograss spreads by rhizomes in the soil and stems present in the water column (Smith et al. 1993). Seed production is highly variable, and its contribution to the overall invasiveness of the species is uncertain. Torpedograss is widespread along numerous water bodies in Florida. It is especially problematic for retention ponds and wetland restoration sites, where it can displace many native plants and form dense, monotypic stands (Stone 2011).

In aquatic systems, herbicides are the only viable tool for long-term control of either species. The toolbox is generally limited to glyphosate and imazapyr, both of which are nonselective (Smith et al. 1993; Hanlon and Langeland 2000; Chaudhari et al. 2012). Single applications of these herbicides do not typically result in eradication; thus, retreatment is needed. Imazapyr is generally the more effective herbicide of the two, and they are also frequently tank mixed. However, nontarget damage by these herbicides in mixed stands of invasive grasses and desirable vegetation can greatly hinder restoration efforts.

*First and second authors: Invasive Plant Extension Specialist and Graduate Research Assistant, University of Florida, Center for Aquatic and Invasive Plants, 7922 NW 71st St., Gainesville, FL 32653. Third author: Research Biologist, U.S. Army Engineer Research and Development Center, 7922 NW 71st St., Gainesville, FL 32653, deceased. Fourth author: Research Analyst, Silvics Analytic, 122 Todd Circle, Wingate, NC 28174. Corresponding author's E-mail address: sfenloe@ufl.edu. Received for publication September 10, 2019 and in revised form October 9, 2019.

Recent interest in expanding the herbicide toolbox prompted research into the use of graminicides for aquatic invasive grass control (Enloe and Netherland 2017; Enloe et al. 2018). Historically, the graminicides have been widely used in agricultural settings for control of many annual and perennial grasses and in natural areas for suppression of certain invasive grasses (Burton et al. 1989; Clay et al. 2006; Kukorelli et al. 2013). Sethoxydim is the first graminicide to be registered for use in aquatics for invasive grass control with a 24(c) Special Local Needs label in Florida (Anonymous 2017). Selectivity has now been documented on a variety of non-Poaceae aquatic emergent species (Enloe and Netherland 2017). Additionally, sequential applications in the late spring have been shown to provide good control of torpedograss (Enloe et al. 2018), and summer or fall applications have been very effective for control of West Indian marsh grass [*Hymenachne amplexicaulis* (Rudge) Nees] (Quincy 2019).

Fluazifop-P-butyl is another graminicide in the aryloxyphenoxypropionate herbicide family, which differs in structure from the cyclohexanediones that include sethoxydim. Fluazifop-P-butyl was also developed in agronomic systems for control of weedy grasses in many broadleaf crops. Recently it received an experimental use permit in Florida to assess its potential for aquatic invasive grass control (Anonymous 2016). In an Australian saltmarsh, fluazifop-P-butyl has been used to successfully control the invasive grass *Spartina anglica* C.E. Hubbard. For this species, a single application of 2.1 kg ha^{-1} resulted in 98% control after 1 yr and 92% control after 3 yr (Pritchard 2005).

In aquatic systems, there is limited information on the efficacy of fluazifop-P-butyl for control of torpedograss and no published studies of its effect on para grass. In mesocosm studies, both Enloe and Netherland (2017) and Prince et al. (2019) found fluazifop-P-butyl provided torpedograss control comparable to glyphosate in saturated conditions. Given the utility of fluazifop-P-butyl for selective control of multiple invasive grasses, our objective was to evaluate its efficacy on para grass and torpedograss in aquatic systems. To accomplish this, we examined its performance against tank mixes of glyphosate and imazapyr in both aerial and airboat application studies. If effective, fluazifop-P-butyl would be another greatly needed selective tool for aquatic invasive grass management.

MATERIALS AND METHODS

Field studies were conducted in south Florida during the period 2016 to 2018 at C-139 Annex, a South Florida Water Management District Property. Studies were located within a 324-ha impoundment referred to as Pond 3 (26°21′41.57″N; 80°58′14.61″W). Historically, Pond 3 was a wet prairie that was leveed to store water for irrigation of surrounding orange groves. The water depth in Pond 3 is seasonally dependent. In winter, dry conditions result in low water levels and a dry surface. In the summer wet season, water depths increase to 60 to 90 cm. The vegetation in Pond 3 comprises numerous bald cypress [*Taxodium distichum* (L.) Rich.] strands interspersed among large open areas of emergent plants. Cattails (*Typha latifolia* L. and *Typha domingensis* Pers.) are patchy throughout the site, and most open areas are monotypic stands of torpedograss or para grass.

2016 to 2017 torpedograss and para grass aerial application study

In previous work (Enloe et al. 2018) reported data comparing aerial (helicopter) applied treatments of sethoxydim to glyphosate and imazapyr for torpedograss control. That study presented data from 12 field plots. Here we include data on six additional fluazifop-P-butyl treated plots that were partitioned from the original published study due to a temporal agreement with the manufacturer. The plots were 27 m in width and 366 to 457 m in length and contained dense, monotypic patches of both torpedograss and para grass. This allowed for three helicopter passes to treat the entirety of each plot. The helicopter application volume was 187 L ha^{-1}. The initial treatments were applied November 4, 2016, with sequential treatments applied 2 wk later November 18, 2016. Treatments included fluazifop-P-butyl[1] at 0.42 kg ai ha^{-1} applied as single or sequential treatments, the commercial standard glyphosate[2] + imazapyr[3] (4.2 + 1.12 kg ha^{-1}) applied as a single treatment, and an untreated control. Although the glyphosate + imazapyr and untreated control data were previously reported for torpedograss (Enloe et al. 2018), they are reported here again for comparison to fluazifop-P-butyl. A methylated seed oil (MSO)[4] was added to each fluazifop-P-butyl treatment at 0.94 L ha^{-1}. The same MSO was added to the glyphosate + imazapyr tank mix at 0.24 L ha^{-1}.

2017 to 2018 torpedograss and para grass airboat application studies

Two additional airboat application studies were also conducted at Pond 3. One focused on para grass and was repeated at a second location in Pond 3. The other focused on torpedograss and was conducted once. Plots were 11 by 36 m. Treatments included fluazifop-P-butyl applied as spot treatment rates of 1, 2, and 3% v/v (equivalent to 2.2, 4.5, and 6.7 kg ai ha^{-1}), a glyphosate (3% v/v) + imazapyr (2% v/v) tank mix (equivalent to 13.4 + 2.24 kg ha^{-1}, respectively), and an untreated control. A methylated seed oil[4] was added to each treatment at 0.94 L ha^{-1}. Plots were treated by airboat with a spray handgun calibrated to deliver 935 L ha^{-1}. Treatments were applied by making one pass along the length of each plot edge, spraying into one-half the plot from each side. This provided good coverage and prevented poor control within airboat trails that can occur when navigating through recently treated areas. Treatments were applied in late October 2017.

Data collection

For the aerial study, torpedograss and para grass were sampled in separate quadrats. For torpedograss, 10 permanent 1 by 1 m quadrats were randomly established along a transect down the length of each plot and marked with PVC poles. For para grass, three quadrats, 3 by 3 m in size, were

Table 1. Torpedograss response to single and sequential aerial herbicide applications at C-139 Annex.

Herbicide	Rate (kg ha^{-1})	No. of Apps	% Cover[1] 0 MAT	2 MAT	4 MAT	8 MAT	11 MAT
Glyphosate + imazapyr	4.2 + 0.56	1	88 a[2]	0	0.3	0.4	0.5
Fluazifop-P-butyl	0.42	1	81 a	24 b *	19 b *	59 a	59 a
Fluazifop-P-butyl	0.42[3]	2	84 a	15 b *	6 b *	50 a	51 a
Untreated	—	—	81 a	74 a	51 a	81 a	71 a

[1]The operational standard (glyphosate + imazapyr) was not included in the analysis of percent cover after 0 MAT because control remained excellent with little variation between plots. The standard errors of quadrat samples for the operational standard were 0.02, 0.25, 0.27, and 0.30% for mean percent cover at 2, 4, 8, and 11 MAT, respectively.
[2]Means within columns followed by the same letter are not significantly different at the 5% level using the Tukey-Kramer adjustment. Means within columns followed by an asterisk are significantly different from the untreated check using Dunnett's test at the 5% level.
[3]The total fluazifop-P-butyl applied for the sequential (two) applications was 0.84 kg ha^{-1}.

randomly placed in dense areas of para grass cover in each plot. For all airboat treatment studies, five permanent 1 by 1 m quadrats were randomly placed along a single transect down the length of each plot. For the aerial study, para grass and torpedograss cover were estimated in each quadrat at 0, 2, 4, 8, and 11 mo after treatment (MAT). For the airboat studies, para grass and torpedograss cover were estimated at 0, 2, and 8 MAT. Additionally, for all studies, water depth at time of treatment and emergent grass height were measured.

Statistical analysis

Treatments were applied to plots in a completely randomized design (CRD) for all studies. For the aerial study, there were six replications of the operational standard and three replications of other treatments. For all airboat application studies, there were three replications per treatment. For all studies, analysis of variance (ANOVA) was performed as a CRD with plot variation within treatment considered a random effect (this was the error term for treatment effects) and quadrat measurements considered subsamples. Location was considered a random effect in the para grass airboat application study that was repeated at two sites. The arcsine-square root transformation was used for percent cover to improve homogeneity of variance. Treatments were compared in terms of percent cover at each sample date. The operational standard for aerial study was not included in the analysis of percent cover after 0 MAT because control was near complete with very little variation. Initial water depth and plant height were tested as covariates but were not included in the final analysis due to lack of significance. Mean comparisons were performed at the 5% level of significance using the Tukey-Kramer adjustment to compare means to each other and Dunnett's adjustment to compare means to the untreated check. ANOVA was performed with PROC MIXED (Littell et al. 2006). All data were analyzed using SAS® v.9.4 software.[5]

RESULTS AND DISCUSSION

2016 to 2017 torpedograss and para grass aerial application study

Mean torpedograss cover in the untreated control plots ranged from a high of 81% at pretreatment in the fall to a low of 51% by late winter during the dry season. This seasonal trend in cover is typical for many tropical grasses in Florida. For torpedograss, the glyphosate + imazapyr treatment reduced cover to near zero by 2 MAT and maintained that level of control for the duration of the study to 11 MAT (Table 1). A single application of fluazifop-P-butyl reduced cover to 24 and 19% by 2 and 4 MAT, respectively, and these were both significantly lower in cover than the untreated control. However, torpedograss subsequently recovered to similar levels as the untreated control by the onset of the summer wet season at 8 MAT. Sequential applications of fluazifop-P-butyl followed a similar pattern and reduced torpedograss cover to 15 and 6% at 2 and 4 MAT, respectively. Torpedograss recovered by 8 MAT and was not different from either the single fluazifop-P-butyl application or the untreated control.

For para grass, cover in the untreated control plots also exhibited a seasonal trend, with high cover in the fall, a decline by late winter, and a subsequent increase with the onset of the summer wet season (Table 2). The glyphosate + imazapyr tank mix reduced torpedograss cover to near zero

Table 2. Para grass response to single and sequential aerial herbicide applications at C-139 Annex.

Herbicide	Rate (kg ha^{-1})	No. of Apps	% Cover[1] 0 MAT	2 MAT	4 MAT	8 MAT	11 MAT
Glyphosate + imazapyr	4.2 + 0.56	1	83 a[2]	0	0	0.1	0.8
Fluazifop-P-butyl	0.42	1	78 a	15 b *	5 b *	58 a	64 a
Fluazifop-P-butyl	0.42[3]	2	78 a	4 b *	4 b *	56 a *	62 a
Untreated	—		81 a	86 a	49 a	86 a	84 a

[1]The operational standard (glyphosate + imazapyr) was not included in the analysis of percent cover after 0 MAT because control remained excellent with little variation between plots. The standard errors of quadrat samples for the operational standard were 0.00, 0.00, 0.07, and 0.92% for mean percent cover at 2, 4, 8, and 11 MAT, respectively.
[2]Means within columns followed by the same letter are not significantly different at the 5% level using the Tukey-Kramer adjustment. Means within columns followed by an asterisk are significantly different from the untreated check using Dunnett's test at the 5% level.
[3]The total fluazifop-P-butyl applied for the sequential (two) applications was 0.84 kg ha^{-1}.

Table 3. Torpedograss response to airboat spot treatment.

Herbicide	Rate (kg ha^{-1})	% Cover[1] 0 MAT	2 MAT	8 MAT
Glyphosate + imazapyr[2]	13.4 + 2.2	53 a	0 b *	0 c *
Fluazifop-P-butyl (1%)	2.2	68 a	3 b *	46 ab
Fluazifop-P-butyl (2%)	6.7	61 a	1 b *	34 b *
Fluazifop-P-butyl (3%)	11.2	56 a	0 b *	41 b *
Untreated	—	70 a	75 a	73 a

[1]Treatment means within columns followed by the same letter are not significantly different from each other at the 5% level using the Tukey-Kramer adjustment for multiplicity. Treatment means within columns followed by an asterisk are significantly different from the untreated check using Dunnett's test at 5%.

Table 4. Para grass response to airboat spot treatment.

Herbicide	Rate (kg ha^{-1})	% Cover[1] 0 MAT	2 MAT	8 MAT
Glyphosate + imazapyr[2]	13.4 + 2.2	60 a	0 b *	2 b *
Fluazifop-P-butyl (1%)	2.2	58 a	1 b *	66 a
Fluazifop-P-butyl (2%)	6.7	67 a	0 b *	48 a
Fluazifop-P-butyl (3%)	11.2	66 a	0 b *	49 a
Untreated	—	66 a	86 a	71 a

[1]Treatment means within columns followed by the same letter are not significantly different from each other at the 5% level using the Tukey-Kramer adjustment for multiplicity. Treatment means within columns followed by an asterisk are significantly different from the untreated check using Dunnett's test at 5%.

by 2 MAT and maintained this level of control for the duration of the study. A single application of fluazifop-P-butyl reduced para grass cover to 15 and 5% by 2 and 4 MAT, respectively. At each sample date, these were significantly lower than para grass cover in the untreated control (Table 2). Similar to torpedograss, para grass recovery occurred by 8 MAT and was not different from the untreated control. Sequential applications of fluazifop-P-butyl reduced para grass cover to 4% at both 2 and 4 MAT. At each of these sample dates, para grass cover was not different between the sequential or single-application treatments. However, at 8 MAT, a significant difference was seen in para grass cover between the sequentially treated plots and the untreated plots. Although statistically significant, this difference had little biological significance because it was only two percentage points lower than the single-application treatment.

2017 to 2018 torpedograss and para grass airboat application studies

For torpedograss, fluazifop-P-butyl at all three concentrations reduced cover to 3% or less at 2 MAT and was similar to glyphosate + imazapyr (Table 3). However, by 8 MAT, torpedograss cover in the 1% treatment averaged 46% and was not different than the untreated control (75%). Torpedograss cover in the 2 and 3% concentrations were 34% and 41%, which were significantly lower than the untreated control but were not different from the 1% treatment. Glyphosate + imazapyr maintained excellent control throughout the duration of the study. For para grass, all three fluazifop-P-butyl concentrations reduced cover to less than 2% at 2 MAT, which was significantly lower than the untreated control (75%) (Table 4). However, by 8 MAT, para grass recovery in all three fluazifop-P-butyl treatments ranged from 48 to 66% and was not different from the untreated control.

These data indicate fluazifop-P-butyl is capable of reducing torpedograss and para grass cover in wetlands. In the aerial study, both single and sequential applications reduced torpedograss cover to less than 20% by 4 MAT and reduced para grass cover to 5%. In the airboat application studies, spot treatment concentrations of 1 to 3% v/v effectively reduced torpedograss cover to near zero for at least 2 mo in the 2017 to 2018 study. Para grass cover was also reduced to near zero, but the length of control was shorter.

Additionally, there was no meaningful improvement in torpedograss or para grass control with aerial sequential applications compared to single treatments. At the time of the sequential treatment, both species were still green and had not senesced. These results are similar to our previously published findings with sethoxydim that demonstrated no meaningful improvement in torpedograss control with fall sequential aerial treatments (Enloe et al. 2018). However, single applications of fluazifop-P-butyl did reduce torpedograss control for a longer period in this study (4 MAT) than did sethoxydim in the previous published study (2 MAT). It is important to note that this study was conducted in conditions that reflect extremely difficult torpedograss control. Average water depth was 55 cm, and torpedograss shoot heights averaged 120 cm across treated plots. This partitioned into an average of 65 cm of dense above water growth and almost as much below water growth. Prince et al. (2019) found reduced herbicide efficacy (including the graminicides) for torpedograss treated in flooded compared to saturated conditions. In many aquatic systems, torpedograss control may be improved where water levels are lower and multiple site visits per year are feasible.

The duration of efficacy may have also been affected by the timing of treatment. Previous work has shown that torpedograss control with sethoxydim was improved with late spring but not fall sequential applications (Enloe et al. 2018). No spring treatments were conducted in this study. Torpedograss and para grass also exhibit reduced growth and some senescence over the cooler, drier winter months. These conditions have the potential to enhance the longevity of herbicide control. This likely occurred as the recovery of both species was generally concomitant with the onset of the rainy season, which was around 8 mo after treatment.

Similar to sethoxydim, these studies indicate that fluazifop-P-butyl may have a useful fit in aquatic invasive grass management. The selectivity it confers, which has been similar to sethoxydim (Enloe and Netherland 2017), would be extremely useful to aquatic managers desiring to maintain diverse emergent communities. Additional studies examining its impact with spring and summer timings on these and additional species such as West Indian marsh grass and tropical watergrass would also be useful.

SOURCES OF MATERIALS

[1]AF12460-GRASS, Syngenta Crop Protection LLC, PO Box 18300, Greensboro, NC 27419.

[2]Rodeo®, Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN, 46268.

[3]Habitat®, BASF Corporation, 26 Davis Drive, Research Triangle Park, NC 27709.

[4]MSO Concentrate, Loveland Products, Inc., Greeley, CO 80632-1286.

[5]SAS Statistical Software, version 9.3, SAS Institute Inc., Cary, NC 27513.

ACKNOWLEDGEMENTS

This research was supported with funding from the U.S. Army Engineer Research and Development Center Aquatic Plant Control Research Program and South Florida Water Management District. This paper is dedicated to the memory of Dr. Michael Netherland, who was a great friend and colleague. The authors would also like to thank Dean Jones, Ryan Brown, Cody Lastinger, and Carl Della Torre for technical assistance. Citation of trade names does not constitute endorsement or approval of the use of such products.

LITERATURE CITED

Anonymous 2016. AF12460 GRASS herbicide—Florida experimental use permit. Syngenta Crop Protection LLC, PO Box 18300, Greensboro, NC 27419.

Anonymous 2017. TIGR herbicide FIFRA 24(c)—Special local needs label. SePRO Corporation, 11550 North Meridian Street, Suite 600, Carmel, IN 46032.

Burton JD, Gronwald JW, Somers DA, Gengenbach BG, Wyse DL. 1989. Inhibition of corn acetyl-CoA carboxylase by cyclohexanedione and aryloxyphenoxypropionate herbicides. Pestic. Biochem. Physiol. 34:76–85.

Chaudhari S, Sellers BA, Rockwood SV, Ferrell JA, Macdonald GE, Kenworthy KE. 2012. Integrating chemical and cultural practices to control para grass (*Urochloa mutica*). J. Aquat. Plant Manag. 50:39–45.

Clay DV, Dixon FL, Willoughby I. 2006. Efficacy of graminicides on grass weed species of forestry. Crop Prot. 25:1039–1050.

Enloe SF, Netherland MD. 2017. Evaluation of three grass-specific herbicides on torpedograss (*Panicum repens*) and seven nontarget, native aquatic plants. J. Aquat. Plant Manag. 55:65–70.

Enloe SF, Netherland MD, Lauer DK. 2018. Evaluation of sethoxydim for torpedograss control in aquatic and wetland sites. J. Aquat. Plant Manag. 56:93–100.

FLEPPC. 2019. List of Invasive Plant Species. Florida Exotic Pest Plant Council. www.fleppc.org. Accessed June 12, 2019.

Hanlon CG, Langeland KA. 2000. Comparison of experimental strategies to control torpedograss. J. Aquat. Plant Manag. 38:40–47.

Kukorelli G, Reisinger P, Pinke G. 2013. ACCase inhibitor herbicides—Selectivity, weed resistance and fitness cost: A review. Int. J. Pest Manag. 59:165–173.

Langeland K, Smith B, Hanlon C. 1998. Torpedograss—forage gone wild. Wildl. Weeds (Summer):4–6.

Littell RC, Milliken GA, Stroup WW, Wolfinger RD, Schabenberger O. 2006. SAS® for mixed models. 2nd ed. Cary, NC: SAS Institute. 814 p.

Prince CM, Quincy KH, Enloe SF, Macdonald GE, Netherland M. 2019. Torpedograss response to herbicide treatment in saturated and flooded conditions. J. Aquat. Plant Manag. 57:23–27.

Pritchard GH. 2005. Herbicide trials on Spartina. p. 66. In: J. Rash, R. Williamson, and S. Taylor (*eds.*). Proceedings of the Australasian Conference on Spartina Control. Victorian Government, Melbourne.

Quincy K. 2019. The ecology and management of West Indian marsh grass (*Hymenachne amplexicaulis*) in Florida wetlands. M.S. thesis. University of Florida, Gainesville, FL. 137 p.

Rojas-Sandoval J, Acevedo-Rodríguez P. 2014. *Urochloa mutica* (para grass). CABI Invasive Species Compendium. https://www.cabi.org/isc/datasheet/109219. Accessed August 6, 2019.

Smith BE, Shilling DG, Haller WT, MacDonald GE. 1993. Factors influencing the efficacy of glyphosate on torpedograss (*Panicum repens* L.) J. Aquat. Plant Manag. 31:199–202.

Stone KR. 2011. *Panicum repens*. U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. 35 pp.

Thompson JB. 1919. Para grass. Univ. of Florida Agr. Exp. Station, Bulletin 308. 2 p.

Wunderlin RP, Hansen BF, Franck AR, Essig FB. 2019. Atlas of Florida plants [S. M. Landry and K. N. Campbell (application development), USF Water Institute.] Institute for Systematic Botany, University of South Florida, Tampa. http://florida.plantatlas.usf.edu/. Accessed June 12, 2019.