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Control of West Indian Marsh Grass with Glyphosate and Imazapyr

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ABSTRACT

West Indian marsh grass (*Hymenachne amplexicaulis* [Rudge] Nees), hereafter referred to as WIMG, is a non-native invasive species present in at least 14 counties of central and south Florida. This perennial grass species out-competes native vegetation and is capable of rapid spread by both seeds and vegetative tissue. Experiments were conducted to determine the optimal timing and herbicide strategy for WIMG in natural areas and to determine the effect of water depth on WIMG control with herbicides. Glyphosate (N-(phosphonomethyl)glycine) at 4.2 kg ai/ha, imazapyr (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1-H-imidazol-2-yl]-3-pyridinecarboxylic acid) at 1.1 and 1.7 kg ai/ha, and glyphosate + imazapyr at 4.2 + 1.1 kg ai/ha provided at least 90% control 3 months after treatment (MAT) at Myakka River State Park and the St. John's River. However, by 6 MAT regrowth of WIMG resulted in only 70% control with glyphosate alone, which was significantly lower than all other treatments. Although timing did not have an impact on WIMG control, it did appear to have some impact on reestablishment of native species. The reestablishment of native species may have been impacted more by the extreme drought conditions following the fall application in 2006. Water depth does not appear to influence control of WIMG with these herbicides. Regardless of water depth, glyphosate + imazapyr reduced WIMG biomass by as much as 97% compared to the untreated control. These data indicate that excellent control of WIMG can be obtained using glyphosate, imazapyr, or a tank-mix of these herbicides at any time during the growing season.

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Key words: floodplains, aquatic grasses, *Hymenachne amplexicaulis*, invasive aquatic plants.

INTRODUCTION

Invasion of exotic plant species poses a serious threat to Florida's natural areas. International trade, tourism, as well as agricultural and urban disturbance have increased the likelihood of establishment of exotic plants. Exotic aquatic plant species in Florida wetlands spread rapidly due to floods, large interconnected waterway systems, and increased use of commercial and recreational boats. Additionally, fertilizer and sediment runoff from agricultural and urban landscapes contribute to successful establishment of exotic aquatic plant species.

Wunderlin and Hansen (2007) reported 1,365 exotic plant species in Florida, with 129 species considered serious threats to natural areas according to the Florida Exotic Pest Plant Council (FLEPPC 2007). Of those, 67 are considered to be highly invasive because they are disruptive to native plant communities. West Indian marsh grass (*Hymenachne amplexicaulis*) is among the 67 highly invasive species listed as a category 1 species (FLEPPC 2007).

West Indian marsh grass, hereafter referred to as WIMG, is a native of South America and the West Indies and has spread to most countries of the neotropics. The timing of introduction of this species into Florida is unknown; however, the first herbarium record was from a wet pasture in Palm Beach County in 1957 (University of Florida Herbarium). This suggests that the grass could have been intentionally introduced as a forage species. Current records indicate that WIMG is present in wetlands and rivers in 14 Florida counties (Wunderlin and Hansen 2007); however, personal observations (B. Sellers) suggest that this species is likely found in the southern-most 24 counties of Florida.

West Indian marsh grass is well adapted to wetland environments and changes in water depth. In the Brazilian Pantanal, its native range, WIMG grows within four habitats: marsh ponds, waterlogged basins, tall grasslands, and forest edges (Pinder and Ross 1998). Observations of marshes in Florida indicate that when subjected to inundation, WIMG is capable of rapid stem elongation, increases in leaf area, and nodal root production (R. Diaz, pers. comm.). Kibbler and Bahnisch (1999) demonstrated that rapid stem elongation maintains the leaves above the water, allowing emergent leaves to function with full photosynthetic capacity. In Venezuela, Tejos (1978) found a positive relationship between WIMG growth and depth of flooding, with biomass production ranging from 5.9 to 18.2 t/ha/yr during the flood period and from 5.5 to 7.8 t/ha/yr during the dry season. Additionally, WIMG grew 8.22 cm/day during the flood period (Tejos 1978).

Invasion of WIMG is favored by aggressive mechanisms of reproduction and dispersal. In Australia, a single inflorescence can produce more than 4,000 seeds (Tropical Weeds Research Centre 2006) with approximately 98% viability (Lyons 1996). Another method of reproduction is through vegetative stolons. West Indian marsh grass plants in experimental colonies at the Indian River Research and Education Center at Fort Pierce, Florida, are easily propagated by planting small pieces of stems containing at least one node (R. Diaz, pers. comm.). Moreover, wet pastures in Australia were easily established by casting pieces of grass stems from boats (Lukacs 1996); therefore, summer floodwaters in Florida can transport WIMG seeds and stolons great distances through watersheds and thereby complicate management programs.

Large infestations of exotic grasses can reduce the biodiversity in aquatic ecosystems. Recent studies in wetlands demonstrate that exotic grasses capable of forming monotypic swards reduce or change the arthropod community (Posey 1988, Talley and Levin 2001, Houston and Duivenvoorden 2002, Herrera and Dudley 2003). These changes can alter trophic structure and habitat usage by birds, fish, and other vertebrates; therefore, management strategies are needed for WIMG in natural areas in Florida, and perhaps in other countries, where this species has invaded aquatic ecosystems. The objective of this research was to determine the timing and herbicide strategy for WIMG in natural areas and to determine the effect of water depth on WIMG control with herbicides.

MATERIALS AND METHODS

Field experiments. Two field experiments were initiated on 3 November 2005 at Myakka River State Park near Sarasota, Florida. These sites, approximately 5 km apart, were designated as 'North' and 'South,' and water levels in the plots at the time of herbicide treatment were 40 and 20 cm, respectively. Ten 3 by 6 m plots were established for herbicide treatments; however, extreme drought during winter 2005-2006 and feral swine rooting in the experimental area resulted in abandonment of these sites within 6 months after the initial herbicide treatments; no treatments were applied in spring/summer as intended. The second field experiment was initiated on 8 August 2006 near the west-central boundary of the Three Forks Marsh Conservation Area of the St. John's River near Palm Bay using individual 3 by 6 m plots where spring/summer and fall herbicide treatments were applied. Water was not standing in any plots at either application timing at this location. All experimental sites were chosen based upon the density of WIMG, and groundcover was at least 95% in all plots.

Herbicide treatments included glyphosate at 4.2 kg ai/ha, imazapyr at 1.1 kg ai/ha and 1.7 kg ai/ha, and a tank-mix of glyphosate + imazapyr at 4.2 + 1.1 kg ai/ha; an untreated check was also included. Half of the WIMG plots were treated during vegetative growth (plants <90 cm tall) and the remaining half at flowering. All herbicides were applied with a 2-person, 3-m hand-held boom calibrated to deliver 468 L/ha at 252 kPa at a speed of 1.6 kph. Herbicide efficacy was evaluated visually at 1, 3, and 6 months after treatment on a scale of 0 to 100%, with 0 equal to no control and 100 equal to complete kill; control plots were rated as 0 for each replication. Whole plant samples were taken from treated plots and the untreated plots to monitor regrowth from nodes to evaluate WIMG control at 1 and 3 months after treatment. Ten individual plants were cut into 2-node sections and placed in water solution. The number of live nodes (nodes with new shoot or root tissue) was recorded two weeks after placing the stem sections in water.

Vault experiment. A controlled experiment was conducted to determine the impact of water depth on WIMG control with glyphosate and imazapyr. Individual WIMG plants were established in 4-L pots containing builder's sand. At approximately 30 cm tall, plants were placed into 3 by 6 m concrete vaults. Water level was adjusted so that plants were not inundated (water level was at the soil surface), inundated with 15 cm of water, or inundated with 30 cm of water. The amount of leaf tissue exposed to intercept herbicide at 0, 15, and 30 cm was approximately 100, 50, and 15% of the total plant. After acclimation to water depth for two weeks, plants were treated with the same treatments as in the field study. Control was assessed visually 30 and 60 days after application, and plants (live and/or dead) were harvested by removing top growth at the soil surface 60 days after application. Dry weights of harvested material were recorded after samples were oven-dried at 60 C for 5 days.

Experimental design and analysis. Field experiments were conducted in a randomized complete block design with a factorial arrangement of application timing and herbicide treatment. Three replications of each treatment, included the untreated control, were utilized at each experimental site. The herbicide timings were based upon early-season and late-season WIMG growth; fall applications were applied when WIMG was flowering and spring/summer applications applied when WIMG plants were approximately 90 cm tall. The vault experiment was conducted with a factorial arrangement of herbicide treatment and water depth in a randomized complete block design. All data were subjected to ANOVA utilizing PROC GLM in SAS (SAS Institute 1999). Data were separated using Fisher's protected LSD at $P = 0.05$.

RESULTS AND DISCUSSION

Field experiments. Herbicides were applied only in the fall within two locations at Myakka River State Park in 2005. There were no significant differences in control between locations ($p = 0.5687$) and treatments ($p = 0.2467$) 3 months after herbicide application (Table 1). These sites were abandoned in 2006 due to extreme drought conditions and disturbance by feral swine.

TABLE 1. PERCENT CONTROL (VISUAL RATINGS OF BIOMASS REDUCTION) OF WEST INDIAN MARSH GRASS AT MYAKKA RIVER STATE PARK IN 2005 AND THE THREE FORKS MARSH CONSERVATION AREA OF THE ST. JOHN'S RIVER IN 2006.

		Myakka	St. Johns River	
Treatment	Rate	3 MAT	3 MAT	6 MAT
	kg ai/ha	---------------	%	---------------
Glyphosate	4.2	97	90	70
Imazapyr	1.1	97	95	96
Imazapyr	1.7	99	97	99
Glyphosate + imazapyr	4.2 + 1.1	98	97	98
LSD (0.05)		NS	NS	25

TABLE 2. NUMBER OF LIVE NODES FROM 2-NODE SECTIONS OF WEST INDIAN MARSH GRASS PLANTS 1 AND 3 MONTHS AFTER HERBICIDE APPLICATION AT MYAKKA RIVER STATE PARK.

		1 month		3 months	
Treatment	Rate	North	South	North	South
	kg/ha	-------------	No. of nodes		-------------
Untreated	0	3.28	3.00	0.27	0.11
Glyphosate	4.2	0.07	0.08	0.06	0.02
Imazapyr	1.1	0.03	0.00	0.02	0.00
Imazapyr	1.7	0.00	0.00	0.01	0.00
Glyphosate + imazapyr	4.2 + 1.7	0.00	0.00	0.00	0.00
LSD (0.05)	—	0.40	0.30	0.07	0.06

At the St. Johns River site, application timing ($p = 0.4181$) and the application timing by herbicide treatment interaction ($p = 0.2076$) were not significant. Therefore, data were combined over application timings. At 3 months after treatment (MAT), there were no significant differences ($p = 0.8567$) among treatments, and all treatments provided at least 90% control (Table 1). Glyphosate alone provided the poorest control (70%) 6 MAT, while all other treatments provided >95% control (Table 1).

Reestablishment of native species was observed 6 MAT at the St. Johns location after the August 2006 herbicide applications. Camphor weed (*Pluchea camphorata* [L.] DC.), Nuttall's thistle (*Cirsium nutalli* L.), and coast cockspur (*Echinochloa walteri* L.) were the predominant species in the treated areas. Para grass (*Urochloa mutica* Forsk.), a non-native, was present only in plots treated with glyphosate. Within two weeks after the August herbicide application, approximately 30 cm of water was present throughout the experimental area. In the November-treated plots, there were few native species growing 6 MAT, with coast cockspur being the most abundant. Considering that the half-life of imazapyr is 2 to 5 days in water (Mallipudi et al. 1991) and glyphosate has no soil activity, it is likely that the presence of water after the August application aided the establishment of native species. Rainfall throughout Florida was well below normal after the November application, which may be the reason for little establishment of native species considering that the half-life of imazapyr in soil ranges from 25 to 142 days (Vencil 2002). However, the establishment of native species in these plots could be due to both the limited rainfall and residual activity of imazapyr.

In addition to visual assessments of treated plots, regrowth was monitored from individual nodes of whole-plant samples (Table 2). At Myakka River State Park, glyphosate-treated plants had higher regrowth 1 MAT than when treated with imazapyr, but these differences were not significant 3 MAT. No regrowth was observed from any treatments at the St. Johns River location (data not shown). This indicates that the herbicides had translocated throughout most of the plant tissues even when water was present at the time of herbicide application at Myakka River State Park. At Myakka River State Park, when water was present at different depths among experimental sites, there seemed to be some differences in control between the two sites 1 MAT (data not shown), but these differences were no longer present 3 MAT. Therefore, water depth at application may influence control of WIMG.

Vault experiments. Water depth at application was of concern because control of torpedograss (*Panicum repens* L.) was influenced by the amount of exposed leaf tissue with application of glyphosate (Smith et al. 1999). We hypothesized that increasing water depth would negatively impact control of WIMG with herbicides. Water depth did not affect control, however, and there was no water depth by herbicide treatment interaction; therefore, data were combined and separated based on herbicide treatment ($p < 0.001$). At 1 MAT, glyphosate provided the poorest level of control (72%), whereas all other treatments provided at least 83% control (Table 3). There were no differences among treatments 2 MAT and all treatments provided at least 96% control. West Indian marsh grass biomass was reduced by as much as 97% 2 MAT, with no significant differences among treatments.

These data indicate that there was sufficient leaf tissue above the water surface to allow for effective herbicide applications to WIMG. Therefore, it seems that WIMG can be treated with glyphosate and/or imazapyr even when inundated. This is important because WIMG can be treated during both the dry and rainy seasons in Florida. Note that retreatment will be necessary with glyphosate because control with this herbicide seems to diminish over time and regrowth does occur (B. Sellers, pers. observ.). Based on both field and vault experiments, imazapyr at 1.1 kg/ha would provide the best control of WIMG at any growth stage or if water is present. Imazapyr also seemed to provide control of para grass, allowing native broadleaf and grass species to reestab-

TABLE 3. VISUAL CONTROL (PERCENT BIOMASS REDUCTION) 30 AND 60 DAYS AND BIOMASS REMAINING 60 DAYS AFTER APPLICATION OF HERBICIDES TO WEST INDIAN MARSH GRASS AVERAGED OVER THREE WATER DEPTHS (THE INFLUENCE OF WATER DEPTH WAS NOT SIGNIFICANT).

Treatment	Rate	30 days	60 days	Biomass
	kg/ha	------ % control	------	g
Glyphosate	4.2	72	97	14
Imazapyr	1.1	85	98	15
Imazapyr	1.7	83	96	10
Glyphosate + imazapyr	4.2 + 1.7	88	99	7
Untreated		—	—	244
LSD (0.05)	—	8	NS	12

lish treated areas. Glyphosate is another option, especially where sensitive oaks (*Quercus* sp.) and other native trees are present, but retreatment will be necessary with any herbicide program because no treatments provided 100% control of WIMG. If glyphosate is applied to remove WIMG, plants will need to be monitored every 6 months to prevent escapes. In contrast, if imazapyr is utilized, WIMG plants should be monitored every 12 months to prevent reestablishment.

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