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Phytotoxicity of Selected Herbicides on Limpograss (*Hemarthria altissima*)

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INTRODUCTION

Limpograss [*Hemarthria altissima* (Poir) Stapf and C. E. Hubbard] is a stoloniferous tropical grass of the family Poaceae. In its native habitat, limpograss is found along stream banks and in other wet or seasonably wet soils in southern Africa (Oakes 1973). Agronomically, it produces little to no viable seed and reproduction occurs vegetatively by rooting at individual nodes (Quesenberry et al. 1984). However, preliminary data indicate that seed is highly viable (unpublished data). No underground rhizomes are produced.

Florida studies revealed that limpograss was well suited for poorly drained soils such as the flatwoods Spodosols and could be grown in Florida as a source of forage for cattle producers (Quesenberry et al. 1984). As a result, the Florida Agriculture Experiment Station released four limpograss cultivars from 1964 to 1984. Presently, only one limpograss cultivar ('Floralta') is widely accepted by Florida cattlemen and has been planted on at least 81,000 ha (Paul Mislevy, personal communication).

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Planting of limpograss in low-lying areas that are subject to flooding provided Florida cattlemen with a forage that could be grown in areas where bahiagrass (*Paspalum notatum* L.), the most widely grown cattle forage in Florida, is not suitable. Although limpograss will grow in these marginal areas, its nutrient value is lower than that of bahiagrass during the summer growing season due to the accumulation of stems near the base of the plant (Euclides 1985). Additionally, limpograss grows nearly year round providing cattlemen with necessary forage (Quesenberry et al.1984). As a result, limpograss is utilized primarily as a specialty forage that is normally stockpiled for winter grazing.

Limpograss has been found in natural areas, and is thought to be competing with native plant communities. As a result, limpograss has been placed on the Florida Exotic Pest Plant Council's Category II invasive plant list, which is a list of plants that are increasing in number, but not causing ecological harm (FLEPPC 2005). However, the University of Florida-IFAS invasive weed assessment indicates that limpograss can currently be recommended by Florida Extension faculty for forage production (Fox et al. 2005). Therefore, it is important that escaped limpograss swards be controlled so that Florida cattlemen can continue to utilize this important forage resource and to prevent the destruction of native ecosystems.

Prior to dechannelization efforts, much of the Kissimmee River floodplain was dry and suitable for grazing cattle. As a result, ranchers began improving the pastures in the floodplain by planting warm-season forages such as bahiagrass and limpograss in seasonally wet areas. Although not all areas of the floodplain were planted to limpograss, one rancher planted at least 400 ha of limpograss in the mid- to late 1990s. However, no limpograss was recorded in a biological survey prior to diverting water from the man-made canal back into the Kissimmee River. In fact, bahiagrass was the main forage grass recorded (Toth 2005).

After the hydrology of the Kissimmee River was restored, much of the floodplain is under water for 4 months of the year. Bahiagrass and other dry land forage species did not survive inundation. Limpograss, however, thrived under such conditions. Today, it is estimated that the total area of the floodplain infested with limpograss totals over 1000 ha in an area where a broadleaf marsh existed prior to channelization (Ferriter et al. 2006). In order to reestablish the native broadleaf marsh, limpograss must be removed. Additionally, limpograss appears to be spreading to other areas of the floodplain, where cattle ranchers did presumably not plant limpograss.

Limpograss is an important forage for winter grazing cattle in south Florida. Recent observations in the Kissimmee River floodplain, however, revealed that limpograss is spreading and is out-competing native vegetation. Therefore, it is important to determine effective control measures for limpograss. The objective of this research was to determine potential herbicides for limpograss control in the Kissimmee River floodplain.

MATERIALS AND METHODS

An experiment was initiated 12 April, 2005 at the Range Cattle Research and Education Center in Ona, FL to determine the activity of selected aquatic and terrestrial herbicides (Table 1) on limpograss. Each herbicide treatment was applied at three rates with four replications to mature limpograss and to limpograss regrowth (approximately 25 cm tall) following a mowing treatment; an untreated check was also included for all four replications of each limpograss site. A 1.5 m wide backpack sprayer calibrated to deliver 187 L/ha at 186 kPa was used to apply all herbicide treatments. Plot size was 1.5 by 6.0 m. Percent ground cover (visual estimation) data were recorded the day prior to herbicide application. Visual observations of limpograss control were recorded 1, 3 and 12 months after application on a scale of 0 to 100, where 0 represents no control and 100 represents complete death. Live biomass was harvested from each plot 6 months after treatment by clipping all above-ground growth 5 cm above the soil surface; 0.6 by 3 m was randomly selected from the center each plot, harvested and total biomass recorded. A sub-sample was dried for 4 days at 50 C to estimate dry matter production for each plot. After biomass harvests were complete, the entire experimental area was flail-chopped to a 30 cm height to visually monitor regrowth 12 months after treatment.

The experimental design was a split-block with four replications. The block treatment was mowed or non-mowed, and the individual plots represented the herbicide treatments. All data were analyzed with analysis of variance and means separated with Fisher's Protected LSD (P=0.05). Data were checked for homogeneity of variance and normality. An arcsin square root transformation was performed on visual control data; however, this transformation did not improve the normality of the data nor affect the assumptions of statistical tests. Biomass data were converted to percent of the untreated check prior to analysis of variance.

RESULTS AND DISCUSSION

Prior to herbicide applications average ground cover ranged from 86 to 100% in the non-mowed portion of the study and 91 to 95% in the mowed portion. The variation in ground cover was greater in the non-mowed portion of the study because of open areas near the edge of the limpograss sward.

The block by treatment interaction was not significant ($p(F) = 0.22$) for visual control ratings 1 month after treatment (MAT) (Table 1). Therefore, data were combined over blocks. Many of the herbicides caused visual injury 1 MAT. Effects of all three glyphosate (N-phosphonomethyl-glycine) rates were statistically similar, ranging from 55 to 83% control. Visual control from glyphosate applied at 2.24 and 3.34 kg ae/ha was significantly higher than treatments of all other herbicides. At this evaluation date, fluazifop at 0.42 kg/ha, with a visual rating of 27%, was similar to 1.12 kg/ha glyphosate and all other herbicide treatments.

There was a block by treatment interaction ($p(F) < 0.0001$) 3 MAT (Table 1). Glyphosate provided 96-99% and 71-95% control 3 MAT in non-mowed and mowed limpograss, respectively, and provided significantly greater control than all other herbicide treatments. Mowing reduced limpograss control when glyphosate was applied at 1.12 kg/ha, compared to non-mowed limpograss. At least 2.24 kg/ha

TABLE 1. VISUAL CONTROL AND BIOMASS (± SE) OF NON-MOWED AND MOWED LIMPOGRASS AFTER TREATMENT WITH TERRESTRIAL AND AQUATIC HERBICIDES. HERBICIDES WERE APPLIED ON 12 APRIL, 2005.

		Visual control[1]					Biomass[2]	
		1 MAT[3]	3 MAT		12 MAT		6 MAT	
Treatment	Rate		Non-mowed	Mowed	Non-mowed	Mowed	Non-mowed	Mowed
	kg/ha	%					% of control	
2,4-D amine	1.07	3 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	116 (9.6)	115 (12.9)
	2.13	8 (2.3)	3 (2.5)	0 (0)	0 (0)	0 (0)	104 (10.9)	82 (3.4)
	4.26	5 (1.0)	0 (0)	0 (0)	0 (0)	0 (0)	113 (9.0)	83 (21.2)
Triclopyr	0.56	3 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	113 (17.2)	98 (14.2)
	1.12	5 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	109 (17.4)	81 (15.9)
	2.24	8 (1.9)	0 (0)	0 (0)	0 (0)	0 (0)	104 (17.1)	77 (13.4)
Imazapic	0.28	10 (3.1)	0 (0)	0 (0)	0 (0)	0 (0)	101 (10.5)	83 (17.0)
	0.56	12 (2.1)	0 (0)	0 (0)	0 (0)	0 (0)	116 (5.6)	78 (15.1)
	1.12	14 (1.8)	15 (8.7)	8 (2.5)	0 (0)	0 (0)	91 (9.8)	77 (14.3)
Glyphosate	1.12	55 (9.2)	96 (1)	71 (4.3)	89 (4.1)	21 (7.2)	4 (2.7)	70 (20.8)
	2.24	83 (2.3)	97 (1.3)	95 (0)	98 (1.1)	84 (4.3)	0 (0)	47 (33.2)
	3.37	73 (12.8)	99 (0.3)	95 (0)	99 (1.3)	66(16.8)	0 (0)	0 (1.4)
Carfentrazone	0.01	3 (3.4)	0 (0)	0 (0)	0 (0)	0 (0)	115 (12.6)	81 (8.0)
	0.02	3 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	130 (16.2)	93 (19.8)
	0.03	4 (1.5)	0 (0)	0 (0)	0 (0)	0 (0)	127 (17.8)	92 (17.7)
Diquat	0.56	4 (0.8)	0 (0)	0 (0)	0 (0)	0 (0)	89 (6.7)	79 (13.2)
	1.12	5 (0.9)	0 (0)	3 (2.5)	0 (0)	0 (0)	113 (19.7)	63 (11.7)
	2.24	8 (2.7)	5 (5.0)	0 (0)	0 (0)	0 (0)	91 (11.8)	66 (6.7)
Penoxsulam	0.035	4 (1.8)	3 (2.5)	0 (0)	0 (0)	0 (0)	143 (10.6)	87 (16.2)
	0.042	3 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	129 (29.8)	88 (17.0)
	0.049	4 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	111 (12.7)	82 (17.8)
Clethodim	0.07	20 (11.4)	0 (0)	0 (0)	0 (0)	0 (0)	115 (15.8)	87 (18.5)
	0.14	15 (3.0)	3 (2.5)	0 (0)	0 (0)	0 (0)	98 (14.9)	96 (16.8)
	0.28	19 (2.1)	5 (2.9)	0 (0)	0 (0)	0 (0)	103 (13.0)	89 (14.2)
Aminopyralid	0.05	1 (0.8)	0 (0)	0 (0)	0 (0)	0 (0)	118 (22.4)	86 (20.4)
	0.09	3 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	113 (19.4)	71 (19.2)
	0.12	3 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	92 (21.1)	88 (22.1)
Nicosulfuron	0.04	8 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	104 (21.5)	80 (12.9)
	0.05	11 (1.8)	0 (0)	0 (0)	0 (0)	0 (0)	105 (25.8)	69 (18.0)
	0.07	12 (1.6)	4 (3.3)	3 (2.5)	0 (0)	0 (0)	121 (5.2)	83 (13.8)
Foramsulfuron	0.22	15 (2.7)	0 (0)	0 (0)	0 (0)	0 (0)	88 (21.4)	71 (19.8)
	0.43	19 (2.5)	13 (4.8)	5 (4.3)	0 (0)	0 (0)	108 (19.9)	71 (17.7)
	0.64	20 (1.9)	14 (2.4)	18 (0)	0 (0)	0 (0)	122 (5.3)	60 (14.8)
Fluazifop + Fenoxaprop	0.13	16 (1.5)	5 (2.9)	5 (4.3)	0 (0)	0 (0)	83 (6.8)	68 (13.4)
	0.21	22 (3.7)	45 (5.0)	23 (0)	0 (0)	0 (0)	59 (6.1)	66 (14.1)
	0.42	22 (1.6)	65 (3.5)	60 (4.1)	0 (0)	0 (0)	55 (7.8)	51 (14.6)
Glufosinate	0.41	11 (2.1)	20 (9.1)	3 (2.5)	0 (0)	0 (0)	91 (3.3)	60 (6.2)
	0.44	10 (1.6)	15 (8.7)	3 (2.5)	0 (0)	0 (0)	77 (10.0)	81 (15.4)
	0.47	9 (1.6)	13 (9.5)	0 (0)	0 (0)	0 (0)	101 (23.5)	89 (16.8)
Fluazifop	0.11	15 (1.9)	3 (2.5)	0 (0)	0 (0)	0 (0)	75 (11.1)	76 (13.3)
	0.21	23 (4.1)	23 (6.3)	10 (4.1)	0 (0)	0 (24.8)	50 (5.5)	62 (7.2)
	0.42	27 (3.3)	66 (4.7)	51 (7.7)	0 (0)	0 (0)	60 (1.8)	50 (14.1)
Carfentrazone + 2,4-D amine	0.03 + 1.07	5 (1.6)	3 (2.5)	0 (0)	0 (0)	0 (0)	78 (9.1)	92 (20.6)
	0.03 + 2.13	3 (0.9)	3 (2.5)	0 (0)	0 (0)	0 (0)	105 (10.7)	69 (12.3)
	0.03 + 4.26	5 (0.9)	8 (2.5)	0 (0)	0 (0)	0 (0)	123 (28.1)	71 (14.8)
LSD1 (0.05)[4]		28	8		12		34	
LSD2 (0.05)		—	8		4		54	
LSD3 (0.05)		—	8		9		32	

[1]Visual control refers to the amount of control based on a scale of 0 to 100, where 0 represents no control and 100 represents complete plant death.
[2]Biomass in the untreated checks averaged 725 g/m^2 in non-mowed and 1074 g/m^2 in mowed limpograss
[3]Abbreviations: MAT, months after treatment.
[4]LSD 1 separates means within a column, LSD2 separates means across columns within the same treatment, LSD3 separates means within and across columns for all treatments.

glyphosate was needed to obtain greater than 90% control of mowed limpograss. Mowing limpograss before herbicide application also affected control by 0.42 kg/ha fluazifop, resulting in 66 and 51% control for non-mowed and mowed limpograss, respectively.

There was a block by treatment interaction (p(F) = 0.0053) for limpograss biomass 6 MAT (Table 1). When limpograss was not mowed prior to herbicide treatment, glyphosate caused at least a 96% reduction in limpograss biomass compared to the untreated check. In contrast, mowing limpograss prior to an application of 1.12 kg/ha glyphosate resulted in only a 30% reduction in biomass compared to the untreated check. Increasing the rate to 2.24 kg/ha glyphosate statistically removed the differences in biomass between non-mowed and mowed limpograss even though the difference between biomass of non-mowed and mowed limpograss was 47%. Although this was not statistically significant, mowing limpograss prior to an application of 2.24 kg/ha glyphosate would not be beneficial, if the desired effect is complete control.

Glyphosate was the only herbicide that controlled limpograss 12 MAT (Table 1). Additionally, a block by treatment interaction (p(F) < 0.001) indicated that mowing reduced limpograss control at all three glyphosate rates. Control by all other herbicide treatments was similar to the untreated check.

Mowing appears to have an influence on limpograss control, especially with glyphosate. It is possible that the non-mowed limpograss was growing from all meristematic tissues, resulting in translocation of the herbicide into the meristems and ultimately, plant death. In mowed limpograss, it is possible that some meristematic tissues were dormant, which would result in glyphosate translocation only to actively growing tissues. Additionally, although regrowth occurred after mowing prior to herbicide application, the amount of leaf area present for herbicide interception and uptake may have impacted glyphosate efficacy. Therefore, if limpograss is mowed prior to herbicide application, 3.36 kg/ha glyphosate will need to be applied for complete control.

The advantage to mowing, however, is removal of top growth allowing light to reach the soil surface, which is needed for germination and establishment of desirable species. In this experiment, dead limpograss material in the non-mowed glyphosate treatments prevented the emergence of weed species. In contrast, species diversity increased in plots where glyphosate was applied to mowed limpograss (data not shown). Therefore, if an area cannot be mowed prior to glyphosate application, we speculate that burning the area after herbicide application may be required for establishing native species.

This research was performed on a poorly drained soil that is not subject to seasonal inundation. Therefore, the effects of these herbicides may be different in areas similar to that of the restored Kissimmee River floodplain. For example, the effect of water depth and/or soil moisture at the time of herbicide application may impact the results (Smith et al. 1999). Therefore, the effect of water depth on glyphosate activity on limpograss needs to be evaluated.

In addition, decomposing limpograss could adversely affect the germination and establishment of native species. Intact limpograss roots have been shown to exude allelopathic chemicals that prevent radicle elongation (Young and Bartholomew 1981; Tang and Young 1982). Therefore, it is possible that decaying limpograss may release these inhibitory chemicals, and more research is needed to understand the effects of decaying limpograss on desirable species.

This research suggests that glyphosate can be utilized for control of limpograss. In addition, it appears that the control of this species is quite simple compared to that torpedograss (*Panicum repens*) and cogongrass (*Imperata cylindrica*) (Smith et al. 1999; MacDonald 2004). The control of limpograss in native ecosystems should not be delayed as limpograss quickly forms monospecific swards out competing and preventing native plant establishment. Therefore, treatment of limpograss swards with glyphosate should be performed with little concern for non-target damage as limpograss has the potential to out compete desirable species.

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LITERATURE CITED

Euclides, V. P. B. 1985. Quality evaluation and cattle grazing behavior on bahiagrass and limpograss pastures. Ph.D. diss. Univ. Florida, Gainesville.

Ferritter, A., B. Doren, C. Goodyear, D. Thayer, J. Burch, L. Toth, M. Bodle, J. Lane, D. Schmitz, P. Pratt, S. Snow and K. Langeland. 1996. Chapter 9: The status of nonindigenous species in the south Florida environment. *In:* G. Redfield (ed.) 2006 South Florida Environment-Volume I. 102 pp.

FLEPPC. 2005. List of Florida's Invasive Species. Florida Exotic Pest Plant Council. Internet: http://www.fleppc.org/list/05list.htm.

Fox, A. M., D. R. Gordon, J. A. Dusky, L. Tyson and R. K. Stocker. 2005. IFAS assessment of the status of non-native plants in Florida's natural areas. Cited from the internet June 13, 2006, http://plants.ifas.ufl.edu/assessment.html.

MacDonald, G. E. 2004. Cogongrass (*Imperata cylindrica*)—biology, ecology, and management. Critical Reviews in Plant Science 23:367-380.

Quesenberry, K. H. 1993. Limpograss cultivars for Florida: Past, present, and future. 42nd Annual Florida Beef Cattle Short Course Proceedings. Gainesville, FL. 5 pp.

Quesenberry, K. H., W. R. Ocumpaugh, O. C. Ruelke, L. S. Dunavin and P. Mislevy. 1984. Floralta-A limpograss selected for yield and persistence in pastures. Florida Agric. Exp. Stn. Circ. S-312.

Smith, B. E., K. A. Langeland and C. G. Hanlon. 1999. Influence of foliar exposure, adjuvants, and rain-free period on the efficacy of glyphosate for torpedograss control. J. Aquat. Plant Manage. 37:13-16.

Tang, C. and C. Young. 1982. Collection and identification of allelopathic compounds from the undisturbed root system of Bigalta limpograss (*Hemarthria altissima*). Plant Physiol. 69:155-160.

Toth, L. A. 2005. Plant community structure and temporal variability in a channelized subtropical floodplain. Southeastern Naturalist. 4:393-408.

Young, C. C. and D. P. Bartholomew. 1981. Allelopathy in a grass-legume association: I. Effects of *Hemarthria altissima* (Poir.) Stapf. And Hubb. root residues on the growth of *Desmodium intortum* (Mill.) Urb. and *Hemarthria altissima* in a tropical soil. Crop Sci. 21:770-774.