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Evaluation of Four Herbicides for Management of American Frogbit (*Limnobium spongia*)

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INTRODUCTION

American frogbit (*Limnobium spongia* (Bosc) Steudel) is a native aquatic monocot found in the southern United States through Texas and up the eastern, coastal states to New Jersey (Gleason and Cronquist 1991). It exhibits two growth habits, a rooted emergent form and a free-floating rosette form (Tarver et al. 1988) and is generally found in marshes or slowly flowing waters (Aulbach-Smith and de Kozlowski 1990). Although a native plant, American frogbit can produce extensive floating mats and create nuisance situations, such as blocking navigation, affecting water quality, fish and wildlife habitat, and recreational usage. From a distance, these mats may be misidentified as waterhyacinth (*Eichhornia crassipes* (Mart.) Solms). In Texas, dense mats occurs as replacement vegetation following herbicide application using 2,4-D (2,4-dichlorophenoxy acetic acid) to control waterhyacinth (R. Helton, TPWD, pers. comm.). It has been reported that American frogbit can be difficult to control with herbicides and that most control efforts in Florida have relied upon various herbicide tank mixtures (Langeland et al. 1995). The purpose of this small-scale study was to examine the efficacy of four aquatic herbicides for managing American frogbit.

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METHODS AND MATERIALS

This research was conducted at the US Army Engineer Waterways Experiment Station's, Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, TX (Latitude 33°04'45"N, Longitude 96°57'33"W) during the summer and fall months of 1993. American frogbit was collected from the J. D. Wildlife Management Area east of Port Arthur, TX, in June and transported to the LAERF. Four free-floating mature plants (mean = 3.69 g dw) were placed into 3.75L (1 gallon) containers (65 total) filled with water from nearby Lake Lewisville. Each container was amended with 4.5 g of ammonium sulfate, and water was added to a uniform level as needed. Plants were grown outdoors for one month prior to herbicide application. Five containers of plant samples were harvested at the time of treatment and processed as described below to provide a pre-treatment estimate of biomass.

Herbicides tested were diquat (6,7-dihydropyrido(1,2-∝:2',1'-c) pyrazinediium dibromide) with the trade name Reward; 2,4-D (2,4-dichlorophenoxy) acetic acid) with the trade name Weedar 64; and glyphosate (N-(phosphonomethyl)glycine) with the trade name Rodeo. In addition, the efficacy of the US EPA Experimental Use Permit aquatic herbicide triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid triethylamine salt) was evaluated with the trade name Renovate. Although 2,4-D and triclopyr are generally used to control dicots, these herbicides provide excellent control of the broad-leaved monocot, waterhyacinth, and therefore were included in this survey.

Herbicides were applied using a CO_2-pressurized spray system. Individual containers of plants were placed in a 0.5m^2 spray box and sprayed for 5 seconds to provide the following application rates: diquat as diquat dibromide, 1.05kg/ha (1 qt Reward/acre), 2.1 kg/ha (2 qt. Reward/

acre), 4.2 kg/ha (4 qt Reward/acre); 2,4-D as the acid, 1.08 kg/ha (1 qt Weedar 64/acre), 2.16 kg/ha (2 qt Weedar 64/acre), 4.32 kg/ha (4 qt Weedar 64/acre); triclopyr as the acid, 0.85 kg/ha (1 qt Renovate/acre), 1.69 kg/ha (2 qt Renovate/acre), 3.38 kg/ha (4 qt Renovate/acre); and glyphosate as the isopropylamine salt, 1.93 kg/ha (1.25 qt Rodeo/acre), 3.86 kg/ha (2.5 qt Rodeo/acre), 7.72 kg/ha (5 qt Rodeo/acre). These doses represented the low (25%), medium (50%) and maximum (100%) of the highest recommended label rates of each compound for treating floating vegetation. In addition, the aquatic surfactant X-77, was added to the tank mix at 0.25% v/v, and water was added as a diluent to deliver a field-equivalent total spray volume of 935L/ha (100 gal/acre).

Treatments were completely randomized and replicated five times. In addition, five containers of frogbit were left untreated as experimental controls. Herbicides were applied in early September and treated plants were monitored for visual damage symptoms weekly. No sub-freezing air temperatures occurred during the study period. Plants were harvested 12 weeks after herbicide application. Living green plant tissue was separated and dried at 55 C in a Blue M forced air oven (General Signal, Atlanta, GA) for 48 hours and weighed. Statistical analyses of biomass between treatments were determined using an ANOVA (analysis of variance), with a Tukey's standard difference test being employed for a comparison of the treatment means. Efficacy ratings were assigned as excellent (75-100% control), good (50-74% control), or poor (<50%) based on percent reduction of biomass.

RESULTS AND DISCUSSION

The contact herbicide diquat gave excellent control (99-100%) of American frogbit for all application rates, with no significant differences between rates and all rates significantly different from the untreated reference ($p < 0.01$) (Figure 1). Within 24 hours posttreatment, the diquat-treated frogbit exhibited necrotic symptoms; and by 96 hours posttreatment the plants were dead. These results are similar to those reported in a previous study which found that diquat controlled American frogbit in Florida (Langeland et al. 1995).

The systemic herbicide 2,4-D gave good to excellent control of American frogbit (53 to 80% reduction in biomass) with no significant differences among treatment rates (Figure 1). All application rates for 2,4-D were significantly different from the untreated reference ($p < 0.02$). The 2,4-D treated plants did not exhibit injury symptoms (necrosis, chlorosis) until 96 hours posttreatment, and then, only plants treated with the maximum label rate showed symptoms. However, all application rates for 2,4-D exhibited visual injury symptoms by nine days posttreatment and necrosis effects through the 12 weeks.

Triclopyr, also a systemic herbicide gave excellent control of American frogbit at all three application rates (Figure 1). All rates were significantly different from the untreated reference ($p < 0.01$) with control values ranging from 78% for the low rate to nearly 95% for the maximum label rate. There were no significant differences among the application rates. Visual injury symptoms were noticeable at 24 hours posttreatment for the maximum application rate, and by nine days posttreatment necrosis was exhibited by all application rates.

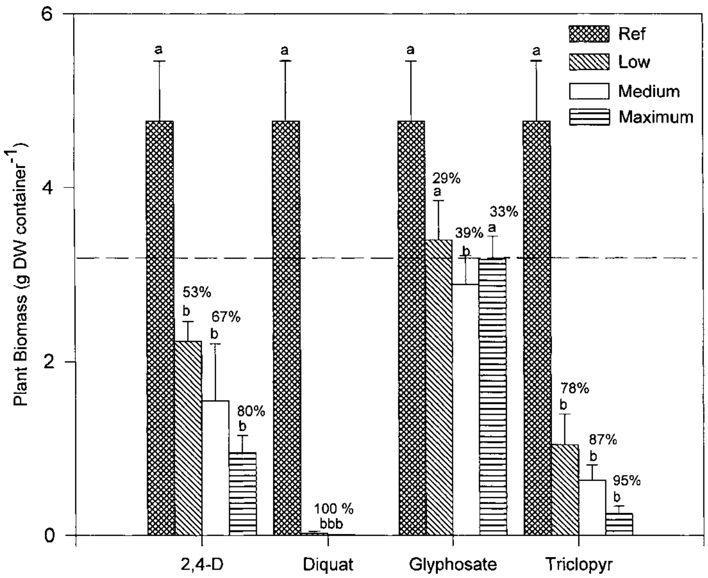

Figure 1. Total plant biomass (g DW container^{-1}) of American frogbit at low, medium and maximum label rate for four herbicides as compared to untreated reference. Bars indicate ± standard error of the mean, and letters and percentages above bars indicate significant difference at $p = 0.05$ using ANOVA and Tukey's comparison of means, and % control, respectively. Dashed horizontal line indicates biomass at the time of treatment.

Only the medium application rate showed significant difference as compared to the untreated reference plants ($p < 0.03$) for the systemic herbicide glyphosate. Although visual inspection found some necrosis and chlorosis, plants generally were not affected by the herbicide treatment. Langeland et al. (1995) reported that glyphosate did not provide adequate control of American frogbit after 3 months posttreatment at comparable application rates.

This study demonstrated good to excellent control of American frogbit at all rates with diquat and triclopyr. However, the application method used in this study ensured nearly complete herbicide coverage of the plants, which may not be possible under field conditions. Efficacy of diquat may be lower under operational conditions than for triclopyr, which translocates throughout the plant. Although this study was conducted on mature frogbit plants, maintenance programs conducted on waterhyacinth in Florida have demonstrated that applying herbicides earlier in the growing season increase efficacy. Field studies should be conducted to evaluate the influence of application timing and the efficacy of tank mixes of these products and various approved surfactants on American frogbit.

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LITERATURE CITED

Aulbach-Smith, C. A. and S. J. De Kozlowski. 1990. Aquatic and Wetland Plants of South Carolina. South Carolina Aquatic Plant Management Council, Columbia, SC. 33 pp.

Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden, Bronx, NY. 638 pp.

Langeland, K., B. Smith, N. Hill, S. Grace, M. Cole, J. Drew, and E. Meadows. 1995. Evaluation of herbicides for control of American frogbit. Aquatics 17(3): 16-19.

Tarver, D. P., J. A. Rodgers, M. J. Mahler, and R. L. Lazor. 1988. Aquatic and Wetland Plants of Florida. Bureau of Aquatic Plant Management, Florida Department of Natural Resources, Tallahassee, FL. 22 pp.