J. Aquat. Plant Manage. 37: 13-16

Influence of Foliar Exposure, Adjuvants, and Rain-free Period on the Efficacy of Glyphosate for Torpedograss Control

B. E. SMITH[1], K. A. LANGELAND[1] AND C. G. HANLON[2]

ABSTRACT

The proportion of torpedograss tissue exposed to glypho-

tissue exposure was more pronounced as application rate decreased. This study suggests that higher rates of glyphosate need to be used during higher water levels, when less torpedograss tissue is exposed to herbicide spray and lower rates may be used during periods of low water levels. Addition of the water conditioning agent Quest® (0.25% v/v) to glyphosate spray mixtures diminished the influence of simulated rain events following glyphosate application. Twelve other adjuvants did not influence the effect of simulated rain events.

Key Words: surfactant, herbicide, *Panicum repens*, perennial.

INTRODUCTION

Torpedograss (*Panicum repens* L. Beauv.) is a perennial, amphibious grass found throughout the subtropical and tropical world (Holm et al. 1977). The Florida Aquatic Plant Survey Report of 1992 (Schardt 1992) ranked torpedograss as the second most prevalent exotic weed found in public waters. In Lake Okeechobee alone nearly 14,000 acres were reported. Problems caused by torpedograss include impeded drainage and thus reduced flood control, displacement of native aquatic vegetation and disturbed wildlife habitat (Tarver 1979).

Torpedograss has an aggressive growth habit with extensive rhizomes, which comprise 70-90% of the total plant biomass (Smith et al. 1993). To effectively control a perennial weed such as torpedograss, the rhizomes must be killed. To kill rhizomes of perennial plants, herbicides must be absorbed and translocated to the rhizomes in quantities that are toxic (Lee 1986, Wyse 1988). Glyphosate is a translocated, nonselective herbicide, which is registered and extensively used to manage torpedograss in aquatic environments (Shilling and Haller 1989). Generally, glyphosate provides excellent control of many perennial species. A single application, however, does not provide long-term (greater than one year) control of torpedograss and repeat applications are necessary (Manipura and Somaratne 1974). The extent of herbicide coverage and corresponding control of torpe-

small portion of the tissue emerged and exposed to the herbicide spray. If a relation exists between the amount of exposed plant tissue and glyphosate efficacy, then aquatic plant managers could schedule glyphosate applications during natural or artificial low water periods when the greatest amount of tissue is exposed to the herbicide or adjust glyphosate rates.

The time of application may influence the success of glyphosate on torpedograss. In temperate zones, fall applications of glyphosate are considered most effective because this coincides with the time of natural basipetal translocation period, and more glyphosate is moved to the rhizomes for better control (Ivany 1975, Parochetti 1975). Another explanation for seasonal effects of glyphosate applications in Florida is the influence of weather patterns. During fall and winter, rain events in Florida are influenced by fronts moving from the north. However, summer weather patterns are characterized by frequent afternoon thunderstorms, especially in south Florida. Diminished torpedograss control in the spring and summer with glyphosate may be due to the herbicide being washed off during storm events. Herbicide adjuvants which hasten glyphosate uptake would ameliorate the problem of wash-off that occurs following rain and enhance torpedograss control (Willard et al. 1997).

The purpose of this research was to investigate the relationship between the proportion of tissue exposed (non-submerged) to glyphosate and subsequent torpedograss control and to evaluate herbicide adjuvants for influence on the negative affect of rain on glyphosate efficacy.

MATERIALS AND METHODS

Experiment 1: Influence of the proportion of tissue exposed to glyphosate on torpedograss control. Mature torpedograss plants (foliage length >60 cm), were grown from 15 cm rhizome sections planted in commercial growing medium (Metro Mix 220®) amended with Osmocote® slow release fertilizer. Torpedograss was planted and matured in 1 liter pots placed under an canopy style plastic greenhouse that was not thermally regulated. Temperature fluctuated from 15 to 38 C. Individual plants received a single dose of glyphosate at rates of 0, 0.28, 0.56, 1.12, 2.24, and 4.48 kg/ha. Glyphosate solutions were prepared using the commercial formulation Rodeo®. Herbi-

[1]University of Florida Institute of Food and Agricultural Sciences, Agronomy Department, Center for Aquatic and Invasive Plants, Gainesville, FL 32653.

[2]Okeechobee Systems Research Division, South Florida Water Management District, West Palm Beach, FL 33416. Received for publication April 10, 1998 and in revised form November 10, 1998.

cide solutions were prepared based on a 935 l/ha (100 GPA) delivery rate. Kinetic®, an organosilicone surfactant was added at 0.25% v/v. Amount of foliage exposed was varied by submerging 20, 40, 60, 80 or 100% leaf tissue (based on shoot length) into a given herbicide solution. Treated plants were kept inverted until dry. Seven days after treatment, plants were pruned to a 5 cm height so that treatment effects were based on regrowth only. After a four week regrowth period, regrown shoots were removed, dried, and weighed. The study was conducted twice with each treatment replicated four times. Data were subjected to analysis of variance and were pooled because there was no interaction between experiments. Means were separated by LSD (P = 0.05).

Experiment 2: Evaluation of herbicide adjuvants to reduce the negative affect of rain on glyphosate efficacy. Mature torpedograss plants (foliage length >60 cm), were grown from 15 cm rhizome sections planted in commercial growing medium (Metro Mix 220®) amended with Osmocote® slow release fertilizer. Torpedograss was planted and matured in 1 liter pots placed under an canopy style plastic greenhouse that was not thermally regulated. Temperature fluctuated from 15 to 38 C. Soil moisture was maintained at field capacity by sub-irrigating. Individual plants received a single 1.12 kg/ha dose of glyphosate using a CO_2 pressurized micro-applicator calibrated to deliver 935 l/ha. The adjuvants tested are described and the concentrations used are given in Table 1 (note Kinetic was increased from 0.1 to 0.25% v/v in study 2). Each of the adjuvents listed in Table 1 were added to the herbicide solution by themselves or were tank-mixed with one of the following at the given rate:

1. SUN-IT II (0.5% v/v) Multi component Spray Adjuvant company: American Cyanamid
2. Quest (0.25% v/v) Water Conditioning Agent and Activator company: Setre Chemical
3. 93SD155 (0.5% v/v) *experimental* Sticker Extender company: Nalco Chemical

Simulated rainfall events (SRE) of 2.54 cm were made at 1, 4, 8, 12, 24, and 72 hours after herbicide application and a control group, receiving no rainfall, was also included. Treated plants were placed in a greenhouse. Seven days after the SRE, treated foliage was pruned to a 5 cm stubble height so that treatment efficacy was based on regrowth only. After an eight week period, all regrown foliage was removed, dried for three days at 70 C, and weighed.

The experimental design was a completely randomized design with factorial arrangement of treatments. The experiment was conducted twice with treatments replicated four times. Data were subjected to analysis of variance and means separated by LSD (P = 0.05). Due to a significant treatment by experiment interaction, experiments were analyzed and presented separately.

RESULTS AND DISCUSSION

Experiment 1: Influence of proportion of tissue exposed to glyphosate on torpedograss control. There was a significant interaction between rate and coverage (Figure 1). The influence of increasing coverage was best observed at the three lowest glyphosate rates (0.28, 0.56, and 1.12 kg/ha). At the 2.24 kg/ha rate, the influence of percent coverage was only evident at 20% exposure. Presumably the 2.24 kg/ha rate was at or near the dose where lethality of the herbicide begins to mask the influence of coverage. The 4.48 kg/ha rate of glyphosate provided ≥90% torpedograss control at all coverages. However, for the 2.24, 1.12, and 0.56 kg/ha rates to achieve 90% control or better, coverage had to be at least 40, 60, and 80%, respectively. The 0.28 kg/ha rate never provided 90% torpedograss control.

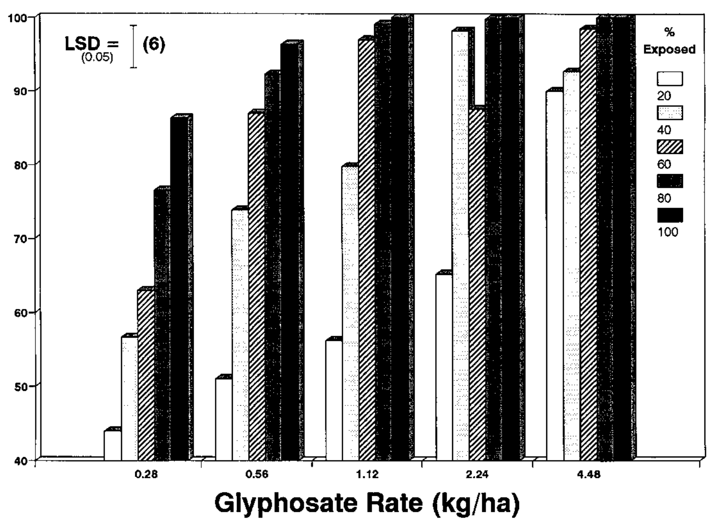

Figure 1. Influence of glyphosate rate (kg/ha) and proportion of tissue exposed (% exposed) on torpedograss control (% inhibition).

TABLE 1. ADJUVANTS TESTED TO ENHANCE GLYPHOSATE EFFICACY ON TORPEDOGRASS.

Adjuvant Name	% vol/vol	Label Description	Company
Kinetic	0.1 (study 1) 0.25 (study 2)	Nonionic Wetter/Spreader/Penetrant Adjuvant	Setre Chemical Company
Sunwet	0.5	Nonionic Wetter/Spreader	Brewer International
Induce	0.5	Nonionic Low Foam Wetter/Spreader Adjuvant	Setre Chemical Company
Unifilm	0.5	Nonionic Spreader Activator	Asgrow Florida Company
Activate Plus	0.5	Nonionic Spreader Activator	Riverside/Terra Corp.
Surfaid	0.5	Nonionic 80/20 Surfactant	Asgrow Florida Company
X-77	0.5	Nonionic Spreader Activator	Loveland Industries, Inc.
Silenergy	0.25	Nonionic Wetter/Spreader/Penetrant Adjuvant	Brewer International
Cide Kick	0.5	Nonionic Activator Adjuvant	JLB International Chemical
Patrol	0.25	Blend of Nitrogen Solution and Nonionic Adjuvant	Setre Chemical Company

The practical implications are that glyphosate rates can be reduced when the majority of the above ground portion of torpedograss is exposed to the herbicide spray. Under highly flooded conditions or in dense torpedograss stands the higher application rates may overcome limited exposure.

Experiment 2: Evaluation of herbicide adjuvants to reduce the negative affect of rain on glyphosate efficacy. In both studies as rain-free period increased there was a corresponding increase in torpedograss control (less regrowth) regardless of adjuvant treatment (Figure 2). Data were highly variable with regard to the influence of adjuvant combinations on the efficacy of glyphosate. Adjuvant combinations with SUN-IT II and the experimental product 93SD155 do not consistently improve glyphosate activity (data not shown). However, three adjuvant combinations always optimized glyphosate efficacy within any given rain-free period in both studies. The three adjuvant treatments were (bolded in Tables 2 and 3):

1. Kinetic (0.1% v/v) with Quest (0.25% v/v) study 1
   Kinetic (0.25% v/v) with Quest (0.25% v/v) study 2
2. Induce (0.5% v/v) with Quest (0.25% v/v)
3. Silenergy (0.25% v/v) with Quest (0.25% v/v)

The common variable among the three treatments that controlled torpedograss best was Quest®. Quest is labeled as a water conditioning agent for herbicide sprays which is a proprietary blend of the ammonium salts of polyacrylic, hydroxy carboxylic, and phosphoric acids at 50% by volume. Quest alone statistically optimized glyphosate performance 5 of the 6 rain-free periods in both studies. Quest was present in 7 of 16 and 10 of 14 treatments that optimized glyphosate performance 5 out of the 6 rain-free periods in study 1 and 2, respectively. Tank-mixing Quest improved glyphosate efficacy on torpedograss in these studies.

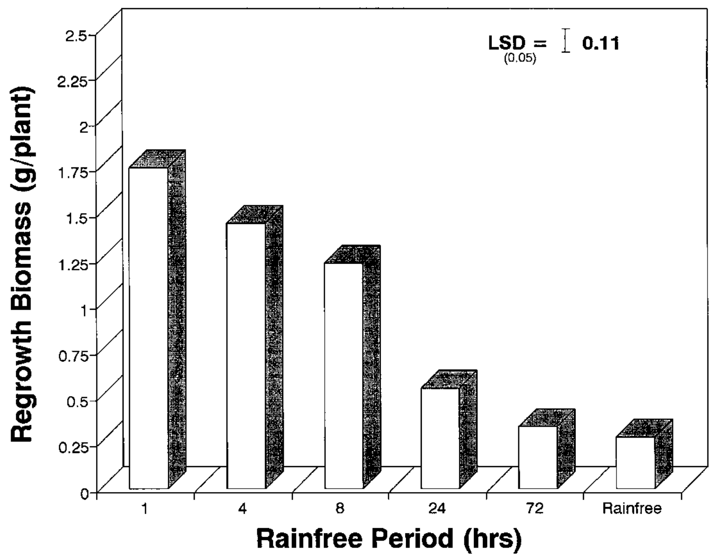

Figure 2. Influence of rain-free period (hrs) on glyphosate efficacy as regrowth biomass (g/plant) on torpedograss.

TABLE 2. THE INFLUENCE OF ADJUVANTS ON GLYPHOSATE EFFICACY ON TORPEDOGRASS (STUDY 1).

Surfactant	% v/v	Additive	% v/v	RFP* 1 hr	RFP 4 hr	RFP 8 hr	RFP 24 hr	RFP 72 hr	RFP Rainfall
				Regrowth Biomass (g)					
Kinetic	0.1	None	0	1.0	1.4	2.1	1.3	1.1	1.1
Sunwet	0.5	None	0	1.4	2.3	0.6	0.9	0.5	0.5
Induce	0.5	None	0	1.4	1.1	1.4	0.3	0.2	0.2
Unifilm	0.5	None	0	1.5	0.5	2.0	0.3	0.3	0.3
Activate Plus	0.5	None	0	1.4	0.7	1.9	0.7	0.0	0.0
Surfaid	0.5	None	0	1.3	1.0	1.2	0.2	0.7	0.7
X-77	0.5	None	0	1.2	1.9	0.9	0.6	0.2	0.2
Silenergy	0.25	None	0	0.9	1.2	2.0	0.5	0.9	0.9
Cide Kick	0.5	None	0	1.9	1.4	0.7	0.4	0.2	0.2
Petrol	0.25	None	0	1.5	0.4	1.7	0.5	0.5	0.5
None	0	None	0	2.6	1.2	1.3	0.6	0.7	0.7
Kinetic	**0.1**	**Quest**	**0.25**	1.1	0.9	1.1	0.2	0.0	0.0
Sunwet	0.5	Quest	0.25	0.9	1.1	0.6	0.7	0.1	0.1
Induce	**0.5**	**Quest**	**0.25**	0.8	1.0	0.5	0.3	0.0	0.0
Unifilm	0.5	Quest	0.25	0.6	1.9	0.7	0.1	0.0	0.0
Activate Plus	0.5	Quest	0.25	0.7	2.1	0.6	0.3	0.0	0.0
Surfaid	0.5	Quest	0.25	1.5	1.9	0.9	0.0	0.0	0.0
X-77	0.5	Quest	0.25	1.9	3.7	0.8	0.1	0.0	0.0
Silenergy	**0.25**	**Quest**	**0.25**	0.9	0.6	0.8	0.1	0.0	0.0
Cide Kick	0.5	Quest	0.25	1.0	1.6	1.4	0.1	0.0	0.0
Petrol	0.25	Quest	0.25	0.4	1.2	0.1	1.1	0.0	0.0
None	0	Quest	0.25	1.3	1.5	0.6	0.3	0.1	0.1
			LSD**	0.87	0.96	1.06	0.51	0.34	0.22

Treatments indicated in bold most consistently improved glyphosate efficacy.
*RFP = Rainfree period.
**Least Significant Difference within a given RFP at the 0.05 significance level.

Table 3. The influence of adjuvants on glyphosate efficacy on torpedograss (Study 2).

Surfactant	% v/v	Additive	% v/v	RFP* 1 hr	RFP 4 hr	RFP 8 hr	RFP 24 hr	RFP 72 hr	RFP Rainfall
				Regrowth Biomass (g)					
Kinetic	0.1	None	0	2.4	2.2	1.4	0.8	0.7	1.0
Sunwet	0.5	None	0	2.1	1.1	1.7	1.8	0.5	0.6
Induce	0.5	None	0	3.8	1.2	1.8	0.9	0.2	0.3
Unifilm	0.5	None	0	2.7	1.7	1.1	1.6	0.4	0.5
Activate Plus	0.5	None	0	0.8	1.3	1.8	0.7	0.9	0.5
Surfaid	0.5	None	0	1.4	1.7	1.0	0.6	0.7	0.7
X-77	0.5	None	0	2.3	1.8	1.6	0.6	0.7	0.5
Silenergy	0.25	None	0	2.4	0.5	0.7	1.7	0.6	0.5
Cide Kick	0.5	None	0	3.2	2.2	1.0	1.0	1.1	1.1
Petrol	0.25	None	0	3.0	0.6	0.6	0.7	0.6	0.4
None	0	None	0	1.8	1.2	1.9	0.9	0.6	0.6
Kinetic	**0.1**	**Quest**	**0.25**	1.5	1.3	1.4	0.4	0.2	0.1
Sunwet	0.5	Quest	0.25	2.1	1.3	1.1	0.2	0.1	0.3
Induce	**0.5**	**Quest**	**0.25**	1.4	1.2	1.0	0.0	0.4	0.0
Unifilm	0.5	Quest	0.25	1.2	1.2	0.7	0.5	0.2	0.5
Activate Plus	0.5	Quest	0.25	1.3	0.7	2.0	0.4	0.1	0.5
Surfaid	0.5	Quest	0.25	1.4	2.3	1.4	0.3	0.1	0.1
X-77	0.5	Quest	0.25	0.8	0.9	1.4	0.3	0.1	0.1
Silenergy	**0.25**	**Quest**	**0.25**	1.2	0.9	1.2	0.2	0.1	0.5
Cide Kick	0.5	Quest	0.25	1.7	0.6	0.9	0.3	0.2	0.1
Petrol	0.25	Quest	0.25	1.7	2.5	2.1	0.2	0.2	0.0
None	0	Quest	0.25	1.1	1.8	0.7	0.4	0.1	0.0
			LSD**	1.27	0.85	1.05	0.7	0.45	0.69

Treatments indicated in bold most consistently improved glyphosate efficacy.
*RFP = Rainfree period.
**Least Significant Difference within a given RFP at the 0.05 significance level.

ACKNOWLEDGMENTS

The authors wish to thank Mr. Neil Hill and Mr. Chance Dubose for their assistance. Contribution of the Florida Agricultural Experiment Station, J. Series No. R-06311. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the University of Florida or the South Florida Water Management District.

LITERATURE CITED

Baird, D. D., G. E. Baker, H. F. Brown, and V. M. Urrutia. 1983. Aquatic weed control with glyphosate in South Florida. Proc. South. Weed Sci. Soc. 36: 430-435.

Holm, L. G., D. L. Plunknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds: Distribution and Biology. University Press of Hawaii, Honolulu. 609 pp.

Ivany, J. A. 1975. Effects of glyphosate applications at different growth stages of quack grass control. Can. J. Plant Sci. 55: 861-863.

Lee, S. A. 1986. Effects of dalapon and glyphosate on *Imparata cylindrica* (L.) Beauv. at different growth stages. MARDI Res. Bull. 14(1): 39-45.

Manipura, W. V. and A. Somaratne. 1974. Some effects of manual and chemical defoliation on the growth and carbohydrate reserves of (*Panicum repens* L. Beauv). Weed Res. 14: 167-172.

Parochetti, J. V., H. P. Wilson, and G. W. Burt. 1975. Activity of glyphosate on johnsongrass. Weed Sci. 23: 395-400.

Schardt, J. D. 1992. Florida Aquatic Plant Survey. Technical Report #942-CGA. 83 pp.

Shilling, D. G. and W. T. Haller. 1989. Interactive effects of diluent pH and calcium content on glyphosate activity on *Panicum repens* L. (Torpedograss). Weed Res. 29: 441-448.

Smith, B. E., D. G. Shilling, W. T. Haller, and G. E. MacDonald. 1993. Factors influencing the efficacy of glyphosate on torpedograss (*Panicum repens* L.). J. Aquat. Plant Manage. 31: 199-202.

Tarver, D. P. 1979. Torpedograss (*Panicum repens* L.). Aquatics 1: 5-6.

Willard, T. R., D. G. Shilling, W. T. Haller, and K. A. Langeland. 1998. Physiochemical factors influencing the control of torpedograss with glyphosate. J. Aquatic Plant Manage. 36: 11-15.

Wyse, K. L. 1988. Perennial weed control. Proc. W. Soc. Weed Sci. 41: 5-7.