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Factors Influencing the Efficacy of Glyphosate on Torpedograss (*Panicum repens* L.)[1]

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ABSTRACT

The effects of burning, disking, and stage of development at the time of glyphosate[3] [(N-phosphonomethyl)glycine] application and a combination of these were evaluated on a natural population of torpedograss (*Panicum repens* L.) during a drawdown of East Lake Tohopekaliga. Disking alone caused an initial reduction of greater than 75% torpedograss in rhizome biomass, and rhizome biomass remained reduced after 1 year by 26% and 44% in 1990 and 1991, respectively. Glyphosate application rates of 1.13, 2.26, and 4.52 kg/ha provided the same level of control regardless of when it was applied or whether the chemical treatment followed disking. Following burning and disking, shoot biomass increased continuously over the 750-day study period. After an initial decrease in rhizome biomass following burning and disking (greater reduction in disked rhizomes), a slight recovery occurred to 20% of the original biomass and then remained constant. The amount of nonstructural carbohydrate in rhizomes increased in the fall suggesting that later herbicide applications might have increased efficacy. Based on these data a single application of glyphosate would provide the best control if applied in the late-fall prior to cold temperatures.

Key words: Disking, burning, mechanical control, stage of development, herbicide, nonstructural carbohydrate.

INTRODUCTION

Torpedograss is a major aquatic and terrestrial weed in the Southeastern United States and other subtropical and tropical regions of the world (3,7,17). Torpedograss has an aggressive growth habit that is supported by an extensive rhizome system. The principal means of dissemination for torpedograss is by rhizomes (4,7,10,15) which are vigorous, competitive, and persistent (7). Torpedograss is especially problematic along shoreline areas of many Florida lakes. Lake margins provide excellent habitat for torpedograss and it forms dense monotypic stands that displace desirable vegetation (16).

The control of torpedograss growing in standing water has proven difficult partially due to the limited amount of herbicide contact (1,14). However, lake levels fluctuate naturally or are controlled artificially. Low water levels provide an exceptional opportunity for intensive torpedograss management. Low water periods expose all the torpedograss foliage allowing better herbicide coverage. Glyphosate is a systemic foliar applied herbicide used for torpedograss control. Generally, glyphosate provides excellent control of many perennial species (9); however, the complete control of torpedograss with a single application rarely occurs (10).

To control a rhizomatous species for a relatively long period, the rhizomes must be destroyed. The herbicide must be absorbed and translocated to the rhizomes in quantities that are phytotoxic (8,18). Glyphosate readily translocates and follows the movement of photosynthates to areas of high metabolic activity (6,12,13). To best control torpedograss with glyphosate, the rhizomes must be the predominant carbohydrate sink at the time of application. A key to improving the control of torpedograss with glyphosate is to better understand the source-sink relationship.

Disturbing rhizomes and allowing regrowth prior to the application of glyphosate has been shown to improve the control of other perennial species (2). Tillage would reduce the stand of torpedograss through direct physical injury, and exposure of the rhizomes to the effects of desiccation, pathogens, and deep burial. Peng and Twu in 1979 (11) reported that disking alone reduced torpedograss biomass by 74%. Furthermore, disking will induce previously inactive axillary buds on the rhizome to produce shoots (3). Additional shoots provide increased sites-of-entry and cause nodes to become active sinks. In addition, by cutting rhizomes into smaller sections, the shoot-to-rhizome ratio will increase. Thus, there will be an increase in the amount of herbicide absorption relative to the mass of rhizome to control.

The objectives of this study were to 1) determine if disking can enhance the activity of glyphosate on torpedograss, 2) determine if time of application influences the

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efficacy of glyphosate, 3) monitor the regrowth of torpedograss following burning and burning plus disking, and 4) assay the seasonal allocation of nonstructural carbohydrates in torpedograss.

METHODS AND MATERIALS

Field studies were conducted during drawdowns of East Lake Tohopekaliga, located near St. Cloud, FL, in 1990 and 1992 on natural stands of torpedograss growing in the littoral zone. In May 1990, a 23-ha field of torpedograss was burned and subsequently one half of this area was disked to a depth of 20 cm. Glyphosate was applied at 1.13, 2.26, and 4.52 kg ae/ha (with 0.5% v/v nonionic surfactant) using a CO_2 backpack sprayer calibrated to deliver 152 L/ha. Untreated plots were included as a control in both the burned and tilled areas. Torpedograss was treated in early July, late July, and August (prebloom, bloom, and late bloom stages of development). Plot size was 15 m^2.

In 1991, burning was not possible, so mowing was substituted for burning. A 1-ha field of torpedograss was mowed and subsequently half this area was disked. Glyphosate was applied at 0.565, 1.13, 2.26, and 4.52 kg ae/ha in the same manner described previously. Due to an unexpected rise in water level only the prebloom treatment was applied.

Shoot and rhizome biomass was collected 1 year after the final treatment in each study. Shoot and rhizome samples were collected from a 1-m^2 quadrat and a 2,000-cm^3 soil core, respectively, from each plot. The soil core sampled to a soil depth of 20 cm. The plant tissue was dried for 72 hr at 70C so that dry weights could be determined.

Time of application and rate were factorially arranged within each of the mechanical practices. The experimental design was a completely randomized block with three replications. The study was conducted twice. Because of logistics, the disking treatment was not randomized and data were analyzed and are presented accordingly. Data were analyzed by analysis of variance to test for main factor effects (rate, stage of development, and year) and interactions. The effects of glyphosate rate were separated using Dunnett's two-tailed "t" test at the 0.05-level of significance. Data are presented as percent (%) inhibition as compared to the untreated control. Mean values are presented with one standard deviation.

Torpedograss regrowth, in areas not treated with a herbicide, was monitored from the burned alone and burned plus disked area from July 1990 through May 1992. Shoot and rhizome samples were collected from a 0.25-m^2 quadrat and a 2,000-cm^3 soil core, respectively. Data are presented as the mean of six replications with one standard deviation.

The rhizome tissue from the soil cores was heat shocked for 1 hr at 100C, then dried at 70C for 72 hr and stored neat for later carbohydrate analysis. Growth parameters measured were shoot number, flower number, shoot dry weight, and rhizome dry weight. Representative shoot and rhizome samples were also analyzed for total nonstructural carbohydrate content utilizing the procedure published by Christiansen (5).

RESULTS

There was no interaction between stage of development or year and herbicide application rate ($P > 0.05$); therefore, rate data are presented averaged across the other two variables. Two months after treatment (based on visual observations), all rates of glyphosate, regardless of other treatments, provided 100% control of treated foliage (data not shown). Regrown shoot and rhizome biomass 1 yr after treatment was inhibited equally by 1.13, 2.26, and 4.52 kg/ha of glyphosate regardless of mechanical practice (Table 1). With the exception of regrown shoots in the disked area, 0.57 kg/ha of glyphosate caused less inhibition of torpedograss than the higher three rates. Rhizome growth was less sensitive to glyphosate than shoot growth in either mechanical practice.

TABLE 1. THE EFFECT OF GLYPHOSATE AND CULTURAL PRACTICES ON TORPEDOGRASS CONTROL IN EAST LAKE TOHOPEKALIGA. THE DATA ARE % INHIBITION BASED ON THE DIFFERENCE BETWEEN SHOOT AND RHIZOME BIOMASS IN CONTROL AND TREATED PLOTS 1 YR POST TREATMENT.[1]

Rate kg/ha	Disked		Nondisked[2]	
	Shoot	Rhizome	Shoot	Rhizome
1.6[3]	89	31	55	56
	(1)	(2)	(5)	(12)
1.1	78	66	88	74
	(5)	(12)	(5)	(4)
2.3	79	55	94	74
	(4)	(15)	(3)	(9)
4.5	82	66	92	68
	(4)	(6)	(2)	(8)

[1] Means represent average of 2 yr, physiological stages of development, and 12 replications each followed by standard deviation. All values are significantly different from respective controls according to Dunnett's "t" test (0.05).
[2] Nondisked area was burned in 1990 or mowed in 1991.
[3] Applied only in 1991.

Burning effectively removed all torpedograss foliage and thatch (initial weight and height of 4725 g/m^2 and 40 cm, respectively). Shoot regrowth was similar in both the burned and disked areas. Regrowth began immediately and continued to increase during the 2-yr study. The final biomass in both areas was approximately 925 g/m^2 which was only 20% (Figure 1). Rhizome biomass was reduced by 66% and 93%

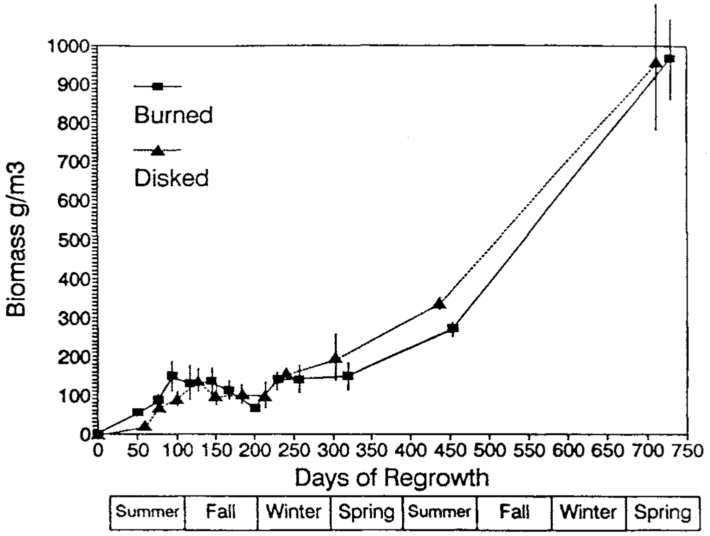

Figure 1. The influence of burning and disking on the regrowth of torpedograss shoots. Data points represent means of six replicates with one standard deviation. At the time of burning, shoot biomass was 4725 g/m^3.

100 days after burning or disking, respectively (Figure 2). Rhizome biomass recovered to approximately 20% of the original biomass (40 kg/m^3) after 250 days and remained constant through 750 days in both the burned and disked areas.

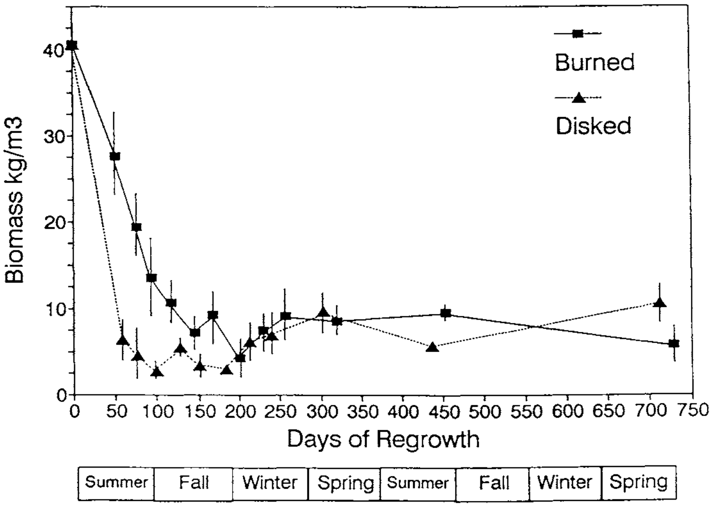

Figure 2. The influence of burning and disking on the regrowth of torpedograss rhizomes. Data points represent means of six replicates with one standard deviation.

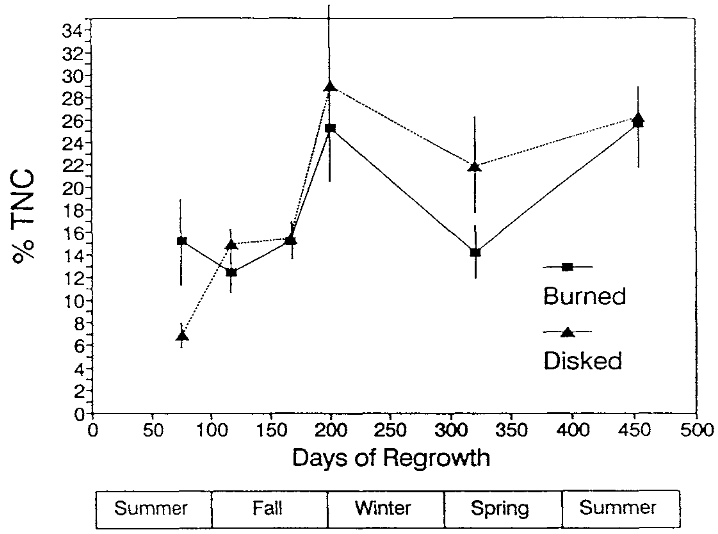

Figure 3. Total nonstructural carbohydrate (TNC) content in torpedograss rhizomes over time in burned and disked areas. Data points represent means of six replicates with one standard deviation.

Total nonstructural carbohydrate (TNC) contents in the rhizomes were 15% and 7% in the burned and disked areas, respectively, after 76 days of regrowth (DOR) (Figure 3). After 167 DOR (*i.e.* midfall), the TNC content in the rhizomes of the disked area had recovered to 15%, similar to that in the burned area. From the midfall through the beginning of winter (167 to 201 DOR), TNC content in the rhizomes increased sharply in the burned and disked areas. TNC content decreased in both mechanical practices through midspring (320 DOR). TNC concentration increased to 26% from midspring through the end of summer in rhizomes regardless of mechanical practice.

DISCUSSION

Torpedograss was well established in the experimental area and had produced extensive thatch over years of growth. Torpedograss was burned or mowed for four reasons: 1) to provide a uniform population of torpedograss for the evaluation of stage of development as a factor affecting the activity of glyphosate, 2) as a possible mechanical control method, 3) to determine if these mechanical control methods interactively influence the control of torpedograss with glyphosate and 4) to allow for disking to be more effective.

Although all rates of glyphosate provided excellent initial control of torpedograss, long-term control of regrowth was not achieved. In order to obtain long-term control of any perennial plant, the response of rhizomes must be considered. However, data based on rhizome biomass could be misleading as this tissue was present in a low oxygen environment which would reduce the rate of decomposition of dead tissue. This lack of decay would tend to lower control estimates based on rhizome biomass.

The three mechanical practices (burning, mowing, and disking) and stage of development did not enhance the activity of glyphosate on torpedograss. These factors have been previously shown to improve the activity of glyphosate on other perennial weeds (2). Disking was hypothesized to have worked additively with glyphosate, because disking reduces the amount of viable rhizomes to be controlled by glyphosate. The lack of an additive or synergistic effect was probably due to not applying glyphosate late enough in the year. Percent TNC in the rhizomes markedly increased from midfall through early winter. However, the last application of glyphosate (1990) was made in late summer due to rising water levels. Therefore, had glyphosate been applied during this time of basipetal (*i.e.* maximum percent TNC in rhizomes) translocation, better control might have been achieved. In addition, the higher percent TNC in disked rhizomes indicated a greater translocation potential which would have been exploited if the herbicide application was properly timed.

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