Glyphosate and Fluridone for Control of Giant Cutgrass (*Zizaniopsis miliaceae*) in Waterfowl Impoundments

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Abstract: We conducted an operational scale trial of the herbicides Sonar® (fluridone) and Rodeo® (glyphosate) to evaluate control of giant cutgrass (*Zizaniopsis miliaceae*) and effects on waterfowl food plants in moist-soil managed impoundments of the Altamaha Waterfowl Management Area, Darien, Georgia. Sonar and Rodeo reduced giant cutgrass frequencies both post-treatment years, although greater reduction occurred in the Rodeo-treated impoundment. Panic grass (*Panicum* spp.) frequency within the Rodeo-treated impoundment decreased the first year post-treatment. First-year frequency of flat sedges (*Cyperus* spp.) decreased in all impoundments when compared to pretreatment frequency. However, second-year frequency did not differ from pretreatment for the Sonar or Rodeo-treated impoundments. First-year smartweed (*Polygonum* spp.) frequency was lower in the Sonar-treated impoundment; second-year frequency was higher in the Rodeo-treated impoundment. During the second year, wild millet (*Echinocloa* spp.) frequency was higher in the Rodeo-treated impoundment when compared to the control. Early fall application of Rodeo appears promising for the control of giant cutgrass and the enhancement of waterfowl food plants.

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Giant cutgrass is a perennial, fresh to slightly brackish water species native to the Atlantic and Gulf coasts and lower Mississippi Valley of North America. Giant cutgrass, also known as Southern wildrice or water millet, inhabits the southeastern states from Florida north to Maryland and west to Texas, Oklahoma, and Arkansas (Godfrey and Wooten 1979). It is a monoecious, rhizomatous aquatic grass with stems

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to 4 m in height (Birch and Cooley 1983). Newman and Thomaston (1979) estimated cutgrass coverage at 1,000 ha in coastal Georgia.

Giant cutgrass can grow in nearly impenetrable stands, often outcompeting other desirable waterfowl plant species and excluding waterfowl. Mabbott (1920) found the proportion of giant cutgrass seeds in waterfowl gizzards small in relation to other plant seeds. Its dense nature also slows water flow, allowing suspended sediments to precipitate, ultimately causing infilling of river channels and reducing storage capacities of reservoirs (Fox 1988).

Giant cutgrass can spread by seed, but local expansion occurs vegetatively by new growth from the nodes of floating stolons (Martin 1959). In Lake Seminole, on the Florida-Georgia-Alabama border, cutgrass stand edges extend at least 1.5 m each year as the outside stalks fall over, with roots and shoots developing at each node (Knight 1980).

On the Altamaha Waterfowl Management Area in coastal Georgia, tidal freshwater impoundments are managed for waterfowl under a moist-soil management regime (Fredrickson and Taylor 1982). However, cutgrass infestations choke out beneficial waterfowl food plants, reducing the value of impoundments for waterfowl. Mechanical disturbance regimes have been attempted to control cutgrass. Mowing and mowing followed by burning have proven unsuccessful in cutgrass control, and disking only provides a temporary (1–2 years) reduction in cutgrass coverage. Furthermore, impoundments must be dried during the growing season to allow disking and therefore are excluded from moist-soil management in that year.

Herbicides are a potentially effective method of giant cutgrass control. Knight (1980) reported good control of giant cutgrass in Lake Seminole, Georgia, using Roundup® (glyphosate). Westerdahl and Getsinger (1988) ranked Sonar as good for cutgrass control. We report on an operational-scale trial of Rodeo and Sonar for use in giant cutgrass control. We also evaluated the effects of these herbicides on the production of waterfowl food plants for 2 years post-treatment.

Methods

The study was conducted on the Butler Island Unit, a diked delta island of the Altamaha Waterfowl Management Area (AWMA) located near Darien, Georgia. Impoundments 3A, 3B, and 4A (38, 40, and 30 ha, respectively) of the Butler Island system were used. The impoundments were adjacent, with similar soils, salinity, and topography.

In September 1993, we established 6 0.04-ha permanent plots in each impoundment in areas of total cutgrass coverage (95%–100%). A series of 100 10×10 cm samples were taken from each plot. Only vegetation rooted within the samples was recorded. Vegetation was recorded by presence/absence and was summarized by frequency of occurrence in each sample plot for each year. Pretreatment vegetation sampling occurred in September 1993. Post-treatment sampling occurred in September 1994 and 1995.

On 14 October 1993, impoundment 4A was treated with Rodeo (Monsanto Company, St. Louis, Mo.) at a rate of 4.66 liters/ha. Rodeo enters the plant via foliar uptake, and maximum efficacy occurs in late summer/fall when plants are actively transporting to the roots. A Bell-47 Tomcat Mark 66 helicopter equipped with a 9.75-m stainless steel microfoil type boom was used to apply the herbicide, with Kinetic® (Helena Chemical Co., Memphis, Tenn), a surfactant, applied at a rate of 1 liter per 400 liters of solution. During treatment, temperature was 23 C with no wind. Impoundment 3A was treated with Sonar SP (Elanco Products Co., Indianapolis, Ind.), a granular formulation, on 5 April 1994 at a rate of 18 kg/ha using a Bell-47 Tomcat Mark 66 helicopter with an aerial seeder (Isolair, Rhododendron, Ore.). Sonar enters plants via root uptake. Therefore, maximum efficacy is expected during spring when plants are actively growing. During treatments, temperature was 27 C with calm winds. Impoundment 3B was an untreated control impoundment.

Impoundments 3A, 3B, and 4A were flooded on 17–18 November as part of normal management activities for waterfowl attraction. The impoundments were dewatered on 18 January 1994 and burned on 23 March 1994. Impoundments were flooded between 24 March and 2 April for Sonar application to impoundment 3A. Impoundments were dewatered on 1 June 1995, as 8 weeks was considered an adequate period for Sonar to kill giant cutgrass (D. Tarver, pers. commun.). Although flooding of impoundments during mid-growing season is not considered normal management, all 3 impoundments were treated identically. Therefore, comparisons of vegetation among impoundments is valid. The impoundments had to be reflooded temporarily during the period 10–24 July 1994 because of extreme flood conditions throughout Georgia. The impoundments were flooded as a precautionary measure to limit damage to dikes in case of overflowing waters from adjacent rivers. Impoundments were also flooded from 16 November 1993 to 23 January 1994 to provide for migrating and wintering waterfowl.

Vegetation frequencies were arcsine square-root-transformed so that residuals were normally distributed. One-factor analysis of variance (ANOVA) was used to compare vegetation among impoundments. If no pretreatment differences were observed among impoundments, large significant differences in post-treatment vegetation frequencies likely were treatment-related. Dunnett's test was used for mean separation when the ANOVA model was significant. SAS (SAS Inst. Inc. 1985) was used to fit models and compute test statistics.

Although our operational-scale trials precluded replication of impoundments, we believe our pseudoreplication of sampling plots within these large impoundments mimicked true replications. Impoundments had similar patterns of variability in vegetation and sample plots were established in areas of total (≥95%) giant cutgrass coverage. We believe that variability among plots within an impoundment reflected variability among impoundments.

Results and Discussion

Pretreatment giant cutgrass frequency did not differ ($F = 0.49$; 2, 15 df; $P = 0.62$) among impoundments (Table 1). However, post-treatment frequency differed among impoundments ($F = 36.5$; 2, 45 df; $P < 0.0001$) and among years ($F = 5.56$;

Table 1. Mean (SE) frequency of vegetation on treated and control impoundments ($N = 6$ subplots) at pretreatment (1993) and 1 (1994) and 2 (1995) years post-treatment, Altamaha Waterfowl Management Area, Georgia. Asterisk signifies that within year and species, means are significantly different than the control impoundment ($P < 0.05$) according to Dunnett's contrast test.

	1993			1994			1995		
Species	Sonar	Control	Rodeo	Sonar	Control	Rodeo	Sonar	Control	Rodeo
Zizaniopsis miliaceae	35.0 (4.4)	29.7 (1.2)	32.8 (4.1)	19.0 (4.3)*	48.5 (5.3)	5.3 (1.1)*	23.5 (6.6)*	47.8 (5.3)	8.7 (1.1)*
Polygonum hydropiperoides	25.8 (9.3)	37.4 (7.8)	16.2 (5.9)	11.5 (4.6)*	34.2 (5.5)	12.5 (7.0)	61.0 (13.6)	42.5 (2.7)	71.0 (5.7)*
Cyperus spp.	5.5 (3.4)	10.3 (3.8)	4.0 (1.4)	—	2.2 (1.1)	0.3 (0.2)	2.5 (1.6)	1.5 (0.7)	3.8 (1.6)
Diodia virginica	0.7 (0.7)	—	—	—	—	—	—	—	—
Panicum spp.	10.0 (2.5)	7.8 (1.7)	22.7 (3.9)*	12.7 (7.6)	35.5 (4.0)	2.5 (0.9)*	12.5 (6.9)	0.3 (0.3)	32.7 (5.6)*
Erechtites hieracifolia	1.3 (0.7)	0.5 (0.2)	—	—	—	—	0.5 (0.5)	—	—
Murdania keisak	2.3 (0.8)	4.2 (1.5)	1.0 (0.4)	—	1.0 (0.5)	—	—	0.2 (0.2)	—
Juncus effusus	1.7 (0.9)	0.2 (0.2)	12.3 (2.4)*	—	—	—	—	0.3 (0.3)	—
Typha latifolia	—	0.2 (0.2)	1.2 (1.2)	—	—	—	—	0.2 (0.2)	—
Alternanthera philoxeroides	0.5 (0.3)	0.5 (0.3)	29.0 (4.0)*	1.2 (0.5)	2.0 (0.8)	3.8 (1.1)	0.2 (0.2)	0.5 (0.5)	0.3 (0.3)
Sagittaria latifolia	—	0.2 (0.2)	1.2 (0.5)	—	—	0.8 (0.4)	0.2 (0.2)	0.2 (0.2)	1.3 (0.4)
Eleocharis quadrangulata	—	—	6.0 (2.9)	—	1.0(0.6)	—	—	—	—
Eleocharis parvula	—	—	0.2 (0.2)	—	—	—	—	—	0.2 (0.2)
Rubus spp.	0.8 (0.8)	—	—	—	—	—	—	—	—
Setaria magna	—	0.5 (0.5)	—	—	—	—	—	—	—
Saururus cernuus	0.5 (0.5)	—	—	—	—	—	—	—	—
Sesbania exaltata	0.2 (0.2)	0.2 (0.2)	—	6.7 (1.7)	2.0 (0.8)	11.5 (3.6)	0.8 (0.8)	—	0.2 (0.2)
Echinoclos crusgalli	—	—	0.3 (0.3)	—	—	—	—	—	—
Echinoclos walterii	—	—	—	—	—	—	2.2 (2.2)	—	3.5 (1.8)
Hydrochloa caroliniensis	—	—	—	—	0.8 (0.5)	27.2 (4.7)*	—	3.8 (3.8)	3.8 (2.9)

2, 45 df; $P = 0.007$). There also was a significant impoundment*year interaction ($F = 11.40$; 4, 45 df; $P \leq 0.0001$).

Dunnett's test indicated significantly lower giant cutgrass frequency in the impoundments treated with Sonar and Rodeo for the 2 post-treatment years when compared to the control impoundment. Within the control impoundment, giant cutgrass frequency was higher during both post-treatment years relative to pretreatment. In contrast, giant cutgrass frequency was lower in the Rodeo-treated impoundment for both post-treatment years relative to pretreatment. Although the Sonar-treated impoundment had a lower cutgrass frequency relative to the control for both post-treatment years, cutgrass frequency within the Sonar impoundment did not differ among years. Apparently, Sonar provided only moderate reduction of established cutgrass stands. This reduction likely will be very temporary due to expansion from residual plants.

Lack of cutgrass control by fluridone may have resulted from acidic water conditions within the impoundments and plant phenology. Sonar activity is reduced by acidic conditions, particularly when pH is less than 5.5 (D. Tarver, pers. commun.). Water pH on the AWMA ranged from 4.5 to 6.0. Eight weeks was considered enough time for uptake of Sonar by vegetation (D. Tarver, pers. commun.). However, greater control of giant cutgrass may have been obtained if the impoundments remained flooded for a longer period of time. Secondly, the impoundment had been burned followed by immediate flooding just prior to Sonar application. These stressors may have decreased growth in the plants, thus decreasing Sonar uptake.

Alligatorweed (*Alternanthera philoxeroides*) and Southern watergrass (*Hydrochloa caroliniensis*) also are considered noxious plants on the AWMA. Both plants readily invade open, sparsely vegetated areas. Watergrass forms extensive mats, choking out other vegetation. Watergrass frequency did not differ among impoundments for the pretreatment year. Frequency in the Rodeo-treated impoundment was significantly higher than the control impoundment for the first year post-treatment. This expansion of watergrass likely is due to the reduction of giant cutgrass. Watergrass frequencies did not differ among impoundments for the second year post-treatment. Alligatorweed frequencies differed in the pretreatment year, with a higher occurrence in the Rodeo-treated impoundment. However, there were no post-treatment differences among the impoundments. Within the Rodeo-treated impoundment, alligatorweed frequencies declined significantly for both post-treatment years. Alligatorweed frequencies did not differ within the control and Sonar-treated impoundments across years. Sonar appeared to arrest the expansion of alligatorweed, but did not control established plants. Rodeo appeared to kill alligatorweed more efficiently.

On the AWMA, Larimer (1982) reported that panic grasses (*Panicum* spp.), smartweeds (*Polygonum* spp.), wild millets (*Echinocloa* spp.), and flat sedges (*Cyperus* spp.), etc., occurred in 62%, 55%, 24%, and 20%, respectively, of all waterfowl gizzards sampled. In our study, pretreatment panic grass frequency was higher in the Rodeo-treated impoundment, but was lower in the Rodeo-treated impoundment for the first year post-treatment. Within the control impoundment, panic grass frequency increased 1 year post-treatment and decreased 2 years post-treatment. At 2 years post-treatment, panic grasses occurred more frequently in the Rodeo-treated impoundment than in the control. Pretreatment frequencies of smartweeds and wild millets did not differ among impoundments. Smartweed frequency was lower in the Sonar-treated impoundment 1 year post-treatment. Within the Rodeo-treated impoundment, smartweed frequency increased 2 years post-treatment. Wild millet frequency was higher in the Rodeo-treated impoundment for the second year post-treatment when compared to the control. Within the Rodeo-treated impoundment, wild millet frequency was higher 2 years post-treatment relative to pretreatment. Flat sedge frequencies did not differ among impoundments for any year.

The first-year post-treatment decreases of panic grass, flat sedges, smartweeds, and wild millets likely were a result of reflooding the impoundments during the middle of the growing season. Apparently, first-year vegetation responses were impacted by treatment and by flooding. Treatment removed cutgrass and alligatorweed and allowed more beneficial vegetation to increase. Before flooding during year 1, preferred vegetation frequency was extremely high in the treated impoundments. Flooding during year 1 may have reduced or eliminated some species, although this effect may not have been equivalent across all treatments. The higher giant cutgrass frequency in the control impoundment helped protect beneficial vegetation from flooding damage by reducing the speed and extent of water flow throughout the impoundment. Cutgrass also provided support for other beneficial vegetation, allowing this vegetation to remain emersed from flood waters. These effects may have caused a disproportionate reduction in preferred vegetation across the treatments.

Sonar did not appear to have any negative effects on preferred waterfowl vegetation. Second-year post-treatment frequencies did not differ from pretreatment for any of the 4 genera. Preferred vegetation generally remained stable or increased following treatment with Rodeo. Second-year post-treatment frequencies were not different from pretreatment frequencies for panic grasses or flat sedges. Second-year post-treatment frequencies were higher than pretreatment frequencies for smartweeds and wild millets. Frequency of occurrence of other vegetative species (Table 1) was highly variable among impoundments and among years and suggested no treatment-related effects.

Management Implications

Sonar was ineffective at the rates and times used in this study. Higher rates or application at a later stage of plant phenology may be necessary for effective control. The persistence of Sonar in soil sediments also may be of concern (Wood 1996).

At the rates and time used in this study, Rodeo decreased cutgrass infestation. However, spot treatments or reapplication likely will be needed to achieve continuing control. Burning of impoundments in the spring before fall application of herbicides may increase efficacy by removing dead standing vegetation that intercepts the herbicide. Between vegetation kill and spring greenup, a second burn to remove newly killed cutgrass may allow understory vegetation to compete with any remaining or newly established cutgrass.

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