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Chemical Control of Giant Burreed (*Sparganium eurycarpum*) in Wild Rice (*Zizania palustris*)[1]

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Abstract. The response of giant burreed to bentazon, propanil, 2,4-D (amine salt), and 2,4-D plus crop oil (0.5% v/v) was evaluated at the 2-aerial-leaf stage of wild rice. Bentazon, 2,4-D, and 2,4-D plus crop oil at 1.1 kg/ha or more in 1984, and propanil and 2,4-D plus crop oil at 4.5 kg/ha in 1985 reduced giant burreed dry weight. Generally, herbicide rates above 1.1 kg/ha injured wild rice and reduced yields compared to weed-free controls. None of the study treatments resulted in effective giant burreed control without unacceptable injury to wild rice. **Nomenclature:** Bentazon, 3-(1-methylethyl)-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide, 2,4-D, (2,4-dichlorophenoxy)acetic acid; propanil, *N*-(3,4-dichlorophenyl)propanamide; giant burreed, *Sparganium eurycarpum* Engelm. #[3] SPGEU; wild rice, *Zizania palustris* L.
Additional index words: Bentazon, propanil, 2,4-D.

INTRODUCTION

Giant burreed is a perennial aquatic monocotyledon plant that infests 90% of wild rice fields in northern Minnesota (7). Giant burreed emerges from the water before, and is taller than, wild rice through the boot stage of wild rice development (2). Giant burreed decreases penetration of photosynthetically active radiation into the wild rice canopy throughout the growing season. Densities of 40 giant burreed shoots per m^2 reduced wild rice yield approximately 60% when compared to wild rice yield from weed-free control plots.

High densities of giant burreed are a localized problem in less than 10% of the infested wild rice fields (unpublished data). Giant burreed reproduces by seeds, corms, and rhizomes. Mechanical operations, such as fall tillage and spring thinning of wild rice stands, may spread reproductive structures to noninfested areas. Therefore, giant burreed has the potential to become a serious weed problem in commercial wild rice fields.

Control or retardation of giant burreed vegetative growth, which would reduce shading, may increase wild rice yields. Herbicidal control of *Sparganium* spp. is not well documented in the literature. Wild rice acreage is limited (7), and development of herbicides exclusively for use in wild rice is impractical. The objective of this study was to identify rice herbicides to potentially control giant burreed in wild rice. The herbicides chosen for this study were bentazon, 2,4-D, and propanil. Bentazon is used for sedge (*Cyperus* spp.) and grass control (3, 5), 2,4-D is used for broadleaf weed control (9), and propanil is used for selective control of grass and some broadleaf weeds in rice (1, 11, 13).

MATERIALS AND METHODS

Herbicide and rate study. Bentazon, propanil, 2,4-D (amine salt), and 2,4-D (amine salt) plus crop oil (0.5% v/v) were applied at 1.1, 2.2, and 4.5 kg/ha to giant burreed and wild rice in a grower's field near Aitkin, MN, on a Cathro soil (loamy, mixed, euic, Terric Borosaprists) with a pH of 5.3 in 1984 and 1985. The field had been in continuous wild rice for 5 yr but was fallow the year before the experiments were conducted. The field was seeded initially but was subsequently self-seeded from the previous wild rice crop. The field was drained before harvest, tilled after harvest, and flooded in the spring of each year. Weed-free and weedy check plots were included in the treatments. Wild rice stand densities were approximately 21 plants per m^2 at time of application, and giant burreed densities ranged from 5 to 15 shoots per m^2.

All herbicides were applied at the 2-aerial-leaf stage (five actual leaves: two below water, one floating, and two above water) of wild rice. Giant burreed was at the 6-leaf stage of development. Plot size was 2.2 by 1.8 m. Herbicides were applied with a backpack sprayer in a volume of 280 kg/ha and at a pressure of 275 kPa. Visual evaluations of herbicide injury were recorded 2, 4, and 6 weeks after herbicide application.

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

Table 1. Giant burreed and wild rice injury 2, 4, and 6 weeks after treatment (WAT) with bentazon, propanil, 2,4-D, and 2,4-D plus crop oil applied at the 3-aerial-leaf stage of wild rice development in 1984 and 1985[a]

		2 WAT		4 WAT		6 WAT	
Treatment	Rate	Giant burreed	Wild rice	Giant burreed	Wild rice	Giant burreed	Wild rice
	(kg/ha)	(0–10)					
Bentazon	1.1	4	3	6	6	3	4
	2.2	5	4	4	7	2	3
	4.5	6	7	8	8	3	7
Propanil	1.1	2	1	2	2	5	1
	2.2	3	2	6	4	3	1
	4.5	2	3	6	4	2	2
2,4-D	1.1	2	0	6	5	5	7
	2.2	1	2	8	5	3	6
	4.5	2	1	9	7	2	5
2,4-D + crop oil[b]	1.1	3	1	7	7	5	6
	2.2	2	1	9	6	3	7
	4.5	5	2	8	9	3	9
LSD (0.05)		3	3	4	3	3	3

[a]Rated on a 0–10 scale. 0 = no injury, 10 = death of plants.

[b]Crop oil applied at 0.5% v/v.

The center 1.2 by 1.2 m of the plot was harvested when wild rice seed reached about 40% moisture. Data recorded at harvest included number of wild rice panicles and plants per unit area. Yield of wild rice was measured after threshing panicles with a head thresher and drying the grain at 65 C for 3 days. Wild rice and giant burreed plant dry weights were recorded after aboveground portions of the plants were dried similar to the grain. Wild rice yield per plant and per panicle and dry weight per plant were calculated.

Bentazon study. The effect of bentazon on giant burreed grown in monoculture and with wild rice was evaluated at the University of Minnesota, North Central Experiment Station, Grand Rapids, MN, in 1986. The soil was an Indus clay loam (very-fine, montmorillonitic, frigid, Typic Ochraqualfs) with 3% organic matter content and a pH of 6.3. Bray-1 P and K contents of the soil were 130 and 260 kg/ha, respectively. The plots were fertilized with 44 kg/ha K and 56 kg/ha N. Giant burreed was planted at 10 corms per m^2 (corm size 10- to 20-mm diam) and wild rice was seeded to obtain a density of 21 plants per m^2. Each plot was 1.8 by 1.8 m. The plot area was flooded to 25 cm depth immediately after planting. Then, 1.5-m diam rings 25.4 cm tall were used to enclose each plot to limit herbicide movement among treatments.

Bentazon was applied to giant burreed grown in monoculture at 0.82, 1.6, and 2.2 kg/ha at the 5-leaf stage (approximately 28 cm of leaf tissue above the water) about 6 weeks after planting. When grown together, bentazon was applied at 0.56, 0.82, 1.1, 1.6, and 2.2 kg/ha when wild rice was in the 3- to 4-aerial-leaf stage (approximately 13 cm of leaf tissue above the water) and giant burreed was at the 3-leaf stage (approximately 20 cm of leaf tissue above the water) about 4 weeks after planting. Herbicides were applied with a backpack sprayer, as described previously. The center 1.1 by 1.1 m of all plots was harvested when wild rice seed had reached about 40% moisture. Plant and yield data were taken as described in the previous study.

Field plots were arranged in a randomized complete block design with treatments replicated four times each year. Analysis of variance for plant and yield data was performed separately for each year. Mean separations for 1984 and 1985 yield data were calculated by either Fischer's protected LSD at the 5% level of probability, or a pooled estimate of the parameter's standard error was calculated with a 95% confidence interval for paired t-tests. Regression equations for the log-transformed giant burreed dry weight data in 1986 were calculated by nonlinear least squares fit of data.

RESULTS AND DISCUSSION

Herbicide and rate study. Giant burreed was injured within 2 weeks after bentazon and 2,4-D plus crop oil applications (Table 1). Symptoms of injury included chlorosis and necrosis of vegetative tissue. Mine and Matsunaka (6) reported these visible injury symptoms

Table 2. The effect of bentazon, propanil, 2,4-D, and 2,4-D plus crop oil on giant burreed and wild rice at harvest in two field seasons.

		1984			1985		
		Giant burreed		Wild rice	Giant burreed		Wild rice
Treatment	Rate	Shoots/m²	Log dry wt[a]	Grain yield	Shoots/m²	Log dry wt[a]	Grain yield
	(kg/ha)	(no.)		(g/m²)	(no.)		(g/m²)
Bentazon	1.1	8	1.09	14.1	15	2.14	3.6
	2.2	14	1.43	7.7	5	1.58	6.7
	4.5	18	1.75	2.3	13	1.68	6.6
Propanil	1.1	27	1.99	9.9	9	1.47	17.7
	2.2	20	1.66	13.8	12	1.70	17.2
	4.5	22	1.96	8.8	6	1.35	21.3
2,4-D	1.1	12	1.26	11.8	16	1.82	7.8
	2.2	6	0.83	10.2	16	1.61	16.5
	4.5	5	0.73	5.8	11	1.59	8.9
2,4-D + crop oil[b]	1.1	9	1.27	8.8	10	1.74	7.9
	2.2	8	0.34	8.9	16	1.97	4.2
	4.5	2	0.12	1.5	12	1.43	1.7
Weedy control		42	2.11	4.0	16	1.92	10.1
Weed-free control		2	0.39	17.5	3	0.26	19.5
95% confidence interval for paired t-tests		12	0.55	6.9	13	0.46	9.1

[a]Dry weight originally measured in g/m².

[b]Crop oil applied at 0.5% v/v.

developed rapidly when bentazon was applied directly to leaves of susceptible plants. Maximum giant burreed injury with all herbicides occurred 4 weeks after herbicide treatment as indicated by visual and evaluation (Table 1). Giant burreed control at the 6-week evaluation date was less than the 4-week control. Regrowth of giant burreed from uninjured corm buds or from rhizomes, or both, may have reduced the visible injury symptoms.

Wild rice injury, on the other hand, increased at each evaluation date (Table 1) but injury was least with propanil at all applied rates and at all evaluation dates. Symptoms of wild rice injury included leaf chlorosis and necrosis and stunting of the plant.

Giant burreed shoot densities at harvest in 1984 were reduced by all herbicide treatments compared to the weedy control (Table 2). However, shoot densities in all herbicide treatments in 1985 were similar to the weedy control. A logarithmic transformation of the giant burreed shoot dry weights for both years was analyzed due to large variances in the data (5). Giant burreed shoot dry weight in 1984 was reduced compared to the weedy control with all rates of bentazon, 2,4-D, and 2,4-D plus crop oil (Table 2). Propanil did not reduce giant burreed shoot dry weight in 1984 compared to the weedy control at any rate tested. Shoot dry weight in 1985 was reduced only with the highest rate of propanil or 2,4-D plus crop oil.

Giant burreed control may have been influenced by water depth. The 1985 field water level was 20- to 30-cm deeper than the 1984 water level at time of application. Giant burreed leaf tissue above the water surface at herbicide application was about 30 cm in 1984 and 15 cm in 1985. However, limited spray coverage of the plants in 1985 visibly injured both species (Table 1).

Giant burreed growth within the weedy control plots differed between years also. In 1984 at harvest, shoots were numerous and had an average dry weight of 3.1 g per plant. In 1985, there were fewer shoots per m², the average dry weight per shoot was 5.2 g per plant, and none of the treatments reduced the dry weight of giant burreed compared to the weedy control.

Wild rice panicle production was reduced by 50% compared to the hand-weeded control with 2,4-D at 4.5 kg/ha plus crop oil and bentazon at 1.1 kg/ha in 1985 (unpublished data). Panicle reduction with bentazon may have been due to competition from giant burreed (Table 2) and to herbicide injury to wild rice (Table 1). Grain yield increased with bentazon or 2,4-D at 1.1 kg/ha in 1984 compared to yields in the weedy control (Table 2). Propanil-treated wild rice had panicle densities similar to the weed-free control.

Propanil applied at 2.2 kg/ha in 1984 and 4.5 kg/ha in 1985 also increased grain yield even though giant burreed growth at harvest was not reduced (Table 2). Propanil injury of giant burreed may have reduced

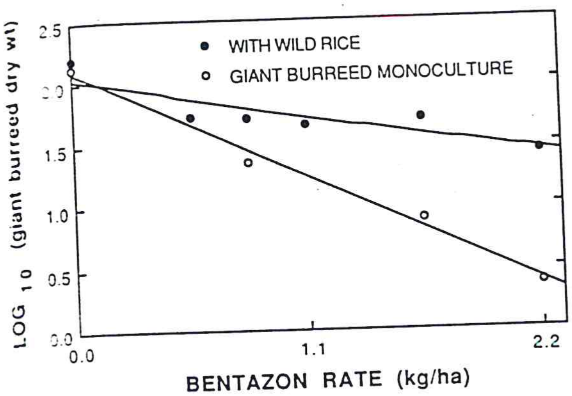

Figure 1. The effect of bentazon rate on giant burreed dry weight. The regression equations for reduction of the log-transformed giant burreed dry weight (Y) on bentazon rate (X) are $Y = 2.1 - 0.8X$ ($r^2 = 0.99$) when giant burreed was grown in monoculture (bentazon applied at 5-leaf growth stage), and $Y = 2.1 - 0.6X + 0.1X^2$ ($r^2 = 0.92$) when giant burreed and wild rice were grown together (bentazon applied at giant burreed 3-leaf growth stage). Giant burreed dry weight originally measured in g/m^2.

shading from giant burreed at a critical stage of wild rice growth which increased yields. Wild rice is sensitive to shade but is able to recover from limited shading. Wild rice removed from 30% shade after 6 weeks and grown in full light for 6 weeks had similar growth compared to wild rice grown in full light for 12 weeks (2).

High herbicide rates were used in these experiments because in earlier trials, 2,4-D applied at 0.26 kg/ha did not control giant burreed (7). High herbicide rates could be used as spot treatments in wild rice fields since high densities of giant burreed are limited. However, wild rice would be injured severely at high application rates.

Bentazon **study.** When bentazon was applied to giant burreed at the 5-leaf stage in monoculture, giant burreed dry weight decreased as bentazon rate increased (Figure 1). However, when bentazon was applied to giant burreed at the 3-leaf stage in wild rice, rates greater than 0.82 kg/ha did not increase giant burreed control. Application to giant burreed at a later growth stage may increase bentazon efficacy. Wild rice yield in bentazon-treated plots did not differ from the weedy check (unpublished data). Yields may have been influenced by giant burreed interference or herbicide injury to wild rice.

Treatments reported in this study did not control giant burreed consistently. However, cultural control techniques and herbicides applied at susceptible giant burreed growth stages may be important for long-term giant burreed control. Herbicide-induced stress may decrease giant burreed corm or rhizome formation or reduce corm size. For example, dichlobenil (2,6-dichlorobenzonitrile) reduced the regrowth of purple nutsedge (*Cyperus rotundus* L.) from tubers (10) and the regrowth of waterlily (*Nymphaea* sp.) from rhizomes (4). Stress, induced by shade, also limited tuber and rhizome production of purple and yellow nutsedges (*Cyperus esculentus* L.) (8).

Reduction in giant burreed corm size due to herbicide or cultural stresses may limit overwinter survival of the corm in the field. Small giant burreed corms (<10 mm diam) were not as viable as large corms (>20 mm diam) after 4 weeks of freezing temperatures (–2 C) under flooded conditions in a laboratory experiment (unpublished data). Also, plants with small corms or tubers may be more susceptible to herbicide injury (6, 12). For example, *Cyperus serotinus* Rottb. and sago pondweed (*Potamogeton pectinatus* L.) plants were more susceptible to herbicide injury if the tubers were small compared to treated plants having large tubers (6, 12).

None of the treatments used in this study should be recommended to control giant burreed consistently. Further studies should be conducted with other rice herbicides to identify optimum application dates and rates that will consistently control giant burreed and limit wild rice injury. Generally, wild rice yields in these studies were reduced with 2,4-D and bentazon treatments because of severe herbicide injury to the wild rice plant. Wild rice does not metabolize bentazon (3), and injury to wild rice was observed (Table 1). The effect of herbicides on giant burreed corm and rhizome production and cultural practices for giant burreed control should be investigated further for long-term management of giant burreed.

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