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Controlling Bamboo (*Phyllostachys* spp.) with Herbicides

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Bamboos are grass species that can escape cultivation and invade lawns, landscapes, and other areas. Limited information is available on ways to control invasive bamboo species. Greenhouse and field studies were initiated to determine the level of bamboo control provided by a single application of selected PRE and POST herbicides. Bamboo species included in the study were golden bamboo in greenhouse experiments and red-margined bamboo in field experiments. In greenhouse trials, MSMA, quinclorac, dithiopyr, clethodim, fenoxaprop, and sethoxydim did not control either species. Glyphosate, glufosinate, and fluazifop significantly reduced bamboo-shoot fresh weight, although regrowth occurred after a single application. In field trials, bamboo control with dichlobenil in the 2002 and 2004 experiments was less than 23%. For the study initiated in 2002, glyphosate and imazapyr provided 76% and 98% bamboo control, respectively, at 58 wk after treatment (WAT). By 161 WAT (approximately 3 yr after treatment), bamboo-control ratings were 40% with glyphosate and 85% with imazapyr. For the study initiated in 2004, at 61 WAT, glyphosate and imazapyr provided 46 and 88% control of bamboo, respectively.
Nomenclature: Clethodim; dichlobenil; dithiopyr; fluazifop; glyphosate; imazapyr; MSMA, quinclorac; sethoxydim; golden bamboo, *Phyllostachys aurea* Carr. ex A. & C. Rivière; red-margined bamboo, *Phyllostachys rubromarginata* McClure.
Key words: landscape weed control, postemergence herbicides.

As well as having many construction and industrial uses, various species of bamboo are often used as ornamental plants. Only one species of bamboo, cane or canebrake bamboo [*Arundinaria gigantea* (Walter) Muhl.], is native to the United States and should not be confused with exotic species. Moreover, this species is generally divided into two subspecies, *A. gigantea* ssp. *gigantea* and *A. gigantea* ssp. *tecta*, the latter being more common in the southeast United States (Meredith 2001). Nearly all the bamboos that have become problems in the United States are nonnative imports. Introduction of many temperate zone nonnative bamboos began around 1860 (Adamson 1978), with the majority of the species coming from the genus *Phyllostachys* (McClure 1957). One of the first species of *Phyllostachys* introduced into the United States was golden bamboo (Meredith 2001; Young and Haun 1961). Not surprisingly, golden bamboo is one of the most invasive bamboos of the southeast United States (Council 2005; Evans 2005; Swearingen 2002). Homeowners, landscapers, and vegetation-management officials often face situations in which they are required to eliminate stands of bamboo; unfortunately, little information is available on chemical control of bamboo. Therefore, the objective of this research was to determine whether a single application of selected herbicides would control bamboo.

Materials and Methods

Greenhouse Trials. Golden bamboo was propagated by division and grown for 6 mo in 4-L plastic pots containing pine bark. Experimental design was a randomized complete block with four replications, and the study was repeated. There was one pot per plot in the first trial, and two pots of golden bamboo per plot in the second trial. The first trial was treated on September 6, 2000, when the air temperature was 22 C with 64% relative humidity at the time of treatment; in the second trial, which was treated on June 11, 2003, air temperature was 32 C with 54% relative humidity at the time of treatment. Bamboo was sprayed over the top using a CO_2-pressurized backpack sprayer using two 8003 flat-fan nozzles[1] delivering 230 L/ha. In the first trial, golden bamboo was 84 cm tall, and in the second trial, it was 102 cm tall at treatment. A nonionic surfactant[2] was added to fluazifop, clethodim, MSMA, and dithiopyr at 0.25% v/v. A crop oil concentrate[3] was added to quinclorac at 1% v/v. Bamboo control was evaluated visually at 1 mo after treatment, using a scale of 0 to 100, with 0 representing no injury and 100 equal to complete control. At 6 wk after treatment (WAT), shoot fresh-weight was recorded. Plants were allowed to regrow for 4 wk, and then, shoot regrowth was weighed. Because results were similar in the two trials, reported results are an average of the two experiments.

Field Trials. A 73- by 12-m-wide strip of red-margined bamboo at the Bamboo Farm and Coastal Gardens in Savannah, GA, was chosen for the study. The planting of red-margined bamboo was established sometime in the 1950s and had achieved an average height of 75 to 90 m. In late winter to early spring of 2002, bamboo was mowed to the ground with a three-point hitch, power-take-off driven, rotary-cut mower.[4] After the area had been cut to the ground, 24 grids (6.1 by 6.1 m) were established by trenching with a mechanical trencher.[5] Trenches were approximately 10 cm wide and 60 cm deep and were left open to keep rhizomes from growing into adjacent treatments (Figure 1). Only 12 of the squares were used in the 2002 study because the others were reserved for the 2004 experiment. Dichlobenil granules were

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Figure 1. Trench cut to prevent spread of red-margined bamboo rhizome growth between treatments.

Figure 2. Area of red-margined bamboo before treatment applications in 2002.

Figure 3. Red-margined bamboo cover 58 wk after treatments were applied in the 2002 experiment (A, nontreated control; B, imazapyr 1.7 kg ai/ha; C, glyphosate 4.5 kg ai/ha).

Table 1. Greenhouse study of golden bamboo percentage of injury at 4 wk after treatment (WAT), shoot fresh-weight 6 WAT, and regrowth shoot fresh-weight 10 WAT, as affected by herbicide application.

Treatment	Rate	Injury	Shoot fresh-weight	Regrowth shoot fresh-weight
	kg ai/ha	%	g	
Nontreated		6	159.6	20.2
Fenoxaprop	0.10	11	161.0	21.0
Fluazifop	0.34	28	59.5	3.0
Clethodim	0.13	13	122.3	36.9
Sethoxydim	0.45	18	105.2	30.0
MSMA	2.24	18	138.9	8.2
Quinclorac	0.84	5	176.7	14.8
Dithiopyr	0.56	3	178.4	20.1
Glyphosate	2.24	42	47.1	0.3
Glufosinate	1.12	68	28.6	0.8
LSD (0.05)		9	41.9	13.5

applied at a rate of 18 kg ai/ha with a handheld spreader on February 12, 2002, and the average height of the bamboo at that time was approximately 30 cm. Glyphosate at 4.5 kg ai/ha and imazapyr at 1.7 kg ai/ha were applied on April 12, 2002, after the bamboo regrowth had reached approximately 60 cm (Figure 2). Glyphosate and imazapyr were applied with 0.25% v/v adjuvant (Dyne-Amic)[6] in a spray volume of 186.9 L/ha. In 2004, a new study was established next to the 2002 experiment. The grid design was still intact from the 2002 experiment, and the plot area was mowed to the ground in early February 2004. Dichlobenil was applied as above on February 12, 2004, and glyphosate and imazapyr were applied on April 24, 2004, after the bamboo regrowth had reached approximately 61 cm. Application rates and addition of the adjuvant to the sprays was identical to the 2002 experiment. Bamboo control ratings from the 2002 study were taken at 3, 10, 54, 58, and 161 WAT and at 8, 16, 25, and 61 WAT for the study that began in 2004. Bamboo control ratings were on a 0-to-100 scale, where 0 was no apparent injury to bamboo; 1 to 40 was slight injury, some yellowing or discoloration; 40 to 60 was definite bamboo injury, noticeable discoloration or phytotoxicity; 60 to 99 was severe injury, discoloration, and necrosis; 100 was dead bamboo with no evidence of regrowth.

Approximately 52 WAT, bamboo shoot biomass from each study was collected from three randomly selected 1-m by 1-m subplots. Bamboo shoot material was cut to the ground, bagged and dried at 70 C for approximately 3 d to remove moisture. Dried shoots were weighted, and an average of the treatment subsamples were analyzed. As a result of a significant treatment-by-year interaction ($\alpha = 0.05$), data from 2002 and 2004 were analyzed and presented separately. All data were subjected to ANOVA, and means were subjected to Fisher's Protected LSD at $P = 0.05$.

Table 2. Control of red-margined bamboo in field plots treated with selected herbicides in 2002.

Treatment	Rate	Application date in 2002	Bamboo control (weeks after treatment)				
			3	10	54	58	161
	kg ai/ha		%				
Nontreated			0	0	0	0	0
Dichlobenil	17.9	February 12	7	0	0	0	0
Glyphosate	4.5	April 12	77	90	80	77	40
Imazapyr	1.7	April 12	50	75	92	99	85
LSD (0.05)			9	9	3	6	10

Table 3. Control of red-margined bamboo in field plots treated with selected herbicides in 2004.

Treatment	Rate	Application date in 2002	Bamboo control (weeks after treatment)			
			8	16	25	61
	kg ai/ha		%			
Nontreated			0	0	0	0
Dichlobenil	17.9	February 12	23	23	0	7
Glyphosate	4.5	April 24	88	88	82	47
Imazapyr	1.7	April 24	87	87	95	88
LSD (0.05)			25	25	3	15

Results and Discussion

Greenhouse Trials. Glufosinate caused the greatest injury to golden bamboo, but the level of control was only 68% at 4 WAT (Table 1). Glyphosate injured bamboo 42% and other treatments caused 28% or less injury at 4 WAT. Glufosinate, glyphosate, and fluazifop reduced golden bamboo shoot-weight by 82, 70, and 63%, respectively, compared with the nontreated plants. Fenoxaprop, quinclorac, and dithiopyr had no effect on golden bamboo shoot-weight, whereas sethoxydim and clethodim caused less than 35% decrease in shoot weight. Glyphosate and glufosinate reduced bamboo regrowth shoot-weight by more than 95%, whereas fluazifop reduced shoot regrowth by 85%. No other treatment caused a significant reduction in bamboo regrowth.

Field Trials. In both the 2002 and 2004 experiments, the control of red-margined bamboo with dichlobenil never exceeded 23%. In the 2002 study, bamboo control with glyphosate varied between 77 and 90% during the first year of ratings. At 161 WAT, control with glyphosate had dropped to 40% (Table 2). Imazapyr provided almost complete control at 58 WAT, but by 161 WAT some regrowth had occurred and control ratings had declined to 85% (Table 2). In the 2004 experiment, bamboo control ratings with glyphosate

Table 4. Red-margined bamboo shoot dry-weight approximately 1 yr after treatment for the 2002 and 2004 field experiments.

Treatment	Rate	Dry weight (weeks after treatment)	
		58[a]	61[b]
	kg ai/ha	g/m^2	
Nontreated		559	482
Dichlobenil	17.9	776	503
Glyphosate	4.5	255	326
Imazapyr	1.7	43	231
LSD (0.05)		359	268

[a] Collected May 24, 2003.

[b] Collected June 26, 2005.

were > 80% during the 8, 16, and 25 WAT ratings but had dropped to 47% by 61 WAT. Imazapyr provided > 87% control during all ratings of the 2004 experiment (Table 3). In both studies, both glyphosate and imazapyr reduced the biomass of the bamboo shoots (Figure 3). In the 2002 experiment, only imazapyr reduced bamboo-shoot biomass relative to the nontreated control (Table 4). Although there was no difference between bamboo-shoot biomass in the 2004 experiment, it should be noted that most of the bamboo shoots collected from the imazapyr treatments were dead. In the 2004 study, there was much more regrowth before treatments were applied, and that correlated into more biomass when the shoots were collected.

A single application of either fluazifop, glufosinate, glyphosate, or imazapyr did not provide complete control of bamboo in either container or field trials. Imazapyr provided the highest level of control in the field trials, but follow-up applications would be necessary for complete eradication. Also, imazapyr has the potential to cause damage to desirable plants growing in the vicinity of the treated bamboo. Depending on the soil type and pH, imazapyr can be readily absorbed by plants growing in close proximity, especially at the high rates used (1.7 kg ai/ha). Although not tested, multiple applications (two or three) of glyphosate may have provided complete control of bamboo. Even with the potential for severe damage via spray drift, glyphosate does not have soil activity and would be a much better choice when desirable plants are growing adjacent to bamboo. Another control option not tested would be continual shoot removal of bamboo by repeated mowing or clipping. Constant depletion of bamboo energy reserves in roots and rhizomes might possibly cause the bamboo to eventually die out. Both of these control options should be considered for future research.

Sources of Materials

[1] Flat-fan nozzles, Spraying System Co., North Ave., Wheaton, IL 60187-7900.

[2] Nonionic surfactant, Latron AG-98, Loveland Industries, Inc., P.O. Box 1289, Greeley, CO 80632-1289.

[3] Agri-Dex crop oil concentrate, Helena Chemical Co., 225 Schilling Blvd., Suite 300, Collierville, TN 38017.

[4] Mower, Woods Equipment Company, 2606 South Illinois Route 2, P.O. Box 1000, Oregon, IL 61061.

[5] Trencher, Vermeer Equipment of Texas, Inc., 3025 N. State Hwy 161, Irving, TX 75062.

[6] Dyne-Amic adjuvant, Propriety blend of polyalkyleneoxide modified polydimethylsiloxane, polyoxypropylene-polyoxyethylene block copolymer, and methylated vegetable oils, Helena Chemical Co., 225 Schilling Blvd., Suite 300, Collierville, TN 38017.

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Literature Cited

Adamson, W. C., G. A. White, H. T. DeRigo, and W. O. Hawley. 1978. Bamboo Production Research at Savannah, Georgia, 1956–77. New Orleans, LA.: U.S. Dept. of Agriculture, Agricultural Research Service, Southern Region ARS-S 176. 17 p.

[Council] Florida Exotic Pest Plant Council. 2005. List of Invasive Species. http://www.fleppc.org/list/05List.htm. Accessed: November 21, 2005.

Evans, C. W., C. T. Bargeron, D. J. Moorhead, and G. K. Douce. 2005. Invasive Weeds in Georgia. The Bugwood Network, The University of Georgia. http://www.gaeppc.org/weeds/bamboo.html. Accessed: November 21, 2005.

McClure, F. A. 1957. Bamboos of the Genus Phyllostachys Under Cultivation in the United States. Washington, DC: U.S. Department. of Agriculture, Agricultural Research Service. 69 p.

Meredith, T. J. 2001. Bamboo for Gardens. Portland, OR: Timber Press. 406 p.

Swearingen, J., K. Reshetiloff, B. Slattery, and S. Zwicker. 2002. Plant Invaders of Mid-Atlantic Natural Areas: Herbaceous Plants. National Park Service and U.S. Fish and Wildlife Service: Washington, D.C., http://www.nps.gov/plants/alien/pubs/midatlantic/bamb.htm. Accessed: November 21, 2005.

Young, R. A. and J. R. Haun. 1961. Bamboo in the United States: Description, Culture, and Utilization, with Key to the Genera by F. A McClure. Washington, DC: U.S. Department of Agriculture, Crop Research Division, Agricultural Research Service Agricultural Handbook 193. 74 p.

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