Broadcast Applications of Glyphosate Control Nutsedge at a South Georgia Forest Tree Nursery

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ABSTRACT: *Nutsedge is a mujor weedprohlem in some southernforest tree nurseries. Although herbicides can control most weeds in nurseries, control of nutsedge is usually dependent on fumigation. The purpose of this study was to examine the effectiveness of broadcast upplications of glyphosate for control of nutsedge. Single and multiple applications of glyphosate at 2.2 kg ai/ha greatly reduced the density of nutsedge shoots and viable tubers at a south Georgia forest tree nursery. The first application in June 1999 reduced nutsedge shoots by approximately 98%. Subsequent upplications during September and October 1999 had no additional detectable effect. Although upplications in August and September2000 greatly reduced the amount of nutsedge in previously untreated areas, their effect did not appear to be as great as glyphosate applications during the first year. Rainfall before and after glyphosate applications, and plant age at the time of application may have influenced the level of nutsedge control in year two. Nutsedge shoots and viable tubers were reduced to near zero levels in plots treated over a 2 yrperiod. The use of broadcast applications of glyphosate may be of value in developing a more cost-effective management program for nutsedge control in southern forest tree nurseries. South. J. Appl. For. 27(3):176–1 79.*

Key Words: Glyphosate, nutsedge, *Cyperus* spp., forest tree nurseries, weed control.

Purple nutsedge *(Cyperus rotundus* L.) and yellow nutsedge *(C. esculentus* L.) are major pest problems in some southern forest tree nurseries (Fraedrich and Smith 1994). Fumigation with methyl bromide has been the primary method for nutsedge control in many nurseries. However, methyl bromide has been identified as an ozone-depleting chemical, and a complete phaseout of its production and use is scheduled for 2005 in accordance with the United States Clean Air Act and the Montreal Protocol (Environmental Protection Agency 1999). Many alternative fumigants have been evaluated in southern forest tree nurseries; however, their efficacy for nutsedge control has been variable (Fraedrich and Dwinell 1997, South et al. 1997, Carey 2000, Cram et al. 2002).

Purple and yellow nutsedge are perennial plants that are among the world's worst weeds (Grichar 1992, Zandstra et al. 1974). Nutsedge can grow quite rapidly under field conditions. Hauser (1962) found that purple nutsedge could increase from less than 25 plants/m^2 to approximately 742 plants/m^2 in 20 wk. Nutsedge reproduces primarily by tubers and basal bulbs; seeds are regarded as an ineffective means of reproduction (Crichar 1992, Moosavi-Nia and Dore 1979). Glyphosate, a nonselective broad-spectrum herbicide, can provide good control of nutsedge (Cools and Locascio 1977, Chase **and** Appleby 1979a, Doll and Piedrahita 1982). The herbicide is absorbed by leaves and translocated throughout plants (Ashton and Monaco 199 1). Glyphosate controls the shoots of nutsedge and is readily translocated into tubers, killing them as well (Zandstra and Nishimoto 1977, Doll and Piedrahita 1982). Many factors can influence the effectiveness of glyphosate including rate of application (Doll and Piedrahita 1982), plant age (Zandstra and Nishimoto 1977), photoperiod and light intensity (Abu-Irmaileh and Jordan 1978), soil moisture availability and plant moisture stress (Chase and Appleby 1979b, Moosavi-Niaand Dore 1979), relative humidity (Chase and Appleby 1979b), and tillage between applications (Chase and Appleby 1979a).

NOTE: Stephen W. Fraedrich can be reached at Phone: (706) 559-4273; Fax: (706) 559-4287; E-mail: sfraedrich@fs.fed.us. The authors thank Johnny Branan, Jeff Fields, Greg Seabolt, and Jerry Scott of the Georgia Forestry Commission for advice and support; John Mexal, Sal Locascio, Kerry Britton, and Stan Zarnoch for helpful comments and suggestions on drafts of the manuscript; and Tony Blalock and Susan Best for technical support. The use of trade names or firm names in this publication is for reader information and does not imply endorsement by the USDA of any product or service. This publication reports research involving pesticides. It does not contain recommendations for their uses, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and federal agencies before they can be recommended. Manuscript received April 22, 2002, accepted September 27, 2002. This article was written by US Government employees and is therefore in the public domain.

Broadcast applications of glyphosate may be a viable and useful practice for managing nutsedge in forest tree nurseries for several reasons. Nursery production areas are relatively small compared to most agricultural production fields, and nursery fields are routinely and intensively managed for weeds and other pest problems. Nursery managers typically alternate pine seedling production with cover crops on 1 to 2 yr cycles, and broadcast applications of glyphosate may be possible while fields are fallow. In addition, nursery fields can be irrigated to stimulate nutsedge sprouting and growth in order to maximize the effectiveness of glyphosate applications. The use of glyphosate for nutsedge control in forest tree nurseries has been previously suggested by South (1984). South believed that nutsedge could be eradicated in nurseries with repeated applications of glyphosate; however no supporting data were provided, and the practice has not been widely used or developed.

Nutsedge has been a constant problem at the Flint River Nursery (Byromville, GA) since its establishment in 1987, and fumigation with methyl bromide has been the primary method for control of this weed. In 1999, a study was established at this nursery to determine the effectiveness of broadcast applications of glyphosate for nutsedge control in a field that had been fumigated in recent years but nutsedge had become reestablished. The objective of this study was to determine if single or repeated applications of glyphosate could be of value for the control of nutsedge in a southern forest tree nursery.

Materials and Methods

The study was conducted in a 3.65 ha field that was fallow during the spring, summer, and early fall of 1999. The field had been previously fumigated with methyl bromide and chloropicrin (MC33) in 199.5; however, nutsedge had become reestablished throughout the field. Purple nutsedge was the primary species in this field, although yellow nutsedge was occasionally noted. The field was divided into three blocks each consisting of four plots, and each plot was 2 13 m x 9.8 m. Plots in each block were randomly assigned to one of four treatments that consisted of glyphosate applied zero, one, two or three times during the spring, summer and fall of 1999. Glyphosate was applied at 2.2 kg ai/ha with a three bed or six bed sprayer. The application schedule for each treatment is summarized in Table I.

On October 20, 1999, soil was excavated to a 15 cm depth on three 0.3 m x 0.6 m sample plots in each treatment plot. The soil was sieved to extract nutsedge tubers, and tubers were counted and treated to induce sprouting using the techniqueof Teo and Nishimoto (I 973). Tubers were placed in clear plastic boxes (17.5 x 12.5 x 6 cm) with moistened germination paper, and the number of sprouted tubers was evaluated after 2 wk. The field was harrowed in early November 1999. Nutsedge shoots emerged during March 2000 and were counted on six 0.3 m x 1.2 m randomly established sample plots in each treatment plot on March 22, 2000. The field was harrowed again in June 2000.

The study was continued during the 2000 growing season with a modification. A second-year control plot (15.2 m $\times$4.9 m) was established in the western portion of each plot that had not received glyphosate applications during 1999. The entire field with the exception of the second-year control plots was sprayed with glyphosate at 2.2 kg ai/ha in August, and again in September 2000 (Table 1). The density of nutsedge tubers and shoots in each treatment plot was evaluated, as previously described, on January 18 and July 11, 2001, respectively. Data collection for all glyphosate-treated plots was restricted to the western portion of the field to be in close proximity to the second-year control plots. The number of viable tubers was determined as previously described.

Data for each year were analyzed by an analysis of variance for a randomized complete block design and Tukey's procedure was used for mean separation (Steel and Torrie 1980). Data from sample plots of each treatment plot were averaged to provide mean plot responses that were used in the analyses. Nutsedge shoot and tuber data were transformed with a square root transformation when necessary to correct for heterogeneity of variance among treatments. Untransformed data are reported in text and tables.

Results and Discussion

The initial glyphosate application in June 1999 greatly reduced the density of nutsedge shoots, tubers (total) and viable tubers compared to the controls (Table 2). The initial application reduced the density of nutsedge shoots by approximately 98% and viable tubers by 94%. Subsequent applications during 1999 did not provide additional detectable reductions in nutsedge shoots and tubers.

Glyphosate applications during 2000 again greatly reduced the density of nutsedge shoots, tubers (total), and viable tubers in areas not previously treated during 1999. The two applications applied during 2000 to previously untreated

Table 1. Summary of glyphosate application dates by treatment during 1999 and 2000.

	1999			2000	
Treatment*	Glyphosate applications (2.2 kg ai/ha)		Treatment†	Glyphosate applications (2.2 kg ai/ha)	
GLY0			GLY0+0		
GLY1	06/16		GLY0+2	08103	09126
GLY2	06116	09102	GLY 1+2	08103	09126
GLY3	06/16	09102 10/14	GLY2+2	08103	09126
			GLY3+2	08103	09/26

* The treatments were: GLY0—No glyphosate applications; GLY1—glyphosate applied once; GLY2—glyphosate applied twice; and GLY3—glyphosate applied three times.

† The treatments were the same as those applied during 1999 plus no glyphosate (+0) or two glyphosate applications (+2) during 2000.

Table 2. Density of nutsedge shoots, total tubers, and viable tubers by treatment following glyphosate applications during 1999 and 2000.

Year	Treatment*	Nutsedge shoots (no./0.093m^2)†	Total tubers (no./0.093m^2)††	Viable tubers (no./0.093m^2)§
1999	GLYO	8.90 a§	47.2 a	43.2 a
	GLY1	0.20 b	7.0 b	2.6 b
	GLY2	0.10 b	3.1 b	0.2 b
	GLY3	0.50 b	9.9 b	1.4 b
2000	GLYO+O	12.30 a§	110.8 a	54.9 a
	GLY0+2	1.80 b	30.3 b	5.1 b
	GLY1+2	0.04"	3.4 c	0#
	GLY2+2	0.00"	1.4 c	0"
	GLY3+2	0.06"	5.4 c	0.1#

* The treatments were: GLYO, GLY1, GLY2 and GLY3 indicating that glyphosate was applied zero, one, two or three times, respectively, during 1999, plus no glyphosate (+0) or two glyphosate applications (+2) during 2000.

† The number of nutsedge shoots was assessed on March 22, 2000 for applications during 1999, and on July 11, 2001 for the applications during 2000.

†† The total number of tubers and the number of viable tubers was assessed on October 20, 1999 for applications during 1999, and on January 18, 2001 for the applications during 2000.

§ Means followed by the same letter within columns and year arc not significantly different according to Tukey's procedure ($P > 0.05$).

Treatment not included in the analysis because values were zero or near-zero for all treatment plots.

areas reduced nutsedge shoots by 85% and viable tubers by 91% compared to control plots. Several factors may have reduced the efficacy of the glyphosate treatments applied during 2000. First, nursery records indicate that 1.9 cm of rain occurred on the day of the August 2000 application. In comparison, no rain occurred during the week following the June 1999 application of glyphosate. Bariuan et al. (1999) found that a 2.5 cm rainfall within 1 and 24 hr after glyphosate applications could reduce efficacy of the herbicide by one-half and one-third, respectively. Secondly, the August and September applications of glyphosate during 2000 were applied about 7 and 15 wk later in the year, respectively, than the first application in 1999. The age of nutsedge plants can affect the uptake and distribution of glyphosate, and there is an increased likelihood that some tubers may survive glyphosate applications as the age of plants increases (Zandstra and Nishimoto 1977, Doll and Piedrahita 1982). Lastly, the nursery received only 2.15 cm of rain during the last 3 wk of August, and 6.35 cm during the first 3 wk of September 2000. The lack of soil moisture at key times may have affected the sprouting of tubers before the application, and the physiological receptiveness of nutsedge plants following application of glyphosate.

Based on the patterns of healthy nutsedge plants in plots following glyphosate applications, it is likely that complete coverage with glyphosate was not attained on some plots during some applications. For instance, one plot that received three glyphosate applications during 1999 probably did not receive complete coverage during the initial application. During data collection in March 2000 we observed a band of nutsedge within the plot that suggested there had been no overlap of the sprays during application or perhaps a spray nozzle malfunctioned. The density of nutsedge shoots on this plot in March 2000 was 1.6/0.093 m^2, but no shoots were recorded on the other plots that received three applications of glyphosate during 1999. Uniform applications of glyphosate across fields and complete coverage of nutsedge plants are essential to achieve maximum control.

Most weeds can be controlled in southern pine nurseries with available herbicides. Although weed control is possible in forest tree nurseries through an integrated program that does not rely on fumigation (South 1979), many managers have relied on fumigation to control some weeds such as nutsedge. In the present study, applications of glyphosate over a 2 yr period reduced the density of nutsedge shoots and viable tubers to near zero levels. The use of broadcast applications of glyphosate could provide a cost-effective alternative to routine fumigation for nutsedge control during years when fields are not in production, and can be left fallow during the spring and summer. Compared to fumigation, glyphosate is relatively inexpensive, even for several applications. Broadcast applications of glyphosate for nutsedge control are presently being evaluated operationally at the Flint River nursery (pers. comm., Jeff Fields, Georgia Forestry Commission, October 9, 2002).

Although broadcast applications of glyphosate were the focus of this study, management of nutsedge through an integrated program may provide more cost-effective and better long-term control than relying on periodic intensive efforts or fumigation alone. Glyphosate can be used in windrows and along risers, and if necessary, as a spot treatment in pine seedling production areas. Glyphosate can also be used with shielded sprayers for nutsedge control in hardwood seedling beds. Other practices, such as frequent washings of machinery (South 1984) and the use of dense cover crops (Ashton and Monaco 1991), can also restrict the establishment and development of nutsedge in fields.

Conclusions

Broadcast applications of glyphosate provided effective control of nutsedge in a fallow field where nutsedge had reestablished following fumigation and production of three pine seedling crops. Multiple applications of glyphosate over a 2 yr period reduced nutsedge shoots and viable tubers to near zero levels. In nurseries where nutsedge is a recurring problem, managers should consider testing

broadcast applications of glyphosate. Optimum control of nutsedge can be best achieved when nutsedge plants are actively growing. During periods of drought, fields should be periodically irrigated prior to glyphosate applications to obtain maximum sprouting of tubers and maintain active plant growth. The number of applications needed to eliminate nutsedge may be reduced by spraying glyphosate when plants are actively growing, and by ensuring complete coverage of foliage. When rains occur within 72 hr following glyphosate applications, nursery managers may need to consider reapplying the herbicide to obtain maximum control. Broadcast application of glyphosate prior to pine seedling production may be useful and cost-effective as part of an integrated management program to control nutsedge.

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