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Authors: DiTomaso, Joseph M., Drewitz, Jennifer J., and Kyser, Guy B.

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Jubatagrass (*Cortaderia jubata*) Control Using Chemical and Mechanical Methods

Joseph M. DiTomaso, Jennifer J. Drewitz, and Guy B. Kyser*

Jubatagrass is one of the most invasive plants along the California and southern Oregon coast. It establishes dense populations that can severely impact native plant diversity and conifer seedling recruitment following forestry operations. This goal of this study was to evaluate the effectiveness of both manual removal and several herbicide control options and application techniques. In addition, a cost analysis was also conducted for the most successful herbicide control methods. Results demonstrate that mechanical removal through digging is effective, although labor intensive. Among the herbicides tested, glyphosate applied as a high-volume (spray-to-wet) application (0.6% ae) in early summer, low-volume application (2.4% ae) in early summer or fall, and ropewick technique in early summer or fall (> 9.9% ae) all provided ≥ 88% jubatagrass control, but the low-volume treatments were the most cost effective. Although the graminicide sethoxydim at the highest rate (0.36% ai) did not give effective control, fluazifop applied in the fall in a low-volume treatment (0.98% ai) gave 87% control of jubatagrass. Imazapyr gave some level of control but does not appear to provide an economical option for jubatagrass management. Results of this study demonstrate that in addition to the more conventional methods of mechanical removal and spray-to-wet glyphosate (0.6% ae), control of jubatagrass can also be equally or more effective with low-volume and ropewick applications of glyphosate.

Nomenclature: Fluazifop; glyphosate; imazapyr; sethoxydim; jubatagrass, *Cortaderia jubata* (Lemoine) Stapf.
Key words: High volume, low volume, perennial grass, ropewick, wildland.

Jubatagrass is a perennial grass native to northern Argentina and the Andes of Bolivia, Peru, and Ecuador (Connor and Edgar 1974, Parson and Cuthbertson 1992). It is a large tufted grass (tussock) with sharp serrated margins on leaf blades that are 2 to 3 cm wide and up to 2 m long. Jubatagrass produces long inflorescences, typically called plumes, on stalks 2 to 4 m tall (Parsons and Cuthbertson 1992). Each inflorescence can produce thousands of wind-dispersed seed through apomixis (asexual seed production) (Drewitz and DiTomaso 2004).

Although its year of introduction into California is unknown, jubatagrass is believed to have been mistakenly imported by the horticultural industry as a variety of pampasgrass (*Cortaderia selloana*), a popular landscaping plant also native to South America (Lippmann 1977). In addition to their ornamental value, both *C. selloana* and *C. jubata* were introduced into the United States (California), South Africa, and New Zealand for their use as dry-land forage, windbreaks, and soil stabilizers (Harradine 1991; Lippmann 1977; Parsons and Cuthbertson 1992).

In California, jubatagrass is localized along the coast in areas with a strong marine influence (cool, wet winters with little frost, and summer temperatures moderated by fog or wind). Previous studies have shown that the species is intolerant to hot and dry inland conditions (Stanton and DiTomaso 2004). Within its range, it invades a variety of habitats, including coastal strand, northern coastal scrub, coastal sage scrub, north coastal coniferous forest, closed cone pine forest, redwood forest, and chaparral (DiTomaso et al. 1999). In addition, it often becomes established on disturbed sites such as slides, roadsides, graded areas, quarries, and previously logged conifer forests (Fritzke and Moore 1998; Harradine 1991; Munz and Keck 1973).

Jubatagrass was originally reported as a weed in California in the 1960s in cut-over redwood forests in Humboldt County (Fuller 1976). Its current California distribution ranges from San Diego to the Oregon border (DiTomaso et al. 1999). It is listed as a highly invasive plant by the California Invasive Plant Council (Cal-IPC 2006) and as a noxious weed by the California Department of Food and Agriculture (CDFA 2003). It establishes dense populations that have been shown to reduce conifer growth, interfere with conifer seedling recruitment, and

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* Cooperative Extension Specialist, Graduate Student, and Staff Research Associate, Department of Plant Sciences, Mail Stop 4, University of California, Davis, CA 95616. Current address of second author: 4310 Expressway, #17, Missoula, MT 59808. Corresponding author's E-mail: jmditomaso@ucdavis.edu

Interpretive Summary

Jubatagrass is one of the most important invasive species of coastal regions from southern California to southern Oregon. In many areas, it forms dense stands that threaten native plant populations and can negatively impact conifer reestablishment following forestry operations. Although effective chemical control methods have been developed in New Zealand and Australia, some of these herbicides are not registered in the United States (e.g., haloxyfop). The most common methods of jubatagrass control in California rely on mechanical removal or high-volume (spray-to-wet) application of glyphosate at 2% solution. This study evaluated these conventional methods, as well as other possible control options at two timings, including low-volume treatments of glyphosate, fluazifop, sethoxydim, and imazapyr as well as ropewick applications of glyphosate. A cost comparison was also conducted on the most successful chemical control methods. Although the most commonly used control methods, including mechanical digging and early summer spray-to-wet glyphosate applications, were effective, other methods were also excellent and equally or more economical. In particular, a low-volume glyphosate application at 8% (product) and a 33% or higher ropewick technique with glyphosate in early summer or fall all gave ≥ 88% jubatagrass control. Of all the treatments, the low-volume glyphosate application was the most cost effective. The graminicide fluazifop applied as a low-volume 4% (product) application in the fall also gave 87% control of jubatagrass. Results of this study demonstrate that, in addition to the more conventional methods, control of jubatagrass can also be equally or more effective with low-volume and ropewick applications of glyphosate.

occupy space otherwise inhabited by native plant species (Harradine 1991).

Control strategies for jubatagrass are limited. Mechanical removal by hand, excavators, and backhoes can be very effective and selective (Harradine 1991; Moore 1994). However, these methods are labor- and cost-intensive, and feasibility depends upon site accessibility, size of the infestation, funding, and availability of volunteer support (Pasquinelli 1998).

Alternatively, herbicides can provide a cost-effective control option where mechanical methods are not feasible. Most herbicide testing on jubatagrass has been conducted in Australia and New Zealand (Davenhill 1988; Harradine 1991; Saville et al. 1986), but some of the compounds shown to be effective are not registered for wildland use in California (e.g., clethodim and haloxyfop). Although imazapyr is registered for use in California, it has not yet been evaluated for jubatagrass control in the United States. In a New Zealand study, however, imazapyr gave 100% control of jubatagrass approximately 1 yr after treatment (Davenhill 1988).

In California, Australia, and New Zealand, high-volume, spray-to-wet foliar applications of glyphosate at 0.72% ae (2% Roundup®) are often used in jubatagrass control programs (Costello 1986; Davenhill 1988; Gadcil et al. 1984; Harradine 1991). Although some control is achieved with glyphosate applications to the regrowth of previously cut plants (Fritzke and Moore 1998; Harradine 1991), these treatments often require a repeat application (Pasquinelli 1998). In addition, wiper applications of glyphosate at 18% ae (50% product) in New Zealand and Australia are also reported to yield effective control (Gadcil et al. 1984; Harradine 1991).

The objectives of this study were to assess the economics and evaluate the effectiveness of both manual removal and several chemical control options for jubatagrass management in California. Because most infestations of jubatagrass occur in nonagricultural lands with desirable native plant species, techniques were evaluated that minimized potential impact to surrounding habitat and vegetation.

Material and Methods

Treatment Summary. A total of 44 treatments including controls (all herbicide treatments are shown in Table 1) were applied to jubatagrass plants. Four different herbicides, some in more than one formulation, were applied at two to three rates, to two to three different plant sizes, using several application techniques. Additional treatments included mechanical (hand removal) and combination treatments (mowing vegetation in the early summer and applying herbicide to regrowth in the fall) (Table 1). We used a completely randomized experimental design with eight replicates per treatment (one plant equivalent to one replicate). A total of 1,488 plants were used including untreated controls.

Study Site. Study sites were located in Santa Barbara County at Vandenberg Air Force Base (VAFB), near the city of Lompoc, California. VAFB occupies approximately 34,800 ha (86,000 acres), of which 600+ ha (1,500+ acres) are infested with varying densities of jubatagrass (C. Gillespie, personal communication). The plant community type found on the infested treatment sites was a central coast maritime chaparral, specifically Burton Mesa chaparral, which includes several endemic plant species such as *Arctostaphylos purissima* and *Arctostaphylos rudis* (Odion et al. 1992). Sites were located within a 1.5-km by 5-km area at approximately 34.7°N latitude, 120.6°W longitude, at 70 m to 105 m elevation. The soils at all field sites are Tangair sand with some concretions, classified as an entisol, mixed, mesic, typic psammaquent. This is a somewhat poorly drained sandy soil formed on old marine terrace deposits.

Experimental sites were established at four heavily infested areas with a range of plant sizes. One field (1998) contained small (0.2- to 0.4-m-diam) and medium (0.6- to 1-m-diam) plants, on about 1.6 ha (4 acres) with an average estimated plant density of about 30 plants/

Table 1. Summary of herbicides, percent ae or ai, percent product, adjuvant, and application method used for in jubatagrass control treatments.

Herbicide	Trade name	% ae or ai	% Product	Adjuvant	Application method
Glyphosate	Roundup Pro®	0.3 ae	1	—	Foliar — high and low volume
		0.6 ae	2	—	Foliar — high and low volume
		1.2 ae	4	—	Foliar — low volume
		2.4 ae	8	—	Foliar — low volume
		4.8 ae	16	—	Ropewick
		9.9 ae	33	—	Ropewick
		15 ae	50	—	Ropewick
		30 ae	100	—	Ropewick
Imazapyr	Stalker®	0.057 ae	0.25	25% Hasten	Foliar — low volume
		0.11 ae	0.5	25% Hasten	Foliar — low volume
		0.23 ae	1	25% Hasten	Foliar — low volume
		0.45 ae	2	25% Hasten	Foliar — low volume
		0.90 ae	4	25% Hasten	Foliar — low volume
Fluazifop-P-butyl	Fusilade® DX	0.25 ai	1	0.05% Sylgard + 1% Herbimax	Foliar — low volume
		0.49 ai	2	0.05% Sylgard + 1% Herbimax	Foliar — low volume
		0.74 ai	3	0.05% Sylgard + 1% Herbimax	Foliar — low volume
		0.98 ai	4	0.05% Sylgard + 1% Herbimax	Foliar — low volume
Sethoxydim	Poast®	0.18 ai	1	0.05% Sylgard + 1% Herbimax	Foliar — low volume
		0.36 ai	2	0.05% Sylgard + 1% Herbimax	Foliar — low volume

100 m^2. The second (also 1998), third (1999 to 2000), and fourth (2002 to 2003) fields contained large (≥ 1.0-m-diam) plants on approximately 1.2 ha (3 acres), 2 ha (5 acres), and 4 ha (10 acres), respectively. The estimated density of these four areas was between 12 and 20 plants/100 m^2.

Treatment Methods. Each plant was given an identification number that corresponded to a specific treatment and replication. The number was noted on a pin flag and etched on a metal tag, both of which were secured near the base of the plant. In the 2002 to 2003 study site, treated plants were mapped using a global positioning system receiver. Maps were developed at each study site to assist in returning to treatment plants for future evaluation.

Glyphosate,[1] imazapyr,[2] fluazifop,[3] and sethoxydim[4] were evaluated at different rates and combinations (Table 1). Glyphosate is a broad-spectrum POST herbicide widely used as a foliar treatment on crop and noncropland weeds, whereas imazapyr is also a broad-spectrum herbicide but with both PRE and POST activity. Imazapyr is most commonly used for the control of herbaceous perennial and woody broadleaf plants in forest plantations and invasive species in wildland areas. Both sethoxydim and fluazifop are foliar-applied grass-selective herbicides, which typically do not harm broadleaf species even at high rates. They provide a more selective application in situations where desirable broadleaf vegetation is present within the infested area.

Foliar applications of herbicides were made using a CO_2 backpack sprayer[5] and a handheld spray wand[6] with a single 8004 flat fan nozzle[7] at 1.40 kg/cm^2 (20 psi). Sethoxydim, fluazifop, and imazapyr were applied only in a low-volume treatment. Glyphosate was applied in both low- and high-volume treatments. The amount of solution applied in low-volume treatments was calibrated to 80 ml/m^2 (e.g., approximately 62 ml of solution for a plant 1 m in diam). This was equivalent to 800 L/ha (86 gal/acre). In the 1999 to 2000 and 2002 to 2003 applications, a standard spray-to-wet treatment was also included. For this application, the spray volume was calculated to be 1,860 L/ha (200 gal/acre). Herbicides were applied as directed (spot) treatment and as such were mixed as percentage of total spray volume (v/v). Applications to each plant were timed to ensure accurate and consistent delivery rates.

Ropewick applications of glyphosate at 4.8, 9.9, 15 and 30% ae (representing 16, 33, 50 and 100% product, respectively) were made with a handheld wiper[8] (Sideswipe®) with a 1.2-m-long hollow handle that acted as a reservoir for the herbicide. The base of the handle contained an L-shaped nylon nap (sponge) that wicked up the herbicide from the reservoir. Plants were treated by wiping the herbicide-saturated, applicator sponge on the plant foliage. The smaller plants were wiped until foam was visible on most of the exterior foliage. For medium and large plants, the base of the plant was wiped until foam appeared.

Control methods also included two mechanical treatments, digging and cutting. Digging was conducted by cutting back foliage with shears, then using a pulaski (combination of single-bit axe with an adze-shaped grub hoe) to section and remove the root ball from the soil. Small, fibrous roots extending from the root ball were not removed. Root sections were turned upside down to minimize root regrowth (Moore 1994). Cutting was performed with a 38-cm chainsaw at a height of 10 to 15 cm.

Treatments using a combination of mechanical cutting and chemical application were also applied in the 1998 study site. After cutting the foliage in early summer (with a chainsaw as previously described), glyphosate was applied to regrowth in the fall at several rates, either as a foliar spray or by ropewick application. Methods used for these glyphosate applications were the same as previously described.

Herbicide treatments were made in early summer (June) of 1998, 2000, and 2002, and fall (October) of 1998, 1999, and 2002. Mechanical treatments were conducted only in June 1998. Final evaluations were conducted 13 to 15 mo after treatment for early summer applications and 22 to 24 mo after treatment for fall applications. Visual evaluations of percentage of control relative to untreated plants were made with all treatments. Estimates of percentage of control were based on the reduction in green living foliage in surviving tillers. Combination treatments (chainsaw plus herbicide) were compared to chainsaw-only treatments. Rainfall was monitored for 60 d before treatment and 60 d after treatment in each year.

Data Analysis. Treatments were compared within each study year using an unbalanced ANOVA for completely randomized design, with three factors: timing (fall vs. early summer), plant size, and treatment. In the 2002 study year, size was not included as a factor. In all years, early summer vs. fall gave different results ($P < 0.0001$). In both 1998 and 1999 to 2000, size was also a significant factor ($P = 0.0368$ and $P < 0.0001$, respectively). For each treatment date and within each size class, treatment effects were compared using single-factor ANOVA followed by means separation using the Student-Newman-Keuls test ($\alpha = 0.05$).

Cost Analysis. The time required to conduct each treatment was recorded on a per-plant basis and used to assess labor costs for each treatment. Most treatments were applied to three sizes of plants: small (0.2 to 0.4 m diam), medium (0.6 to 1 m diam), and large (1.2 to 3 m diam). Combination treatments were only performed on medium and large plants.

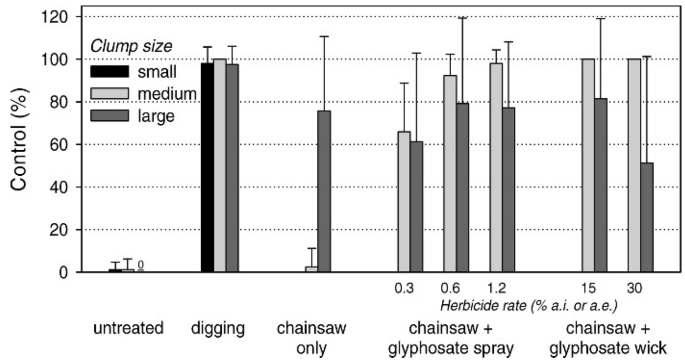

Figure 1. Control of small, medium, and large jubatagrass plants using mechanical methods and a combination of mechanical cutting followed by glyphosate treatment to recovered plants. All mechanical treatments were made on June 9, 1998, and glyphosate treatments were made on October 18, 1998. Evaluations were conducted on July 12, 1999 (early summer) and October 25, 2000 (fall). Small plants were not used in chainsaw treatments. Lines above bars represent one standard deviation of mean.

The costs of successful treatments were evaluated assuming an average plant size of 1 m^2 and labor costs of \$20/h. Time required to apply the treatment to the plant, walk to the next plant, and refill the spray tank or wick applicator were all recorded. Data are represented as the average cost of control for 1 m^2 of plant area.

Results and Discussion

Mechanical and Combination Treatments. Mechanical removal (digging) of jubatagrass was very effective with all size classes, providing 98 to 100% control (Figure 1). This method, however, can be very labor intensive, particularly with medium and large plants (Pasquinelli 1998). The feasibility of using digging as a control option depends on the availability of human and financial resources.

Nearly all combination treatments (chainsaw plus ropewick and chainsaw plus foliar spray) gave $> 90\%$ control of medium-sized plants, except a foliar application with 0.3% glyphosate (1% product) (Figure 1). Large plants, however, were not effectively controlled with the chainsaw-plus-glyphosate treatments. Neither the chainsaw alone nor the herbicide combinations gave better than 85% control 2 yr after application. One benefit to a combination of these two control methods is that less standing vegetation remains on site after treatment. This may be beneficial in revegetation projects or for aesthetic value. However, the approach requires considerable labor and repeated visits to the treatment site. With these limitations, and the lack of effective control of larger plants, the combination is unlikely to be a practical solution to jubatagrass management.

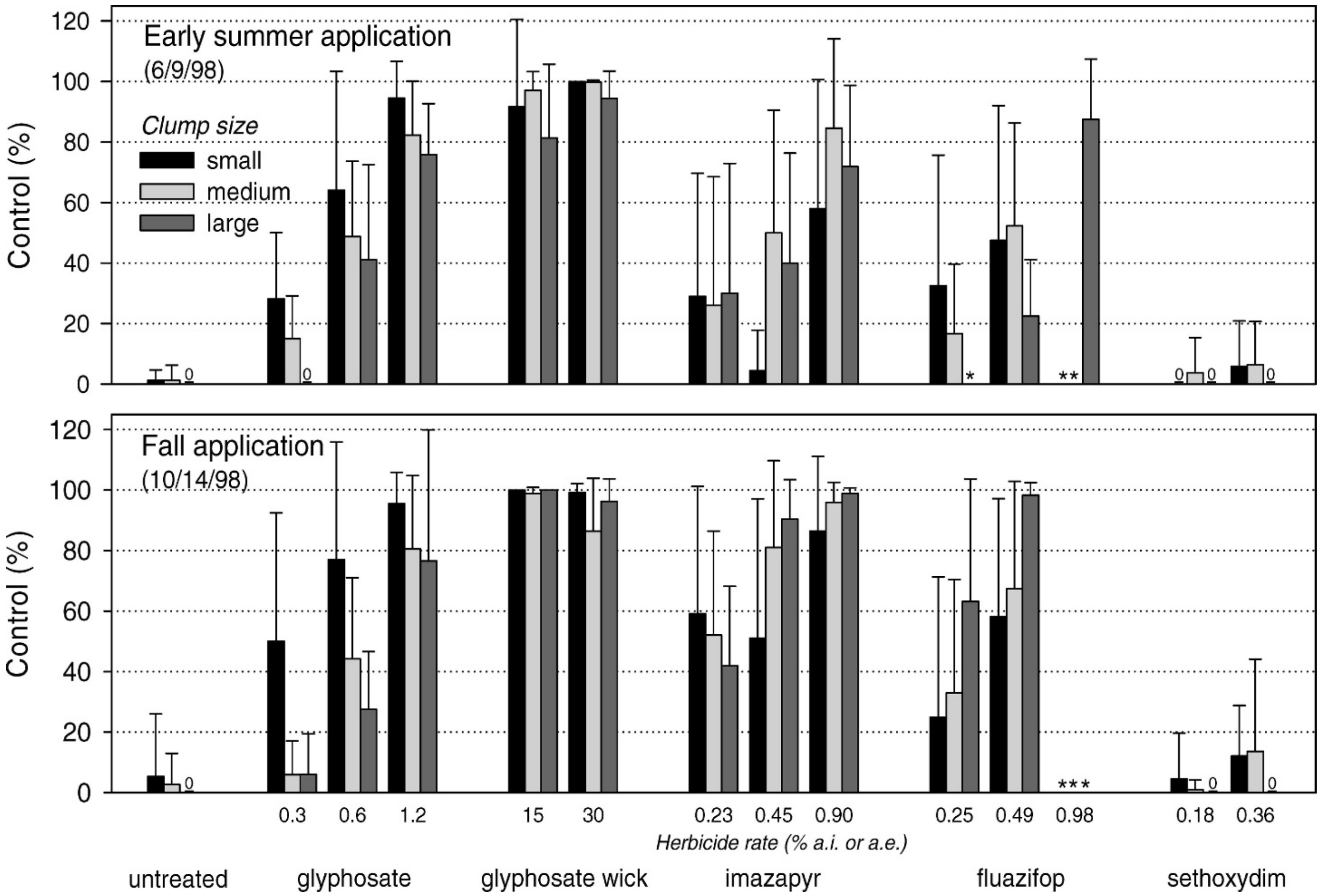

Figure 2. Control of small, medium, and large jubatagrass plants using various herbicides treated in early summer (June 9) and fall (October 14) 1998. Evaluations were conducted on July 12, 1999 (early summer) and October 25, 2000 (fall). Herbicide treatments with asterisk were not tested. Lines above bars represent one standard deviation of mean.

Foliar Herbicide Treatments. Of the four foliar applied herbicides used in this study, the graminicide sethoxydim was the only one that did not provide effective control of any plant size in either early summer or fall (1998) treatments (Figure 2). As a result, sethoxydim was no longer included in the trials conducted from fall 1999 to fall 2002.

Although more effective compared to sethoxydim, control of jubatagrass with the other graminicide, fluazifop, was erratic both seasonally and among years and did not control small or medium-sized plants. The only fluazifop treatments that provided > 80% control of large jubatagrass plants by 2 yr after treatment were the fall 1998 application (98%) at 0.49% ai (2% product), and the early summer 1998 (88%) and 2000 (86%) treatment at 0.98% ai (4% product) (Figures 2 and 3). In the 2002 treatments, no fluazifop rate provided more than 62% control (Figure 3). The effectiveness of fluazifop did not appear to be correlated with precipitation before or after the herbicide application. Lower rates of fluazifop appeared to give successful control 1 yr posttreatment, but control did not persist into the second year (data not shown).

Results with imazapyr were also inconsistent from year to year and between seasons. Imazapyr applications in fall 1998 at 0.45 and 0.9% ae (2 and 4% product) ranged from 80 to 99% control of medium and large plants and were much more effective than early summer applications (Figure 2). However, jubatagrass control with imazapyr was very poor at all rates and plant sizes in both the fall 1999 and early summer 2000 treatments (Figure 3). In the 2002 treatments, control was again poor except for the fall application at 0.9% ae (4% product), which provided 84% control (Figure 4). As with fluazifop, control ratings were high 1 yr after treatment, but plants recovered in most treatments by the second year after herbicide application (data not shown).

Tank mixes of imazapyr and glyphosate have been successfully used for the control of saltcedar (*Tamarix* spp.) (Duncan and McDaniel 1998). Similar combinations were tested for jubatagrass control in the fall 1999 and early

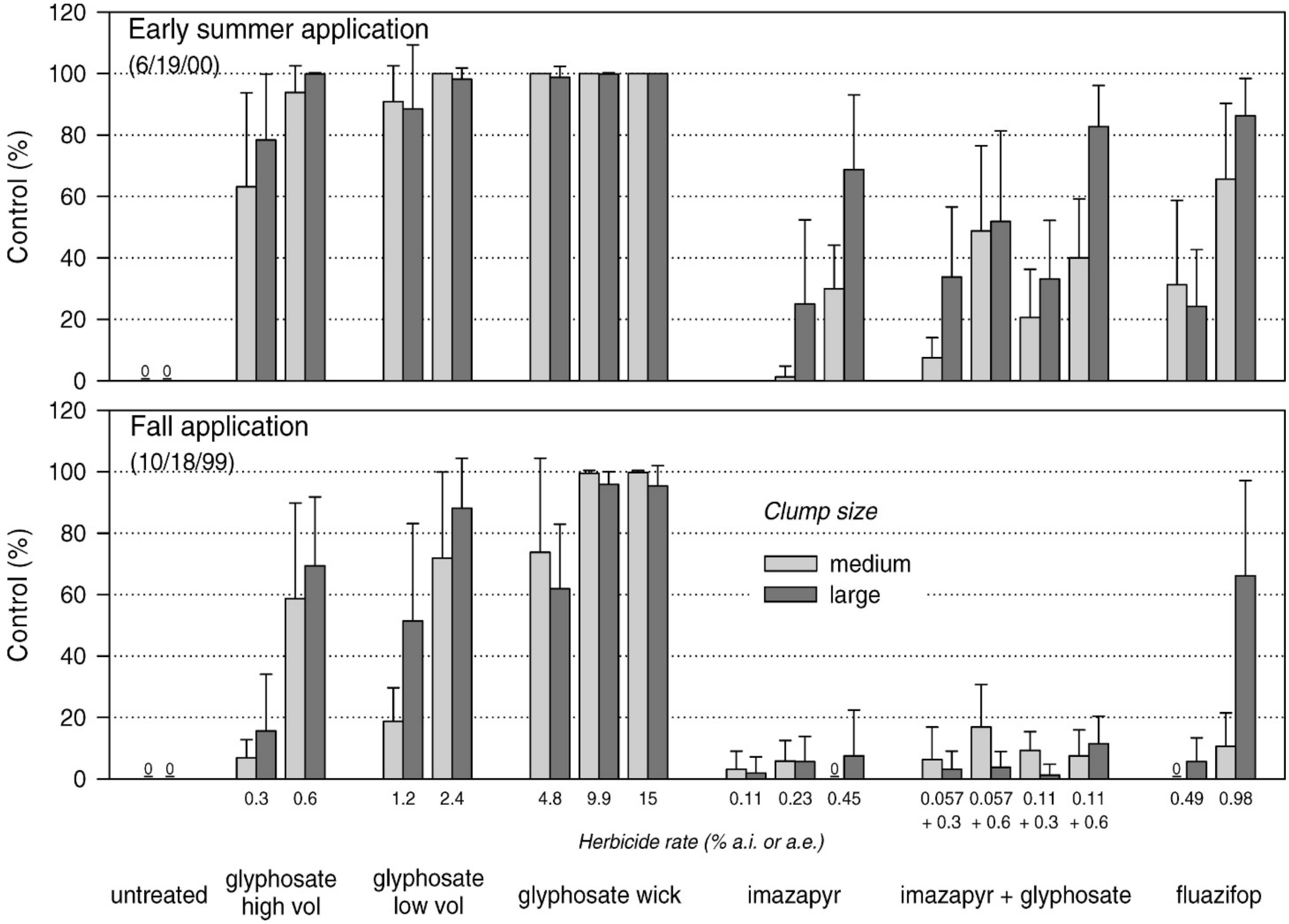

Figure 3. Control of medium and large jubatagrass plants using various herbicides treated in fall (October 18) 1999 and early summer (June 19) 2000. Evaluations were conducted on August 27, 2001. Lines above bars represent one standard deviation of mean.

summer 2000. However, only the early summer application at the highest rates of the two herbicides gave > 82% control with large plants (Figure 3). This combination appears less effective on jubatagrass than on other invasive species. As a result, the treatment was not repeated in the 2002 study.

Of the four foliar-applied herbicides, glyphosate provided the most consistent jubatagrass control with all plant sizes in both fall and early summer. Low-volume spray treatments with 0.3 and 0.6% ae (1 and 2% product) did not control jubatagrass sufficiently in either early summer or fall 1998 (Figure 2), but 1.2% ae (4% product) controlled small plants (95 to 96%) and adequately controlled medium (80 to 82%) and large (76 to 77%) plants. In fall 1999, only the 2.4% ae (8% product) treatment effectively controlled (88%) large jubatagrass plants using a low-volume treatment, but in early summer 2000, treatments with both 1.2 and 2.4% ae (4 and 8% product) controlled (88 to 100%) medium and large plants (Figure 3). In 2002, low-volume treatments with 2.4% ae (8% product) achieved > 98% control of large plants in both early summer and fall (Figure 4).

High-volume (spray-to-wet) treatments with glyphosate at 0.6% ae (2% product) applied in early summer 2000 effectively controlled (94 to 100%), but fall treatments were not as effective, nor were lower rates (Figure 3). In 2002, high-volume applications of 0.6% ae (2% product) gave only 74 to 75% control of jubatagrass in fall and early summer treatments, respectively (Figure 4). This level of control, although adequate, is not considered acceptable under most conditions.

Of all the foliar treatments, 2.4% ae (8% product) glyphosate in a low-volume application consistently gave the most effective jubatagrass control in both fall and early summer. This was followed by 0.6% ae (2% product) glyphosate in a high-volume application.

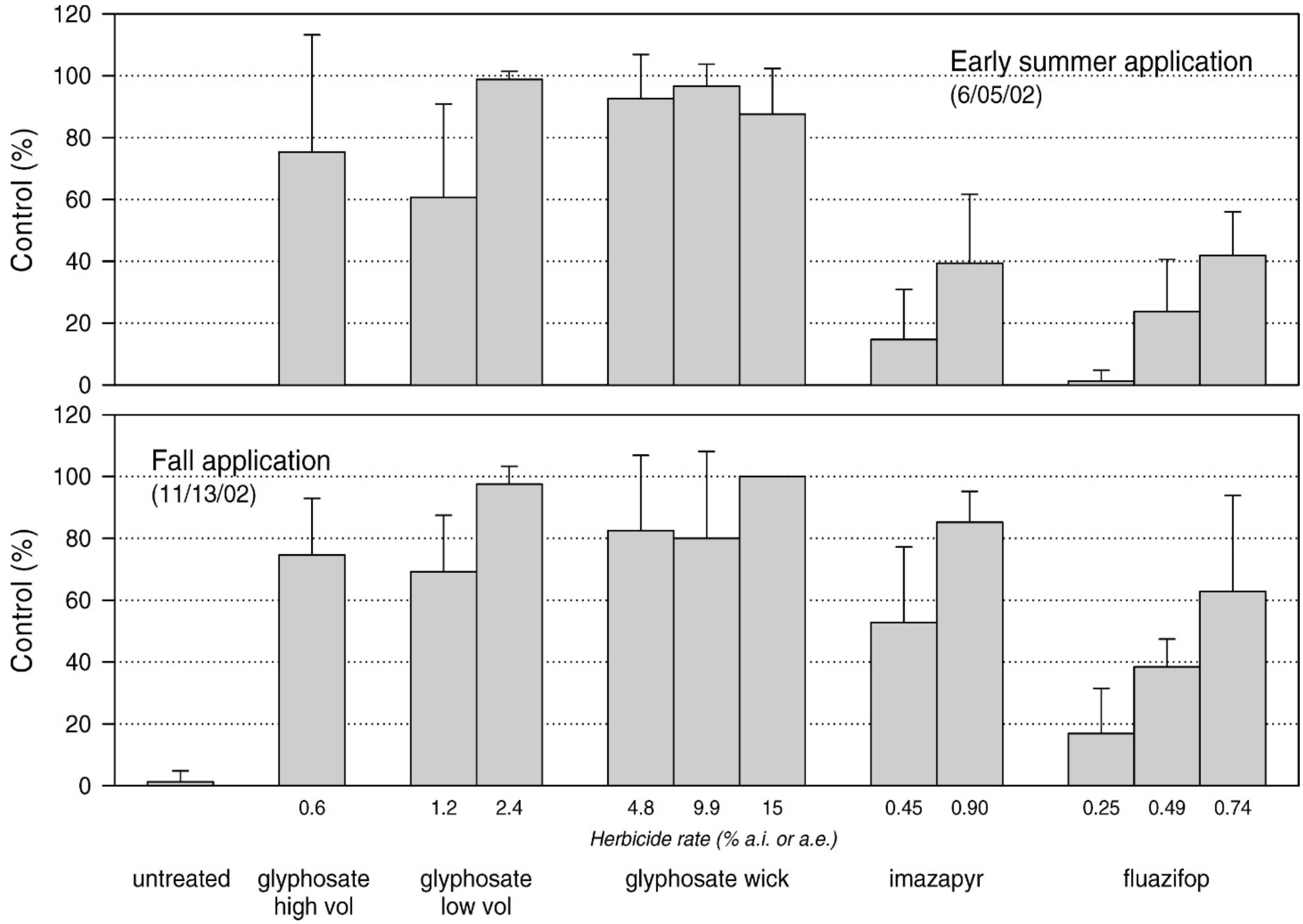

Figure 4. Control of large jubatagrass plants using various herbicides treated in early summer (June 5) 2002 and fall (November 13) 2002. Evaluations were conducted on October 5, 2004. Lines above bars represent one standard deviation of mean.

Ropewick Treatment. A ropewick applicator can be used to selectively wipe a broad-spectrum herbicide (e.g., glyphosate) onto a single target plant with minimal herbicide drift potential and with reasonable safety to adjacent desirable plants. Overall, ropewick applications of glyphosate were very effective for control of all size classes of jubatagrass. Both fall and early summer treatments, with rates of 9.9 to 30% ae (33 to 100% product), gave an average of 95% control of large plants (Figures 2–4). Early summer treatments with 4.8% ae (16% product) also gave 96% control of large plants, but fall treatments only gave an average of 68% control.

Cost Analysis. Cost analysis of all chemical treatments was based on labor costs (time required to treat target plants, travel time to the next plant, and time to refill the spray tank or wick applicator) and costs of adjuvants and herbicides (based on average 2007 prices). Results in Table 2 are calculated as the estimated cost to treat a 1-m^2 plant area. Only treatments that provided an average of $>$ 85% control in each season of treatment are represented in the table. Costs can be reduced by decreasing the amount of herbicide applied per plant and/or by decreasing labor costs by reducing treatment time per plant or frequency of refilling the spray tank. However, it is important to note that application cost saving that also result in reduced control may actually increase overall costs by requiring retreatment of escaped plants.

Results of the analysis demonstrate that the most economical treatment ($0.28 per plant) for large jubatagrass plants was a low-volume (800 L/ha [86 gal/acre]) application in either early summer or fall with 2.4% ae (8% product) glyphosate (Table 2). Although the most common method to control jubatagrass is a high-volume (spray-to-wet) treatment with 0.6% ae (2% product) glyphosate (Costello 1986), this treatment cost an additional $0.10 per plant.

Table 2. Cost analysis for effective chemical control of jubatagrass. Analysis includes chemical and adjuvant cost and labor costs. Labor costs based on $20/h. Final calculations are represented as the average cost of control for large plants, and the data are represented as costs per 1 m^2 plant area. Only treatments providing > 85% control are included.

Herbicide	Timing	Treatment	Rate (% product, % ai or ae)	Average % control	Average herbicide cost ($)	Average adjuvant cost ($)	Average labor cost based on $20/h ($)	Estimated cost per 1 m^2 plant ($)
Glyphosate	Early summer	Low volume	8 (2.4 ae)	99	0.08	0	0.20	0.28
	Fall	Low volume	8 (2.4 ae)	93	0.08	0	0.20	0.28
	Early summer	High volume	2 (0.6 ae)	88	0.05	0	0.33	0.38
	Early summer	Ropewick	16 (4.8 ae)	97	0.17	0	0.63	0.80
	Early summer	Ropewick	33 (9.9 ae)	98	0.35	0	0.63	0.98
	Fall	Ropewick	33 (9.9 ae)	88	0.35	0	0.63	0.98
	Early summer	Ropewick	50 (15 ae)	90	0.53	0	0.63	1.16
	Fall	Ropewick	50 (15 ae)	99	0.53	0	0.63	1.16
	Early summer	Ropewick	100 (30 ae)	94	1.06	0	0.63	1.69
	Fall	Ropewick	100 (30 ae)	96	1.06	0	0.63	1.69
Imazapyr	Early summer	Low volume	4 (0.90 ae)	92	0.30	0.11	0.20	0.61
Fluazifop	Fall	Low volume	4 (0.98 ai)	87	0.12	0.03	0.20	0.35

Low-volume application resulted in a reduction in labor costs, because individual plants could be treated in less than half the time of the high-volume treatments and fewer trips were required to refill the backpack sprayer. Conventional spray-to-wet treatments can use volumes ranging from 1,860 to 2,325 L/ha (200 to 250 gal/acre). In this comparison, 1,860 L/ha (200 gal/acre) was used as a standard spray-to-wet volume. Furthermore, jubatagrass control using 0.6% ae (2% product) spray-to-wet glyphosate treatments was inadequate in fall applications, averaging 72%, and inconsistent in early summer applications (100% control in 2000 and 75% control in 2002). The most economical control option may depend not only on reduced costs of application, but also on lower likelihood of having to retreat escaped plants.

Although the graminicide fluazifop controlled jubatagrass less consistently than other treatments, it did offer more selectivity and a reasonably economical option with a fall low-volume treatment at 0.98% ai (4% product). This would be a good control choice in areas where few desirable grass species co-occur with jubatagrass. However, its relatively low cost would be offset if control was poor enough to require retreatment.

Unlike fluazifop, imazapyr did not consistently control jubatagrass and, in general, does not appear to provide an economical option for its management. Results reported by Davenhill (1988) in New Zealand demonstrated 100% control of jubatagrass with imazapyr approximately 1 yr after treatment, but our results were much less consistent between seasons and years.

Ropewick applications require a more concentrated glyphosate solution and greater application time, and thus considerably higher chemical and labor costs. Although the treatment was not as cost effective as the foliar applications of glyphosate, they can be used to give good selective jubatagrass control with minimal potential for off-site drift. These two factors could be important considerations in some jubatagrass-infested areas where sensitive native or desirable species are in close proximity to jubatagrass.

Mechanical removal is a reliable control method, but labor intensive. Although mechanical removal may be prohibitively expensive using paid employees, it can be a very effective and desirable control option using volunteer labor provided by church, school, correctional facilities, or concerned citizen groups. Many programs have used volunteer groups in invasive weed educational activities, with the benefit of achieving cost-effective control in infested areas. Mechanical removal can, in some situations, be the best method to control jubatagrass on steep terrain that is too dangerous for individuals burdened with spray equipment. It should be noted that mechanical removal creates soil disturbance where individual plants are removed. This may be a consideration when working in areas containing sensitive plant species or areas susceptible to erosion or reinvasion.

The cost analysis reported here is based on the specific site conditions in this study. Conditions at other sites such as topography, accessibility, and jubatagrass density might impact costs in a variety of ways. Depending on the physical characteristics, limitations, economics, and long-term objectives of the infested site, a combination of the methods reported here can be used in an effective integrated weed management program to achieve long-term management or even local eradication of jubatagrass.

Sources of Materials

[1] Glyphosate, Roundup Pro®.
[2] Imazapyr, Stalker®.
[3] Fluazifop, Fusilade® DX.
[4] Sethoxydim, Poast®.
[5] CO_2 backpack sprayer, R&D Sprayers, Opelousas, LA 70570.
[6] Handheld spray wand, R&D Sprayers, Opelousas, LA 70570.
[7] 8004 flat fan nozzle, TeeJet Technologies, Wheaton, IL 60189-7900.
[8] Handheld wiper, Sideswipe®.

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