Preemergence Control of Black Cottonwood in Nursery Containers[1]

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Abstract

Two experiments were conducted to evaluate preemergence herbicides for control of black cottonwood (*Populus trichocarpa*) in nursery containers. In 2006, granular preemergence herbicides were applied to recently filled, weed-free containers in May just prior to seed release from mature cottonwood trees. Flumioxazin provided the most effective cottonwood control, although control with isoxaben + trifluralin, oxyfluorfen + oryzalin, and pendimethalin was also effective. In 2007, containers were filled February 15, and herbicides were applied to separate groups of containers on February 22, March 14, April 16, and May 15. Containers were over-seeded with cottonwood for a 2-week period starting on May 16. Control with most herbicides improved as the date of application neared the date of seeding. Flumioxazin provided the most effective control throughout the experiment, but control from it also improved as the date of application neared the time of seeding.

Index words: woody weed species, poplar, weed control.

Herbicides used in this study: Ornamental Herbicide II (OH2, pendimethalin + oxyfluorfen), *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine + 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene; Rout (oryzalin + oxyfluorfen), 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide + 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene; Snapshot 2.5TG (isoxaben + trifluralin), *N*-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide + 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine; Pendulum 2G (pendimethalin); Ronstar G (oxadiazon), 3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one; BroadStar (flumioxazin), 2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2*H*-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1*H*-isoindole-1,3(2*H*)-dione; Regal O-O (oxadiazon + oxyfluorfen); RegalKade (prodiamine), 2,4 dinitro-N^3,N^3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine; RegalStar (oxadiazon + prodiamine).

Species used in this study: black cottonwood (*Populus trichocarpa*).

Significance to the Nursery Industry

Several cottonwood species (*Populus* spp.) are native throughout the United States. While cottonwoods are essential to local ecosystems, they can also be a serious weed problem in nurseries. Commonly used preemergence herbicides can prevent establishment of these species in nursery containers. Flumioxazin provided the most effective preemergence control of black cottonwood across two experiments. Timing of herbicide application is important for obtaining effective control. Cottonwood species release seed in a narrow window of time between May and June in Oregon, and late spring in general throughout the rest of the United States. After seed release, seed must germinate within 2 weeks before losing all viability. Herbicides that are applied more than one month prior to seed release will be less effective than applications made immediately prior to seed release. The author recommends applying preemergence herbicides to containers prone to cottonwood infestation, one to two weeks prior to seed release. Cottonwood trees can be observed for swelling catkins to accurately time applications. When precise timing is not feasible, and applications must be made more than 4 weeks before probable seed release, flumioxazin should be applied (per label instructions).

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Introduction

Cottonwoods are regionally abundant native trees that can become weedy in container and field nurseries. Black cottonwood (*Populus trichocarpa*) is the species native throughout western Oregon, Washington, and British Columbia. Cottonwood species native to other regions of North America include balsam cottonwood (*P. balsamifera*), eastern cottonwood (*P. deltoides*), Fremont cottonwood (*P. freemontii*), and narrowleaf cottonwood (*P. angustifolia*).

Black cottonwood can reproduce vegetatively or sexually. Vegetative reproduction occurs by stem and root sprouting. This has profound consequences in natural ecosystems, but is of little consequence in terms of spread throughout a container nursery. Seed dispersal from mature cottonwood into nursery containers is the primary route of entry for cottonwood infestations. Black cottonwood is a dioecious species, with male and female flowers occurring on separate plants. Black cottonwoods disseminate seeds mid May to early June in the northern Willamette Valley of Oregon (personal observation). A mature tree can release up to 125 million seeds (3) attached to a white, cotton-like appendage called the coma, which aids in wind dispersal.

Upon release, seeds of cottonwood must land in a suitable environment for germination or die. Seed viability is 94% (8) on the first day after release from the mother plant, but declines rapidly thereafter. If a seed lands in a suitable site, germination occurs in 8 to 24 hours. Disturbed soil with no competing vegetation, coupled with abundant light and available water is necessary for germination and establishment. In natural ecosystems, riparian areas along streams, rivers, and lakes are ideal. Container crops are also conducive sites for germination, due to their exposed substrate surfaces (high light) and exposure to frequent irrigation or abundant

rainfall during the time of seed release. Black cottonwood grows successfully on a variety of soil types from sand or gravelly soils of river bars to clay soils with high organic matter typical of inland and stream-side sites (5). Adaptability to a variety of soil types allows black cottonwood to infest nursery substrates that vary from coarse and well-drained to fine-textured. Smith (13) reported that soils with abundant moisture, nutrients, and oxygen, with pH 6 to 7 are ideal for cottonwood production; these characteristics are typical of many nursery substrates. Black cottonwood is shade-intolerant (5), thus its germination in container crops with mature canopies should be limited.

Cottonwoods are commercially grown for stream restoration, soil stabilization, and as a source of pulp and veneer wood (4). There is literature that addresses the safety of herbicide use among small cottonwood transplants for the purpose of controlling weeds among cottonwood (6, 7); however, none of this research addresses the use of preemergence herbicides currently labeled for nursery crops, nor does it address applications of herbicide to prevent cottonwood establishment from seed. Neal and Derr (11) state that the species is not easily controlled by preemergence herbicides, although both authors have commented that this information is observational and not based on data or experimentation (personal communications). Current research in the United Kingdom demonstrated that isoxaben, oxadiazon, metolachlor, and flumioxazin provided complete control of grey willow (*Salix cinerea*) when herbicides were applied preemergence, while pendimethalin failed to provide control (personal communication, John Atwood, Senior Horticultural Consultant, ADAS, United Kingdom). Willow and cottonwood are in the same family (*Salicaceae*), have similar reproductive biology, and have similar weedy characteristics in nursery containers.

If preemergence herbicides were found to provide effective control of cottonwood, timing of preemergence herbicide application with respect to seed dispersal could be an important factor in cottonwood management. Preemergence herbicides degrade over time. Judge et al. (10) demonstrated that trifluralin dissipation in a pine bark substrate occurred rapidly up to 21 days after application. The narrow window of cottonwood seed release and subsequent viability of black cottonwood seed dictate a very narrow and predictable window of germination. Timing of preemergence herbicide applications just prior to seed release could improve control over applications made one or more months prior to application.

Among holly (*Ilex* ×*meserveae* 'Blue Girl') and hydrangea (*Hydrangea macrophylla* 'Nikko Blue'), cottonwood were shown to accelerate water loss from containers with water loss increasing linearly with increasing number of cottonwood seedlings (1). Both holly and hydrangea growth were reduced with one to five cottonwood seedlings per container. Due to the weedy nature of black cottonwood in Oregon (personal observation) and other cottonwood species throughout the United States (11), the objective of this research was to evaluate commonly used preemergence herbicides and their timing of application for cottonwood control in container nurseries.

Materials and Methods

2006. On May 15, 2006, #1 containers were filled with 100% Douglas fir (*Pseudotsuga menziesii*) bark amended with 9.5 kg·m^{-3} (16 lbs·yd^{-3}) Apex 18N–2.6P–10K (18N–6-P_2O_5–12K_2O, Pursell Technologies, Sylacauga, AL), 3.0 kg·m^{-3} (5 lbs·yd^{-3}) of dolomitic lime, and 0.9 kg·m^{-3} (1.5 lbs·yd^{-3}) Micromax micronutrients (Scott's Co., Marysville, OH). Granular herbicides (Table 1) were applied May 25 with a handheld shaker. A non-treated control group was also maintained. Containers were irrigated immediately after herbicide application with 1.2 cm (0.5 in) water. Due to difficulty in collecting, storing, and applying cottonwood seed, containers were placed on a wagon and moved beneath a mature black cottonwood tree located on our research station in order to collect naturally falling seed. Containers were initially moved to the cottonwood tree following herbicide application. The wagon was moved back to the nursery production site daily and irrigated, then returned to beneath the tree. On June 5, containers were moved to the nursery production site and remained there until the conclusion of the experiment. There were eight single-container replications per treatment arranged in a completely randomized design. Data collected included cottonwood number per container and height 15 days after containers were finally moved back to the nursery production site (hereafter referred to as days after seeding, DAS), and cottonwood number, height, and shoot dry weight (SDW) 60 DAS.

2007. The objective of this experiment was to determine if application timing (from February to May) affects granular herbicide efficacy. The experiment was conducted similarly to 2006 with the following exceptions. Oxadiazon + oxyfluorfen, prodiamine, and oxadiazon + prodiamine were added to the study. Containers were filled February 21, 2007, and maintained on a gravel nursery production site. Herbicides were applied to separate groups of containers on February 22, March 14, April 16, and May 15. On May 16, containers were placed on a wagon and moved beneath a mature black cottonwood tree for 2 weeks to collect falling seed. Containers were hand irrigated twice daily while they remained beneath the tree. On May 31, containers were moved back to the nursery production site and received overhead irrigation in two cycles totaling 1.2 cm (0.5 in) per day. Containers were maintained at the nursery production site for the remainder of the experiment. Cottonwood number in each container were counted 18, 47, and 75 DAS. Cottonwood height was measured 47 DAS, and cottonwood SDW was measured 75 DAS at termination of the study. Containers from all treatments and herbicide application dates were arranged in a completely randomized design with eight single-container replications per herbicide and application date.

Data from both experiments were subjected to repeated measures analysis of variance. Weed number data were square root transformed prior to analysis, but actual data are presented for clarity. Means were separated with Duncan's multiple range test ($\alpha = 0.05$).

Results and Discussion

2006. At 15 DAS, flumioxazin reduced weed numbers by 98% compared to non-treated controls, more than all other treatments (Table 1). Weed height 15 DAS was variable across all treatments, with herbicide treatment explaining just 22% of the total variation in ANOVA tables (ANOVA not shown). While mean height of cottonwood growing in flumioxazin-treated containers was numerically less than other treatments, cottonwood heights among all containers were statistically similar.

Table 1. Black cottonwood (*Populus trichocarpa*) number, height, and shoot dry weight in containers treated with preemergence herbicides on May 25, 2006.

Herbicide	Rate (kg ai·ha^{-1})	15 DAS[z]		60 DAS		
		Number[y]	Height (cm)	Number	Height (cm)	SDW[x] (g)
Oxyfluorfen + Oryzalin	2.2 + 1.2	2.9de[w]	22.2a	8.1cd	31.4c	2.9c
Isoxaben + Trifluralin	4.5 + 1.1	4.6d	14.3a	5.5d	34.0bc	6.2c
Pendimethalin	4.5	5.4d	18.6a	7.5cd	47.3abc	7.2c
Oxadiazon	4.5	12.8c	24.2a	13.0b	53.1ab	15.1b
Flumioxazin	0.4	0.8e	11.9a	0.9e	27.4c	4.5c
Oxyfluorfen + Pendimethalin	2.2 + 1.1	20.9b	30.3a	25.4b	56.0a	22.1ab
Non-treated control		32.5a	32.2a	39.3a	54.5ab	25.4a

[z]Days after seeding containers with cottonwood from natural seed drop. 15 and 60 DAS occurred on June 20 and August 4, 2006, respectively.

[y]Black cottonwood number data were square-root transformed prior to analysis, but actual data are presented.

[x]Shoot dry weight of black cottonwood seedlings.

[w]Means within a column are similar according to Duncan's multiple range test.

At 60 DAS, flumioxazin still provided the most effective control in terms of weed number with less than one plant per container. Height of cottonwood in flumioxazin treated containers was reduced by over 50% compared to non-treated controls. Cottonwood height and SDW were highly correlated (r = 0.849). Although flumioxazin reduced cottonwood numbers more than other herbicides, average height and SDW were similar to oxyfluorfen + oryzalin, isoxaben + trifluralin, and pendimethalin. This indicates that the few surviving cottonwood in each container treated with flumioxazin grew relatively large. Conversely, the greater numbers of seedlings that established in containers treated with oxyfluorfen + oryzalin, isoxaben + trifluralin, and pendimethalin remained stunted with little growth. Oxyfluorfen + oryzalin, isoxaben + trifluralin, and pendimethalin each contain a dinitroaniline (DNA) herbicide that inhibits root formation. Cottonwood that established in containers treated with these DNA herbicides survived but were stunted. Flumioxazin is absorbed by roots and shoots as seedlings emerge through the soil, causing peroxidation of cells and irreversible damage to cell membranes (12). While reduction of cottonwood establishment was initially more effective with flumioxazin than other herbicides, those that survive initial emergence appear more capable of growth thereafter.

2007. Repeated measures analysis indicate cottonwood numbers changed over time within herbicide and application timing treatments (P = 0.001); however, differences in numbers recorded 18 and 47 DAS were minor and thus data from 47 DAS are omitted for brevity. At 18 DAS, there was an interaction between herbicide and application date (Table 2). Cottonwood numbers in containers treated with pendimethalin, oxyfluorfen + pendimethalin, oxyfluorfen + oxadiazon, and prodiamine did not respond to date of application. Furthermore, numbers in containers treated with the aforementioned herbicides were similar to non-treated

Table 2. Black cottonwood (*Populus trichocarpa*) numbers in nursery containers treated with various granular preemergence herbicides on four different dates, data collected June 18, 2007, 18 days after seeding.

Herbicide	Rate (kg ai/ha)	Black cottonwood number				
		February 22	March 14	April 16	May 15	Significance[z]
Oxyfluorfen + Oryzalin	2.2 + 1.2	24	32	28	21	Q**
Isoxaben + Trifluralin	4.5 + 1.1	30	35	27	7	Q***
Pendimethalin	4.5	33	31	33	32	NS
Oxadiazon	4.5	16	15	8	10	L*
Flumioxazin	0.4	6	3	1	0	L***
Oxyfluorfen + Pendimethalin	2.2 + 1.1	30	30	23	33	NS
Oxyfluorfen + Oxadiazon	2.2 + 1.1	17	25	17	30	NS
Oxadiazon + Prodiamine	1.1 + 0.2	26	23	16	12	L***
Prodiamine	0.6	32	44	35	33	NS
Control		31	33	35	41	L*
		$LSD_{(0.05)}$ = 18				
Main effects		Pr > F				
Herbicide		0.0001				
Application date		0.0001				
Interaction		0.0001				

[z]L and NS represent linear or non-significant responses to the number of days preceding seed release.

*, **, and *** represent P-values less than 0.05, 0.01, and 0.001, respectively.

Table 3. Black cottonwood (*Populus trichocarpa*) number and shoot dry weight in nursery containers treated with various granular preemergence herbicides either February 22, March 14, April 16, or May 15. Data were collected August 14, 2007, approximately 75 days after seeding.

Herbicide	Rate (kg ai/ha)	Black cottonwood number[z]					Black cottonwood shoot dry weight (g)				
		February 22	March 14	April 16	May 15	Signif.[y]	February 22	March 14	April 16	May 15	Signif.
Oxyfluorfen + Oryzalin	2.2 + 1.2	32	32	28	13	L***	24	26	17	2	L***
Isoxaben + Trifluralin	4.5 + 1.1	34	35	25	3	L***	21	30	19	2	Q***
Pendimethalin	4.5	34	29	14	9	L***	28	30	15	8	L***
Oxadiazon	4.5	20	15	8	9	L***	15	17	8	11	NS
Flumioxazin	0.4	3	2	1	0	L**	6	2	0	0	L*
Oxyfluorfen + Pendimethalin	2.2 + 1.1	36	32	25	28	NS	27	25	22	19	L**
Oxyfluorfen + Oxadiazon	2.2 + 1.1	18	27	20	32	NS	20	28	22	28	NS
Oxadiazon + Prodiamine	1.1 + 0.2	33	22	17	10	L***	24	19	18	14	L*
Prodiamine	0.6	29	35	24	19	L*	6	11	7	1	Q*
Control		39	39	48	48	NS	32	33	31	31	NS
		$LSD_{(0.05)} = 20$					$LSD_{(0.05)} = 14$				
Main effects		Pr > F					Pr > F				
Herbicide		0.0001					0.0001				
Application date		0.0001					0.0001				
Interaction		0.0001					0.0001				

[z]Black cottonwood number data were square-root transformed prior to analysis, but actual data are presented.

[y]L and NS represent linear or non-significant responses to the number of days preceding seed release.

*, **, and *** represnet P-values less than 0.05, 0.01, and 0.001, respectively.

controls regardless of application date. Oxyfluorfen + oryzalin responded quadratically with decreasing time between herbicide application and seeding; however, cottonwood numbers were high (> 20) with each application date. Isoxaben + trifluralin also responded quadratically and reduced cottonwood numbers 83% compared to non-treated controls when applications were made May 15. Cottonwood numbers decreased linearly as the time between application and seeding decreased when treated with oxadiazon, flumioxazin, and oxadiazon + prodiamine. Only flumioxazin reduced cottonwood numbers compared to non-treated controls when applications were made February 22. Flumioxazin applied May 15, just prior to seeding, provided complete control. These results concur with research on grey willow, in that flumioxazin provided excellent preemergence control (personal communication, John Atwood).

By 75 DAS, weed number within a treatment had changed slightly from 18 DAS due to competition or seedling mortality, although trends in weed number were similar between the two dates (Table 3). Only flumioxazin reduced cottonwood number compared to non-treated controls at each application date. Cottonwood number decreased when herbicide applications were made closer to seeding date among all herbicides with the exception of oxyfluorfen + pendimethalin and oxyfluorfen + oxadiazon. All herbicides, with the exception of oxyfluorfen + pendimethalin and oxyfluorfen + oxadiazon, reduced cottonwood numbers when applied May 15.

Cottonwood height measured 47 DAS and SDW measured 75 DAS were highly correlated (r = 0.877, n = 320, $P = 0.0001$), thus height data were omitted. Flumioxazin, oxadiazon, and prodiamine reduced cottonwood SDW regardless of application date. All herbicides with the exception of oxyfluorfen + pendimethalin and oxyfluorfen + oxadiazon, reduced cottonwood SDW when applied May 15. Results from containers treated with herbicides on May 15 concur with results observed in 2006 (which had a similar application timing). In both years, all herbicides with the exception of oxyfluorfen + pendimethalin (and oxyfluorfen + oxadiazon in 2007) reduced cottonwood number and SDW. Also in both years, flumioxazin reduced cottonwood number most effectively, but resulted in similar SDW to oxyfluorfen + oryzalin, isoxaben + trifluralin, and pendimethalin.

In summary, these data demonstrate that some herbicides provide effective preemergence cottonwood control. Most herbicides evaluated here provided some control contingent that the application occurred relatively soon prior to seed release from cottonwood trees. Among herbicides that provided some control with a May application, all were less effective as the time between application and seed release increased. This was expected considering that herbicides degrade relatively quickly in container substrates (9). Northern willowherb (*Epilobium ciliatum*) establishment and growth were greater when seed were introduced just four weeks after herbicide application compared to when seeds were applied immediately after application (2). Timing of preemergence herbicide application is especially relevant concerning weeds like cottonwood that have a single predictable seed release date coupled with a short period of time (2 weeks) for germination and establishment. Flumioxazin provided the most effective control throughout the experiment, although control from it also responded to application date. In circumstances where precise timing of preemergence herbicides is not practical and applications might be made more than 4 weeks prior to seed release, flumioxazin will provide the most effective control.

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