FOREST RESEARCH LABORATORY

RESEARCH NOTE 81

Efficacy of Imazapyr and Metsulfuron Methyl for Site Preparation and Conifer Release in the Oregon Coast Range

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Abstract

Efficacy of imazapyr and metsulfuron methyl, two new chemicals with potential for forestry applications, was evaluated on several Oregon Coast Range shrub species, including red alder, bigleaf maple, salmonberry, and evergreen and Himalaya blackberry. Injury to Douglas-fir seedlings also was assessed. Imazapyr was highly effective on red alder and bigleaf maple, but less effective on salmonberry and both blackberry species. Metsulfuron methyl was ineffective on red alder and bigleaf maple, but gave excellent control of salmonberry and both blackberry species. Both chemicals caused severe injury to Douglas-fir seedlings, especially when applied during the growing season. Imazapyr (currently registered for limited forestry use in Oregon and Washington) and metsulfuron methyl (currently registered for rights-of-way and roadsides) are promising for site preparation in the Coast Range but are limited as broadcast applications for Douglas-fir release.

Introduction

Imazapyr (Arsenal®; AC 252,295) and metsulfuron methyl (Escort®) are two new chemicals with potential for forestry application. Evaluated on several Oregon Coast Range forest sites, they have been shown highly effective for suppressing such plant species as red alder (Alnus rubra Bong.), salmonberry (Rubus spectabilis L.) and other Rubus species, and bigleaf maple (Acer macrophyllum Pursh) (Cole et al. 1986). Both chemicals are broad-spectrum, post-emergence herbicides that act on foliage and soil. Imazapyr, which belongs to the imidazolinone chemical family, is highly soluble in water and minimally toxic to mammals. It is now registered for non-crop use and has a special local-need label (24c) for spot control and trunk injection of bigleaf maple and red alder.[1] Research in the southern U.S. shows imazapyr to be highly effective on many brush and deciduous species (American Cyanamid Co., 1985, unpublished data). Metsulfuron methyl, which belongs to the sulfonyl-urea chemical family, has shown good (70 to 80 percent) control of shrubs at application rates as low as 0.25 oz/acre (E.I. DuPont de Nemours, Inc., 1986, unpublished data).

We report here the results of a series of trials designed to evaluate efficacy of imazapyr and metsulfuron methyl for forest site preparation and conifer release in the Douglas-fir region of western Oregon.

[1] As of the date of this publication, imazapyr is registered for limited forestry use in Oregon and Washington, and metsulfuron methyl is registered for rights-of-way and roadsides. Potential users should obtain current registration information.

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Materials and Methods

Site Descriptions

Study sites, established in several common shrub associations, were selected to reflect coastal deciduous shrub and sprouting hardwood species likely to be encountered on rehabilitation sites.

The "Coastal" site, located near Toledo, Oregon, a few miles from the Pacific Ocean, had been clearcut and scarified in 1982. It contained large numbers of seedling red alders, in addition to seedlings and sprouts of salmonberry, seedling Himalaya blackberry (Rubus procerus Muell.), and seedling evergreen blackberry (Rubus laciniatus Willd.). When treatments were applied in early July and late August, 1984 (Table 1), red alder seedlings ranged from 3 to 7 feet tall, seedling salmonberry from 10 to 14 inches tall, salmonberry sprouts from 2 to 4 feet tall, and seedling blackberry from 1 to 3 feet tall. Coastal Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco var. menziesii] seedlings, in their third growing season after planting as 1-0 plug stock, were 2 to 4 feet tall.

TABLE 1.

TREATMENTS APPLIED TO THREE SITES IN THE OREGON COAST RANGE.

Treatment, by site	Rate/acre	Season and year
Coastal		
Imazapyr	0.5 lb 1.0 lb 2.0 lb	July & August 1984
Metsulfuron methyl	0.5 oz 1.0 oz 2.0 oz	July & August 1984
Control	—	—
Bummer Creek		
Imazapyr	0.25 lb 0.50 lb 0.75 lb	May 1985
Metsulfuron methyl	0.5 oz 1.0 oz 2.0 oz	May & June 1985
Control	—	—
Bigleaf Maple		
Imazapyr	1.0 lb 2.0 lb	August 1984
Metsulfuron methyl	2.0 oz 4.0 oz	August 1984
Control	—	—

The "Bummer Creek" site, located midway through the Coast Range, south of Alsea, Oregon, was logged in 1983 and planted in winter 1984 with 2-1 Douglas-fir seedlings. When treatments were applied in early May and mid-June, 1985, both red alder and seedling salmonberry were 1 to 2 feet tall; salmonberry sprouts were 3 to 4 feet tall.

The "Bigleaf Maple" site, located near Eddyville, Oregon, was sprayed with herbicides and burned in summer 1982. The following winter, 2-1 bareroot Douglas-fir seedlings were planted. The seedlings and the bigleaf maple clumps, which measured 6 to 13 feet tall and 4 to 13 feet in crown width, were 2 years old when treatments were applied in late August 1984.

Experimental Design

Coastal Site

Imazapyr and metsulfuron methyl each were applied at a low, medium, and high rate on 0.01-acre (29- x 15-foot) plots in a complete factorial experiment. An additional plot served as an untreated control. The seven treatments (2 herbicides x 3 rates + 1 control) were replicated 3 times, for a total of 21 plots.

Each herbicide was applied at 10 gallons total spray volume/acre, the nominal rate for aerial application. Plots were treated by backpack sprayer with a single adjustable Chapin® nozzle and the "waving wand" technique (Newton and Knight 1981). Spray volume per acre was calibrated by measuring delivery rate of the nozzle per second and applying coverage in two, timed passes, usually in opposite directions. On a few plots, heavy slash or dense vegetation dictated that both passes be from the same direction. For all plots, spray time was clocked so that the second pass could compensate for inadvertent variation in the first pass. Nearly all plots received ±5 percent of the planned dosage.

Up to 10 healthy shrubs per plot of each major species were tagged before or just after treatment for evaluation in late June 1985 and 1986, when each tagged shrub was ocularly rated for percent crown reduction and stem dieback. Douglas-fir seedlings growing on the plots were rated for injury on a 5-point scale: 1—no injury; 2—minor injury to foliage; 3—major injury to foliage and some dieback of terminal leaders; 4—dieback of at least one-third of the crown; and 5—dead.

To evaluate possible residual herbicide activity in the soil, we covered three Douglas-fir seedlings

per plot with plastic bags to prevent them from being sprayed. In March 1985, we also planted 20 2–0 Douglas–fir seedlings per plot in the plots treated with medium and high rates of both herbicides to determine if soil residues could affect seedlings planted 7 to 8 months after chemicals were applied. Both the bagged and planted seedlings were evaluated for injury with the same 5–point scale previously described.

Bummer Creek Site

As for the Coastal site, the two herbicides each were applied at three rates on the same size plots in a complete factorial experiment. An additional plot served as the control. The seven treatments were replicated 2 times, for a total of 14 plots.

Application technique was the same as for the Coastal site. Shrubs were again tagged by species for later evaluation of crown reduction and stem dieback, and Douglas–fir seedlings growing on the site were later rated on the 5–point injury scale.

Bigleaf Maple Site

Imazapyr and metsulfuron methyl each were applied at a low and high rate to groups of three nearby maple clumps each. Groups of three clumps each also served as untreated controls. Treatments were randomly assigned to a group. Each of the five treatments (2 herbicides x 2 rates + 1 control) was applied to three groups of three clumps each (9 clumps/treatment), for a total of 45 clumps.

Clumps were individually treated by backpack sprayer with a single adjustable Chapin® nozzle. Before treatment, height and crown width of each clump were measured, and the volume of herbicide mixture for each clump was varied according to crown area (portion of the ground obscured by the crown) to approximate a nominal application rate of 10 gallons total spray volume/acre. The volume of liquid necessary for the proper dosage per clump was calculated and converted into seconds of spray time (hence spray volume per clump) and calibrated with a stopwatch during application. Half the dosage was applied to each "side" of a clump. Nearly all clumps received ±5 percent of the planned dosage.

Clumps were measured and evaluated for injury in late June 1985 and July 1986. Width, taken in two perpendicular directions, and height were measured in each year. The percentage of crown reduction and stem dieback was ocularly rated in 1985. Percent change in the volume of clump crowns was calculated by subtracting volume measurements taken in 1985 and 1986 from those taken before treatment in 1984. The formula for an ellipsoid (volume = $1/6 \times \pi \times W1 \times W2 \times H$, where W1 and W2 = two width measurements and H = height) was used, rather than that of a sphere, to accommodate both width measurements. Condition of Douglas–fir seedlings was noted only for seedlings directly beneath maple clumps; injury was rated on the same 5–point scale previously described.

Data Analysis

For all three sites, data were subjected to a factorial analysis of variance. Differences among means were compared with Duncan's multiple range test ($\alpha = 0.05$).

Results

Coastal Site

Imazapyr

Imazapyr caused almost complete defoliation of red alder and significant amounts of stem dieback (Table 2). No differences among rates were found, but the July treatments caused significantly greater stem dieback (90 to 99 percent) than did the August treatments (19 to 44 percent). Crown reduction was slightly but not significantly greater with July than August application (90 to 100 percent compared to 83 to 97 percent). The first year after treatment, alder foliage exhibited "littleleaf disease" (foliage does not expand fully during the growing season) similar to that resulting from glyphosate application, but the alder that survived had healthy foliage the second year after treatment.

Imazapyr reduced salmonberry crowns and stems 82 to 100 percent at the medium and high rates and 54 to 73 percent at the low rate (Table 2). No differences in effectiveness between the medium and high rates were found, but the low rate was significantly less effective than the high rate. Season of application had no effect. New foliage on some of the shrubs was stunted and chlorotic the first year after treatment, but not the second year.

TABLE 2.

EFFECTS OF IMAZAPYR AND METSULFURON METHYL ON CROWNS AND STEMS OF VARIOUS BRUSH SPECIES (MEASURED IN 1985) FOR THE COASTAL SITE.

Treatment	Rate/acre	Treatment season (1984)	Crown reduction	Stem dieback	Crown reduction	Stem dieback
			(%)			
			Red alder		Salmonberry	
Imazapyr	0.5 lb	July	97 a[1]	90 a	73 b	68 b
	1.0 lb	July	100 a	93 a	88 ab	82 ab
	2.0 lb	July	100 a	99 a	100 a	100 a
	0.5 lb	Aug	83 a	19 bc	58 b	54 b
	1.0 lb	Aug	91 a	44 b	95 a	83 ab
	2.0 lb	Aug	97 a	43 b	97 a	96 a
Metsulfuron methyl	0.5 oz	July	14 b	9 c	100 a	100 a
	1.0 oz	July	10 b	3 c	100 a	100 a
	2.0 oz	July	34 b	12 c	100 a	100 a
	0.5 oz	Aug	1 b	0 c	100 a	100 a
	1.0 oz	Aug	2 b	0 c	100 a	100 a
	2.0 oz	Aug	4 b	1 c	100 a	100 a
Control	—	—	0 b	0 c	0 c	0 c
			Evergreen blackberry		Himalaya blackberry	
Imazapyr	0.5 lb	—[2]	12 bc	5 b	0 b	0 b
	1.0 lb	—	30 b	21 b	2 b	1 b
	2.0 lb	—	7 bc	1 b	21 b	10 b
Metsulfuron methyl	0.5 oz	—[2]	100 a	98 a	88 a	85 a
	1.0 oz	—	100 a	83 a	100 a	99 a
	2.0 oz	—	99 a	86 a	100 a	100 a
Control	—	—	0 c	0 b	0 b	0 b

[1] In a column within species, means followed by the same letter are not significantly different ($\alpha = 0.05$, Duncan's multiple range test).

[2] Because the treatment x season interaction was not significant, data have been pooled over seasons.

For both Himalaya and evergreen blackberry, control was poor (0 to 30 percent crown reduction, 0 to 21 percent stem dieback; Table 2). Growth was vigorous the first year after treatment, and shrubs rapidly recovered to pretreatment size by the second year.

Injury to all unbagged Douglas-fir seedlings sprayed in July and 33 percent of those sprayed in August was severe, including terminal dieback and some mortality. Severity of injury was not affected by application rate. Severely injured seedlings did not recover, whereas those with slight terminal dieback had healthy new foliage and new terminals from lateral branches. Bagged seedlings exhibited stunted foliage and terminal dieback the first year after treatment, the more severe injury occurring with July application. Apparently, herbicide was taken up from the soil, although little rain fell before September. By the second year after treatment, 80 percent of the bagged seedlings had recovered and their current growth was healthy.

Douglas-fir seedlings planted 7 to 8 months after treatment were not seriously injured by imazapyr residues in the soil in this environment. Survival of these seedlings, planted in March 1985, was 100 percent in June 1985 and 95 percent in June 1986. Some chlorosis of needles, stunting, and loss of lower crown foliage, as might be observed in "planting check," was evident in 1985; but all seedlings appeared healthy and had vigorous new growth a year later.

Metsulfuron Methyl

Metsulfuron methyl was generally ineffective on red alder, regardless of application rate (1 to 34 percent crown reduction, 0 to 12 percent stem dieback; Table 2). Although the July treatments appeared more effective than the August treatments, none was significantly different from the control. In contrast, metsulfuron methyl was highly effective on salmonberry (100 percent kill) and the two blackberry species (83 to 100 percent kill; Table 2). Some of the unaffected shrubs were located under other vegetation, suggesting canopy interception of the herbicide.

One year after treatment, 63 percent of the unbagged Douglas-fir seedlings were severely injured by metsulfuron methyl, suffering terminal dieback, foliage loss, and some mortality. Two years after treatment, severely injured seedlings were not recovering. As with imazapyr, seedlings with less severe injury, such as slight terminal dieback, had healthy new foliage and new terminals.

Bagged seedlings had only minor injury to foliage and slight terminal dieback. Soil uptake of herbicide appeared minor, and injury may have resulted when contaminated bags were reused or when basal foliage was exposed during spraying. By the second year after treatment, all bagged seedlings had recovered and showed normal growth.

Survival of Douglas-fir seedlings planted in March 1985, 7 to 8 months after application, was 100 percent in June 1985 and 95 percent in June 1986. Residues of metsulfuron methyl in the soil caused minor chlorosis of needles in the plots treated at the high application rate. No effects were observed in 1986.

Bummer Creek Site

Imazapyr

The high application rate resulted in 100 percent crown and stem kill on red alder (Table 3). The medium and low rates provided moderate control of red alder—50 to 75 percent crown reduction and stem dieback. The herbicide was less effective on salmonberry (1 to 68 percent crown reduction, 22 to 41 percent stem dieback); best control was achieved with the high rate.

Douglas-fir seedlings were slightly injured when imazapyr was applied at the moderate and low rates. Needle dieback and stunting were noticed on foliage present at the time of treatment or emerging soon after. However, the first year after treatment, most of the foliage appeared healthy. Despite some terminal dieback at the high application rate, all seedlings except those severely injured (20 percent) were recovering.

TABLE 3.

EFFECTS OF IMAZAPYR AND METSULFURON METHYL ON CROWNS AND STEMS OF RED ALDER AND SALMONBERRY (MEASURED IN 1986) FOR THE BUMMER CREEK SITE.

Treatment	Rate/acre	Treatment season (1985)	Crown reduction	Stem dieback	Crown reduction	Stem dieback
			Red alder (%)		Salmonberry (%)	
Imazapyr	0.25 lb	May	50 c[1]	48 c	54 bc	31 bc
	0.50 lb	May	76 b	74 b	41 c	22 c
	0.75 lb	May	100 a	100 a	68 b	41 b
Metsulfuron methyl	0.5 oz	May	8 de	7 d	95 a	92 a
	1.0 oz	May	1 e	0 d	100 a	100 a
	2.0 oz	May	12 de	12 d	100 a	100 a
	0.5 oz	June	14 de	11 d	100 a	100 a
	1.0 oz	June	20 d	17 d	100 a	100 a
	2.0 oz	June	16 de	14 d	100 a	100 a
Control	—	—	0 e	0 d	0 d	0 d

[1] In a column within species, means followed by the same letter are not significantly different ($\alpha = 0.05$, Duncan's multiple range test).

Metsulfuron Methyl

Metsulfuron methyl was ineffective on red alder (1 to 20 percent crown reduction, 0 to 17 percent stem dieback) regardless of application rate or season (Table 3). Only one treatment (1.0 oz/acre in June) caused significant crown reduction, and none caused significant stem dieback.

In contrast, metsulfuron methyl was highly effective on salmonberry; only one treatment (0.5 oz/acre in May) resulted in less than 100 percent kill (Table 3). Although this one exception did not differ statistically from the other treatments, it may indicate that early-season application of metsulfuron methyl at low rates is less effective on salmonberry. Cole et al. (1987) observed only 23 percent crown reduction and 18 percent stem dieback when metsulfuron methyl was applied in April at 0.5 oz/acre.

May application of metsulfuron methyl caused severe injury and some mortality at the high rate and minor injury, such as needle dieback and slight terminal dieback, at the lower rates. The first year after treatment, seedlings with minor injury were recovering, and most of the current foliage appeared healthy. June application caused more severe injury than did May application and some mortality at all rates. Most of these seedlings were not recovering even 2 years after treatment.

Bigleaf Maple Site

Imazapyr

Both application rates caused essentially total defoliation (Table 4). New leaf formation was inhibited, and foliage the first year after treatment was chlorotic and stunted. The high rate resulted in significantly greater stem dieback in 1985 (91 percent compared to 59 percent). Even though

TABLE 4.

EFFECTS OF IMAZAPYR AND METSULFURON METHYL ON CROWNS AND STEMS OF BIGLEAF MAPLE MEASURED IN 1985 (AUGUST 1984 APPLICATION) FOR THE BIGLEAF MAPLE SITE.

Treatment	Rate/acre	Crown reduction (%)	Stem dieback (%)
Imazapyr	1.0 lb	99 a[1]	59 b
	2.0 lb	99 a	91 a
Metsulfuron methyl	2.0 oz	74 b	53 bc
	4.0 oz	58 b	33 c
Control	—	0 c	0 d

[1] In a column, means followed by the same letter are not significantly different ($\alpha = 0.05$, Duncan's multiple range test).

stem dieback at the low rate was not 100 percent initially, clumps have continued to decline. By 1986, only one clump remained alive; it was maintaining a very small leaf area and would not be highly competitive. Crown volume decreased from pretreatment volumes of 539 ft^3/clump (clumps to receive low rate) and 361 ft^3/clump (clumps to receive high rate) to zero 2 years after treatment, while crown volumes for untreated clumps tripled (Table 5).

TABLE 5.

MEAN CROWN VOLUME OF MAPLE CLUMPS FOR THE BIGLEAF MAPLE SITE.

Treatment	Rate/ acre	Maple crown volume: 1984 (pretreatment) (ft^3)	1985 (ft^3)	1985 (%)[1]	1986 (ft^3)	1986 (%)[1]
Imazapyr	1.0 lb	539 a[2]	2 b	1 b	0 b	0 c
	2.0 lb	361 a	1 b	0 b	0 b	0 c
Metsulfuron methyl	2.0 oz	339 a	138 b	45 b	184 b	62 b
	4.0 oz	495 a	173 b	33 b	380 b	75 b
Control	—	556 a	1170 a	236 a	1595 a	307 a

[1] Current volume expressed as a percent of pretreatment volume.
[2] In a column, means followed by the same letter are not significantly different ($\alpha = 0.05$, Duncan's multiple range test).

Douglas-fir seedlings directly beneath the bigleaf maple clumps intercepted little herbicide and showed no visible signs of injury. Seedlings near the clumps and exposed to imazapyr showed signs of severe injury, including terminal dieback.

Metsulfuron Methyl

No differences in effectiveness between the two application rates were detected. Overall, crown reduction was 58 to 74 percent and stem dieback 33 to 53 percent (Table 4). Most crown reduction was topkill; the lower portions of the crown generally recovered and exhibited little herbicide injury. Injury to Douglas-fir seedlings was similar to that caused by imazapyr. However, because most of the herbicide damage to maple clumps occurred as topkill, the Douglas-fir seedlings under the maple canopy were not released. By 1986, the clumps were recovering but were 62 percent (low rate) and 75 percent (high rate) of pretreatment volumes (Table 5). Douglas-fir seedlings near the clumps were still suppressed.

Summary and Discussion

Imazapyr is highly effective (almost 100 percent kill) when applied on red alder in May, July, or August and on bigleaf maple in late August. Control of red alder is comparable to that obtained by standard treatments with 2,4-D or triclopyr ester (Newton and Knight 1981, Conard and Emmingham 1984). When imazapyr is applied in August, injury to bigleaf maple is generally greater than that from either 2,4-D or triclopyr ester (Newton and Knight 1981, Conard and Emmingham 1984). Imazapyr currently has a 24c label for control of bigleaf maple and red alder in Oregon and Washington, and users should follow label guidelines for proper application.

Although good control (70 to 80 percent) of salmonberry can be expected with higher rates or summer applications of imazapyr, control is less than from conventional treatments with glyphosate or triclopyr ester (Newton and Knight 1981, Conard and Emmingham 1984). Control of blackberry is poor, and shrubs tend to recover to pretreatment levels rapidly.

Imazapyr can cause severe injury to Douglas-fir seedlings. Although injury to seedlings is less when the chemical is applied early in the season (May) at low rates, such application provides less effective control of shrub species. Because Douglas-fir seedlings protected from spray by dense foliage usually escape severe injury, their release from maple clumps is feasible with careful application.

Metsulfuron methyl is generally ineffective on red alder regardless of rate or season of application and would not be used for this purpose because other, more effective chemicals are available. Control of blackberry and salmonberry is excellent, with June, July, and August applications more effective than May applications. Control of Himalaya blackberry is comparable to that from conventional treatments with glyphosate or triclopyr ester, and control of salmonberry is comparable to that from conventional treatments with glyphosate (Newton and Knight 1981, Conard and Emmingham 1984). Metsulfuron methyl currently is registered for rights-of-way and roadsides.

Metsulfuron methyl caused Douglas–fir seedlings to die during all seasons tested. Injury varied according to season and application rate, the least occurring when the chemical was applied in May at low rates.

All treatments with these two chemicals caused at least some injury to Douglas–fir seedlings, mainly through foliage activity. All of the seedlings with minor injury are recovering. Seedlings with severe injury to terminals are recovering slowly or not at all and have lost 1 to 2 years' growth. Douglas–fir seedlings planted 7 to 8 months after application showed only minor signs of injury, primarily at high application rates.

In these trials, imazapyr and metsulfuron methyl show promise for site–preparation treatments in the Oregon Coast Range, but have limited use for Douglas–fir release, except for imazapyr applied to bigleaf maple clumps. We do not anticipate that metsulfuron methyl can be developed for Douglas–fir release. The generally injurious nature of this product suggests it be limited to site preparation and right–of–way management. There is enough evidence that imazapyr injury to Douglas–fir can be minimized (E.C. Cole and M. Newton, 1987, unpublished data) to suggest further experimentation for release. However, until such findings are confirmed and published, use for release is risky. For the present, users may apply either chemical selectively by spraying away from conifers (directed spray) or by injecting trunks carefully and avoiding spillage near conifer roots. Used in this manner or for site preparation, both products offer promise of controlling heretofore troublesome competitors of conifers.

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British/Metric Conversion

1 in.	= 2.54 cm	1 gal.	= 3.7853 L
1 ft	= 0.3048 m	1 oz	= 28.3495 g
1 ft^3	= 0.0283 m^3	1 lb	= 453.59 g
1 ac	= 0.4047 ha		

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