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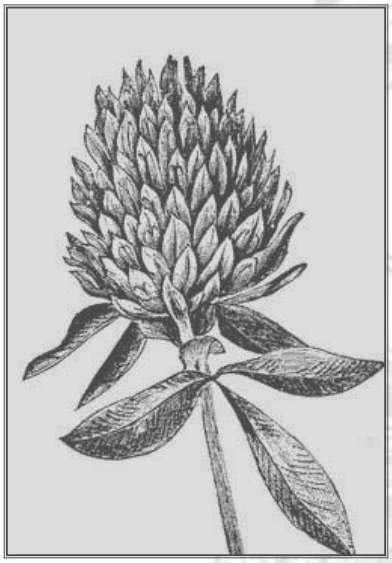

Forage Species Tolerance to Imazapyr and Imazapic

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Abstract

Weed control with imazapyr (Arsenal), imazapic (Plateau), and hexazinone (Velpar) was better with summer than with spring applications, but dry weather was a factor in the spring application performance. Imazapic provided less control of horseweed and common cocklebur than imazapyr and hexazinone. Populations, heights, and dry weights of Austrian winterpea, annual ryegrass, hairy vetch, crimson clover, and white clover were higher following spring herbicide application as compared with summer application. Late-season yields were as high with imazapyr treatments as they were with the untreated check for all species in both the spring and summer applications. Yields of annual ryegrass, crimson clover, and white clover were lower following imazapic than following imazapyr with spring applications. There were no differences in yield of Austrian winterpea and hairy vetch across treatments following the summer applications. There were no reductions in the population or height of the spring-planted species (partridge pea, American jointvetch, Kobe lespedeza, and serecia lespedeza) across treatments, except for the spring 1989 application when the crops were planted 2 days after herbicide application. In this test, populations and heights in all treatments were less than the check, 0.125 lb/A of imazapyr, or 0.125 lb/A of imazapic. The latter had the highest populations and heights compared with all other treatments except the untreated check. Field tests have therefore shown that there is tolerance of these species to imazapyr and imazapic, but application timing is important.

Forage Species Tolerance to Imazapyr and Imazapic

Introduction

In the 1980s, thousands of acres of land were removed from agricultural production and placed in the conservation reserve program (CRP). This has created an interest in managing idle land as a productive wildlife habitat, while still complying with required regulations. Highway departments and utility companies are also interested in managing their rights-of-way for wildlife habitat. These interests have created a need to identify weed control methods that will allow the growth and establishment of preferred wildlife foods. Imazapyr and hexazinone are herbicides that control a broad spectrum of weed species and allow some preferred plant species for wildlife food/forage to grow. When imazapyr was applied to pine (*Pinus taeda* L.) plantations for control of competing herbaceous plants, preferred wildlife food forbs and legumes were twice as prevalent as in the untreated check *(3,5)*. Species transition after imazapyr treatments was from grasses and woody plants to more desirable wildlife foods such as forbs, vines, and legumes, especially lespedeza (*Lespedeza*) species *(10)*. Hexazinone promotes the growth of forbs and legumes when used in pine plantations. When hexazinone was used as a site preparation treatment, there were many legumes present for wildlife forage, with 46% forbs and 22% grass in the ground cover *(4)*. The forbs provided food for whitetail deer (*Odocoileus virginianus*). Grasses provided forage for turkey (*Meleagris gallapavo*) and cover for rodent species. Legumes provided food for bobwhite quail (*Colin virginianus*). Other research has shown that hexazinone used as a site preparation treatment in pines produced an abundance of legumes such as partridge pea (*Cassia fasiculata* L.) and lespedeza species *(6)*. In application timing studies on a pine plantation, a March or June application of imazapyr controlled competing herbaceous plants well *(3)*. Imazapyr was used to control weeds during fallow in a wheat (*Triticum aestivum* L.)-fallow-wheat rotation in Texas *(12)*. In that study, 0.5 lb/A of imazapyr controlled all weeds at least 80% for 14 months, with no reduction in wheat yields in the following crop. Imazapyr also controlled competing vegetation well late into the season on pastureland that had been planted to pines and had only 14% ground cover *(1)*.

Legumes have shown resistance to the imidazolinone herbicides. Hurst *(5)* found that legumes, especially lespedeza species, were resistant to imazapyr, and Shaw *(8)* found that soybeans [*Glycine max* (L.) Merr.] were more tolerant of imazapic than imazapyr. Imazapic has also shown promise as a soybean herbicide for control of sicklepod [*Senna obtusifolia* (L.) Irwin and Barnaby] *(8)*. The imidazolinones are absorbed through both foliage and roots, which results in both preemergence and postemergence activity. Imazapyr is translocated in both xylem and phloem to accumulate in the meristematic regions of the plant *(11)*, but it has very limited vertical and lateral movement in the soil *(9)*. Apparently, legumes are tolerant to imazapyr because they can metabolize it to an inactive form *(7)*. Legume tolerance to imazapyr, imazapic, and hexazinone has created an interest in their use on CRP land and rights-of-way to control unwanted vegetation and promote the establishment of plants preferred for wildlife food. The objective of this study was to evaluate partridge pea, American jointvetch (*Aeschynomene americana* L.), Kobe lespedeza [*Lespedeza striata* (Thunb.) H. and A.], serecia lespedeza [*Lespedeza cuneata* (Dumont) G. Don], Austrian winterpea (*Lathyrus hirsutus* L.), annual ryegrass (*Lolium multiflorum* Lam.), hairy vetch (*Vicia villosa* Roth.), crimson clover (*Trifolium incarnatum* L.), and white clover (*Trifolium repens* L.) for tolerance to imazapyr, imazapic, and hexazinone at selected rates and various planting times after application.

MATERIALS AND METHODS

Experiments were conducted in 1988 and 1989 on a Smithdale loamy sand (fine-loamy, siliceous, Thermic Typic Paleudult) near Water Valley, Mississippi, and on a Forrestdale silty clay loam (fine, montmorillonitic, Thermic Typic Ochraqualf) near Greenwood, Mississippi. A spring application (March 1988) experiment and a summer application (June 1988) experiment were conducted at both locations. Each test had four spring-planted species (partridge pea, American jointvetch, Kobe lespedeza, and serecia lespedeza) and five fall-planted species (Austrian winterpea, annual ryegrass, hairy vetch, crimson clover, and white clover). Each experiment was conducted with herbicide plots in a randomized complete block design. Each forage species was planted into each herbicide plot.

Several herbicide treatments were used: imazapyr at 0.25, 0.5, 0.75, and 1 lb/A of active ingredient; imazapic at 0.25 and 0.5 lb/A of active ingredient; hexazinone at 1 lb/A of active ingredient; and an untreated check. Treatments were applied in 30 gallons of water per acre using a tractor with a roller pump-powered sprayer.

Each species was planted in 7-inch rows with a no-till grain drill across the herbicide plots. Planting rates varied by species: partridge pea and white clover at 10 lb/A; American jointvetch, Kobe lespedeza, and serecia lespedeza at 20 lb/A; hairy vetch at 30 lb/A; crimson clover at 35 lb/A; annual ryegrass at 40 lb/A; and Austrian winterpea at 50 lb/A.

Weed control for the spring 1988 application at Water Valley was rated visually 20 weeks after treatment for horseweed [*Conyza canadensis* (L.) Cronq.], common cocklebur (*Xanthium strumarium* L.), common ragweed (*Ambrosia artemisiifolia* L.), barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], broadleaf signalgrass [*Brachiaria platyphylla* (L.) Griseb.], and entireleaf morningglory (*lpomoea hederacea* var. *integriuscula* Gray) and (*Ipomoea lacunosa* L.). The rating scale was 0 to 100, where 0 equaled no control and 100 equaled total control. At Greenwood, horseweed, barnyardgrass, broadleaf signalgrass, and morningglory control were also visually evaluated 20 weeks after the spring herbicide application using the same scale.

Weed control for summer herbicide application was estimated at both locations 6 weeks after treatment. Species rated at Water Valley were horseweed, prickly sida (*Sida spinosa* L.), common ragweed, barnyardgrass, broadleaf signalgrass, and morningglory. Control of the same species, except common ragweed and prickly sida, was evaluated at Greenwood.

Spring 1988 Application, Fall 1988 Planting

Before the 1988 fall planting in plots treated with herbicides in the spring, plots were mowed and then treated with glyphosate at 1 lb/A of active ingredient to burn down vegetation present. Population and height measurements were determined 7 weeks after planting for each of the five species tested to determine tolerance to the herbicides. These species were harvested twice during the growing season. Six months after planting and 12 months after herbicide applications, a 24-by-10-inch section of each species in each treatment was harvested, and dry weight yield was determined. Eight months after planting and 14 months after herbicide applications, a 24-by-84-inch swath was cut across each species in each treatment, and dry weight yield was again measured.

Summer 1988 Application, Fall 1988 Planting

Twelve weeks after herbicide application, Austrian winterpea, annual ryegrass, hairy vetch, crimson clover, and white clover were planted. Before planting, all plots were mowed and treated with glyphosate at 1 lb/A. Seven weeks after planting, plant populations and heights were measured for each treatment and species. In April, 6 months after planting and 9 months after herbicide applications, a 24-by-10-inch section was harvested from each plot for dry weight yield determination. Eight months after planting and 11 months after application, a 20-by-84-inch swath was harvested from each plot, and dry weight yield was again measured.

Spring 1988 Application, Spring 1989 Planting

In April 1989, 13 months after herbicide application, the spring species were planted in the plots treated with herbicides the previous year. Before emergence, paraquat at 0.4 lb/A of active ingredient was applied to all plots to burn down existing vegetation. Seventeen weeks after planting and 17 months after herbicide application, populations and heights of each species were recorded.

Summer 1988 Application, Spring 1989 Planting

Partridge pea, American jointvetch, Kobe lespedeza, and serecia lespedeza were planted 10 months after herbicide applications. Seventeen weeks after planting and 13 months after applications, populations and heights were recorded for each species and treatment.

Spring 1989 Application, Spring 1989 Planting

Since there was no crop emergence of species planted in the spring of 1988, a spring application and spring planting study was initiated at Greenwood and Starkville on soybean fields that had not been tilled after the 1988 harvest. The soil type in Starkville was a Leeper silty clay loam (fine, montmorillonitic, nonacid, Thermic Vertic Haplaquept). Treatments were the same as in 1988, but rates were half the previous rates used and the crop species tested were planted 2 days after herbicide applications. Herbicide application was with a backpack sprayer in 30 gallons of water per acre. The plots were 50 feet by 6 feet, with four replications. Partridge pea, American jointvetch, Kobe lespedeza, and serecia lespedeza were planted, and all plots were treated with 0.4 lb/A of paraquat to burn down existing vegetation and allow for emergence. Populations and heights of each species were measured 17 weeks after planting. All data were analyzed using analysis of variance, and means were separated by Fisher's protected Least Significant Difference at the 5% level. Data were combined over locations for analysis, except for weed control and spring 1989 application height data.

Results and Discussion

Weed control resulting from spring herbicide applications was variable for weed species and locations (Tables 1 and 2). Imazapyr and hexazinone at 1 lb/A controlled horseweed 100% at each location, and several lower rates of imazapyr controlled the weed 100% at Greenwood. Horseweed control was less at Water Valley with imazapic than with other treatments (Table 1); however, at Greenwood, the 0.5-lb/A rate provided control equivalent to the other treatments (Table 2). Barnyardgrass control increased at each location with rates of imazapyr greater than 0.25 lb/A. Imazapic and hexazinone controlled barnyardgrass equally as well as imazapyr. At Water Valley, broadleaf signalgrass control was not different among treatments (Table 1), but at Greenwood, control was enhanced as imazapyr rates increased above 0.25 lb/A (Table 2). Hexazinone provided less control than imazapic and rates of imazapyr less than 0.75 lb/A. All treatments controlled morningglory 100% at Greenwood (Table 2); however, at Water Valley, imazapyr at 0.75 lb/A, imazapic, and hexazinone resulted in better control than imazapyr at 0.25 lb/A (Table 1). Common cocklebur and common ragweed occurred only at Water Valley. Imazapic at 0.5 lb/A controlled common cocklebur better than imazapyr at rates less than 1 lb/A (Table 1), but there was no difference in control between imazapyr at 1 lb/A and hexazinone at the same rate. The 0.25-lb/A rate of imazapyr was the only treatment with lower common ragweed control than other treatments.

There were no differences in control of morningglory species, broadleaf signalgrass, and barnyardgrass at Greenwood with July herbicide applications (Table 4). Imazapic controlled horseweed less than the other herbicide treatments at both Greenwood and Water Valley (Tables 3 and 4). Control of common ragweed at Water Valley was less with the 0.25-lb/A imazapyr treatment than with the other treatments, but there were no other weed control differences between rates, chemicals, and species (Tables 3 and 4).

Table 1. Weed control 20 weeks after spring application of herbicides at Water Valley, Mississippi.[1]

Herbicide	Rate	Horseweed	Common cocklebur	Common ragweed	Barnyardgrass	Broadleaf signalgrass	Morningglory species
	lb/A	*%*	*%*	*%*	*%*	*%*	*%*
Imazapyr	0.25	68	53	50	53	50	35
Imazapyr	0.50	93	42	100	59	48	50
Imazapyr	0.75	75	48	98	90	71	80
Imazapyr	1.00	100	85	95	87	58	71
Imazapic	0.25	38	66	66	85	59	86
Imazapic	0.50	23	92	85	95	91	91
Hexazinone	1.00	0	70	100	66	45	90
Check		0	0	0	0	0	0
LSD 0.05		31	27	31	37	53	33

[1]Herbicides were applied on March 29, 1988.

Table 2. Weed control 20 weeks after spring application of herbicides at Greenwood, Mississippi.[1]

Herbicide	Rate	Horseweed	Barnyardgrass	Broadleaf signalgrass	Morningglory species
	lb/A	*%*	*%*	*%*	*%*
Imazapyr	0.25	100	69	26	100
Imazapyr	0.50	100	100	71	100
Imazapyr	0.75	100	95	91	100
Imazapyr	1.00	100	100	98	100
Imazapic	0.25	54	100	97	100
Imazapic	0.50	90	100	100	100
Hexazinone	1.00	100	45	55	100
Check		0	0	0	0
LSD 0.05		23	31	21	0

[1]Herbicides were applied on March 22, 1988.

Table 3. Weed control 6 weeks after summer application of herbicides at Water Valley, Mississippi.[1]

Herbicide	Rate	Horse-weed	Common cocklebur	Common ragweed	Barnyard-grass	Broadleaf signalgrass	Morningglory species
	lb/A	*%*	*%*	*%*	*%*	*%*	*%*
Imazapyr	0.25	82	100	65	100	100	96
Imazapyr	0.50	97	100	100	100	89	100
Imazapyr	0.75	100	100	100	100	100	100
Imazapyr	1.00	100	100	100	100	98	100
Imazapic	0.25	35	88	80	100	100	100
Imazapic	0.50	35	96	98	100	96	100
Hexazinone	1.00	100	100	100	100	100	100
Check		0	0	0	0	0	0
LSD 0.05		15	10	23	0	7	2

[1]Herbicides were applied on July 15, 1988.

Table 4. Weed control 6 weeks after summer application of herbicides at Greenwood, Mississippi.[1]

Herbicide	Rate	Horseweed	Barnyardgrass	Broadleaf signalgrass	Morningglory species
	lb/A	*%*	*%*	*%*	*%*
Imazapyr	0.25	86	100	100.0	100
Imazapyr	0.50	94	100	100.0	100
Imazapyr	0.75	100	100	100.0	100
Imazapyr	1.00	99	100	100.0	100
Imazapic	0.25	45	100	100.0	100
Imazapic	0.50	48	100	100.0	99
Hexazinone	1.00	100	99	99.0	100
Check		0	0	0.0	0
LSD 0.05		22	1	.7	1

[1]Herbicides were applied on June 29, 1988.

Spring 1988 Application, Fall 1988 Planting

Plant populations of all five fall-planted species evaluated were equal to or greater than the check with most herbicides and rates, indicating tolerance to the herbicides (Table 5). Exceptions were crimson clover and white clover. Compared with the untreated check, crimson clover populations were reduced by the 0.25-lb/A imazapic and 0.75-lb/A imazapyr treatments, and white clover was reduced by the 1-lb/A imazapyr treatment. There were no differences in populations of Austrian winterpea, hairy vetch, or annual ryegrass between treated and untreated plots. White clover populations were also reduced by the higher rates of imazapyr.

Plant height also indicated tolerance of these species to the herbicides (Table 6). There was no difference in the height of hairy vetch between the treated and untreated check. Austrian winterpea, annual ryegrass, and crimson clover were reduced in height only after treatment with 0.5 lb/A of imazapic as compared with the untreated check. White clover was shorter when treated with 1 lb/A of imazapyr and each rate of imazapic as compared with the untreated check.

Early-season dry weight yields of Austrian winterpea, annual ryegrass, and hairy vetch (6 months after planting and 12 months after herbicide application) did not vary with herbicide treatments (Table 7). Crimson clover yields were less than the untreated check with the 0.5-lb/A imazapic treatment. There were more differences in late-season yields (8 months after planting and 14 months after herbicide application) than early-season yields (Tables 7 and 8). Austrian winterpea had greater yields in plots receiving the 0.75-lb/A imazapyr treatment and the 0.5-lb/A imazapic treatment than the untreated check. Annual ryegrass yields after treatment with imazapyr at rates greater than 0.25 lb/A were higher than the untreated check or imazapic at 0.5 lb/A. There were no reductions in annual ryegrass yields following any herbicide treatment. Yields of hairy vetch and white clover did not vary across treatments, and only the low rate of imazapic reduced yield of crimson clover.

The late-season dry weight yields of all five species evaluated were equal to or greater than the untreated check following all imazapyr treatments. The only late-season yields less than the untreated check were in crimson clover following the 0.25-lb/A imazapic treatment.

Table 5. Populations of five plant species planted in fall 1988 and rated 7 weeks after planting and 8 months after herbicide application.

Herbicide	Rate	Plants per hectare (x 1,000)				
		Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover	White clover
	lb/A	*no.*	*no.*	*no.*	*no.*	*no.*
Imazapyr	0.25	54	508	251	370	232
Imazapyr	0.50	86	441	229	344	169
Imazapyr	0.75	59	564	229	306	159
Imazapyr	1.00	75	417	209	353	88
Imazapic	0.25	77	423	203	288	153
Imazapic	0.50	58	442	226	332	140
Hexazinone	1.00	62	394	203	361	115
Check		54	517	194	411	200
LSD 0.05		22	213	56	97	97

Table 6. Heights of five plant species planted in fall 1988 and measured 7 weeks after planting and 8 months after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover	White clover
	lb/A	*cm*	*cm*	*cm*	*cm*	*cm*
Imazapyr	0.25	14.5	15.5	16.5	5.3	2.4
Imazapyr	0.50	14.6	20.4	16.3	6.0	2.6
Imazapyr	0.75	14.0	17.6	12.3	5.4	1.8
Imazapyr	1.00	14.4	19.3	15.9	4.8	1.4
Imazapic	0.25	15.1	12.4	13.9	4.5	1.3
Imazapic	0.50	11.8	6.8	12.9	3.1	1.0
Hexazinone	1.00	14.9	13.1	15.4	6.0	2.9
Check		15.4	15.6	16.3	6.1	3.0
LSD 0.05		3.4	6.4	4.7	1.7	1.2

Table 7. Early-season dry weight yields of five plant species planted in fall 1988 and harvested 6 months after planting and 12 months after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover
	lb/A	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
Imazapyr	0.25	3,759	2,596	4,136	17,596
Imazapyr	0.50	4,673	4,780	4,260	16,773
Imazapyr	0.75	4,099	3,831	2,613	14,284
Imazapyr	1.00	4,601	4,475	2,202	13,676
Imazapic	0.25	4,690	2,327	1,737	11,384
Imazapic	0.50	4,386	735	2,310	7,303
Hexazinone	1.00	4,905	3,043	2,453	15,143
Check		2,936	1,988	2,632	13,730
LSD 0.05		1,875	1,389	2,091	5,876

Table 8. Late-season dry weight yields of five plant species planted in fall 1988 and harvested 8 months after planting and 14 months after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover	White clover
	lb/A	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
Imazapyr	0.25	867	3,720	2,501	3,515	1,571
Imazapyr	0.50	1,272	4,046	2,664	3,778	1,340
Imazapyr	0.75	1,618	4,283	2,328	2,748	1,445
Imazapyr	1.00	993	4,157	2,165	3,032	932
Imazapic	0.25	930	3,169	1,408	1,650	320
Imazapic	0.50	1,613	1,613	2,217	2,480	199
Hexazinone	1.00	946	3,631	2,743	2,354	1,377
Check		541	2,275	2,259	2,869	1,240
LSD 0.05		925	1,458	1,066	1,166	1,067

Summer 1988 Application, Fall 1988 Planting

Plant populations established after herbicide applications in summer 1988 were variable among species and herbicide treatments (Table 9). Hairy vetch and Austrian winterpea populations were not affected by herbicide treatments. Annual ryegrass populations decreased as imazapyr and imazapic rates increased, and populations were significantly less than the untreated check after the 0.5-lb/A imazapic treatment. Crimson clover populations were lower than the check following the 0.5-lb/A imazapic treatment and the 0.5-, 0.75-, and 1-lb/A imazapyr treatments. White clover populations were lower than the untreated check following all imazapyr treatments and the 0.5-lb/A imazapic treatment. Hexazinone did not reduce populations of any of the species evaluated.

Plant heights of the species planted in the fall after summer 1988 herbicide application varied with treatments, except for hairy vetch (Table 10). Austrian winterpea was shorter following the 0.5-lb/A imazapic treatment and the 0.5- and 1-lb/A imazapyr treatments than the untreated check. Annual ryegrass was shorter after the 1-lb/A imazapyr treatment and the 0.25- and 0.5-lb/A imazapic treatments than the untreated check. Crimson clover and white clover were shorter following all imazapyr and imazapic treatments than the check or the hexazinone treatment. Hexazinone did not cause height reduction in the species evaluated.

Early-season dry weight yields (6 months after planting and 9 months after herbicide application) also varied among herbicide treatments, except for Austrian winterpea (Table 11). Annual ryegrass yields were reduced only after imazapic treatments, and crimson clover yields were reduced only after the 0.5-lb/A imazapic treatment. Hairy vetch yields were reduced after the 0.5-lb/A imazapic, 0.75-lb/A imazapyr, and 1-lb/A hexazinone treatments when compared with the untreated check.

Late-season dry weight yields (8 months after planting and 11 months after herbicide application) in all species and in all herbicide treatments were equivalent to the untreated check (Table 12). There were yield reductions of crimson clover and annual ryegrass following the 0.5-lb/A imazapic treatment as compared with the 0.25-lb/A imazapic treatment. Hairy vetch yields were lowest after the 0.25-lb/A imazapyr treatment.

Table 9. Populations of five plant species planted in fall 1988 and rated 7 weeks after planting and 19 weeks after herbicide application.

Herbicide	Rate	Plants per hectare (x 1,000)				
		Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover	White clover
	lb/A	*no.*	*no.*	*no.*	*no.*	*no.*
Imazapyr	0.25	81	529	147	350	125
Imazapyr	0.50	71	458	150	259	84
Imazapyr	0.75	70	400	162	270	41
Imazapyr	1.00	78	364	159	200	48
Imazapic	0.25	129	4,111	135	303	166
Imazapic	0.50	76	270	141	241	65
Hexazinone	1.00	66	390	135	364	204
Check		82	458	165	364	232
LSD 0.05		45	169	43	87	87

Table 10. Heights of five plant species planted in fall 1988 and measured 7 weeks after planting and 19 weeks after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover	White clover
	lb/A	*cm*	*cm*	*cm*	*cm*	*cm*
Imazapyr	0.25	11.1	16.6	12.3	3.9	1.8
Imazapyr	0.50	10.9	12.9	11.3	2.9	0.9
Imazapyr	0.75	11.5	12.4	11.6	3.9	0.9
Imazapyr	1.00	10.3	9.6	12.0	2.3	0.5
Imazapic	0.25	11.8	7.8	11.9	3.1	1.1
Imazapic	0.50	9.9	4.8	10.6	2.6	0.5
Hexazinone	1.00	12.1	21.5	12.5	6.8	3.1
Check		14.3	17.6	12.8	5.6	2.9
LSD 0.05		3.4	5.5	3.3	1.6	0.9

Table 11. Late-season dry weight yields of five plant species planted in fall 1988 and harvested 8 months after planting and 11 months after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover
	lb/A	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
Imazapyr	0.25	851	3,142	1,345	1,839
Imazapyr	0.50	1,660	3,121	2,643	2,522
Imazapyr	0.75	1,655	4,225	2,338	1,834
Imazapyr	1.00	2,128	3,941	3,158	2,575
Imazapic	0.25	1,545	1,277	2,680	2,958
Imazapic	0.50	1,040	878	1,829	972
Hexazinone	1.00	1,261	3,594	2,207	1,597
Check		1,818	2,848	2,013	2,591
LSD 0.05		1,204	2,022	1,156	1,782

Table 12. Late-season dry weight yields of five plant species planted in fall 1988 and harvested 8 months after planting and 11 months after herbicide application.

Herbicide	Rate	Austrian winterpea	Annual ryegrass	Hairy vetch	Crimson clover
	lb/A	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
Imazapyr	0.25	851	3,142	1,345	1,839
Imazapyr	0.50	1,660	3,121	2,643	2,522
Imazapyr	0.75	1,655	4,225	2,338	1,834
Imazapyr	1.00	2,128	3,941	3,158	2,575
Imazapic	0.25	1,545	1,277	2,680	2,958
Imazapic	0.50	1,040	878	1,829	972
Hexazinone	1.00	1,261	3,594	2,207	1,597
Check		1,818	2,848	2,013	2,591
LSD 0.05		1,204	2,022	1,156	1,782

Spring 1988 Application, Spring 1989 Planting

There was little difference among treatments in the populations of species planted in spring 1989 (Table 13). There were no differences in populations of partridge pea and Kobe lespedeza across treatments or when compared with the untreated check. Imazapyr treatments of 0.75 and 1 lb/A reduced populations of American jointvetch more than the 0.25-lb/A imazapyr treatment, but no treatment resulted in a reduction when compared with the untreated check. Serecia lespedeza populations were lower with the 1-lb/A imazapyr treatment than the untreated check.

Plant heights of the species planted in spring 1989 following 1988 herbicide application were not affected by the herbicide treatments (Table 14). This finding indicates a tolerance of these species to any residues that were present 17 months after herbicide application.

Table 13. Populations of four plant species planted in spring 1989 and measured 17 weeks after planting and 17 months after herbicide application.

Herbicide	Rate	Plants per hectare (x 1,000)			
		Partridgepea	Jointvetch	Kobe lespedeza	Serecia lespedeza
	lb/A	*no.*	*no.*	*no.*	*no.*
Imazapyr	0.25	51	281	68	132
Imazapyr	0.5	56	198	69	97
Imazapyr	0.75	68	170	99	182
Imazapyr	1.0	65	145	93	79
Imazapic	0.25	55	212	113	129
Imazapic	0.5	56	266	115	154
Hexazinone	1.0	48	225	116	128
Check		48	248	67	160
LSD 0.05		25	110	51	78

Table 14. Heights of four plant species planted spring 1989 and measured 17 weeks after planting and 17 months after herbicide application.

Herbicide	Rate	Partridgepea	Jointvetch	Kobe lespedeza	Serecia lespedeza
	lb/A	*cm*	*cm*	*cm*	*cm*
Imazapyr	0.25	55.4	82.0	25.3	25.3
Imazapyr	0.5	63.3	85.5	24.0	19.2
Imazapyr	0.75	68.8	71.4	21.4	27.0
Imazapyr	1.0	59.4	61.6	24.1	18.0
Imazapic	0.25	61.4	74.5	27.3	22.0
Imazapic	0.5	73.5	85.6	23.9	26.3
Hexazinone	1.0	55.3	77.5	28.4	16.4
Check		65.4	86.9	16.3	25.5
LSD 0.05		37.6	38.0	13.2	12.3

Spring 1988 Application, Spring 1989 Planting

Serecia lespedeza was the only spring-planted species to have lower populations than the untreated check following summer 1988 herbicide application (Table 15). Populations of serecia lespedeza were lower after the 0.5-lb/A imazapic treatment and the 0.5-, 0.75-, and 1-lb/A imazapyr treatments than the untreated check or hexazinone treatment. None of the herbicide treatments applied in the summer of 1988 resulted in reduced heights of species planted in spring 1989 (Table 16).

Table 15. Populations of four plant species planted in spring 1989 and measured 17 weeks after planting and 13 months after herbicide application.

Herbicide	Rate	Plants per hectare (x 1,000)			
		Partridgepea	Jointvetch	Kobe lespedeza	Serecia lespedeza
	lb/A	*no.*	*no.*	*no.*	*no.*
Imazapyr	0.25	27	109	162	95
Imazapyr	0.50	28	113	37	69
Imazapyr	0.75	43	118	44	48
Imazapyr	1.00	47	84	40	69
Imazapic	0.25	48	103	48	76
Imazapic	0.50	32	98	62	56
Hexazinone	1.00	37	153	19	123
Check		25	90	28	123
LSD 0.05		15	96	34	53

Table 16. Heights of four plant species planted in spring 1989 and measured 17 weeks after planting and 13 months after herbicide application.

Herbicide	Rate	Partridgepea	Jointvetch	Kobe lespedeza	Serecia lespedeza
	lb/A	*cm*	*cm*	*cm*	*cm*
Imazapyr	0.125	42.3	37.5	15.0	16.5
Imazapyr	0.250	49.0	36.9	21.8	22.5
Imazapyr	0.375	50.0	40.9	19.6	25.6
Imazapyr	0.500	59.9	44.5	19.5	21.4
Imazapic	0.125	48.4	37.1	18.8	26.8
Imazapic	0.250	36.6	27.8	17.9	16.4
Hexazinone	0.500	44.5	51.3	8.9	22.9
Check		32.3	29.3	16.1	17.4
LSD 0.05		20.8	18.1	7.7	9.8

Spring 1989 Application, Spring 1989 Planting

Populations of species planted in spring 1989 were less in all herbicide treatments than in the untreated check (Table 17). American jointvetch and Kobe lespedeza populations were reduced following increased rates of imazapyr. Partridge pea and serecia lespedeza populations were greater following the 0.125-lb/A imazapic treatment than any of the imazapyr treatments or the 0.5-lb/A hexazinone treatment.

At 2 days after the spring 1989 herbicide application, plant heights of all the 1989 spring-planted species were reduced at one or more rates of each herbicide (Table 18). The 0.125-lb/A imazapic treatment was the only one that did not reduce partridge pea height less than the untreated check. Kobe lespedeza height was reduced as rates of imazapyr and imazapic increased, but its height after the 0.125-lb/A imazapyr and 0.125-lb/A imazapic treatments was no different from the untreated check. Serecia lespedeza had reduced height after all treatments except 0.125 lb/A of imazapic at the Starkville location. American jointvetch height was reduced following all herbicide treatments at the Greenwood location, and following the 0.25- and 0.5-lb/A imazapyr treatments at the Starkville location.

Table 17. Populations of four plant species planted in spring 1989 and measured 17 weeks after planting and 17 weeks after herbicide application.

Herbicide	Rate	Plants per hectare (x 1,000)			
		Partridgepea	Jointvetch	Kobe lespedeza	Serecia lespedeza
	lb/A	*no.*	*no.*	*no.*	*no.*
Imazapyr	0.125	28	94	38	7
Imazapyr	0.250	22	51	32	1
Imazapyr	0.375	21	48	10	7
Imazapyr	0.500	18	28	5	1
Imazapic	0.125	59	94	47	104
Imazapic	0.250	38	79	28	35
Hexazinone	0.500	34	51	9	12
Check		93	198	100	165
LSD 0.05		21	46	27	41

Table 18. Heights of four plant species planted in spring 1989 and measured 17 weeks after planting and 17 weeks after herbicide application at Starkville (S) and Greenwood (G), Miss.

Herbicide	Rate	Partridgepea		Jointvetch		Kobe lespedeza		Serecia lespedeza	
		S	G	S	G	S	G	S	G
	lb/A	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
Imazapyr	0.125	15.5	52.5	19.3	24.8	14.0	9.5	3.3	1.8
Imazapyr	0.250	21.3	17.5	15.0	19.0	12.5	0.0	0.3	0.0
Imazapyr	0.375	17.8	28.3	19.8	9.0	6.3	0.0	4.5	0.0
Imazapyr	0.500	15.5	11.8	11.8	3.5	4.5	0.0	1.0	0.0
Imazapic	0.125	28.8	59.5	18.5	16.0	14.3	4.0	15.3	8.0
Imazapic	0.250	23.3	38.8	20.3	3.3	6.3	0.0	8.8	0.0
Hexazinone	0.500	21.0	57.5	23.3	16.0	2.0	1.5	9.8	5.3
Check		42.0	77.0	28.8	48.5	14.3	8.3	18.3	40.3
LSD 0.05		17.2		13.2		7.5		6.9	

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