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FOREWORD

The 2023 Research Progress Report of the Western Society of Weed Science (WSWS) is a compilation of research investigations contributed by weed scientists in the western United States of America. The objective of the Research Progress Report is to provide an avenue for presentation and exchange of on-going research to the weed science community. The information in this report is preliminary; therefore, it is not for the development of endorsements or recommendations.

The reports contained herein and their respective content, format, and style are the responsibility of the author(s) who submitted them. Reports are printed as received from the authors.

WSWS appreciates the time and effort of the authors who shared their research results with the members of WSWS.

Traci Rauch
Research Progress Report Editor
Western Society of Weed Science
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Winter annual grass and broadleaf weed control at natural sites. Lisa C. Jones and Timothy Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established on grass-dominated Latah County parkland to examine broadleaf weed control after winter annual grass control in Moscow, ID. Plots 10 by 30 ft were arranged in a randomized complete block design with four replications of seven treatments plus an untreated check. All herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 15 gpa at 25 psi and 3 mph (Table 1). The winter annual grass species present were ventenata (*Ventenata dubia*), Japanese brome (*Bromus japonicus*), and medusahead (*Taeniatherum caput-medusae*) and were targeted with a fall application. The broadleaf weed species present were field bindweed (*Convolvulus arvensis)*, common teasel (*Dipsacus fullonum)*, prickly lettuce (*Lactuca serriola*), St. John's wort (*Hypericum perforatum*), western salsify (*Tragopogon dubius)*, and rush skeletonweed (*Chondrilla juncea*) and were targeted with a spring application. Perennial grasses (primarily smooth brome, *Bromus inermis*) were dormant at the time of the fall application and vegetative at the time of the spring application. The spring treatments were applied only to the plots that received the first four fall treatments (Table 2). Plant cover and weed control were visually evaluated on July 9, 2021 (9 MAT-fall; 2 MAT-spring) and July 8, 2022 (21 MAT-fall; 14 MAT-spring) using reduction in foliar cover contrasted to the untreated check as the dependent variable.

Table 1. Application data.

Application date	September 24, 2020	May 21, 2021
Winter annual grass growth stage	Pre-emergent	Boot
Broadleaf weed stage	Varied by species	Vegetative
Air temperature (F)	55	53
Relative humidity (%)	56	49
Wind (mph, direction)	4, NE	1, NW
Cloud cover (%)	50	100
Soil temperature at 2 inches (F)	56	48

Table 2. List of treatments with application timings and herbicide rates.

Treatment Number	Treatment[1]	Application timing	Rate
			lb ai/A
1	Indaziflam	Sept. 2020	0.065
	Aminopyralid[2]	May 2021	0.092
2	Indaziflam	Sept. 2020	0.065
	Aminopyralid/florpyrauxifen-benzyl[2]	May 2021	0.104/0.010
3	Indaziflam + rimsulfuron	Sept. 2020	0.065 + 0.047
	Aminopyralid[2]	May 2021	0.092
4	Indaziflam + rimsulfuron	Sept. 2020	0.065 + 0.047
	Aminopyralid/florpyrauxifen-benzyl[2]	May 2021	0.104/0.010
5	Indaziflam + aminopyralid[2]	Sept. 2020	0.065 + 0.092
6	Indaziflam + aminopyralid/florpyrauxifen-benzyl[2]	Sept. 2020	0.065 + 0.104/0.010
7	Indaziflam	Sept. 2020	0.065

[1]All treatments were applied with a non-ionic surfactant at 0.25% v/v.
[2]Herbicide rate reported in lb ae/A.

At the July 9, 2021 evaluation, there were no differences between treatments in winter annual grass control ($p=0.12$) or broadleaf weed control ($p=0.96$). Winter annual grasses (sum of all species) were controlled 62% to 100% on average. Broadleaf weeds (sum of all species) were controlled 61% to 90% on average. Epinasty of broadleaf weeds, especially western salsify and common teasel, was observed in all spring-treated plots. Of all broadleaf weed species, field bindweed was most likely to avoid injury from the spring herbicide application.

At the July 8, 2022 evaluation, there were no differences between treatments in winter annual grass control ($p=0.58$) but there was a difference in broadleaf weed control ($p<0.01$). Winter annual grasses (sum of all species) were controlled 96% to 100% on average. Greatest control of broadleaf weeds (sum of all species) was achieved in plots that received the spring 2021 application except for the third treatment. In the third treatment, one out of the four plots had high cover (28%) of field bindweed. As noted from visual observations on July 9, 2021, field bindweed appeared most resistant to herbicide injury from the spring application. Plots that received the spring 2021 application had an average broadleaf weed control of 87% while plots that did not receive the spring application had an average control of 30%.

Downy brome control with aerial applications of indaziflam and imazapic. Lisa C. Jones and Timothy S. Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333). A study was established on sagebrush steppe rangeland near Wilbur, WA to observe the efficacy of aerial applications of indaziflam and indaziflam plus imazapic for control of downy brome (*Bromus tectorum*). Herbicide applications were made on August 18, 2021 by fixed wing airplane calibrated to deliver 5 gpa (Table 1). Spray swaths were approximately 1,000 ft long by 60 ft wide with a 60 ft untreated buffer on both sides. The placement of the two herbicide treatments and an untreated check were randomized and included three replicates. Weed control was visually evaluated on May 26, 2022 (9 MAT) using reduction in foliar cover contrasted to the untreated check as the dependent variable. Cover and density of other plant functional groups were recorded to investigate non-target and indirect effects. The dominant perennial grass was Sandberg's bluegrass (*Poa secunda*) and the dominant deep-rooted perennial grasses were Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). The dominant perennial forbs were biscuitroot (*Lomatium* spp.), buckwheat (*Eriogonum* spp.), and agoseris (*Agoseris* spp.)

Table 1. Application and soil data.

Application type	Fixed wing airplane
Application date	August 18, 2021
Winter annual grass growth stage	Pre-emergence
Air temperature (F)	71
Relative humidity (%)	38
Wind (mph, direction)	6, W
Cloud cover (%)	10
Soil texture	Silt loam

Nine MAT, treatments controlled downy brome by an average of 74% with variation in control spanning 0-100%. Control from indaziflam plus imazapic may not be significantly different than control from indaziflam alone (p=0.08). Indaziflam plus imazapic had a mean control of 80% compared to 68% for indaziflam alone (Table 2). Cover of deep-rooted perennial grasses did not differ between treatments (p=0.22, Table 2). Density of deep-rooted perennial grasses may not be significantly different between treatments (p=0.08) but there was a trend of higher density in plots treated with indaziflam plus imazapic (Table 2). Cover of perennial forbs did not differ between treatments (p=0.12), but density was higher in plots treated with indaziflam plus imazapic (p=0.01; Table 2). Plots will continue to be monitored in summer 2023 to assess long-term treatment efficacy and native plant response.

Table 2. Cover and density of deep-rooted perennial grasses and perennial forbs following pre-emergent applications of indaziflam and imazapic 9 MAT.

		Downy brome	Perennial grass[2]		Perennial forb[2]	
Treatment[1]	Rate	control	Cover	Density	Cover	Density
	lb ai/A	%	%	#/m^2	%	#/m^2
Untreated		0	9.2	8.5	3.1	10.6 a
Indaziflam	0.065	68	11.3	11.1	2.0	10.1 a
Indaziflam + imazapic	0.065 + 0.078	80	13.9	14.1	3.6	26.0 b
LSD (α = 0.05)		NS	NS	NS	NS	11.8

[1]All herbicide treatments were applied with a non-ionic surfactant at 4 oz/gal.

[2]Within columns, means followed by different letters are statistically different; no letters indicate no statistical difference.

Winter annual grass control and native plant response with aerial and ground applications of indaziflam and imazapic. Lisa C. Jones, Georgia R. Harrison, and Timothy S. Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333). A study was established on sagebrush steppe rangeland at Rinker Rock Creek Ranch near Hailey, ID to observe how helicopter, fixed wing airplane, and ground application droplet coverage affect indaziflam efficacy for control of invasive winter annual grasses. Indaziflam and imazapic were applied on September 16 and 19, 2019 (Table 1).

Table 1. Application and soil data.

Application type	Fixed wing airplane, helicopter	Ground - UTV
Application date	September 16, 2019	September 19, 2019
Winter annual grass growth stage	Pre-emergence	
Air temperature (F)	68	50
Relative humidity (%)	34	73
Wind (mph, direction)	2, E	1, SE
Cloud cover (%)	80	100
Soil temperature at 2 inches (F)	--	51
Soil pH	6.5	
Soil texture	Sandy loam	

Fixed wing airplane and helicopter treatments used four carrier rates with indaziflam alone (0.065 lb ai/A) or indaziflam plus imazapic (0.065 + 0.078 lb ai/A). We calculated percent droplet coverage using water-sensitive papers placed on the ground. Droplet coverage ranged from 2 to 21%. UTV ground applications used 10 and 20 gpa of indaziflam alone and indaziflam plus imazapic at the same rates listed above. Because of a light rain occurring at the time of application with the UTV, we do not have percent droplet coverage values for those treatments, but instead report results using carrier rate. All treatments were applied with a non-ionic surfactant at 0.25% v/v. Treatment groups were based on application type, herbicide, and carrier rate (ground application only).

Permanent assessment plots of 9 sq m were arranged within treatment areas in locations that were representative of the surrounding plant community assemblages. Pre-treatment plant cover was recorded on October 3, 2019 and post-treatment plant cover was recorded on June 10, 2020, May 26, 2021, and May 18, 2022. Within each plot, plant foliar cover by species was recorded using cover classes; data were analyzed using the midpoint of cover classes averaged among treatment groups. Percent control was summarized by summing midpoint cover of both downy brome (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*). We used ANOVA with a post-hoc Tukey HSD test to evaluate treatment effects on annual grass control and perennial grass cover. Because there is concern that indaziflam can delay plant recruitment from the seedbank, during the May 2022 assessment we also recorded recruitment by species. Vegetation cover by species within plots will continue to be monitored in summer 2023 to assess long-term treatment efficacy and native plant response.

Results: Annual grass control

Nine MAT, treatments controlled winter annual grasses by 78% on average. When herbicide droplet coverage was less than 7%, control varied from 0 to 100% (average 71%); but when coverage was greater than 7%, control was less variable and ranged from 75 to 100% (average 88%; Figure 1). Because indaziflam has limited soil mobility, a droplet coverage of at least 7% resulted in good annual grass control. In addition, in the aerially-treated plots, control averaged 66% with indaziflam, but increased to 90% with indaziflam plus imazapic ($p<0.01$). Of the UTV-treated plots, only herbicide, and not carrier rate, affected control ($p=0.01$). Control averaged 92% with indaziflam plus imazapic and 70% with indaziflam. Regardless of application equipment, the addition of imazapic to indaziflam improved annual grass control the first year after treatment. Altogether, all treated plots averaged 9% annual grass cover, compared to 41% cover in untreated plots.

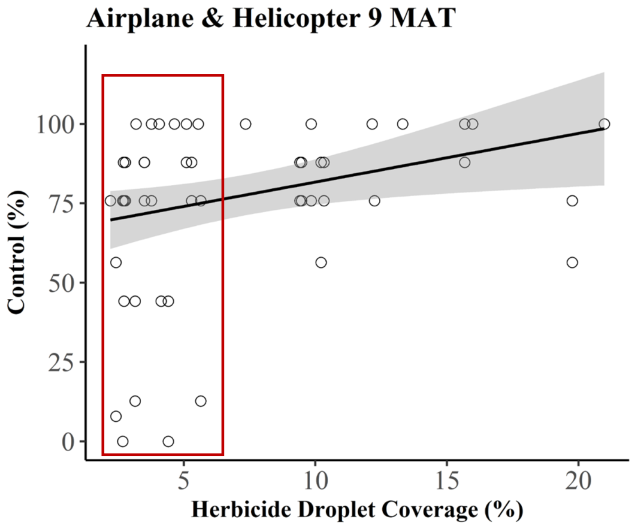

Figure 1. Annual grass control 9 MAT (June 10, 2020) across all aerially-treated plots. Hollow circles represent each plot, the black line with gray shading represents the regression with 95% confidence, and the red box highlights the large variability in control when herbicide droplet coverage was <7%.

Twenty MAT, treatments controlled winter annual grasses by 97% on average. Herbicide droplet coverage no longer affected control (p=0.61). The differential control from herbicide decreased, though control was still better with indaziflam plus imazapic at 99% compared to indaziflam alone at 96% (p=0.04). Of the UTV-treated plots, neither herbicide nor carrier rate affected control (p>0.05). Altogether, all treated plots averaged <1% annual grass cover, compared to 24% cover in untreated plots. Annual grass cover region-wide was reduced in 2021 due to extreme drought conditions.

Thirty-two MAT, treatments controlled winter annual grasses by 85% on average. Neither herbicide droplet coverage (p=0.18) nor herbicide (p=0.27) influenced control. Of the UTV-treated plots, neither herbicide nor carrier rate affected control (p>0.05). Altogether, all treated plots averaged 6% annual grass cover, compared to 41% cover in untreated plots.

Results: Perennial grass cover
Nine MAT, perennial grass cover was lowest in plots treated by helicopter (p<0.01; Table 2). Within the UTV-treated plots, perennial grass cover was lowest in plots treated with indaziflam plus imazapic compared to indaziflam alone (p<0.01; Table 3).

Twenty MAT, perennial grass cover was lower when treated with indaziflam plus imazapic (mean 29%) compared to indaziflam alone (mean 37%; p=0.02). Untreated plots averaged 31% perennial grass cover, statistically equivalent to both herbicide treatments. Among aerially-treated plots, perennial grass cover differed by droplet coverage (p<0.01, Figure 2), herbicide (p=0.02), and application type (p<0.01; Table 2). Perennial grass cover was highest in areas with higher droplet coverage (Figure 2), treated by airplane (Figure 2a), and treated with indaziflam alone (Tables 2 and 3, Figure 2). Herbicide impacts indicate the combination of indaziflam plus imazapic had negative non-target effects on desirable grasses. Among the UTV-treated plots, herbicide and carrier rate did not affect perennial grass cover (p>0.17; Table 3). Cover values were generally lower than in 2020 because the study area experienced a severe drought in 2021.

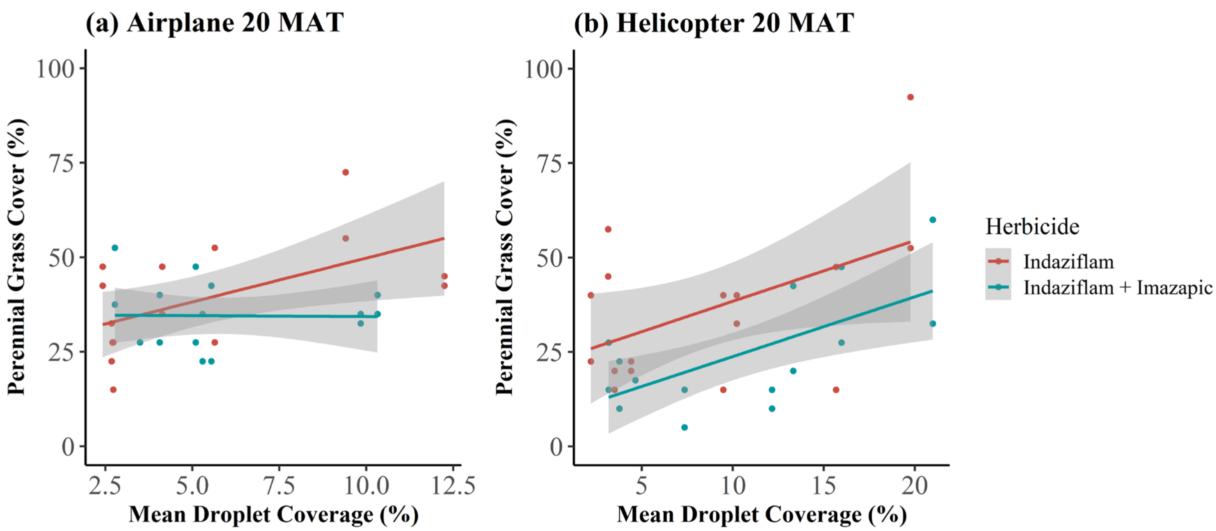

Figure 2. Average perennial grass cover 20 MAT (May 26, 2021) in plots treated by (a) airplane and (b) helicopter.

Thirty-two MAT, across all plots, perennial grass cover did not differ by herbicide or application type ($p=0.10$ and 0.75, respectively; Tables 2 and 3). Among aerially-treated plots, perennial grass cover increased with increasing droplet coverage, but the effect was stronger for plots treated with indaziflam alone compared to indaziflam plus imazapic (Figure 3). Herbicide impacts indicate the combination of indaziflam and imazapic continued to have negative non-target effects on desirable grasses; however average cover was 45% which is considered high in this ecosystem. Among UTV-treated plots, herbicide and carrier rate affected perennial grass cover ($p<0.01$ and $p=0.02$, respectively). Perennial grass cover was higher in plots treated with indaziflam alone compared to indaziflam plus imazapic (Table 3) and in plots treated with10 GPA compared to 20 GPA (data not shown).

Table 2. Average perennial grass foliar cover by application type.

Application Type	Average perennial grass foliar cover[1]			
	Pre-treatment[2]	9 MAT[3]	20 MAT[4]	32 MAT[5]
	----------------------	------------%-----------	----------------------	
None	23	50 a	31 a	62 a
Airplane	24	46 a	37 b	52 a
Helicopter	31	23 b	30 a	50 a
UTV	27	49 a	30 a	46 a

[1]Within columns, means followed by different letters are statistically different.
[2]Evaluations made October 3, 2019.
[3]Evaluations made June 10, 2020.
[4]Evaluations made May 26, 2021.
[5]Evaluations made May 18, 2022.

Table 3. Average perennial grass foliar cover by application type and herbicide treatment.

Application Type	Treatment[1]	Average perennial grass foliar cover[2] Pre-treatment[3]	9 MAT[4]	20 MAT[5]	32 MAT[6]
		----------------	-------%	--------	--------
None	Untreated	23	50 a	31 a	62 a
Airplane	Indaziflam	19	50 a	39 a	50 a
Airplane	Indaziflam + imazapic	28	42 a	35 a	53 a
Helicopter	Indaziflam	38	25 a	36 a	54 a
Helicopter	Indaziflam + imazapic	24	21 a	24 b	46 a
UTV	Indaziflam	27	62 a	34 a	57 a
UTV	Indaziflam + imazapic	26	35 b	26 a	35 b

[1]For all treatments, indaziflam and imazapic were applied at 0.065 lb ai/A and 0.078 lb ai/A, respectively, with 0.25% v/v non-ionic surfactant.
[2]Within columns, means followed by different letters are statistically different by herbicide treatment within the given application type.
[3]Evaluations made October 3, 2019.
[4]Evaluations made June 10, 2020.
[5]Evaluations made May 26, 2021.
[6]Evaluations made May 18, 2022.

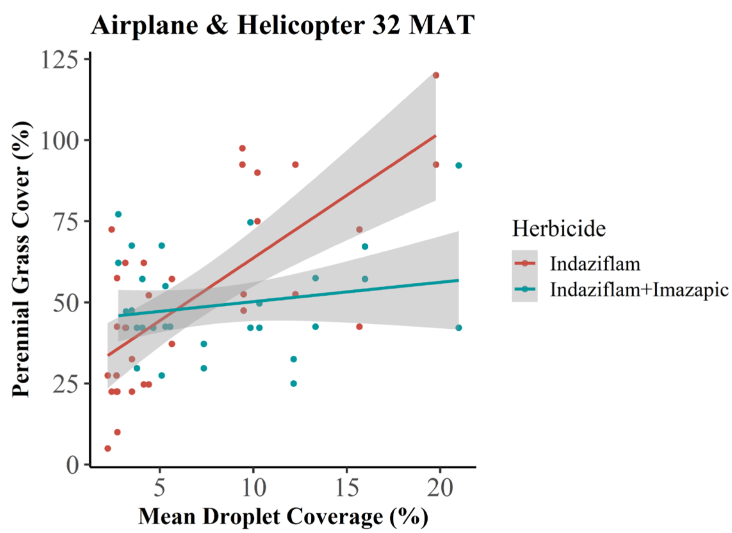

Figure 3. Average perennial grass cover 32 MAT (May 18, 2022) across all aerially-treated plots. Perennial grass cover differed with herbicide droplet coverage and the effect varied depending on herbicide.

Results: Recruitment
Thirty-two MAT, we observed recruitment from the seedbank of 29 native species of forbs, grasses, and shrubs. Twenty-one were forb species listed as preferred by sage grouse. There was no difference in recruitment abundance between treated and untreated plots ($p=0.24$, data not shown). Among aerially-treated plots, recruitment abundance was greater in plots treated by airplane compared to helicopter ($p=0.01$, data not shown). Among UTV-treated plots, herbicide and carrier rate did not affect recruitment ($p>0.09$, data not shown). Recruitment data indicate that in the third growing season after treatment, the herbicides have no negative impact to native plant germination from the seedbank, while continuing to control the winter annual grass.

Grass weed control and tolerance in Kentucky bluegrass with indaziflam. Traci A. Rauch and Joan M. Campbell. (Dept of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Studies were conducted in Kentucky bluegrass to evaluate interrupted windgrass, ivyleaf speedwell and downy brome control and tolerance with indaziflam. Studies were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). All studies, except Nezperce variety Tumalo, were over sprayed for broadleaf weed control by the grower. Weed control and crop injury were evaluated visually during the growing season. In the tolerance study, Kentucky bluegrass was swathed on July 12, 2022 and harvested with a small plot combine on July 27, 2022.

Table 1. Application and soil data.

Location	Nezperce, ID			Nezperce, ID		
K. bluegrass variety and age	Tumalo – 2nd year			Everest – 2nd year		
Application timing	early fall	late fall	spring	early fall	late fall	spring
Application date	9/21/2021	10/19/2021	5/10/2022	9/29/2021	10/19/2021	5/17/2022
Growth stage						
Kentucky bluegrass	No green-up	40% green-up (2 inch)	5 tiller (10 inch)	No green-up	15% green-up (2 inch)	3 tiller (3 inch)
Interrupted windgrass	pre	pre	1 leaf	--	--	--
Ivyleaf speedwell	pre	pre	flower	--	--	--
Downy brome	--	--	--	pre	pre	4 tiller (4 inch)
Air temperature (F)	62	61	53	58	58	60
Relative humidity (%)	52	42	52	63	50	65
Wind (mph, direction)	4, E	2, ESE	1, E	4, ESE	5, ESE	2, NW
Cloud cover (%)	0	0	75	30	0	70
Next moisture occurred	9/29/2021	10/22/2021	5/13/2022	10/18/2021	10/22/2021	5/27/2022
Soil moisture	dry	dry	wet	dry	dry	wet
Soil temperature at 2 inch (F)	50	50	48	50	50	52
pH		4.6			5.3	
OM (%)		5.2			5.6	
CEC (meq/100g)		11			19	
Texture		silty clay loam			silt loam	

Location	Gifford, ID		
K. bluegrass variety and age	Action – 8th year		
Application timing	early fall	late fall	Spring
Application date	9/24/2021	10/19/2021	5/10/2022
Growth stage			
Kentucky bluegrass	2% green-up (0.5 inch)	15% green-up (2 inch)	5 tiller (12 inch)
Air temperature (F)	73	68	53
Relative humidity (%)	36	31	65
Wind (mph, direction)	2, E	4, E	4, NW
Cloud cover (%)	0	0	80
Next moisture occurred	9/29/2021	10/22/2021	5/13/2022
Soil moisture	dry	dry	Wet
Soil temperature at 2 inch (F)	60	60	60
pH		5.1	
OM (%)		3.9	
CEC (meq/100g)		15.1	
Texture		silt loam	

On June 7, interrupted windgrass control was 94% or greater for all fall treatments (Table 2). All indaziflam treatments controlled ivyleaf speedwell 91 to 99% regardless of application time. Downy brome control was 92 to 99% with all the fall treatments (Table 3). All treatments injured Kentucky bluegrass 11 to 24% on May 12 (Table 4). On June 2, injury tended to be greater at the early fall timing high rate (18%) and all rates at the late fall timing (11 to 21%) but did not differ among treatments. Seed yield ranged from 735 to 887 lb/A and did not differ among treatments including the untreated check. Seed germination is still to be determined.

Table 2. Interrupted windgrass and ivyleaf speedwell control with indaziflam in Kentucky bluegrass near Nezperce, ID in 2022.

Treatment	Rate	Application timing	Weed control[1] Interrupted windgrass	Weed control[1] Ivyleaf speedwell
	lb ai/A		%	%
Indaziflam	0.026	early fall	94	91
Indaziflam	0.039	early fall	99	92
Indaziflam	0.052	early fall	98	92
Indaziflam	0.026	late fall	94	93
Indaziflam	0.039	late fall	97	99
Indaziflam	0.052	late fall	98	99
Indaziflam	0.026	spring	42	99
Indaziflam	0.039	spring	62	99
Indaziflam	0.052	spring	75	99
LSD (0.05)			8	7
Density (plants/ft^2)			25	10

[1]Evaluated on June 7, 2022.

Table 3. Downy brome control with indaziflam in Kentucky bluegrass near Nezperce, ID in 2022.

Treatment	Rate	Application timing	Downy brome control[1]
	lb ai/A		%
Indaziflam	0.026	early fall	99
Indaziflam	0.039	early fall	99
Indaziflam	0.052	early fall	99
Indaziflam	0.026	late fall	92
Indaziflam	0.039	late fall	94
Indaziflam	0.052	late fall	99
Indaziflam	0.026	spring	55
Indaziflam	0.039	spring	60
Indaziflam	0.052	spring	22
LSD (0.05)			32
Density (plants/ft^2)			0.5

[1]Evaluated on June 7, 2022.

Table 4. Kentucky bluegrass response to indaziflam near Gifford, ID in 2022.

Treatment	Rate	Application timing	Kentucky bluegrass injury May 12	Kentucky bluegrass injury June 2	K. bluegrass seed yield[1]
	lb ai/A		%	%	1b/A
Indaziflam	0.026	early fall	21	9	799
Indaziflam	0.039	early fall	14	9	887
Indaziflam	0.052	early fall	22	18	835
Indaziflam	0.026	late fall	18	11	771
Indaziflam	0.039	late fall	24	19	754
Indaziflam	0.052	late fall	19	21	735
Indaziflam	0.026	spring	18	12	811
Indaziflam	0.039	spring	11	0	748
Indaziflam	0.052	spring	14	6	866
Untreated check	--	--	--	--	850
LSD (0.05)			NS	NS	NS

[1]Only 3 replications included due to delayed sample processing.

Italian ryegrass control in chickpea with pronamide. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established to evaluate Italian ryegrass control with pronamide in chickpea near Moscow, ID. The plots were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). The field was oversprayed with glyphosate at 0.75 lb ae/A on May 1, 2022 prior to planting. Weed control was evaluated visually during the growing season.

Table 1. Application and soil data.

Application date	5/1/2022
Seeding date-variety	5/22/2022-Sierra
Air temperature (F)	59
Relative humidity (%)	60
Wind (mph)	0
Cloud cover (%)	100
Next moisture occurred	5/5/2022
Soil moisture	adequate
Soil temperature at 2 inch (F)	45
pH	5.5
OM (%)	3.6
CEC (meq/100g)	16.2
Texture	silty clay loam

No treatment visibly injured chickpea (data not shown). Italian ryegrass control was poor but similar at 52 DAT ranging from 34 to 64% (Table 2). By 82 DAT, a rate response was visible but control was unacceptable (8 to 28%).

Table 2. Italian ryegrass control in chickpea with pronamide in 2022.

		Italian ryegrass control	
Treatment	Rate	52 DAT	82 DAT
	lb ai/A	%	%
Pronamide	0.129	34	8
Pronamide	0.258	41	15
Pronamide	0.387	64	20
Pronamide	0.516	50	28
LSD (0.05)		NS	11
Density (plants/ft^2)		3	

Residual herbicides as single and sequential treatments for efficacy in corn. Patrick W. Geier and Randall S. Currie. (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment compared residual herbicides applied preemergence or as split applications for season-long weed control in corn. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application dates, environmental, and plant information is given in Table 1. Plots size was 10 by 35 feet, and the study was arranged as a randomized complete block replicated four times. Soil was a Beeler silt loam containing 2.4% organic matter, pH of 7.5, and CEC of 17.8. Visual weed control ratings were taken June 3 and July 27, 2022. These dates were 16 and 70 days after the postemergence treatments (DA-B), respectively.

Table 1. Application, environmental, and plant information for the residual and sequential herbicides in corn.

Application timing	Preemergence	Postemergence
Application date	April 28, 2022	May 18, 2022
Air Temperature (F)	65	67
Relative humidity (%)	78	57
Soil temperature (F)	56	64
Wind speed (mph)	3 to 6	0 to 3
Wind direction	Southwest	North
Soil moisture	Good	Good
Corn		
Height (inches)	---	3 to 5
Leaves (no.)	0	1 to 2
Kochia		
Height (inches)	---	1 to 3
Density (plants/ft^2)	0	0.2
Russian-thistle		
Height (inches)	---	1 to 4
Density (plants/ft^2)	0	0.2
Palmer amaranth		
Height (inches)	---	0.5 to 1.5
Density (plants/ft^2)	0	0.2
Common lambsquarters		
Height (inches)	---	0.5 to 2
Density (plants/ft^2)	0	0.1
Green foxtail		
Height (inches)	---	1 to 2
Density (plants/ft^2)	0	0.1
Johnsongrass		
Height (inches)	---	0.5 to 1.5
Density (plants/ft^2)	0	0.2

Control of Palmer amaranth, common lambsquarters, Russian-thistle, and green foxtail was 90% or more with all treatments at 16 and 70 DA-B, and did not differ between herbicides (data not shown). Similarly, all herbicides controlled kochia 95% or more at each rating date (Table 2). Johnsongrass control early in the season was 96% or more when S-metolachlor/glyphosate/mesotrione/bicyclopyrone or S-metolachlor/atrazine/mesotrione/bicyclopyrone were applied POST or when acetochlor/clopyralid/mesotrione was applied sequentially. However, johnsongrass control did not exceed 78% with any treatment late in the season.

Table 2. Weed control and grain yield in the residual herbicide study in corn.

Treatment	Rate[1]	Timing[2]	Kochia 16 DA-B[3]	Kochia 70 DA-B	Johnsongrass 16 DA-B	Johnsongrass 70 DA-B
	lb/A		% Visual		% Visual	
S-metolachlor/ Atrazine/ Mesotrione	2.48	PRE	99	98	93	58
Atrazine	0.5	PRE				
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.58	PRE	100	100	91	63
Atrazine	0.5	PRE				
S-metolachlor/ Atrazine/ Mesotrione	1.24	PRE	100	100	100	78
Atrazine	0.5	PRE				
S-metolachlor/ Glyphosate/ Mesotrione/ Bicyclopyrone	2.02	POST				
Atrazine	0.5	POST				
Nonionic surfactant	0.5%	POST				
Ammonium sulfate	2.0%	POST				
Atrazine/ S-metolachlor	2.25	PRE	100	100	100	73
S-metolachlor/ Glyphosate/ Mesotrione/ Bicyclopyrone	2.02	POST				
Atrazine	0.5	POST				
Nonionic surfactant	0.5%	POST				
Ammonium sulfate	2.0%	POST				
S-metolachlor/ Atrazine/ Mesotrione	2.06	PRE	100	99	100	75
Atrazine	0.5	PRE				
S-metolachlor/ Glyphosate/ Mesotrione/ Bicyclopyrone	2.02	POST				
Atrazine	0.5	POST				
Nonionic surfactant	0.5%	POST				
Ammonium sulfate	2.0%	POST				

S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.29	PRE	100	100	99	75
Atrazine	0.38	PRE				
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.29	POST				
Atrazine	0.38	POST				
Glyphosate	0.95	POST				
Ammonium sulfate	2.0%	POST				
Acetochlor/ Clopyralid/ Mesotrione	1.23	PRE	100	100	96	48
Acetochlor/ Clopyralid/ Mesotrione	1.23	POST				
Glyphosate	0.95	POST				
Ammonium sulfate	2.0%	POST				
Dimethenamid/ Saflufenacil	0.61	PRE	96	95	91	45
Dicamba/ Diflufenzopyr	0.175	POST				
Glyphosate	0.95	POST				
Nonionic surfactant	0.5%	POST				
Ammonium sulfate	2.0%	POST				
Acetochlor/ Atrazine	3.22	PRE	100	100	91	40
Dicamba/ Tembotrione	0.4	POST				
Glyphosate	0.95	POST				
Crop oil concentrate	1.0%	POST				
Urea ammonium nitrate	2.0%	POST				
LSD (0.05)			2	NS	5	9

[1] Herbicides rates are in pounds active ingredient except for glyphosate, which is in acid equivalent.
[2] PRE is preemergence; POST is postemergence.
[3] DA-B is days after the postemergence treatment.

Efficacy of topramezone mixtures and timings in field corn. Patrick W. Geier and Randall S. Currie. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate topramezone mixtures and application timings for efficacy in corn. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application information and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block with four replications. Soil was a Beeler silt loam with a pH of 7.9, 2.4% organic matter, and CEC of 17.8. Visual weed control ratings were taken on June 15 and July 20, 2022. These dates were 7 and 42 days after the late postemergence treatment (DA-D), respectively.

Table 1. Application, environmental, and weed data for the topramezone study in corn.

Application Timing	Preemergence	Early postemergence	Postemergence	Late postemergence
Application date	April 25, 2022	May 22, 2022	June 2, 2022	June 8, 2022
Air temperature (F)	58	55	60	78
Relative humidity (%)	30	44	58	44
Soil temperature (F)	53	55	57	74
Wind speed (mph)	4 to 8	3 to 9	0 to 2	5 to 8
Wind direction	NNE	SSE	South	NNW
Soil moisture	Good	Good	Good	Good
Corn				
Height (inches)	---	3 to 5	8 to 10	12 to 15
Leaves (no.)	0	2 to 3	3 to 4	5 to 6
Kochia				
Height (inches)	---	1 to 3	2 to 5	6 to 10
Density (plants/ft^2)	0	1.5	2.5	1.5
Russian-thistle				
Height (inches)	---	1 to 2	3 to 5	5 to 10
Density (plants/ft^2)	0	0.3	0.5	0.1
Palmer amaranth				
Height (inches)	---	1 to 2	---	---
Density (plants/ft^2)	0	0.2	0	0
Common lambsquarters				
Height (inches)	---	---	---	2 to 4
Density (plants/ft^2)	0	0	0	0.2
Green foxtail				
Height (inches)	---	1 to 2	2 to 3	3 to 5
Density (plants/ft^2)	0	0.2	0.2	0.2
Johnsongrass				
Height (inches)	---	---	1 to 3	2 to 6
Density (plants/ft^2)	0	0	1.0	2.5

All herbicides controlled Palmer amaranth and common lambsquarters 95% or more throughout the season (data not shown). Similarly, green foxtail control was excellent with all herbicides except when metolachlor preemergence (PRE) was followed by topramezone alone late postemergence (LPOST) at 7 DA-D. Kochia and Russian-thistle were controlled 90% or more with most treatments throughout the season (Table 2). However, metolachlor PRE followed by topramezone LPOST controlled these weeds 70 to 84%. All early postemergence (EPOST) and postemergence (POST) herbicides controlled johnsongrass 89 to 98% early in the season. However, control decreased to less than 91% by 42 DA-D.

Table 2. Weed control in the topramezone mixtures study.

Treatment[1]	Rate[2]	Timing[3]	Kochia 7 DA-D[4]	Kochia 42 DA-D	Russian-thistle 7 DA-D	Russian-thistle 42 DA-D	Johnsongrass 7 DA-D	Johnsongrass 42 DA-D
	lb/A		% Visual					
Acetochlor/ Topramezone	1.68	EPOST	95	91	100	100	89	80
Atrazine	1.5	EPOST						
MSO	0.5%	EPOST						
AMS	2.5	EPOST						
Acetochlor/ Topramezone	1.12	EPOST	98	93	100	98	94	85
Topramezone	0.011	EPOST						
Atrazine	1.5	EPOST						
MSO	1.0%	EPOST						
AMS	2.5	EPOST						
Acetochlor/ Topramezone	1.12	EPOST	96	90	100	100	93	83
Atrazine	1.5	EPOST						
Glyphosate	1.0	EPOST						
MSO	0.5%	EPOST						
AMS	2.5	EPOST						
Acetochlor/ Topramezone	1.68	EPOST	96	90	99	98	94	90
Clopyralid/ Flumetsulam	0.128	EPOST						
Glyphosate	1.0	EPOST						
MSO	0.5%	EPOST						
AMS	2.5	EPOST						
Topramezone/ Glufosinate	0.56	EPOST	98	95	100	99	94	86
Atrazine	1.5	EPOST						
Metolachlor	1.27	EPOST						
MSO	1.0%	EPOST						
AMS	2.5	EPOST						
Metolachlor	1.43	PRE	98	90	98	95	98	89
Acetochlor/ Topramezone	1.12	POST						
Atrazine	0.5	POST						
MSO	0.5%	POST						
AMS	2.5	POST						
Metolachlor	1.43	PRE	99	94	100	100	91	85
Topramezone	0.022	POST						
Atrazine	0.5	POST						
MSO	1.0%	POST						
AMS	2.5	POST						
Metolachlor	1.43	PRE	97	95	100	99	89	76
Topramezone/ Glufosinate	0.48	POST						
Atrazine	0.5	POST						
MSO	1.0%	POST						
AMS	3.0	POST						

Metolachlor	1.43	PRE	70	80	70	84	70	70
Topramezone	0.033	LPOST						
MSO	1.0%	LPOST						
AMS	3.0	LPOST						
LSD (0.05)			7	7	2	6	6	12

[1] MSO is methylated seed oil, AMS is ammonium sulfate.
[2] Glyphosate rate is in lb ae/A.
[3] EPOST is early postemergence, PRE is preemergence, POST is postemergence, and LPOST is late postemergence.
[4] DA-D is days after the late postemergence applications.

Tiafenacil and pyraflufen with tank mixtures for fallow weed control. Patrick W. Geier and Randall S. Currie (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment compared tiafenacil and pyraflufen, each tank mixed with glyphosate and/or 2,4-D, for kochia control in fallow. All herbicides were applied using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi (Table 1). Soil was a Beeler silt loam with 2.2% organic matter and pH of 7.9. Plots were 10 by 30 feet and arranged in a randomized complete block replicated four times. Visual weed control was determined on May 5, May 12, May 20, and May 26, 2022. These dates were 7, 14, 22, and 28 days after treatment (DAT), respectively.

Table 1. Application, environmental, and plant information for the residual fallow experiment.

Application timing	Early postemergence
Application date	April 28, 2022
Air Temperature (F)	72
Relative humidity (%)	65
Soil temperature (F)	60
Wind speed (mph)	7 to 10
Wind direction	Southwest
Soil moisture	Dry
Kochia	
Height (inches)	0.5 to 1.5
Density (plants/ft^2)	10

Glyphosate alone provided no kochia control at any rating date (Table 2). The addition of pyraflufen increased kochia control 38 to 58% compared to glyphosate alone, whereas tiafenacil increased control 54 to 89%. Generally, tiafenacil was more effective on kochia than pyraflufen regardless of tank mix partner. However, no treatment provided as much as 90% kochia control, and control began to decline after 22 DAT.

Table 2. Kochia control with tiafenacil and pyraflufen in fallow.

Treatment	Rate	7 DAT[1]	14 DAT	22 DAT	28 DAT
	lb ai/A	% Visual			
Pyraflufen Glyphosate Ammonium sulfate	0.00325 1.03 2.0%	38	48	58	50
Glyphosate Ammonium sulfate	1.03 2.0%	0	0	0	0
Pyraflufen 2,4-D amine Crop oil concentrate Ammonium sulfate	0.00325 0.5 1.0% 2.0%	53	58	73	63
Pyraflufen Glyphosate 2,4-D amine Ammonium sulfate	0.00325 1.03 0.5 2.0%	50	70	80	68
Tiafenacil Crop oil concentrate Ammonium sulfate	0.0442 1.0% 2.0%	65	75	84	79
Tiafenacil 2,4-D amine Crop oil concentrate Ammonium sulfate	0.0221 0.5 1.0% 2.0%	70	78	85	75
Tiafenacil Glyphosate Crop oil concentrate Ammonium sulfate	0.0221 1.03 1.0% 2.0%	73	79	89	86
Tiafenacil Glyphosate 2,4-D amine Ammonium sulfate	0.0221 1.03 0.5 2.0%	63	75	84	78
LSD (0.05)		9	7	8	9

[1] DAT is days after treatment.

<u>Isoxaflutole and flumioxazin preemergence for fallow weed control.</u> Patrick W. Geier and Randall S. Currie (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment compared residual herbicides applied preemergence either alone or as tank mix partners for weed control in fallow. All herbicides were applied on May 10, 2022 using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi (Table 1). The experimental site was weed-free at the time of application. Three days after application, 1.1 inches of sprinkler irrigation was applied to promote weed germination and activate the herbicides. Soil was a Ulysses silt loam with 2.7% organic matter and pH of 7.9. Plots were 10 by 30 feet and arranged in a randomized complete block replicated four times. Visual weed control was determined on May 20, June 6, and June 29, 2022. These dates were 10, 24, and 50 days after treatment (DAT), respectively.

Table 1. Application, environmental, and plant information for the residual fallow experiment.

Application timing	Preemergence
Application date	May 10, 2022
Air Temperature (F)	83
Relative humidity (%)	29
Soil temperature (F)	68
Wind speed (mph)	2 to 5
Wind direction	West-northwest
Soil moisture	Dry

Kochia control at 10 DAT was 98% or more with all herbicides except dicamba or 2,4-D alone (Table 2). Flumioxazin alone, isoxaflutole alone, and isoxaflutole with dicamba, 2,4-D, or flumioxazin controlled kochia 90 to 98% at 24 DAT. However, only the treatments containing isoxaflutole provided 90% kochia control by 50 DAT. Flumioxazin alone or with isoxaflutole, 2,4-D or dicamba controlled Russian-thistle 90 to 98% at 10 DAT. Russian-thistle control declined with all herbicides by 50 DAT. Consequently, only isoxaflutole alone or with 2,4-D or flumioxazin provided as much as 78% Russian-thistle control late in the season.

Table 2. Preemergence weed control in the residual fallow study.

Treatment	Rate	Kochia			Russian-thistle		
		10 DAT[1]	24 DAT	50 DAT	10 DAT	24 DAT	50 DAT
	lb ai/A	% Visual			% Visual		
Isoxaflutole	0.094	100	98	93	88	85	78
Dicamba	0.5	68	48	20	73	50	18
2,4-D amine	0.75	50	5	0	53	5	0
Flumioxazin	0.064	100	90	78	98	85	63
Isoxaflutole Dicamba	0.094 0.5	100	96	91	83	88	74
Isoxaflutole 2,4-D amine	0.094 0.75	100	96	90	88	90	80
Isoxaflutole Flumioxazin	0.094 0.064	100	98	94	95	93	86
2,4-D amine Flumioxazin	0.75 0.064	98	88	80	93	87	75
Saflufenacil Dicamba	0.045 0.5	98	79	43	90	75	40
LSD (0.05)		7	8	8	10	9	10

[1] DAT is days after treatment.

Industrial weed control with indaziflam/aminocyclopyrachlor/imazapyr. Patrick W. Geier and Randall S. Currie. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate persistent, nonselective herbicides at three application timings and three rates for season-long weed control in an industrial setting. Herbicides were applied using either standard flat-fan nozzles or a boomless nozzle. A tractor-mounted, compressed-CO_2 sprayer delivering 25 gpa was used to apply all herbicides. Pressure and ground speed for the flat-fan nozzles was 30 psi and 4.1 mph, whereas 60 psi and 3.0 mph were used for the boomless nozzle applications. Application and environmental conditions are shown in Table 1. Plots size was 10 by 35 feet and arranged in a randomized complete block with four replications. Soil was a Ulysses silt loam with 2.7% organic matter, pH of 7.9, and CEC of 28.4. Visual weed control was determined on May 5, July 5, and October 3, 2022. These dates were 1, 3, and 6 months after the spring applications (MA-C), respectively.

Table 1. Application, environmental, and weed data for the industrial weed control study.

Application Timing	Fall	Winter	Spring
Application date	November 15, 2021	February 18, 2022	April 4, 2022
Air temperature (F)	81	58	65
Relative humidity (%)	14	23	20
Soil temperature (F)	53	42	55
Wind speed (mph)	3 to 8	3 to 6	5 to 9
Wind direction	North	Northwest	South-southeast
Soil moisture	Dry	Fair	Dry
Kochia			
Height (inches)	---	---	0.5
Density (plants/ft^2)	0	0	10

Kochia control was 98% or more with all treatments except indaziflam/aminocyclopyrachlor/imazapyr at 0.54 lb/A applied in the fall using a boomless nozzle at 1 MA-C, or any rate of indaziflam/aminocyclopyrachlor/imazapyr applied in the spring using a boomless nozzle (Table 2). These treatments also controlled kochia less than 90% at 3 MA-C. By 6 MA-C, kochia control was best when indaziflam/aminocyclopyrachlor/imazapyr at 0.8 or 1.07 lb/A was applied using flat fan nozzles regardless of application timing. Similar kochia control at 6 MA-C with the boomless nozzle only occurred when indaziflam/aminocyclopyrachlor/imazapyr was applied at 1.07 lb/A in the fall or winter (80 to 83%). These results indicate that higher use rates and earlier application times are needed when using boomless nozzles compared to traditional sprayers.

Table 2. Kochia control in the industrial weed control study.

Treatment	Rate[1]	Timing	Nozzle[2]	1 MA-C[3]	3 MA-C	6 MA-C
	lb/A			% Visual		
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Fall	Flat Fan	100	91	70
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Fall	Flat Fan	98	96	88
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Fall	Flat Fan	100	95	88
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Fall	Boomless	93	81	68
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Fall	Boomless	100	91	79
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Fall	Boomless	100	93	80
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Winter	Flat Fan	100	94	78
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Winter	Flat Fan	99	98	89
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Winter	Flat Fan	100	98	91
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Winter	Boomless	99	91	70
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Winter	Boomless	100	93	79
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Winter	Boomless	100	96	83
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Spring	Flat Fan	99	93	74
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Spring	Flat Fan	100	96	83
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Spring	Flat Fan	100	97	90
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.54 1.86 0.25%	Spring	Boomless	76	79	65

Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	0.8 1.86 0.25%	Spring	Boomless	81	83	73
Indaziflam/aminocyclopyrachlor/imazapyr Glyphosate Nonionic surfactant	1.07 1.86 0.25%	Spring	Boomless	79	80	74
LSD (0.05)				5	7	14

[1] Indaziflam/aminocyclopyrachlor/imazapyr rate is pounds ai/A, glyphosate rate is pounds ae/A.
[2] Flat fan nozzles were six TeeJet TT11003, boomless nozzle was a single TeeJet OC-12.
[3] MA-C is months after the spring applications.

Winter wheat yield following fall and spring applications of picloram for control of rush skeletonweed in fallow with precision and broadcast sprayers. Mark Thorne, Marija Savic, and Drew Lyon (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164) Precision sprayer (WEED-IT, Hoge Wesselink 8, 7221 CJ Steenderen, The Netherlands) and standard broadcast applications of picloram in fall and spring were compared for control of rush skeletonweed (*Chondrilla juncea*) in a winter wheat/no-till fallow system. Precision sprayers can be effective at spot spraying weeds in fallow, thus reducing chemical inputs compared to a complete coverage broadcast application. Picloram is an effective herbicide for controlling rush skeletonweed and is labeled for fallow applications at 0.25 lb ae/A. However, picloram applied in fallow at high rates or too close to planting can result in subsequent crop injury.

The fall-applied trial was initiated in October 2020 near LaCrosse, WA, and the spring-applied trials were initiated at field sites near Hay and LaCrosse, WA in May 2021. All three trial sites were in winter wheat stubble undisturbed from the 2020 wheat crop and managed in a winter wheat/no-till fallow cropping system at the time of application. Picloram was applied at 0.125, 0.25, and 0.5 lb/A with both the broadcast applicator and the precision sprayer if set to spray in continuous mode. The broadcast application spray volume was 15 gpa at 3 mph. The spray volume of the precision sprayer, in continuous spray mode, was 29.4 gpa at 5 mph; however, the total output per plot in spot-spray mode depended on the density of rush skeletonweed; therefore, the volume sprayed in each plot was measured to determine the area sprayed per plot to calculate the amount of picloram applied. All plots measured 10 by 35 ft, but the precision sprayer only covered a width of 6.7 ft through the center of each plot. Winter wheat was planted in October 2021 at each location, 12 and 5 months following the fall and spring applications. Herbicide injury was assessed in June 2022 as plants were fully tillered and in the jointing stage. Plots were harvested in late July and early August using a Wintersteiger plot combine cutting a 5-ft swath through the center of each plot. Grain samples were bagged in the field and returned to the Palouse Conservation Field Station, Pullman, WA for cleaning and weighing. Test weights were measured with a DICKEY-john® mini GAC® Plus grain moisture analyzer.

Table 1. Application and soil data.

Location	LaCrosse, WA		Hay, WA
Application date	October 15, 2020	May 19, 2021	May 19, 2021
Rush skeletonweed growth stage	post-flowering stems and rosettes	rosettes and bolting stems	rosettes and bolting stems
Crop phase	no-till fallow	no-till fallow	no-till fallow
Air temperature (°F)	47	56	52
Relative humidity (%)	50	33	39
Wind (mph, direction)	0-2, SW	3, SW	3-6, SW
Cloud cover (%)	100	100	100
Soil temperature at 2 inches (°F)	51	60	60
Soil texture	Walla Walla silt loam		
Soil organic matter 0-6 inches (%)	2.1		2.4
Soil pH	5.9		5.9

The precision sprayer consistently applied lower amounts of product compared with the broadcast application method (Table 2). The precision sprayer applications in the fall ranged between 24 and 32% of the full picloram broadcast rate per acre. The spring precision sprayer applications ranged between 5 and 20% of the full broadcast rates; however, the reduced coverage rates also reflected the rush skeletonweed density at the time of application, which was lower in spring than in the fall (data not shown). None of the precision sprayer applications exceeded the maximum labeled picloram rate of 0.25 lb ae/A.

Wheat yields in 2022 were exceptionally high as rainfall in the region was above average. Rainfall recorded near LaCrosse, WA, with a long-term average of 14.3" annually, totaled 15.3" during the period October 1, 2021, through July 31, 2022 (WSU AgWeatherNet). At all three sites, the highest-yielding treatments yielded over 100 bu/A. Yields for the fall picloram applications were highest for the broadcast picloram treatments of 0.125 and 0.25 lb ae/A and the precision sprayer treatments of 0.25 and 0.5 lb ae/A, which yielded between 101 and 103 bu/A (Table 3). Yields were slightly lower for the two fall nontreated checks suggesting some yield loss from rush skeletonweed competition. At the 0.5 lb ae/A picloram rate, yield associated with the broadcast application was slightly lower compared with the precision application suggesting potential yield loss resulting from herbicide injury; however, none of the treatments showed any crop injury symptoms during the boot or heading stages.

In contrast, picloram applications substantially reduced winter wheat yield in both spring-applied trials, particularly from the broadcast applications (Table 3). Winter wheat injury symptoms, including stunting and twisted leaves, were observed with each broadcast rate at both locations and increased in severity with each increase in rate of picloram applied. At LaCrosse, WA, wheat yields were highest for both nontreated checks and all precision application treatments yielding 99 to 107 bu/A. Wheat yields associated with each broadcast rate were lower than their corresponding precision application rate with the 0.5 lb ae/A picloram rate yielding the lowest overall at 36 bu/A. At the Hay, WA site, herbicide injury was not observed with the 0.125 lb ae/A broadcast rate, but the 0.5 lb ae/A precision application rate did result in 3% injury compared with the nontreated check. All broadcast rates resulted in lower yields compared with their respective precision application rate with the 0.5 lb ae/A rate yielding only 8 bu/A. However, the precision application rates of 0.25 and 0.5 lb ae/A also resulted in yields less than the nontreated checks.

Picloram applied up to the maximum labeled rate of 0.25 lb ae/A does not appear to reduce yield when applied to rush skeletonweed-infested fallow in the fall of the fallow year with either application method; however, the precision application method substantially reduces the total amount of herbicide applied. Fall applications in a wheat/fallow system allow an 11 to 12-mo interval between spraying and planting, which appears to be an adequate period for herbicide breakdown in this region. Waiting to apply picloram in the following spring shortens the preplant intervals and appears to increase crop injury risk. The labeled planting interval for Washington state is 90 days and this may not be adequate in some situations. For example, the 2020-21 fallow period coincided with one of the top-ten worst drought periods on record for the region, therefore, the lack of rainfall may have increased the risk of crop injury in these trials.

Table 2. Amount of picloram applied with a precision sprayer compared with a standard broadcast application.

Amount of picloram applied		
Broadcast	Precision sprayer	Percent of the broadcast rate applied by the precision sprayer
lb ae/A	lb ae/A	%
	Fall 2020 applied	
0.125	0.04	32
0.25	0.06	24
0.5	0.15	30
	Spring 2021 applied – LaCrosse, WA	
0.125	0.01	11
0.25	0.03	12
0.5	0.03	5
	Spring 2021 applied – Hay, WA	
0.125	0.02	16
0.25	0.05	20
0.5	0.06	12

Table 3. Winter wheat yield in response to picloram applications with a precision sprayer and broadcast sprayer for control of rush skeletonweed in no-till summer fallow.

		Crop injury	Winter harvest in 2022**	
Application method*	Rate	visual rating	Yield	Test weight
	lb ae/A	%	bu/A	lb/bu
fall-applied 2020 – LaCrosse, WA				
nontreated check – 1	0	0 a	91 c	60 d
nontreated check - 2	0	0 a	94 bc	61 cd
precision sprayer	0.125	0 a	94 bc	61 cd
broadcast	0.125	0 a	101 ab	61 bc
precision sprayer	0.25	0 a	102 a	61 bc
broadcast	0.25	0 a	102 a	62 a
precision sprayer	0.5	0 a	103 a	61 cd
broadcast	0.5	0 a	95 bc	61 ab
spring-applied 2021 – LaCrosse, WA				
nontreated check – 1	0	0 d	100 ab	60 d
nontreated check - 2	0	0 d	99 ab	60 cd
precision sprayer	0.125	0 d	105 a	61 cd
broadcast	0.125	7 c	95 b	62 ab
precision sprayer	0.25	0 d	107 a	61 bc
broadcast	0.25	40 b	78 c	62 a
precision sprayer	0.5	0 d	104 a	60 cd
broadcast	0.5	70 a	36 d	61 bc
spring-applied 2021 – Hay,WA				
nontreated check – 1	0	0 d	100 a	62 a
nontreated check - 2	0	0 d	100 ab	62 a
precision sprayer	0.125	0 d	96 abc	63 a
broadcast	0.125	0 d	71 d	63 a
precision sprayer	0.25	0 d	94 bc	63 a
broadcast	0.25	16 b	25 e	58 b
precision sprayer	0.5	3 c	91 c	62 a
broadcast	0.5	68 a	8 f	47 c

*Nontreated checks 1 and 2 are in relation to the precision and broadcast applications, respectively.
**Means are based on four replicates per treatment. Means within a column for each location followed by the same letter are not significantly different (α=0.05).

Control of smooth scouringrush with glyphosate and chlorsulfuron/metsulfuron in wheat/fallow cropping systems. Mark Thorne, Marija Savic, and Drew Lyon (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164) Smooth scouringrush (*Equisetum laevigatum*) control in wheat/fallow rotations in eastern Washington has been difficult because of limited effective herbicide options. Different studies have shown that applications of chlorsulfuron/metsulfuron in fallow can have activity on smooth scouringrush for at least two years after application; however, tank mixing glyphosate with chlorsulfuron/metsulfuron in fallow-year applications may increase control of smooth scouringrush into the following crop year and beyond. Glyphosate has been effective when applied at a high rate and with an organosilicone surfactant. In contrast, chlorsulfuron/metsulfuron is effective for at least two years after application, but when applied alone, does not control some other weeds that might be present in the fallow. This ongoing study examines the effect of chlorsulfuron/metsulfuron and glyphosate applied alone or in combination at different glyphosate rates multiple years after fallow application.

Table 1. Application and soil data.

Location	Dayton, WA	Steptoe, WA	Reardan, WA
Application date	July 6, 2020	July 6, 2020	July 9, 2021
Smooth scouringrush growth stage	stems with strobili	stems with strobili	stems with strobili
Crop phase	no-till fallow	no-till fallow	no-till fallow
Air temperature (°F)	75	79	76
Relative humidity (%)	35	36	36
Wind (mph, direction)	2-4, SW	1, SW	3-4,
Cloud cover (%)	0	0	0
Soil temperature at 2 inches (°F)	67	90	72
Soil texture	Walla Walla silt loam	Covello silt loam	Athena silt loam
Soil organic matter 0-6 inches (%)	2.1	2.9	2.4
Soil pH	5.4	5.8	4.9

Long-term trials were initiated near Dayton, WA and Steptoe, WA in 2020, and Reardan, WA in 2021 (Table 1). The Dayton site is on a 30-40% northwest-facing slope while the Steptoe site is on a low-lying flat that is sometimes inundated with water during winter or early spring. The Reardan site is on a gentle NW-facing slope midway between a draw bottom and the ridgetop. All plots measure 10 by 30 ft and are arranged in a randomized complete block design with four replications per treatment. All treatments in 2020 were applied with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 25 psi. The 2021 applications near Reardan were applied with TeeJet® AIXR110015 nozzles at 40 psi. Spray output for all treatments was 15 gpa at 3 mph, and all treatments included an organosilicone surfactant. Smooth scouringrush initial density in 2020 averaged 326 and 279 stems/yd^2 at the Dayton and Steptoe sites, respectively, and 247 stems/yd^2 in 2021 at Reardan (Table 2). The Reardan site was seeded to winter wheat in October 2021. In 2022, the Dayton site was in spring peas, the Steptoe site was in spring wheat, and the Reardan site was in winter wheat at the time of counting.

Stem density at all three sites was greatest in the nontreated checks but reduced from the respective initial density, which occurred during a fallow year at each location (Table 2). It has been observed that smooth scouringrush density is greatest in a fallow year compared with when the field is growing a crop, especially a winter wheat crop. Furthermore, the Steptoe site was plowed following the 2021 winter wheat crop, which appeared to have slowed smooth scouringrush stem emergence the following year. Glyphosate alone at 1.13 lb ae/A reduced density, compared with the nontreated check, 32, 89, and 30% at Dayton, Steptoe, and Reardan, respectively. At Dayton, stem density 2 years after treatment (YAT) with glyphosate alone at 2.25 lb ae/A was not different from the 1.13 lb ae/A rate but was also not different from the 3.38 lb ae/A rate, suggesting the highest glyphosate rate added no benefit compared with the 2.25 lb ae/A rate. This was also the outcome at Steptoe and Reardan as stem density 2 YAT at Steptoe and 1 YAT at Reardan was not different between the 2.25 and 3.38 lb ae/A glyphosate rates. The chlorsulfuron/metsulfuron treatments at all three sites were consistently effective in reducing stem density; however, at Steptoe and Reardan, stem densities were not different from zero for all treatments other than the nontreated check and the 1.13 lb ae/A glyphosate alone rate. At Dayton, treatments with chlorsulfuron/metsulfuron resulted in lower stem densities compared with treatments with only glyphosate. In previous research, we have found the effectiveness of glyphosate alone is dependent on the addition of an organosilicone surfactant, and that is likely why glyphosate alone in these trials resulted in reduced stem density compared with the nontreated check, and not different from treatments with chlorsulfuron/metsulfuron. Chlorsulfuron/metsulfuron has also been found to be very effective in controlling smooth scouringrush. It is not yet evident in these trials that tank mixing glyphosate with chlorsulfuron/metsulfuron increases long-term control of smooth scouringrush; however, adding glyphosate would be beneficial if other weeds are present that would not be controlled by chlorsulfuron/metsulfuron alone. All three trials will be reevaluated in 2023.

Table 2. Smooth scouringrush density following application in fallow of glyphosate and chlorsulfuron/metsulfuron at Dayton, Steptoe, and Reardan, WA.

		Smooth scouringrush density at each location in relation to the number of years after treatment (YAT)		
Treatments	Rates*	Dayton 2 YAT	Steptoe 2 YAT	Reardan 1 YAT
	lb ae/A + lb ai/A	stems/yd^2**		
nontreated check	none	151 a	28 a	81 a
glyphosate	1.13	102 b	3 b	57 b
chlorsulfuron/metsulfuron	0.02/0.004	7 d	0 c	0 c
glyphosate + chlorsulfuron/metsulfuron	1.13 + 0.02/0.004	1 d	0 c	1 c
glyphosate	2.25	80 bc	0 c	21 c
glyphosate + chlorsulfuron/metsulfuron	2.25 + 0.02/0.004	0 d	0 c	0 c
glyphosate	3.38	57 c	0 c	9 c
glyphosate + chlorsulfuron/metsulfuron	3.38 + 0.02/0.004	3 d	0 c	0 c
Initial stem density at the time of application		326	279	247

*All herbicide treatments included an organosilicone surfactant at 0.5% v/v.
**Means, based on four replicates per treatment, within a column for each location followed by the same letter are not different (α=0.05).

Weed control with imazamox rates and timings in imidazolinone-tolerant forage sorghum. Patrick W. Geier and Randall S. Currie (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment compared imazamox at two rates, two timings, and with several tank mix partners for efficacy and tolerance in imidazolinone-tolerant forage sorghum. All herbicides were applied with a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application information is given in Table 1. Treatments were arranged in a randomized complete block design with four replications. Plot size was 10 by 35 feet. Soil was a Beeler silt loam with 2.4% organic matter, pH of 7.5, and CEC of 17.8. Weed control and sorghum injury were assessed visually on June 29 and July 26, 2022. These dates were 2 and 29 days after the postemergence treatments (DA-B), respectively.

Table 1. Application, environmental, and plant information for the imidazolinone-tolerant forage sorghum trial.

Application timing	Preemergence	Postemergence
Application date	June 10, 2022	June 27, 2022
Air Temperature (F)	76	70
Relative humidity (%)	86	35
Soil temperature (F)	67	69
Wind speed (mph)	3 to 7	7 to 11
Wind direction	North	South-southwest
Soil moisture	Good	Good
Forage sorghum		
Height (inches)	---	5 to 7
Leaves (no.)	0	4 to 5
Volunteer corn		
Height (inches)	---	6 to 8
Density (plants/ft^2)	0	0.2
Johnsongrass		
Height (inches)	---	2 to 4
Density (plants/ft^2)	0	0.2
Palmer amaranth		
Height (inches)	---	1 to 2
Density (plants/ft^2)	0	0.1
Crabgrass		
Height (inches)	---	0.5 to 1
Density (plants/ft^2)	0	0.1

All herbicides controlled Palmer amaranth and crabgrass 90% or more throughout the season (data not shown). Preemergence applications of imazamox provided less than 50% volunteer corn control early in the season (Table 2). However, corn control at 29 DA-B was 90% or more with all imazamox treatments except when imazamox plus S-metolachlor PRE was followed by atrazine POST. Johnsongrass control at 2 DA-B was best when imazamox was applied PRE (73 to 80%). By 29 DA-B, imazamox at any timing, controlled johnsongrass 90% or more. Postemergence treatments containing dicamba caused 18% sorghum injury early on, but no visible injury was detected at 29 DA-B (data not shown).

Table 2. Weed control in the imidazolinone-tolerant forage sorghum study.

Treatment[1]	Rate	Timing[2]	Volunteer corn		Johnsongrass	
			2 DA-B[3]	29 DA-B	2 DA-B	29 DA-B
	lb ai/A		% Visual		% Visual	
S-metolachlor	1.27	PRE	0	0	60	0
Atrazine	1.2	POST				
COC	1.0%	POST				
S-metolachlor	1.27	PRE	38	85	73	93
Imazamox	0.07	PRE				
Atrazine	1.2	POST				
COC	1.0%	POST				
S-metolachlor	1.27	PRE	0	96	65	98
Imazamox	0.047	POST				
Atrazine	1.2	POST				
COC	1.0%	POST				
UAN	2.5%	POST				
S-metolachlor	1.27	PRE	45	90	80	93
Atrazine	1.0	PRE				
Imazamox	0.07	PRE				
Atrazine	1.0	POST				
COC	1.0%	POST				
UAN	2.5%	POST				
S-metolachlor	1.27	PRE	0	94	65	94
Atrazine	1.0	PRE				
Imazamox	0.047	POST				
Atrazine	1.0	POST				
COC	1.0%	POST				
UAN	2.5%	POST				
S-metolachlor	1.27	PRE	33	90	78	90
Imazamox	0.07	PRE				
Dicamba	0.188	POST				
Atrazine	1.2	POST				
NIS	0.25%	POST				
UAN	2.5%	POST				
S-metolachlor	1.27	PRE	0	95	60	98
Atrazine	1.2	PRE				
Imazamox	0.047	POST				
Dicamba	0.188	POST				
NIS	0.25%	POST				
UAN	2.5%	POST				
LSD (0.05)			8	8	10	8

[1] COC is crop oil concentrate, UAN is 28% urea-ammonium nitrate, NIS is nonionic surfactant.
[2] PRE is preemergence, POST is postemergence.
[3] DA-B is days after the postemergence treatment.

Efficacy and crop response with quizalofop in ACCase-tolerant grain sorghum. Patrick W. Geier and Randall S. Currie (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment evaluated quizalofop applied late postemergence for weed control and crop response in acetyl-CoA carboxylase (ACCase)-tolerant grain sorghum. Various broadleaf herbicides were applied early postemergence to minimize competition from broadleaf weeds. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application information is given in Table 1. Plots, which were 10 by 35 feet, were arranged in a randomized complete block and replicated four times. Soil was a Beeler silt loam with 2.4% organic matter, pH of 7.5, and CEC of 17.8. Visual weed control was assessed on July 13 and September 1, 2022. These dates were 8 and 58 days after the late postemergence (DA-C) treatments, respectively. Crop injury was visually rated on July 13 and 27, 2022, which was 8 and 22 DA-C. Sorghum yields were determined October 31, 2022 by mechanically harvesting the center two rows of each plot and adjusting grain moisture to 14.0%.

Table 1. Application, environmental, and plant information for the quizalofop study in grain sorghum

Application timing	Preemergence	Early postemergence	Late postemergence
Application date	June 10, 2022	June 28, 2022	July 5, 2022
Air Temperature (F)	64	72	74
Relative humidity (%)	100	59	61
Soil temperature (F)	66	65	73
Wind speed (mph)	2 to 4	5 to 9	1 to 5
Wind direction	North	South-southwest	South
Soil moisture	Good	Good	Good
Grain sorghum			
Height (inches)	---	6 to 8	10 to 14
Leaves (no.)	0	4 to 5	5 to 6
Volunteer corn			
Height (inches)	---	6 to 9	8 to 12
Density (plants/ft^2)	0	0.2	0.2
Johnsongrass			
Height (inches)	---	2 to 6	5 to 10
Density (plants/ft^2)	0	0.25	0.25
Palmer amaranth			
Height (inches)	---	2 to 3	---
Density (plants/ft^2)	0	0.01	0

Palmer amaranth control was 90% or more regardless of herbicide treatment or evaluation date (data not shown). Quizalofop applied late postemergence controlled volunteer corn and johnsongrass 73 to 80% within 8 days of application (Table 2). Corn control was 95% or more with quizalofop by 58 DA-C. Johnsongrass control was slightly lower at 58 DA-C, 86 to 91% regardless of postemergence treatment. The early postemergence treatments of dicamba and 2,4-D/bromoxynil/fluroxypyr caused 3 to 15% sorghum epinasty at 8 and 22 DA-C (Table 3). All quizalofop treatments resulted in minor leaf necrosis at 22 DA-C. However, sorghum recovered completely later in the season. Yields from sorghum receiving quizalofop late postemergence yielded 41 to 55 bu/A more grain than the nontreated control. Sorghum treated with atrazine/metolachlor alone preemergence yielded similarly to the nontreated control.

Weed control in the quizalofop ACCase sorghum trial.

Treatment	Rate	Timing[1]	Volunteer corn		Johnsongrass	
			8 DA-C[2]	58 DA-C	8 DA-C	58 DA-C
	lb ai/A		— % Visual —		— % Visual —	
Atrazine/ Metolachlor	1.38	PRE	0	0	0	0
Atrazine/ Metolachlor	1.38	PRE	75	100	75	89
Dicamba	0.25	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	78	100	78	90
Bromoxynil	0.25	EPOST				
Atrazine	1.0	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	78	100	75	89
Bromoxynil/ Pyrasulfotole	0.256	EPOST				
Atrazine	1.0	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	73	95	78	86
2,4-D/ Bromoxynil/ Fluroxypyr	0.75	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	75	100	75	88
Atrazine	1.0	EPOST				
Crop oil concentrate	1.0%	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ S-metolachlor/ Mesotrione	2.48	PRE	80	100	78	91
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
LSD (0.05)			8	4	8	9

[1] PRE is preemergence, EPOST is early postemergence, LPOST is late postemergence.
[2] DA-C is days after the late postemergence treatments.

Table 3. Crop response in the quizalofop ACCase sorghum trial.

Treatment	Rate	Timing[1]	Epinasty 8 DA-C[2]	Epinasty 22 DA-C	Necrosis 22 DA-C	Grain yield
	lb ai/A		% Visual	% Visual	% Visual	bu/A
Nontreated control	---	---	0	0	0	12.2
Atrazine/ Metolachlor	1.38	PRE	0	0	0	11.2
Atrazine/ Metolachlor	1.38	PRE	3	4	5	65.7
Dicamba	0.25	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	0	0	6	54.6
Bromoxynil	0.25	EPOST				
Atrazine	1.0	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	0	0	6	60.1
Bromoxynil/ Pyrasulfotole	0.256	EPOST				
Atrazine	1.0	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	15	13	6	57.2
2,4-D/ Bromoxynil/ Fluroxypyr	0.75	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ Metolachlor	1.38	PRE	0	0	5	52.9
Atrazine	1.0	EPOST				
Crop oil concentrate	1.0%	EPOST				
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
Atrazine/ S-metolachlor/ Mesotrione	2.48	PRE	0	0	5	67.2
Quizalofop	0.065	LPOST				
Crop oil concentrate	1.0%	LPOST				
LSD (0.05)			2	3	3	17.0

[1] PRE is preemergence, EPOST is early postemergence, LPOST is late postemergence.

[2] DA-C is days after the late postemergence treatments.

Imazamox rates, timings, and mixtures for efficacy in imidazolinone-tolerant grain sorghum. Patrick W. Geier and Randall S. Currie (Kansas State University Southwest Research-Extension Center, Garden City, KS 67846) An experiment compared imazamox at two rates, two timings, and with several tank mix partners for efficacy and tolerance in imidazolinone-tolerant grain sorghum. All herbicides were applied with a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application information is given in Table 1. Treatments were arranged in a randomized complete block design with four replications. Plots were 10 by 35 feet. Soil was a Beeler silt loam with 2.4% organic matter, pH of 7.5, and CEC of 17.8. Weed control was assessed visually on July 8 and August 18, 2022. These dates were 11 and 52 days after the postemergence treatments (DA-B). Sorghum injury was assessed on June 28 and July 8, 2022, which was 1 and 11 DA-B, respectively. Sorghum maturity was determined by visually estimating 50% pollen shed within each plot and recorded as days after planting (DAP). The center two rows of each plot were mechanically harvested on October 31, 2022 and grain weights adjusted to 14.0% to determine yields.

Table 1. Application, environmental, and plant information for the imidazolinone-tolerant grain sorghum trial.

Application timing	Preemergence	Postemergence
Application date	June 11, 2022	June 27, 2022
Air Temperature (F)	80	70
Relative humidity (%)	80	33
Soil temperature (F)	71	68
Wind speed (mph)	3 to 5	5 to 10
Wind direction	South	South-southwest
Soil moisture	Good	Good
Grain sorghum		
Height (inches)	---	5 to 8
Leaves (no.)	0	4 to 5
Volunteer corn		
Height (inches)	---	3 to 6
Density (plants/ft^2)	0	0.2
Johnsongrass		
Height (inches)	---	2 to 5
Density (plants/ft^2)	0	0.1
Palmer amaranth		
Height (inches)	---	1 to 3
Density (plants/ft^2)	0	0.1

Palmer amaranth control was essentially complete regardless of herbicide treatment throughout the season (data not shown). Imazamox applied either preemergence (PRE) or postemergence (POST) controlled volunteer corn 65 to 75% at 11 DA-B (Table 2), and the POST treatments controlled corn greater than 90% at 52 DAB. Johnsongrass control with any treatment containing imazamox was 90% or more regardless rating date, and did not differ between treatments. Treatments without imazamox did not provide any corn or johnsongrass control. Mesotrione-containing treatments caused minor sorghum chlorosis at 1 DAB, whereas dicamba-containing treatments resulted in 6 to 13% sorghum epinasty at 11 DAB (Table 3). However, sorghum injury did not persist. Sorghum receiving imazamox plus S-metolachlor PRE followed by atrazine POST or S-metolachlor plus mesotrione PRE followed by imazamox and atrazine POST matured sooner than sorghum in the nontreated control or when sorghum received S-metolachlor/mesotrione PRE followed by dicamba and atrazine POST. Yields from imazamox-treated grain sorghum were 34 to 46 bu/A greater than yields from the nontreated controls. However, sorghum receiving other herbicides yielded similarly to the check.

Table 2. Weed control in the imidazolinone-tolerant grain sorghum study.

Treatment	Rate	Timing[1]	Volunteer corn		Johnsongrass	
			11 DA-B[2]	52 DA-B	11 DA-B	52 DA-B
	lb ai/A		——— % Visual ———		——— % Visual ———	
Imazamox	0.07	PRE	73	83	100	95
S-metolachlor	1.27	PRE				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Imazamox	0.07	PRE	68	83	100	93
Mesotrione	0.188	PRE				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Imazamox	0.07	PRE	65	83	95	93
S-metolachlor	1.27	PRE				
Mesotrione	0.188	POST				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
S-metolachlor	1.27	PRE	75	93	95	93
Mesotrione	0.188	PRE				
Imazamox	0.047	POST				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor	1.27	PRE	75	93	100	90
Mesotrione	0.188	PRE				
Imazamox	0.047	POST				
Dicamba	0.188	POST				
Atrazine	1.0	POST				
Nonionic surfactant	0.25%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor	1.27	PRE	0	0	0	0
Atrazine	1.0	PRE				
Dicamba	0.188	POST				
Nonionic surfactant	0.25%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor/ Mesotrione	1.84	PRE	0	0	0	0
Dicamba	0.188	POST				
Atrazine	1.0	POST				
Nonionic surfactant	0.25%	POST				
Urea- ammonium nitrate	2.5%	POST				
LSD (0.05)			10	11	5	10

[1] PRE is preemergence, POST is postemergence.
[2] DAB is days after the postemergence treatments.

Table 3. Crop response in the imidazolinone-tolerant grain sorghum study.

Treatment	Rate	Timing[1]	Chlorosis 1 DA-B[2]	Epinasty 11 DA-B	Maturity	Yield
	lb ai/A		% Visual	% Visual	DAP[3]	bu/A
Nontreated check	---	---	0	0	64	39.5
Imazamox	0.07	PRE	3	1	63	85.3
S-metolachlor	1.27	PRE				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Imazamox	0.07	PRE	9	0	63	80.6
Mesotrione	0.188	PRE				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Imazamox	0.07	PRE	5	0	62	76.9
S-metolachlor	1.27	PRE				
Mesotrione	0.188	POST				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
S-metolachlor	1.27	PRE	4	0	62	73.8
Mesotrione	0.188	PRE				
Imazamox	0.047	POST				
Atrazine	1.0	POST				
Crop oil concentrate	1.0%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor	1.27	PRE	6	13	63	80.9
Mesotrione	0.188	PRE				
Imazamox	0.047	POST				
Dicamba	0.188	POST				
Atrazine	1.0	POST				
Nonionic surfactant	0.25%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor	1.27	PRE	0	10	63	48.4
Atrazine	1.0	PRE				
Dicamba	0.188	POST				
Nonionic surfactant	0.25%	POST				
Urea-ammonium nitrate	2.5%	POST				
S-metolachlor/ Mesotrione	1.84	PRE	8	6	64	38.9
Dicamba	0.188	POST				
Atrazine	1.0	POST				
Nonionic surfactant	0.25%	POST				
Urea- ammonium nitrate	2.5%	POST				
LSD (0.05)			5	3	1.5	13.8

1 PRE is preemergence, POST is postemergence.
2 DA-B is days after the postemergence treatments.
3 DAP is days after planting.

Winter wheat response to imazamox plus fluxapyroxad/pyraclostrobin/propiconazole and mesosulfuron/ thiencarbazone combined with various herbicides under early season conditions. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Winter wheat injury can increase under early season conditions (low nighttime temperatures or large day/night temperature fluctuations) and/or herbicide combinations with imazamox and mesosulfuron/thiencarbazone. Studies were established to evaluate 'Magic' winter wheat tolerance to imazamox and mesosulfuron/thiencarbazone combined with various herbicides under early season conditions near Moscow, ID. The plots were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). The mesosulfuron/thiencarbazone study and the untreated checks in the imazamox study were oversprayed with fluxapyroxad/pyraclostrobin/propiconazole at 0.3 lb ai/A for stripe rust control on May 25 and 27, 2022, respectively. Crop injury was evaluated visually during the growing season. Grain was harvested with a small plot combine on August 15, 2022.

Table 1. Application and soil data.

	Imazamox	Mesosulfuron/thiencarbazone
Winter wheat seeding date	10/8/21	
Application date	5/5/22	4/24/22
Growth stage		
Winter wheat	2 tiller	2 tiller
Air temperature (F)	62	64
Relative humidity (%)	58	30
Wind (mph, direction)	3, SE	3, SE
Cloud cover (%)	100	30
Soil moisture	adequate	adequate
Soil temperature at 2 inch (F)	50	55
Next rain occurred	5/5/22	4/26/22
pH	4.7	
OM (%)	2.8	
CEC (meq/100g)	13	
Texture	silt loam	

In the imazamox study, freezing temperatures were present 5 out of 14 days (7 before and after treatment). Temperature fluctuation of 30F or greater was observed twice in that same time frame. At 6 DAT, winter wheat injury was greater than 10% for the dicamba containing treatments, Rugged (2,4-D acid), and fluroxypyr/2,4-D combined with imazamox and fluxapyroxad/ pyraclostrobin/propiconazole (Table 2). At 20 DAT, dicamba containing treatments injured winter wheat 22% and fluroxypyr/2,4-D 11%. Grain yield and test weight was greatest for the untreated check compared to all treatments. Grain yield was lowest for the 2,4-D treatments and Vision (dicamba acid) combinations. Test weight was lowest for Vision but not different from the other dicamba treatment.

In the mesosulfuron/thiencarbazone study, freezing temperatures were present 8 out of 14 days (7 before and after treatment). Temperature fluctuation of 30F or greater was observed once in that same time frame. At 7 DAT, all treatments injured winter wheat 4 to 10% (Table 3). At 17 DAT, winter wheat injury was 10% or greater with mesosulfuron/thiencarbazone combined with bromoxynil/MCPA containing treatments, pyrasulfotole/bromoxynil plus clopyralid/fluroxypyr, or clopyralid/fluroxypyr/halauxifen. By 30 DAT, only bromoxynil/MCPA combined with mesosulfuron/thiencarbazone injured winter wheat 18%. Grain yield was lowest for the bromoxynil/MCPA treatment but did not differ from the pyrasulfotole/bromoxynil alone or plus bromoxynil/MCPA or clopyralid/fluroxypyr or florasulam/fluroxypyr. Test weight ranged from 60.4 to 61.0 lb/bu.

Table 2. Winter wheat response with imazamox and fluxapyroxad/pyraclostrobin/propiconazole combined with various herbicides in 2022.

Treatment[1]	Rate	Injury[2] 6 DAT	Injury[2] 20 DAT	Yield[2]	Test weight[2]
	lb ai/A	%	%	lb/A	lb/bu
Imazamox +	0.047				
Clarity (dicamba)	0.125	18a	22a	5297bc	59.0cd
Imazamox +	0.047				
Vision (dicamba acid)	0.125	15ab	22a	5174bcd	58.8d
Imazamox +	0.047				
fluroxypyr /2,4-D	0.83	14abc	11b	5071cd	59.6bc
Imazamox +	0.047				
Rugged (2,4-D acid)	0.57	11a-d	8bc	5109cd	60.0b
Imazamox +	0.047				
Embed Extra (2,4-D acid)	0.95	9b-e	5cd	5119cd	60.2b
Imazamox +	0.047				
Unison (2,4-D acid)	0.503	8cde	8bc	4896d	59.8b
Imazamox +	0.047				
MCPA/bromoxynil/fluroxypyr	0.75	5de	2cd	5360bc	59.7b
Imazamox +	0.047				
clopyralid/fluroxypyr/halauxifen	0.288	4e	0d	5527b	59.9b
Untreated check	--	--	--	6481a	61.2a

[1]All treatments included fluxapyroxad/pyraclostrobin/propiconazole at 0.116 lb ai/A, urea ammonium nitrate (URAN) at 20% v/v and methylated seed oil (Super Spread MSO) at 1% v/v.
[2]Within columns, means followed by different letters are statistically different at LSD (0.05).

Table 3. Winter wheat response with mesosulfuron/thiencarbazone combined with various herbicides in 2022.

Treatment[1]	Rate	Injury 7 DAT	Injury 17 DAT	Injury 31 DAT	Yield	Test weight
	lb ai/A	%	%	%	lb/A	lb/bu
Mesosulfuron/thiencarbazone	0.051	4a	4d	0b	6395a	60.4a
Mesosulfuron/thiencarbazone +	0.051					
pyrasulfotole/bromoxynil	0.217	6a	6cd	2b	5958bcd	60.4a
Mesosulfuron/thiencarbazone +	0.051					
pyrasulfotole/bromoxynil +	0.217					
bromoxynil/MCPA	0.5	9a	14b	6b	5793cd	60.6a
Mesosulfuron/thiencarbazone +	0.051					
pyrasulfotole/bromoxynil +	0.217					
florasulam/fluroxypyr	0.092	5a	6cd	0b	6037bcd	60.7a
Mesosulfuron/thiencarbazone +	0.051					
pyrasulfotole/bromoxynil +	0.217					
clopyralid/fluroxypyr	0.188	5a	11bc	2b	6025bcd	60.6a
Mesosulfuron/thiencarbazone +	0.051					
pyrasulfotole/bromoxynil +	0.217					
clopyralid/fluroxypyr/halauxifen	0.288	7a	9bcd	2b	6109abc	60.4a
Mesosulfuron/thiencarbazone +	0.051					
clopyralid/fluroxypyr	0.234	7a	6cd	0b	6203ab	60.8a
Mesosulfuron/thiencarbazone +	0.051					
clopyralid/fluroxypyr/halauxifen	0.288	8a	10bc	5b	6169ab	61.0a
Mesosulfuron/thiencarbazone +	0.051					
bromoxynil/MCPA	0.75	10a	20a	18a	5750d	60.4a
Untreated check	--	--	--	--	6440a	60.8a

[1]All treatments included urea ammonium nitrate (URAN) at 10% v/v and nonionic surfactant (R-11) at 0.5% v/v.
[2]Within columns, means followed by different letters are statistically different at LSD (0.05).

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