WESTERN SOCIETY OF WEED SCIENCE

2020 RESEARCH PROGRESS REPORT

ISSN-0090-8142

Hyatt Regency Maui

MAUI, HAWAII

March 2-5, 2020

FOREWORD

The 2020 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.

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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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Native forb tolerance and downy brome control with indaziflam combinations. Hailey L. Buell, Corey V. Ransom, and Stephen L. Young. (Department of Plants, Soils, and Climate, Utah State University, Logan, UT 84322). A field study was established near Richmond, Utah in 2018 to test the efficacy of indaziflam alone and in combinations for control of downy brome as well as herbicide tolerances of the desirable vegetation on the site. The site was chosen for its moderate infestation of downy brome and its wide variety of native and naturalized perennial forbs and grasses. The study was a randomized complete block design with four replicates. Plots measured 6 m by 18 m. Treatments were applied on November 9, 2018 with a CO_2-pressurized backpack sprayer calibrated to deliver 234 L/ha at 40 psi. On June 11, 2019, plots were evaluated for percent cover using the point-line intercept method with a point recorded every 15 cm on a transect line run lengthwise through one half of each plot.

Percent cover data were arcsine square root transformed prior to analysis with ANOVA to account for heterogeneous variance and statistical significance corresponds to transformed data. Untransformed means are presented in Table 1. All treatments significantly reduced downy brome cover to less than half of the cover in the untreated control. Rimsulfuron and indaziflam alone and in all combinations showed the greatest reduction of downy brome cover. Balsamroot cover was not different across most plots; the untreated control was among the lowest and the indaziflam and rimsulfuron combination was among the highest. Lomatium cover across all plots did not differ from the control and mule’s ear cover was equal to or greater than the control for all treatments. Wheatgrass cover was not statistically different from the control for any treatment, but it was noticeably injured by all treatments that included glyphosate and the combination of indaziflam and imazapic. In general, treatments controlled downy brome while having minimal negative impacts on desirable vegetation.

Table 1. Downy brome and desirable species response to herbicide treatments.

		Species Cover†									
Treatment*	Rate	Downy brome		Balsamroot		Lomatium		Mule’s ear		Wheatgrass	
	g ai/ha	%									
Untreated	-	36.65	a	22.67	c	4.24	ab	4.03	bc	10.17	abcd
Imazapic	175	14.41	b	32.84	ab	3.60	b	4.66	bc	12.71	abc
Propoxycarbazone	59	10.38	b	27.33	bc	4.87	b	6.78	ab	20.76	a
Glyphosate	210	4.66	c	33.69	ab	5.93	ab	8.47	ab	4.87	cd
Rimsulfuron	70	1.91	d	26.06	bc	3.39	b	11.23	a	18.64	ab
Indaziflam	102	0.21	d	27.33	bc	5.51	ab	11.44	a	13.77	abc
Indaz + propoxy	102 + 59	0.42	d	28.39	bc	5.72	ab	10.81	a	16.74	ab
Indaz + rimsulf	102 + 70	0.00	d	40.47	a	2.54	b	6.36	ab	13.14	abc
Indaz + imaz	102 + 175	0.00	d	27.54	bc	3.18	b	7.84	ab	8.05	bcd
Indaz + gly	102 + 210	0.00	d	25.00	bc	9.75	a	7.42	ab	2.97	d

*All treatments included a non-ionic surfactant at 0.25% v/v.

†Values within each column labeled with the same letter are not significantly different according to Fisher’s protected LSD at p = 0.05.

<u>Medusahead control with different rates and timings of aminopyralid at natural sites.</u> Lisa C. Jones and Timothy Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established on a pasture to examine medusahead control in Fenn, ID. Plots 10 by 30 ft were arranged in a randomized complete block design with three replications of seven treatments plus an untreated check. All herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi and 3 mph (Table 1). Perennial grasses were dormant at the time of treatment application. Plant cover and medusahead control were visually evaluated on July 3, 2018 and July 30, 2019 using reduction in foliar cover contrasted to the untreated check as the dependent variable.

Table 1. Application data.

Application timing	Fall 2017	Winter 2018	Spring 2018	Fall 2018	Winter 2019	Spring 2019
Application date	Sept 28, 2017	Mar 20, 2018	Apr 26, 2018	Sept 28, 2018	Apr 12, 2019	May 15, 2019
Medusahead growth stage	Pre-emergent	Boot stage	Early reproductive stage	Pre-emergent	Boot stage	Early reproductive stage
Air temperature (F)	71	56	77	70	58	64
Relative humidity (%)	39	40	34	35	47	52
Wind (mph, direction)	2, SSE	4, S	4, NE	2, E	1, W	1, S
Cloud cover (%)	0	20	0	5	90	95
Soil temperature at 2 inches (F)	64	50	58	70	44	67

Upon evaluation in July 2018, only two treatments had received both application timings. Both the low and high rates of aminopyralid applied in fall 2017 and spring 2018 had equally good control of medusahead (Table 2). Average perennial bunchgrass cover in these treatments were 21 and 36%, respectively, which was not statistically different (data not shown). For comparison, the untreated plots averaged 16% cover of perennial bunchgrasses. Meadow foxtail (*Alopecurus pratensis*) was the dominant bunchgrass, followed by Kentucky bluegrass (*Poa pratensis*) and intermediate wheatgrass (*Thinopyrum intermedium*).

In July 2018, we randomly collected ten mature medusahead seed heads from each plot. From that collection, in January 2019, we randomly selected twenty seeds from each plot, placed them on filter paper in Petri dishes, and allowed them to germinate in a growth chamber for thirty days. Thus, we attempted to germinate 60 seeds from each treatment, including the untreated check. The growth chamber had a 12-hour light (28 µmol m-2)/dark period with 21°F and 15 °F day/night temperatures. Average percent germination per treatment is shown in the figure below. Seeds with poor germination tended to be deformed and small compared to untreated seeds.

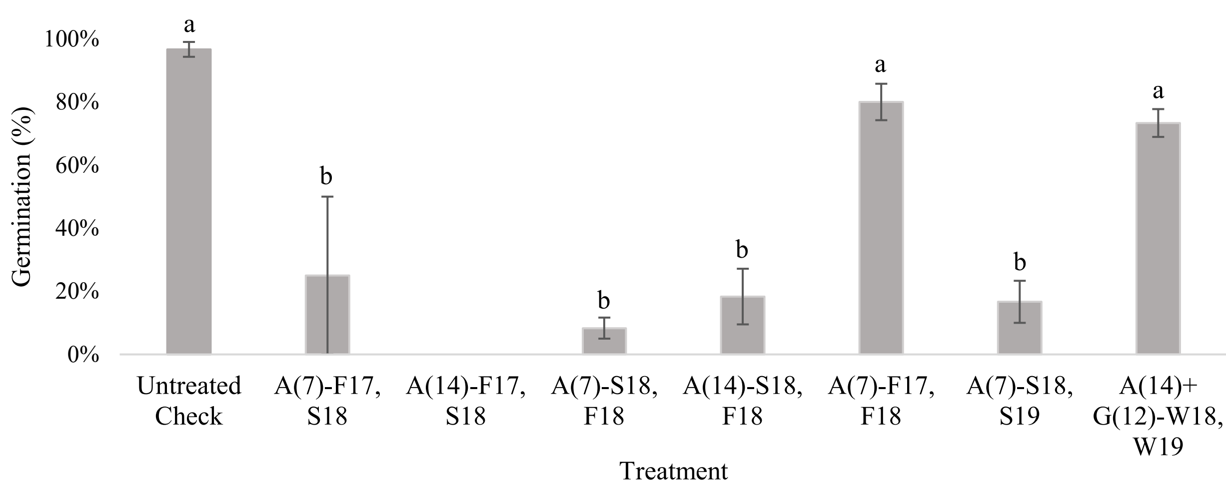

Figure. Average percent germination of medusahead seeds collected July 2018. Treatment labels are chemical (rate oz/A)-Application time. Example: A(7)-F17, S18 is aminopyralid 7 oz/ac in fall 2017 and spring 2018. Due to 100% medusahead control in plots treated with A(14)-F17, S18, no seeds could be collected for germination. Note that fall 2018, winter 2019, and spring 2019 application timings had not occurred at the time of evaluation; therefore, observed effects are from the first treatment only. Means denoted with the same letter are not statistically different.

Upon evaluation in July 2019, all treatments except the winter applications of aminopyralid + glyphosate controlled medusahead 76 to 100% compared to the untreated check (Table 2). From the 2018 evaluation time to the 2019 evaluation time, medusahead control decreased moderately (18%) in plots treated with the low rate of aminopyralid in fall 2017 and spring 2018. Control remained about the same in plots treated with the high rate of aminopyralid at those application times. The dual fall applications resulted in good control both years. Where the initial spring 2018 application did not control medusahead the first year, germination from those plots was substantially reduced (Figure). That effect, combined with a second herbicide application, resulted in improved control in 2019. Winter application had poor control after one and both applications, and the initial application had no effect on germination rates. While not statistically significant (p = 0.49), July 2019 average perennial bunchgrass cover between treatments ranged from 14 to 36% (data not shown). For comparison, the untreated plots averaged 23% cover of perennial bunchgrasses in 2019.

Table 2. Medusahead control following applications of aminopyralid at different rates and times.[1]

Treatment	Rate		Application timing	Medusahead control	
				2018 evaluation[2]	2019 evaluation[4]
	oz/A	lb ae/A[5]		---------------------%---------------------	
Aminopyralid	7	0.092	Fall 2017	94 a	76 a
Aminopyralid	7	0.092	Spring 2018		
Aminopyralid	14	0.184	Fall 2017	100 a	99 a
Aminopyralid	14	0.184	Spring 2018		
Aminopyralid	7	0.092	Spring 2018	60[3]	98 a
Aminopyralid	7	0.092	Fall 2018		
Aminopyralid	14	0.184	Spring 2018	61[3]	100 a
Aminopyralid	14	0.184	Fall 2018		
Aminopyralid	7	0.092	Fall 2017	96[3]	98 a
Aminopyralid	7	0.092	Fall 2018		
Aminopyralid	7	0.092	Spring 2018	65[3]	82 a
Aminopyralid	7	0.092	Spring 2019		
Aminopyralid + glyphosate[5]	14 + 12	0.184 + 0.475	Winter 2018	59[2]	32 b
Aminopyralid + glyphosate[5]	14 + 12	0.184 + 0.475	Winter 2019		
LSD (α = 0.05)				NS	*

[1]Within columns, means followed by the same letter are not statistically significantly different.
[2]Evaluations made July 3, 2018.
[3]Effects of the second application timing are not included in this evaluation and were not statistically evaluated.
[4]Evaluations made July 30, 2019.
[5]Glyphosate is expressed as lb ai/A.
*Due to a missing observation, LSD cannot be calculated.

Medusahead management with aminopyralid combinations. Hailey L. Buell and Corey V. Ransom. (Department of Plants, Soils, and Climate, Utah State University, Logan, UT 84322). A field study was established in Honeyville, Utah in 2018 to test the efficacy of aminopyralid alone and in combinations with other herbicides for control of medusahead and bulbous bluegrass. The site was chosen for its heavy stand of medusahead. The study was a randomized complete block design with four replicates. Plots measured 3 m by 9 m. Treatments were applied on September 17, 2018 with a CO_2-pressurized backpack sprayer calibrated to deliver 234 L/ha at 40 psi. Plots were evaluated visually on May 29, 2019 for control of medusahead and bulbous bluegrass and for purple threeawn injury.

Data were analyzed using ANOVA. Visual data for all treated plots were compared to the untreated plots. Tebuthiron alone at 420 g ai/ha showed among the lowest means for control of medusahead and bulbous bluegrass as well as injury of purple threeawn. The combination of aminopyralid and indaziflam showed among the highest means for both control and injury. Three treatments in particular stand out for high control of medusahead and bulbous bluegrass and low injury of purple threeawn: aminopyralid plus tebuthiron, aminopyralid plus imazapic, and imazapic alone. No treatment means exceeded 20% injury of purple threeawn and all means surpassed 50% control of medusahead. Bulbous bluegrass control was much more variable among treatments. In general, most treatments controlled medusahead while causing minimal injury to purple threeawn.

Table 1. Medusahead, bulbous bluegrass, and purple threeawn response to herbicide treatments.

		Control†				Injury†	
Treatment*	Rate	Medusahead		Bulbous bluegrass		Purple threeawn	
	g ai/ha			%			
Tebuthiron	420	56.3	d	0.0	f	0.0	b
Tebuthiron	560	70.0	bc	30.0	de	11.3	ab
Aminopyralid	123	62.5	cd	10.0	ef	0.0	b
Indaziflam	73	73.3	bc	37.5	cde	3.8	b
Imazapic	123	76.3	b	80.5	ab	3.8	b
Amino + imaz	123 + 123	70.0	bc	81.3	ab	7.5	ab
Amino + imaz	245 + 123	78.0	b	90.5	ab	0.0	b
Amino + tebu	123 + 420	96.3	a	48.8	cd	11.3	ab
Amino + tebu	123 + 560	95.8	a	65.0	bc	8.1	ab
Amino + indaz	123 + 73	97.5	a	93.3	a	18.8	a

*All treatments included a non-ionic surfactant at 0.25% v/v.

†Values within each column labeled with the same letter are not significantly different according to Fisher's protected LSD at p = 0.05.

Ventenata control with different rates of indaziflam/rimsulfuron compared to operational standards 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 Conservation Reserve Program land to examine ventenata control in Moscow, ID. Plots 10 by 30 ft were arranged in a randomized complete block design with three replications of eight treatments plus an untreated check. All herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi and 3 mph (Table 1). Perennial grasses (primarily smooth brome, *Bromus inermis*) were dormant at the time of treatment application. Plant cover and ventenata control were visually evaluated on June 15, 2016 (3 MAT), June 2, 2017 (16 MAT), June 7, 2018 (27 MAT), and July 1, 2019 (39 MAT) using reduction in foliar cover contrasted to the untreated check as the dependent variable.

Table 1. Application and soil data.

Application date	March 21, 2016
Ventenata growth stage	1 leaf
Air temperature (F)	68
Relative humidity (%)	47
Wind (mph, direction)	3, W
Cloud cover (%)	10
Soil temperature at 2 inches (F)	46
Soil pH	6.2
Soil texture	silt loam

Three months after treatment, all treatments except glyphosate controlled ventenata 57 to 100% compared to the untreated check (Table 2). The indaziflam + glyphosate treatments had worse control—57% and 75% for the respective low and high rates of indaziflam—than the remaining treatments at this early evaluation date. Differences in perennial grass cover between treatments were not statistically significant ($p = 0.14$). Treatments had an average perennial grass cover of 21 to 65% (data not shown).

Sixteen months after treatment, all treatments except glyphosate controlled ventenata 63 to 100% compared to the untreated check (Table 2). Ventenata control of 89% and higher was achieved with both rates of indaziflam + glyphosate, rimsulfuron at the high rate, indaziflam/rimsulfuron premixture at the high rate, and imazapic. Differences in perennial grass cover between treatments was not statistically significant ($p = 0.27$). Treatments had an average perennial grass cover of 28 to 58% (data not shown).

Twenty-seven months after application, all treatments except the low rate of rimsulfuron, imazapic, and glyphosate controlled ventenata 67 to 100% compared to the untreated check (Table 2). Ventenata control of 84% and higher was achieved with the four treatments that included indaziflam. Differences in perennial grass cover between treatments were not statistically significant ($p = 0.25$). Treatments had an average perennial grass cover of 12 to 43%, which was significantly lower than the cover three MAT (data not shown). Notably, upon evaluation 27 MAT, smooth brome plants in plots treated with the high rate of indaziflam + glyphosate were observed to be taller and have more inflorescences compared to smooth brome plants in other plots.

Thirty-nine months after treatment, all treatments except the low rate of rimsulfuron, imazapic, and glyphosate controlled ventenata 81 to 91% compared to the untreated check (Table 2). Differences in perennial grass cover between treatments were not statistically significant ($p = 0.81$). Treatments had an average perennial grass cover of 27 to 50% (data not shown), which was not significantly different compared to prior evaluations.

Initially, percent control from the indaziflam + glyphosate treatments increased from 3 to 16 MAT. Then control from these treatments decreased slightly, though remained little changed from 27 to 39 MAT. Percent control from both rates of rimsulfuron alone decreased over time, with control from the low rate decreasing more strongly. Similarly, percent control from the indaziflam/rimsulfuron treatments gradually decreased, with control from the low rate decreasing more strongly. Imazapic provided good control at 3 and 16 MAT, but efficacy was lost upon subsequent evaluations. At no evaluation time point did glyphosate alone provide any control.

Table 2. Ventenata control following applications of indaziflam and rimsulfuron at different rates.[1]

Treatment[2]	Rate		Ventenata control			
			3 MAT[3]	16 MAT[4]	27 MAT[5]	39 MAT[6]
	oz/A	lb ai/A	%			
Indaziflam + glyphosate	5 + 12	0.065 + 0.516	57 b	94 ab	84 ab	81 a
Indaziflam + glyphosate	7 + 12	0.092 + 0.516	75 b	94 ab	93 ab	84 a
Rimsulfuron	3	0.047	97 a	63 b	33 c	25 c
Rimsulfuron	4	0.063	99 a	89 ab	67 b	84 a
Indaziflam/rimsulfuron	4.5	0.119	98 a	81 ab	96 ab	81 ab
Indaziflam/rimsulfuron	6	0.158	100 a	100 a	100 a	91 a
Imazapic	7	0.109	100 a	90 ab	34 c	21 c
Glyphosate	12	0.516	13 c	9 c	9 c	30 bc
LSD (α = 0.05)			22	34	30	52

[1]Within columns, means followed by the same letter are not statistically significantly different.
[2]All treatments were applied with a non-ionic surfactant at 0.25% v/v.
[3]Evaluations made June 15, 2016.
[4]Evaluations made June 2, 2017.
[5]Evaluations made June 7, 2018.
[6]Evaluations made July 1, 2019.

Ventenata control with different rates of indaziflam contrasted with sulfosulfuron and imazapic 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 Conservation Reserve Program land to examine ventenata control in Moscow, ID. Plots 10 by 20 ft were arranged in a randomized complete block design with three replications of five treatments plus an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 15 gpa at 30 psi and 3 mph (Table 1). Perennial grasses (primarily smooth brome, *Bromus inermis*) were dormant at the time of application. Plant cover and ventenata control were visually evaluated on July 11, 2017 (8 MAT), June 4, 2018 (19 MAT), and July 8, 2019 (32 MAT) using reduction in foliar cover contrasted to the untreated check as the dependent variable.

Table 1. Application and soil data.

Application date	November 8, 2016
Ventenata growth stage	1 leaf
Air temperature (F)	64
Relative humidity (%)	48
Wind (mph, direction)	3, NW
Cloud cover (%)	0
Soil temperature at 4 inches (F)	47
Soil pH	5.5
Soil texture	silt loam

Eight months after application, all treatments except imazapic + glyphosate controlled ventenata 93 to 100% contrasted to the untreated check (Table 2). Differences in perennial grass cover between treatments were not statistically significant (p = 0.08). Treatments had an average perennial grass cover of 38 to 70% upon evaluation on July 11, 2017 (data not shown).

Nineteen months after treatment, the three treatments with indaziflam + glyphosate maintained control of ventenata at 99 to 100% contrasted to the untreated check (Table 2). The sulfosulfuron + glyphosate treatment that controlled ventenata the first year lost this effect at the second evaluation date. Differences in perennial grass cover between treatments were not statistically significant (p = 0.16). Treatments had an average perennial grass cover of 39 to 60% upon evaluation on June 4, 2018 (data not shown).

Thirty-two months after treatment, the same three treatments with indaziflam + glyphosate maintained control of ventenata relative to the untreated check (Table 2). While the low rate of the treatment had 67% control, this measure was artificially reduced because one untreated check replicate had very little ventenata, thereby decreasing the calculated efficacy of this treatment in that replicate. Thus, when disregarding this outlier, the low rate of indaziflam + glyphosate had 100% control of ventenata 32 months after treatment. Differences in perennial grass cover between treatments were not statistically significant (p = 0.15). Treatments had an average perennial grass cover of 30 to 58% upon evaluation on July 8, 2019 (data not shown), which was not significantly different compared to prior evaluations.

Table 2. Ventenata control following applications of indaziflam at different rates.[1]

Treatment[2]	Rate		Ventenata control		
			8 MAT[3]	19 MAT[4]	32 MAT[5]
	oz/A	lb ai/A	----------%----------		
Indaziflam + glyphosate	3 + 6	0.039 + 0.238	99 a	99 a	67 a
Indaziflam + glyphosate	4 + 6	0.052 + 0.238	100 a	100 a	100 a
Indaziflam + glyphosate	5 + 6	0.065 + 0.238	100 a	100 a	100 a
Sulfosulfuron + glyphosate[2]	1.33 + 6	0.002 + 0.238	93 a	33 b	0 b
Imazapic + glyphosate[2]	6 + 6	0.093 + 0.238	21 b	35 b	0 b
LSD (α = 0.05)			31	39	47

[1]Means followed by the same letter are not statistically significantly different.
[2]Treatments were applied with a non-ionic surfactant at 0.25% v/v.
[3]Evaluations made July 11, 2017.
[4]Evaluations made June 4, 2018.
[5]Evaluations made July 8, 2019.

Ventenata control with different rates and timings of indaziflam and rimsulfuron 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 Conservation Reserve Program land to examine ventenata control in Kendrick, ID. Plots 10 by 30 ft were arranged in a randomized complete block design with three replications of ten treatments plus an untreated check. All herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi and 3 mph (Table 1). Perennial grasses (primarily smooth brome, *Bromus inermis*, and tall wheatgrass, *Thinopyrum ponticum*) were dormant at the time of application. Plant cover and ventenata control were visually evaluated on June 5, 2018 (7-9 MAT) and June 5, 2019 (19-21 MAT), using reduction in foliar cover contrasted to the untreated check as the dependent variable.

Table 1. Application and soil data.

Application date	September 19, 2017	October 10, 2017	November 9, 2017
Ventenata growth stage	pre-emergent	1 leaf	2 leaf
Air temperature (F)	46	57	43
Relative humidity (%)	82	41	72
Wind (mph, direction)	1, S	5, SE	4, S
Cloud cover (%)	100	100	100
Soil temperature at 2 inches (F)	50	50	40
Soil pH		5.8	
Soil texture		silt loam	

At the June 5, 2018 evaluation, all treatments except imazapic controlled ventenata 100% (Table 2). Differences in perennial grass cover between treatments were not statistically significant (p = 0.22). Treatments had an average perennial grass cover of 5 to 24% (data not shown). The lowest perennial grass cover occurred in plots treated with the low rate of indaziflam + rimsulfuron in November (ventenata in the two-leaf stage). In comparison, the untreated plots had an average of 22% perennial bunchgrass cover. In addition, plots treated with the high rate of indaziflam + rimsulfuron had an average 13% cover of perennial grasses and approximately 80% injury to tall wheatgrass in the form of stunting was observed (data not shown).

At the June 5, 2019 evaluation, all treatments except imazapic controlled ventenata 98 to 100% (Table 2). Differences in perennial grass cover between treatments were not statistically significant (p = 0.49). Treatments had an average perennial grass cover of 15 to 25% (data not shown), which was not significantly different compared to the prior evaluation. The perennial grass cover in plots treated with the low rate of indaziflam + rimsulfuron increased to an average of 15% compared to the 5% cover observed in 2018. Perennial grasses in plots treated with the high rate of indaziflam + rimsulfuron still appeared stunted relative to the other plots even though cover increased to 25% in 2019.

Table 2. Ventenata control following applications of indaziflam at different rates and times.[1]

Treatment[2]	Rate		Application timing	Ventenata control 7-9 MAT[3]	Ventenata control 19-21 MAT[4]
	oz/A	lb ai/A		-------------%	%-------------
Indaziflam	5	0.065	Sept 19	100 a	100 a
Indaziflam	7	0.092	Sept 19	100 a	100 a
Indaziflam/rimsulfuron	4.5	0.119	Sept 19	100 a	100 a
Imazapic	7	0.109	Sept 19	23 b	21 b
Indaziflam	5	0.065	Oct 10	100 a	100 a
Indaziflam	7	0.092	Oct 10	100 a	100 a
Indaziflam/rimsulfuron	4.5	0.119	Oct 10	100 a	100 a
Imazapic	7	0.109	Oct 10	8 c	0 c
Indaziflam + rimsulfuron	5 + 3	0.065 + 0.047	Nov 9	100 a	98 a
Indaziflam + rimsulfuron	7 + 4	0.092 + 0.063	Nov 9	100 a	100 a
LSD (α = 0.05)				8	6

[1]Within columns, means followed by the same letter are not statistically significantly different.
[2]All treatments were applied with a non-ionic surfactant at 0.25% v/v.
[3]Evaluations made June 5, 2018.
[4]Evaluations made June 5, 2019.

Postemergence herbicides efficacy for liverseedgrass control. Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). A small plot field experiment was conducted on low maintenance common bermudagrass turf at the Greenwood Cemetery in Phoenix, AZ. Treatment plots measured 5 ft by 10 ft and were replicated three times in a randomized complete block design. POST treatments were applied on 13 May 2019 when the air temperature was 86°F, clear sky, and wind at 2-4 mph. All sprays were applied using a backpack CO_2 sprayer equipped with a hand-held boom with 3 Turbo TeeJet 11002 nozzles spaced 20 inches apart. Sprays were applied in 50 gpa water and an adjuvant, Adigor was added to pinoxaden, and a non-ionic surfactant, Latron CS-7 at 0.25% v/v was added to the other two herbicides. POST treatments were applied when liverseedgrass size ranged from 2-6 leaves after emergence. POST treatments were all comparable at approximately 1 month after treatment to provide better than 90% liverseedgrass control.

Table. Postemergence herbicides applied early for liverseedgrass control, Phoenix, AZ, 2019

Treatment	Rate (lb a.i./A)	UROPA control	
		23 May	12 Jun
		------------------ % --------------------	
Untreated check		0 c	0 b
thiencarbazone + foramsulfuron + halosulfuron	0.02 + 0.04 + 0.062	88 ab	92 a
thiencarbazone + iodosulfuron + dicamba	0.02 + 0.006 + 0.18	83 b	92 a
pinoxaden	0.25	92 a	90 a

POST herbicides applied on 13 May 2019.
Adigor surfactant at 1 oz/gallon added to pinoxaden and Latron CS-7 added to other two at 0.25% (v/v)
Means within a column followed by the same letter are not significantly different by Tukey-Kramer HSD (p=0.05).

Purple nutsedge control with ALS-inhibiting herbicides in turf. Kai Umeda (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). A small plot field experiment was conducted in a non-play rough area with common bermudagrass at the Wigwam Golf Club in Litchfield Park, AZ. Treated plots measured 5 ft by 10 ft and were replicated three times in a randomized complete block design. Sprayable herbicides were applied using a backpack CO_2 sprayer equipped with a hand-held boom with three Turbo TeeJet 11002 flat fan nozzles spaced 20 inches apart. The herbicides were mixed in water with a non-ionic surfactant, Latron CS-7 at 0.25% v/v, and sprayed at 50 gpa at 40 psi. Pyrimisulfan was spread as a granular using a plastic cup with holes punched in the bottom to act as a shaker to evenly disperse the material in each replicate plot. Weather conditions at the time of applications were: 09 July 2019 was 88°F with a clear sky and no detectable wind with soil temperature at 82°F; 21 August was 92°F, clear sky, with a slight breeze at <2 mph, and soil temperature at 86°F. Nutsedge control was visually rated at intervals following each application.

At 20 days after the first application (DAT-1) on 29 July, all of the herbicides provided better than acceptable control of 87%. At 35 and 43 DAT-1, trifloxysulfuron, sulfosulfuron, flazasulfuron, and imazosulfuron continued to give close to 80% control or better. Halosulfuron, imazaquin, and pyrimisulfan were less effective and required retreatment. Following the sequential application, all treatments showed very good control of nutsedge at 13 to 19 DAT-2 at acceptable levels of 80% or better. At 80 DAT-2, trifloxysulfuron, sulfosulfuron, flazasulfuron, and imazosulfuron reduced nutsedge to acceptable control around 80%. Halosulfuron and imazaquin offered 50% control while pyrimisulfan did not provide longer effective control into the season.

Table. Purple nutsedge control following sequential application of ALS-inhibiting herbicides.

Treatment	Rate (lb a.i./A)	CYPRO control						
		29 Jul	13 Aug	21 Aug	28 Aug	03 Sep	09 Sep	11 Oct
		------------------------------- % -------------------------------						
untreated check		0 b	0 d	0 c	0 b	0 b	0 b	0 c
halosulfuron	0.062	92 a	73 ab	63 ab	90 a	93 a	93 a	53 ab
imazaquin	0.5	92 a	53 b	53 ab	85 a	92 a	93 a	53 ab
trifloxysulfuron	0.025	92 a	87 a	87 a	95 a	96 a	96 a	83 a
sulfosulfuron	0.06	91 a	94 a	90 a	94 a	93 a	96 a	80 a
flazasulfuron	0.047	93 a	80 a	78 a	93 a	95 a	95 a	78 a
imazosulfuron	0.66	88 a	95 a	87 a	95 a	96 a	98 a	83 a
pyrimisulfan	0.047	87 a	25 c	25 bc	52 a	83 a	85 a	8 bc

Treatments applied on 09 July and 21 August 2019

Means within a column followed by the same letter are not significantly different by Tukey-Kramer HSD (p=0.05).

Spring transition using pinoxaden herbicide. Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040) A small plot field trial was conducted on a baseball field at the Diablo Stadium Complex in Tempe, AZ to remove overseeded perennial ryegrass from transitioning bermudagrass 'Tifway 419'. Treatment plots measured 5 ft by 10 ft and were replicated 4 times in a randomized complete block design. Treatments were applied with a backpack CO_2 sprayer equipped with a hand-held boom with 3 Turbo TeeJet 11002 nozzles spaced 20 inches apart. Sprays were applied in 40 gpa water pressurized to 30 psi. All pinoxaden treatments included an adjuvant, Adigor at 0.5% v/v and penoxsulam treatments included the non-ionic surfactant, Latron CS-7 at 0.25% v/v. The weather conditions at the early timing of applications on 01 May 2019 were air temperature at 74°F, clear sky, no wind, and soil temperature at 70°F. On 14 May, the late timing, the air temperature was 78°F, clear sky, wind at 2 mph, and soil temperature at 75°F.

At the early timing of application, pinoxaden at 1, 2, or 3 weeks after treatment (WAT) affected ryegrass comparably at all rates. Penoxsulam was less injurious on ryegrass at 1 WAT and at 3 WAT than pinoxaden. At about 1 WAT of the late timing application, pinoxaden exhibited a rate response with the high rate removing ryegrass better than the lowest rate. Penoxsulam removed only 30% ryegrass compared to 71% for pinoxaden treatments. At 4 WAT of the late timing, all ryegrass was removed with the pinoxaden treatments, early and late. Penoxsulam late-treated ryegrass had few small patches of ryegrass remaining while the early timing removed all ryegrass. Turf quality was diminished at 1, 2, or 3 WAT in pinoxaden treated plots compared to penoxsulam treatments and the untreated. When transition was complete, the pinoxaden treated bermudagrass turf quality was comparable to the untreated and penoxsulam treated turf. The bermudagrass was of slightly less quality when treated with pinoxaden at the high rate applied late versus the early timing at the lowest rate.

Table. Evaluation of pinoxaden herbicide for ryegrass removal, Tempe, AZ, 2019

Treatment	Rate (lb a.i./A)	Timing	Ryegrass injury		Ryegrass removed		Turf Quality*			
			08 May	14 May	22 May	11 Jun	08 May	14 May	22 May	11 Jun
			---------- % -----------		----------- % ---------					
untreated			0 b	0 b	0 e	75 b	8.5 a	7.8 a	7.8 a	7.5 ab
pinoxaden	0.008	Early	55 a	63 a	85 ab	99 a	5.8 bc	3.3 b	2.5 d	7.8 a
pinoxaden	0.015	Early	58 a	61 a	76 ab	99 a	5.5 bc	3.5 b	3.3 d	7.5 ab
pinoxaden	0.032	Early	65 a	73 a	90 a	99 a	4.8 c	3.0 b	2.3 d	7.5 ab
penoxsulam	0.058	Early	26 b	41 a	55 c	99 a	7.0 ab	4.3 b	5.3 bc	7.5 ab
pinoxaden	0.008	Late			71 b	98 a			3.8 cd	6.8 ab
pinoxaden	0.015	Late			83 ab	99 a			3.3 d	7.0 ab
pinoxaden	0.032	Late			88 a	99 a			3.0 d	6.3 b
penoxsulam	0.058	Late			30 d	91 a			6.0 ab	7.3 ab

Early timing applied on 01 May 2019 and late timing applied on 14 May.
*Turf quality rated 1=poor and 9=best.
Means within a columns with the same letter are not significantly different by Tukey-Kramer HSD (p=0.05).

<u>Efficacy and comparison of multiple applications of amicarbazone for *Poa annua* control.</u> Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). Two small plot field experiments were conducted at the Raven Golf Course in Phoenix, AZ and at the Tournament Players Club, Stadium Course, in Scottsdale, AZ on fairways with dormant hybrid bermudagrass overseeded with perennial ryegrass heavily infested with *P. annua.* At Raven GC, each treated plot measured 5 ft x 10 ft and treatments were replicated three times in a randomized complete block design. At TPC, the plots measured 10 ft x 10 ft. All amicarbazone (Xonerate 2SC) sprays were applied using a backpack CO_2 sprayer equipped with a hand-held boom with three TurboTeeJet 11002 flat fan nozzles spaced 20 inches apart (Table 1). The sprays were applied in 40 gpa water pressurized to 35 psi.

At the Raven GC, initial activity with amicarbazone was observed with 50-63% *P. annua* injury at 4 weeks after the first application (WAT-1) or 2 weeks after the second application (WAT-2) (Table 2). Acceptable control levels with two or three applications were observed at 2 WAT-3 or 4 WAT-2. Within 2 months of initiating amicarbazone applications, *P. annua* control was nearly complete with a total of 0.25 or 0.28 lb a.i./A applied in 2 or 3 applications.

At the TPC Stadium Course, first applications were initiated 33 days after the Raven GC start date. Within 12 days of the first application (DAT-1), a rate response ranging from 40% to 50% to 70% for 0.094, 0.125 and 0.140 lb a.i./A, respectively, was observed to cause initial *P. annua* injury. At 23 DAT-3, all treatments exhibited acceptable visual weed control at better than 85%. Turf quality was poor due to removal of *P. annua* and no acceptable ryegrass or bermudagrass cover to fill in.

Table 1. Conditions at the times of applications in 2019

<u>Raven</u>	
15 February	Air temperature – 70°F; cloudy; <3 mph wind; 60°F soil temperature
01 March	Air temperature – 61°F; cloudy-partly sunny; <2-3 mph wind; 60°F soil temperature
15 March	Air temperature – 64°F; clear sky; <3-4 mph wind; 60°F soil temperature
<u>TPC Stadium</u>	
20 March	Air temperature – 73°F; high clouds; <2-3 mph wind; 60°F soil temperature
01 April	Air temperature – 72°F; high thin clouds; 2-3 mph wind; 60°F soil temperature
15 April	Air temperature – 76°F; clear – few puffy thin clouds; <1.5 mph wind; 62°F soil temperature

Table 2. Efficacy and comparison of multiple applications of amicarbazone for *P. annua* control, Phoenix and Scottsdale, AZ, 2019

Amicarbazone rate (lb a.i./A)	Raven GC				TPC			
	POANN injury	POANN control			POANN injury	POANN control		Turf Quality
	15 Mar	29 Mar	16 Apr	07 May	01 Apr	15 Apr	08 May	08 May
	%	---------------- % ---------------			%	--------- % ---------		
untreated	0 c	0 b	0 b	0 b	0 d	0 c	0 d	7.0 a
0.125 + 0.125	63 a	90 a	97 a	96 a	50 bc	85 ab	88 c	4.0 b
0.125 + 0.063 + 0.063	53 b	90 a	98 a	96 a	47 bc	77 b	96 ab	3.0 b
0.140 + 0.140	50 b	85 a	97 a	98 a	68 ab	85 ab	92 bc	3.3 b
0.140 + 0.063 + 0.063	50 b	88 a	98 a	96 a	78 a	93 a	99 a	1.7 b
0.094+ 0.094 + 0.094	-	-	-	-	40 c	82 ab	98 a	2.3 b

Raven Golf Course treated on 15 February 2019, 01 March, and 15 March.
Tournament Players Club treated on 20 March 2019, 01 April, and 15 April.
Turf quality ratings 1 = poor, 9 = best
Means within a column followed by the same letter are not significantly different by Tukey's HSD (p=0.05).

Crabgrass control with 4-HPPD herbicides tembotrione, topramezone, and tolpyralate in sweet corn. Ed Peachey and Pete Sturman, Horticulture Dept., Oregon State University, Corvallis, 97331.

A study was established in sweet corn in 2019 at the Oregon State University Vegetable Research Farm to evaluate crabgrass control with the herbicides tembotrione, tolpyralate, and topramezone. These herbicides have broad-spectrum control, particularly when tank mixed with atrazine. When applied without atrazine, weeds such as crabgrass and common purslane are partially controlled. The soil at the experimental site was a Chehalis silty clay loam with a CEC of 24.66 meq/100 g soil, 6.3 pH, and 3.87% organic matter. Sweet corn (var. Driver, sh2) was planted on 30-May at 28,000 seeds/a on 30 inch rows into plots 25 feet long by 10 ft wide. Treatments were replicated three times in a RCB experimental design. PRE herbicides were applied on 2-Jun, 2 days after planting. POST herbicides were applied at the V2 (crabgrass was coleoptile to 2-leaf stage) and V4 growth stages of corn. Irrigation was applied weekly to match estimated ET. Corn was harvested by hand from 16.4 ft of row on 5-Sept, when kernels were at 72% moisture.

Table 1. Herbicide application data.

Date	2-Jun 2019	15-Jun 2019	21-Jun 2019
Crop stage	PRE, 2 DAP	V2, all, 1% V3, 6 inch	V4, 90%; a few at v3
Herbicide/treatment	PRE	V2	V4
Application timing	PRE 2 DAP	V2	V4
Start/end time	10:15-10:30	7-7:30 AM	7:30-9AM
Air temp/soil temp (2")/surface	68/74/68 F	61/63/64 F	62/64/72 F
Rel humidity	62%	70%	64%
Wind direction/velocity	E 1-3	NE 2-4	E 0-1
Cloud cover	0%	0%	95%
Plant moisture	-	Dry	Dew, light
Sprayer/PSI	BP CO_2 25 PSI	BP CO_2 25 PSI	BP CO_2 25 PSI
Mix size (ml)	2100	2100	2100
Gallons $H_2 0$/acre	20	20	15
Nozzle type	5-XR8003	5-XR8003	5-XR8003
Nozzle spacing and height	20/20	20/20	20/20
Soil inc. method/implement	Irrigation 6-3-19	-	-

Crabgrass control with tolpyralate was slightly better than tembotrione and topramezone when applied with methylated seed oil (MSO) and urea ammonium nitrate (UAN) adjuvants (Table 1). Tembotrione and tolpyralate controlled crabgrass equally when tankmixed with carfentrazone or bentazon and crop oil concentrate (COC) was included as the adjuvant. COC is typically substituted for UAN+MSO when 4-HPPD herbicides are applied with carfentrazone or bentazon to avoid excessive crop injury. Crabgrass control was very poor when topramezone was tankmixed with carfentrazone or bentazon and applied with COC. It is unclear whether this difference was due to an antagonism between the tank mixed herbicides or the adjuvant used with this tankmix. Dimethenamid-P applied PRE with V2 and V4 herbicides provided exceptional crabgrass control.

Crop injury and stunting was greater for tolpyralate and tembotrione than topramezone when applied with carfentrazone at V4. Tankmixes with bentazon caused less injury than tankmixes with carfentrazone. Tolpyralate tankmixed with bentazon yielded 16.7 tons/a with no indication of crop injury and 78% control of crabgrass at harvest.

Table 2. Response of sweet corn and crabgrass to tembotrione, tolpyralate, and topramezone.

	Herbicide	Timing	Rate	Phyto rating (8 DA V4 application @ V6 growth stage)	Stunting (8 DA V4 application @ V6 growth stage)	Crabgrass control (43 DA V4; corn 4 ft tall)	Harvest (72% moisture) Ear number	Harvest (72% moisture) Avg. ear wt.	Harvest (72% moisture) Ear yield	Weed control at harvest Crab-grass	Weed control at harvest Overall control
				0-10	*%*	*%*	*no/A*	*lbs*	*ton/A*	*%*	*%*
1	Dimethenamid-P	PRE	0.75	0.0	17	95	30100	1.13	17.0	100	100
	Topramezone+atrazine[1]	V4	0.33+0.023								
	MSO	V4	1%								
	UAN	V4	2.5%								
2	Dimethenamid-P	PRE	0.75	5.3	50	98	26200	1.13	14.9	99	98
	Topramezone+atrazine[1]	V4	0.33+0.023								
	Carfentrazone	V4	0.0156								
	MSO	V4	1%								
3	Dimethenamid-P	PRE	0.75	0.3	20	100	25900	1.19	15.2	100	100
	Tolpyralate	V4	0.035								
	Atrazine	V4	0.335								
	MSO	V4	1%								
	UAN	V4	2.5%								
4	Dimethenamid-P	V2	0.75	0.3	27	98	28000	1.13	15.8	100	100
	Topramezone	V2	0.0219								
	Atrazine	V2	0.5								
	MSO	V2	0.5%								
	UAN	V2	2.5%								
5	Dimethenamid-P	V2	0.75	6.0	80	97	27600	1.12	15.5	98	99
	Topramezone	V2	0.0219								
	Carfentrazone	V2	0.0156								
	Atrazine	V2	0.335								
	MSO	V2	0.5%								
	UAN	V2	2.5%								
6	Dimethenamid-P	V2	0.75	0.3	5	94	26200	1.18	15.5	93	95
	Topramezone	V2	0.0219								
	Bentazon	V2	0.625								
	Atrazine	V2	0.25								
	MSO	V2	1.0%								
7	Topramezone	V4	0.0219	0.0	8	83	29400	1.11	16.4	70	75
	MSO	V4	0.25%								
	UAN	V4	2.5%								
8	Topramezone	V4	0.0219	2.7	18	40	28000	1.10	15.4	27	40
	Carfentrazone	V4	0.0156								
	COC	V4	1.0%								
9	Topramezone	V4	0.0219	0.7	13	50	25900	1.09	14.0	25	48
	Bentazon	V4	0.625								
	COC	V4	1.0%								
10	Tolpyralate	V4	0.035	0.3	13	93	29800	1.13	16.9	91	91
	MSO	V4	0.25%								
	UAN	V4	2.5%								
11	Tolpyralate	V4	0.035	5.7	53	83	25000	1.09	13.7	88	87
	Carfentrazone	V4	0.0156								
	COC	V4	1.0%								
12	Tolpyralate	V4	0.035	0.0	0	88	29800	1.12	16.7	78	85
	Bentazon	V4	0.625								
	COC	V4	1.0%								
13	Tembotrione	V4	0.082	0.3	2	75	26200	1.17	15.4	68	57
	MSO	V4	0.25%								
	UAN	V4	2.5%								
14	Tembotrione	V4	0.082	7.0	47	97	28300	1.04	14.8	83	85
	Carfentrazone	V4	0.0156								
	COC	V4	1.0%								
15	Tembotrione	V4	0.082	0.3	33	83	28700	1.16	16.5	80	80
	Bentazon	V4	0.625								
	COC	V4	1.0%								
16	Nontreated		-	-	-	-	26300	1.02	13.3	0	3
	FPLSD (0.05)			1.5	17	14	ns	ns	2.1	23	19

[1] Premix, ImpactZ

<u>Response of radish grown for seed to fluroxypyr herbicide.</u> Ed Peachey, Horticulture Dept., Oregon State University, Corvallis OR, 97330.

A trial was set at the Oregon State University Vegetable Research Farm on a Chehalis silty clay loam soil with a CEC of 24.12 meq/100 g soil, 6.7 pH, and 3.65% organic matter. Experimental plots were 30 feet long with 3 rows on 26 inch centers. Herbicides were applied at 20 GPA with a CO_2 backpack sprayer. Treatments were replicated 4 times. Trifluralin was applied to designated treatments and soil incorporated on 1-May 2019 followed the same day by direct-seeding an open pollinated red globe variety of red radish. Post plant surface (PPS) herbicides were applied on 2-May. Two and four-leaf treatments were applied on 14-May and 20-May, respectively. Weed-free plots were hand-hoed on 24-May and 12-Jun, and all plots were cultivated on 28-May. A crop biomass cut was taken on 12-Jul from 12 ft of the middle row. Radish plants were pulled from the soil and windrowed in early September to hasten drying because of wet conditions in September. Seed was harvested with a Hege combine on 8-Oct. Seed germination was tested on a temperature gradient table for 6 days with a temperature range of 59 to 86 F at 6.75 F intervals.

As in previous studies, fluroxypyr may have caused slight stunting of the crop and some phytotoxicity shortly after treatment. Two weeks after the 4-lf treatment was applied, stunting was even more visible and may have reduced crop growth by 33% when fluroxypyr was applied to 4-lf radish at 0.131 lb ai/a (Table). However, when the crop was harvested, the improvement in weed control was substantial, particularly for hairy nightshade, and seed yield was comparable to the non-treated plots that were hand-weeded. Seed yield did not differ statistically among the treatments, but the average seed yield of treatments that caused stunting was nearly the same as yield in the hand-weeded plot. Seed germination tests indicated no effect on seed germination with the exception that the nontreated weedy treatments had a slightly slower germination rate than most other treatments at 4 days after the start of the germination test.

Table 1. Effect of rate and timing of fluroxypyr on radish grown for seed.

							Radish aboveground biomass harvest (less roots)		Seed yield and germination				
	Herbicide	Timing	Rate	Phyto (6-Jun)	Stunting (6-Jun)	Hairy nightshade control (6-Jun)	Stand	Biomass	Seed wt.	100 seed wt.	Germination across temperature range of 59 to 84F		
			lb ai/A	*0-10*	*%*	*%*	*no/12 ft*	*lbs/12 ft*	*lb/A*	*g*	*No. of 10 seeds that germinated at 2, 4, and 6 days after start*		
1	Fluroxypyr Trifluralin	2 lf PPI	0.044 0.500	0.0	19	89	28	13.6	589	1.07	7.4	9.7	9.9
2	Fluroxypyr Trifluralin	2 lf PPI	0.088 0.500	0.5	25	70	27	19.6	591	1.05	6.3	9.3	9.7
3	Fluroxypyr Trifluralin	4 lf PPI	0.131 0.500	0.8	33	93	28	18.0	622	1.10	8.1	9.7	9.9
4	Fluroxypyr Trifluralin	4 lf PPI	0.263 0.500	1.3	23	94	32	14.8	634	1.12	7.8	9.9	9.9
5	S-metolachlor Trifluralin	PPS PPI	0.650 0.500	0.0	8	95	31	16.2	653	1.06	7.5	9.5	9.7
6	Napropamide Trifluralin	PPS PPI	1.000 0.500	0.0	11	13	28	10.0	652	1.09	7.1	9.3	9.5
7	S-metolachlor Trifluralin	2 lf PPI	0.650 0.500	0.0	24	61	25	12.1	617	1.08	7.0	9.2	9.8
8	Nontreated	-	-	0.5	5	0	25	11.3	469	1.03	6.8	8.8	9.8
9	Nontreated	Hand-weeded		0	0	0	29	14.1	647	1.06	7.3	9.9	10.0
10	Ethalfluralin	PPS	0.75	0	14	64	31	12.6	509	1.07	7.7	9.9	10.0
	FPLSD (0.05)			0.81	19	29	ns	5.9	ns	ns	ns	0.7	ns

Kentucky bluegrass tolerance to pyroxasulfone. Traci A. Rauch and Joan M. Campbell. (Dept of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was conducted in a two-year-old Kentucky bluegrass field to evaluate pyroxasulfone tolerance near Southwick, Idaho. The study was 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 study was over sprayed with pyrasulfotole/bromoxynil at 0.217 lb ai/A for broadleaf weed control. Crop injury was evaluated visually during the growing season. Kentucky bluegrass was swathed on June 28 and harvested with a small plot combine on July 11, 2019.

Table 1. Application and soil data.

Variety and planting date	'Wild Horse' – 11/6/16			
Application timing	early fall	fall	late fall	spring
Application date	10/8/2018	10/30/2018	11/6/2018	5/13/2019
Growth stage				
Kentucky bluegrass	20% green-up	40% green-up	20% dormant	3 to 6 inch regrowth
Air temperature (F)	50	46	48	75
Relative humidity (%)	70	76	72	35
Wind (mph, direction)	3, E	0	2, W	4, SSW
Cloud cover (%)	100	100	100	10
Next moisture occurred	10/28/2018	11/1/2018	11/24/2019	5/17/2018
Soil moisture	dry	good	wet	dry
Soil temperature at 2 inch (F)	55	40	40	60
pH	5.0			
OM (%)	5.6			
CEC (meq/100g)	13.0			
Texture	silt loam			

On April 12, 2019, the high rate of pyroxasulfone plus metribuzin applied at the fall and late fall timings injured Kentucky bluegrass 20 and 19%, respectively (Table 2). Kentucky bluegrass injury was greatest with the same treatments on May 20. Seed yield from the untreated check did not differ from propiconazole or fluxapyroxad/pyraclostrobin (fungicides applied in the spring) and dimethenamid applied early fall. All pyroxasulfone plus metribuzin treatments at any application time reduced seed yield 26 to 54% compared to the untreated check. Seed yield of pyroxasulfone plus metribuzin treatments applied early fall averaged 258 lb/A, applied fall averaged 260 lb/A, and applied late fall averaged 296 lb/A.

Table 2. Kentucky bluegrass response to pyroxasulfone near Southwick, ID in 2019.

Treatment	Rate	Application timing	Kentucky bluegrass injury April 12	Kentucky bluegrass injury May 20	Seed yield
	lb ai/A		%	%	1b/A
Pyroxasulfone +	0.098				
metribuzin	0.094	early fall	2	6	281
Pyroxasulfone +	0.195				
metribuzin	0.188	early fall	6	9	234
Dimethenamid	0.84	early fall	6	1	353
Pyroxasulfone +	0.098				
metribuzin	0.094	fall	11	8	315
Pyroxasulfone +	0.195				
metribuzin	0.188	fall	20	18	204
Dimethenamid	0.84	fall	6	5	242
Pyroxasulfone +	0.098				
metribuzin	0.094	late fall	9	6	331
Pyroxasulfone +	0.195				
metribuzin	0.188	late fall	19	18	262
Dimethenamid	0.84	late fall	9	8	222
Propiconazole	0.113	spring	--	0	425
Propiconazole +	0.113				
fluxapyroxad/pyraclostrobin	0.13	spring	--	0	479
Fluxapyroxad/pyraclostrobin	0.195	spring	--	0	429
Untreated check	--	--	--	--	448
LSD (0.05)			4	7	108

Early postemergence and sequential herbicides for weed control in corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research & Extension Center near Garden City, KS to compare various herbicides applied preemergence (PRE), followed by postemergence (POST) or early postemergence (EPOST), for weed control and crop response in corn. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on June 17, July 8, and July 22, 2019. These dates were 7, 28, and 42 days after the POST applications (DA-C), respectively. Corn injury ratings were determined on June 7, June 17, and June 27, 2019, and these dates were 4 days after the EPOST applications (DA-B) and 7 or 17 DA-C. Yields were determined on September 19, 2019 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Early postemergence	Postemergence
Application date	May 1, 2019	June 3, 2019	June 10, 2019
Air temperature (F)	51	68	66
Relative humidity (%)	75	67	45
Soil temperature (F)	53	67	63
Wind speed (mph)	3 to 6	5 to 8	4 to 6
Wind direction	South-southeast	South-southwest	South-southwest
Soil moisture	Good	Good	Good
Corn			
Height (inch)	0	5 to 8	8 to 12
Leaves (no.)	---	2 to 3	4 to 5
Kochia			
Height (inch)	0	1 to 2	1 to 2
Density (plants/m^2)	---	5	2
Palmer amaranth			
Height (inch)	0	0.5 to 2	1 to 2
Density (plants/m^2)	---	5	1
Russian thistle			
Height (inch)	0	1 to 2	0
Density (plants/m^2)	---	2	0
Quinoa			
Height (inch)	0	1 to 3	0
Density (plants/m^2)	---	2	0
Green foxtail			
Height (inch)	0	0.5 to 1	1 to 2
Density (plants/m^2)	---	5	1

All herbicides controlled Russian thistle, quinoa, and green foxtail 96% or more regardless of rating date, and did not differ between treatments (data not shown). Kochia control at 7 and 42 DA-C was slightly less with thiencarbazone/tembotrione plus acetochlor/atrazine, dicamba, and glyphosate applied EPOST compared to the other herbicides and with dicamba/tembotrione plus acetochlor/atrazine and glyphosate applied EPOST at 42 DA-C (Table 2). All herbicides except atrazine/*S*-metolachlor/mesotrione/bicyclopyrone PRE followed by atrazine/*S*-metolachlor/mesotrione/bicyclopyrone plus glyphosate POST controlled Palmer amaranth 98% or more at 7 and 28 DA-C. By 42 DA-C, no differences occurred among herbicides for Palmer amaranth control. Corn chlorosis was 6 to 11% with the EPOST herbicides at 4 DA-B but did not persist (Table 3). All POST treatments containing mesotrione caused 11 to 19% corn chlorosis at 7 DA-C, but visible corn injury at 17 DA-C was 5% or less regardless of herbicide treatment. Grain yields did not differ between herbicide treatments, however all herbicide--treated corn yielded 56 to 65% more grain than the untreated controls.

Table 2. Sequential and early postemergence weed control in corn.

Treatment[1]	Rate	Timing[2]	Kochia			Palmer amaranth		
			7 DA-C[3]	28 DA-C[3]	42 DA-C[3]	7 DA-C[3]	28 DA-C[3]	42 DA-C[3]
	lb/A							
Isoxaflutole/ Thiencarbazone	0.068	PRE	100	100	100	98	99	96
Atrazine	1.0	PRE						
Acetochlor/ Mesotrione	1.2	POST						
Atrazine	0.5	POST						
Glyphosate	1.125	POST						
NIS	0.5%	POST						
AMS	1.0%	POST						
Isoxaflutole	0.049	PRE	100	100	99	100	100	99
Acetochlor/ Atrazine	2.1	PRE						
Thiencarbazone/ Tembotrione	0.082	POST						
Atrazine	0.5	POST						
Glyphosate	1.125	POST						
HSOC	0.5%	POST						
AMS	1.0%	POST						
Isoxaflutole	0.049	PRE	100	100	100	100	99	98
Acetochlor/ Atrazine	2.1	PRE						
Tembotrione	0.082	POST						
Atrazine	0.5	POST						
Acetochlor	1.125	POST						
Glyphosate	1.125	POST						
HSOC	0.5%	POST						
AMS	1.0%	POST						
Acetochlor/ Mesotrione/ Clopyralid	1.03	PRE	100	100	100	100	99	98
Atrazine	1.0	PRE						
Acetochlor/ Mesotrione/ Clopyralid	1.03	POST						
Atrazine	0.5	POST						
Glyphosate	1.125	POST						
NIS	0.5%	POST						
AMS	1.0%	POST						
Atrazine/ Acetochlor	1.75	PRE	100	100	100	100	100	100
Atrazine	1.0	PRE						
Acetochlor/ Mesotrione	1.2	POST						
Atrazine	0.5	POST						
Glyphosate	1.125	POST						
NIS	0.5%	POST						
AMS	1.0%	POST						
Atrazine/ *S*-metolachlor/ Mesotrione/ Bicyclopyrone	1.0	PRE	99	100	99	95	94	95
Atrazine/	1.0	POST						

S-metolachlor/								
Mesotrione/								
Bicyclopyrone								
Glyphosate	1.125	POST						
NIS	0.5%	POST						
AMS	1.0%	POST						
Isoxaflutole	0.049	PRE	100	100	100	100	99	100
Acetochlor/	1.5	PRE						
Atrazine								
Tembotrione	0.082	POST						
Acetochlor/	1.5	POST						
Atrazine								
Glyphosate	1.125	POST						
HSOC	0.5%	POST						
AMS	1.0%	POST						
Dicamba/	0.53	EPOST	98	96	96	100	100	100
Tembotrione								
Acetochlor/	3.0	EPOST						
Atrazine								
Glyphosate	1.125	EPOST						
HSOC	0.5%	EPOST						
AMS	1.0%	EPOST						
Thiencarbazone/	0.081	EPOST	93	95	94	100	100	100
Tembotrione								
Acetochlor/	3.0	EPOST						
Atrazine								
Dicamba	0.25	EPOST						
Glyphosate	1.125	EPOST						
HSOC	0.5%	EPOST						
AMS	1.0%	EPOST						
LSD (0.05)			3	NS	3	3	4	NS

[1] NIS is nonionic surfactant, AMS is ammonium sulfate, and HSOC is high-surfactant oil concentrate.
[2] PRE is preemergence, POST is postemergence, and EPOST is early postemergence.
[3] DA-C is days after postemergence treatment.

Table 3. Crop response to sequential and early postemergence herbicides applied in corn.

Treatment[1]	Rate	Timing[2]	Chlorosis 4 DA-B[3]	Chlorosis 7 DA-C[3]	Stunting 4 DA-B[3]	Necrosis 17 DA-C[3]	Yield
	lb/A		% Visual	% Visual	% Visual	% Visual	bu/A
Untreated		---	0	0	0	0	67.2
Isoxaflutole/ Thiencarbazone	0.068	PRE	0	19	0	5	104.8
Atrazine	1.0	PRE					
Acetochlor/ Mesotrione	1.2	POST					
Atrazine	0.5	POST					
Glyphosate	1.125	POST					
NIS	0.5%	POST					
AMS	1.0%	POST					
Isoxaflutole	0.049	PRE	0	5	0	3	117.7
Acetochlor/ Atrazine	2.1	PRE					
Thiencarbazone/ Tembotrione	0.082	POST					
Atrazine	0.5	POST					
Glyphosate	1.125	POST					
HSOC	0.5%	POST					
AMS	1.0%	POST					
Isoxaflutole	0.049	PRE	0	5	0	1	110.0
Acetochlor/ Atrazine	2.1	PRE					
Tembotrione	0.082	POST					
Atrazine	0.5	POST					
Acetochlor	1.125	POST					
Glyphosate	1.125	POST					
HSOC	0.5%	POST					
AMS	1.0%	POST					
Acetochlor/ Mesotrione/ Clopyralid	1.03	PRE	0	16	0	5	108.0
Atrazine	1.0	PRE					
Acetochlor/ Mesotrione/ Clopyralid	1.03	POST					
Atrazine	0.5	POST					
Glyphosate	1.125	POST					
NIS	0.5%	POST					
AMS	1.0%	POST					
Atrazine/ Acetochlor	1.75	PRE	0	19	0	5	114.8
Atrazine	1.0	PRE					
Acetochlor/ Mesotrione	1.2	POST					
Atrazine	0.5	POST					
Glyphosate	1.125	POST					
NIS	0.5%	POST					
AMS	1.0%	POST					
Atrazine/ S-metolachlor/ Mesotrione/ Bicyclopyrone	1.0	PRE	0	11	0	1	113.7

Atrazine/ S-metolachlor/ Mesotrione/	1.0	POST					
Bicyclopyrone		POST					
Glyphosate	1.125	POST					
NIS	0.5%	POST					
AMS	1.0%						
Isoxaflutole	0.049	PRE	0	1	0	0	111.2
Acetochlor/ Atrazine	1.5	PRE					
Tembotrione	0.082	POST					
Acetochlor/ Atrazine	1.5	POST					
Glyphosate	1.125	POST					
HSOC	0.5%	POST					
AMS	1.0%	POST					
Dicamba/ Tembotrione	0.53	EPOST	6	3	4	1	110.1
Acetochlor/ Atrazine	3.0	EPOST					
Glyphosate	1.125	EPOST					
HSOC	0.5%	EPOST					
AMS	1.0%	EPOST					
Thiencarbazone/ Tembotrione	0.081	EPOST	11	3	10	0	119.8
Acetochlor/ Atrazine	3.0	EPOST					
Dicamba	0.25	EPOST					
Glyphosate	1.125	EPOST					
HSOC	0.5%	EPOST					
AMS	1.0%	EPOST					
LSD (0.05)			3	5	5	3	22.8

[1] NIS is nonionic surfactant, AMS is ammonium sulfate, and HSOC is high-surfactant oil concentrate.
[2] PRE is preemergence, POST is postemergence, and EPOST is early postemergence.
[3] DA-B is days after early postemergence applications, DA-C is days after postemergence applications.

Single and sequential herbicide treatments for efficacy in corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research & Extension Center near Garden City, KS to compare preemergence (PRE), early postemergence (EPOST), and PRE followed by postemergence (POST) herbicide treatments for efficacy in corn. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual estimates of weed control were taken on June 27 and July 23, 2019, which were 1 and 27 days after the POST applications (DA-C), respectively. Yields were determined September 19, 2019 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Early postemergence	Postemergence
Application date	May 18, 2019	June 10, 2019	June 26, 2019
Air temperature (F)	51	68	68
Relative humidity (%)	64	34	61
Soil temperature (F)	60	69	71
Wind speed (mph)	0 to 2	3 to 6	3 to 5
Wind direction	North	South-Southwest	South
Soil moisture	Good	Good	Good
Corn			
Height (inch)	0	6 to 9	15 to 20
Leaves (no.)	---	2 to 3	6 to 7
Palmer amaranth			
Height (inch)	0	1 to 3	2 to 4
Density (plants/m^2)	---	10	1
Kochia			
Height (inch)	0	1 to 3	2 to 3
Density (plants/m^2)	---	10	1
Russian thistle			
Height (inch)	0	1 to 3	3 to 5
Density (plants/m^2)	---	3	1
Quinoa			
Height (inch)	0	1 to 2	0
Density (plants/m^2)	---	2	---
Green foxtail			
Height (inch)	0	1 to 2	2 to 3
Density (plants/m^2)	---	10	1

Quinoa control was essentially complete with all herbicides regardless of rating date (data not shown). All herbicide treatments containing pyroxasulfone/fluthiacet PRE controlled Palmer amaranth 95 to 100% at 1 and 27 DA-C, as did the treatment of acetochlor/mesotrione/clopyralid (Table 2). Isoxaflutole/thiencarbazone plus atrazine PRE followed by acetochlor/mesotrione plus atrazine and glyphosate POST also controlled Palmer amaranth 95% at 27 DA-C. Kochia control at 1 and 27 DA-C was slightly less with *S*-metolachlor/atrazine/mesotrione/bicyclopyrone PRE or pyroxasulfone/fluthiacet plus mesotrione and atrazine EPOST, compared to the most efficacious treatments. Russian thistle control was 95% or more with all herbicide at each rating date, and did not differ between treatments at 27 DA-C. Green foxtail control was 95% or more with all herbicides except pyroxasulfone/fluthiacet plus mesotrione and atrazine PRE and S-metolachlor/glyphosate/mesotrione plus atrazine EPOST at 27 DA-C. Yields of herbicide-treated corn ranged from 99.8 to 115.4 bu/A, which was 61 to 77 bu/A more than nontreated corn.

Table 2. Single and sequential herbicide efficacy in corn.

Treatment[1]	Rate	Timing[2]	Palmer amaranth 1 DA-C[3]	Palmer amaranth 27 DA-C	Kochia 1 DA-C	Kochia 27 DA-C	Russian thistle 1 DA-C	Russian thistle 27 DA-C	Green foxtail 1 DA-C	Green foxtail 27 DA-C	Corn Yield
	lb/A		% Visual		% Visual		% Visual		% Visual		bu/A
Untreated			---	---	---	---	---	---	---	---	38.3
Pyroxasulfone/ Fluthiacet	0.134	PRE	98	99	100	100	100	100	96	95	105.3
Isoxaflutole	0.047	PRE									
Atrazine	1.5	PRE									
Pyroxasulfone/ Fluthiacet	0.134	PRE	100	100	100	100	100	98	95	93	110.1
Mesotrione	0.125	PRE									
Atrazine	1.0	PRE									
Isoxaflutole/ Thiencarbazone	0.115	PRE	85	86	100	100	100	100	96	95	99.8
Atrazine	1.5	PRE									
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.15	PRE	91	89	91	90	100	99	100	96	107.6
Acetochlor/ Mesotrione/ Clopyralid	2.06	PRE	98	100	99	96	100	99	100	99	109.7
Pyroxasulfone/ Fluthiacet	0.101	EPOST	89	90	94	93	100	95	100	99	108.7
Mesotrione	0.094	EPOST									
Atrazine	1.0	EPOST									
Glyphosate	1.2	EPOST									
AMS	1.0%	EPOST									
S-metolachlor/ Glyphosate/ Mesotrione	1.94	EPOST	89	86	99	95	100	100	96	94	115.4
Atrazine	1.0	EPOST									
NIS	0.25%	EPOST									
AMS	1.0%	EPOST									
Pyroxasulfone/ Fluthiacet	0.134	PRE	95	100	100	100	95	99	98	100	104.0
Mesotrione	0.094	PRE									
Atrazine	1.5	PRE									
Dicamba/ Diflufenzopyr	0.14	POST									
Glyphosate	1.2	POST									
AMS	1.0%	POST									
Isoxaflutole/ Thiencarbazone	0.115	PRE	86	95	95	99	100	100	100	99	104.9

Atrazine	1.0	PRE									
Acetochlor/ Mesotrione	1.2	POST									
Atrazine	0.5	POST									
Glyphosate	1.2	POST									
AMS	1.0%	POST									
LSD (0.05)			8	9	5	6	3	NS	3	5	15.4

[1] NIS is nonionic surfactant and AMS is ammonium sulfate.
[2] PRE = preemergence, EPOST is early postemergence, and POST is postemergence.
[3] DA-C is days after the postemergence treatments.

Pre-emergent herbicides for kochia control in chemical fallow. John Spring (Colorado State University Extension, Julesburg CO 80737). Trials were established near Akron and Ovid CO to evaluate control of glyphosate-resistant kochia in no-till chemical fallow with pre-emergence herbicides applied at late fall and early spring timings, both alone and in 2 mode-of-action tank-mixes. Plots were arranged in a randomized complete block design with 5 replicates and individual plot size of 10 by 20 feet. Herbicide treatments (Table 1, Table 2) were applied with a CO_2 powered hand boom sprayer calibrated to deliver 10 gpa at 35psi and 3 mph through Teejet AIXR11015 nozzles. Each treatment was applied at both late fall and early spring applications. Fall applications were made on October 17 (Akron) or 22 (Ovid) 2018, once soil temperature at 2 inch depth had fallen below 50°F. Spring applications were made prior to any kochia germination on March 20 (Akron) or 21 (Ovid) 2019. At least 0.25" of precipitation was received within 14 d of all applications. Soil at both sites was a silt loam under long-term no-till management. Rotation at the Akron site was winter wheat-corn-millet-fallow, and winter wheat-fallow at Ovid. Final counts of emerged kochia were taken at 12 (Akron) or 14 (Ovid) weeks after spring herbicide application. Precipitation was normal or below over the winter and through April at both sites. From April to the end of the trial, conditions were unusually cool and wet. Kochia emergence was not observed in non-treated check plots until late April (Akron) or early May (Ovid), approximately 3-4 weeks later than the typical onset of kochia emergence at each site.

Table 1. Herbicide treatments and mean emerged kochia plants per square yard at final evaluation in mid-June either 12 (Akron) or 14 (Ovid) weeks after application of spring herbicide treatments for single active ingredients.

Treatment	Application timing	lb ai(ae) · ac^{-1}	Emerged kochia			
			Akron		Ovid	
			plants · yd^{-2}		plants · yd^{-2}	
non-treated	-	-	7.5	*de* [1]	0.7	*e* [1]
atrazine	fall	0.5	1.5	*bcde*	0.6	*e*
metribuzin	fall	0.25	0.7	*abc*	0.1	*abcd*
sulfentrazone	fall	0.14	0.2	*ab*	0.01	*abc*
flumioxazin	fall	0.06	2.7	*cde*	0.09	*abcd*
isoxaflutole	fall	0.06	10.9	*e*	0.3	*de*
atrazine	spring	0.5	1.9	*bcde*	0.15	*abcde*
metribuzin	spring	0.25	0.1	*a*	0.1	*abcd*
sulfentrazone	spring	0.14	0.6	*abcd*	0.009	*abc*
flumioxazin	spring	0.06	0.9	*abcd*	0.3	*bcde*
isoxaflutole	spring	0.06	3.9	*cde*	0.008	*ab*
dicamba	spring	0.5	2.4	*cde*	0.3	*cde*

[1]Within a column, means followed by the same letter are not statistically distinguishable by Tukeys' multiple comparison procedure (alpha=0.05)

Table 2. Herbicide treatments and mean emerged kochia plants per square yard at final evaluation in mid-June either 12 (Akron) or 14 (Ovid) weeks after application of spring herbicide treatments for 2 mode-of-action tank mixes.

Treatment	Application timing	lb ai · ac^{-1}	Emerged kochia Akron		Emerged kochia Ovid	
			plants · yd^{-2}		plants · yd^{-2}	
non-treated	-	-	14	*c* [1]	1.3	*b* [1]
sulfentrazone + metribuzin	fall	0.14 + 0.25	0.3	*ab*	0.009	*a*
sulfentrazone + atrazine	fall	0.15 + 0.5	0.2	*ab*	0.009	*a*
flumioxazin + metribuzin	fall	0.06 + 0.25	0.8	*ab*	0.02	*a*
flumioxazin + atrazine	fall	0.06 + 0.05	0.6	*ab*	0.04	*a*
isoxaflutole + metribuzin	fall	0.06 + 0.25	0.7	*ab*	0.09	*a*
isoxaflutole + atrazine	fall	0.06 + 0.5	1.5	*bc*	0.17	*a*
sulfentrazone + metribuzin	spring	0.14 + 0.25	0.2	*ab*	0.009	*a*
sulfentrazone + atrazine	spring	0.15 + 0.5	0.4	*ab*	0.009	*a*
flumioxazin + metribuzin	spring	0.06 + 0.25	0.08	*ab*	0.009	*a*
flumioxazin + atrazine	spring	0.06 + 0.05	0.4	*ab*	0.09	*a*
isoxaflutole + metribuzin	spring	0.06 + 0.25	0.1	*ab*	0.009	*a*
isoxaflutole + atrazine	spring	0.06 + 0.5	1.0	*abc*	0.009	*a*

[1]Within a column, means followed by the same letter are not statistically distinguishable by Tukeys' multiple comparison procedure (alpha=0.05)

Generally, multiple-mode-of-action tank mixes reduced kochia emergence markedly more than single active ingredients (Table 1, Table 2). Tank mixes containing sulfentrazone generally gave best and longest lasting control of kochia, but other tank mixes also provided useful levels of control and longevity. Atrazine performed better at the Ovid site than at Akron, particularly later in the season, presumably due to the presence of known biological accelerated atrazine degradation at the Akron site but not at the Ovid site (which had no atrazine use history). Flumioxazin, both alone and in tank mixes, provided 6 to 8 weeks of kochia control, but rapidly declined after that (data not shown). Performance of most tank mixes was comparable for 6 to 8 weeks after spring application, with meaningful differences in control becoming evident only after 9 to 12 weeks after application (data not shown).

Spring applications tended to have better longevity than fall applications, with the exception of tank mixes containing sulfentrazone and metribuzin, which had good efficacy regardless of application timing. Isoxaflutole had particularly large differences in efficacy between fall and spring applications. For other herbicides, logistic considerations are probably more important than the relatively small efficacy differences between application timings.

This work was supported with funding from the Colorado Wheat Research Foundation.

Evaluation of preemergence herbicides for the control of Russian-thistle in chemical fallow. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A trial was established on chemical fallow ground on the Smith Farm near Lind, WA to evaluate timings of preemergence herbicides for the control of Russian-thistle. The chemical fallow period followed spring wheat. It was such a dry fall that a burndown application across the trial area was not necessary at the time of the initial application on November 28, 2018 (referred to as the late fall application timing). The second application occurred on March 28, 2019 (referred to as the late winter application timing). The trial area was sprayed on March 28th with glyphosate + AMS (1.1 lb ae/A + 17 lb/100 gal) to primarily control volunteer wheat. Plots were 10 ft by 35 ft and arranged in a randomized complete block design with four replications. All herbicide treatments were applied with a CO_2-powered backpack sprayer set to deliver 10 gpa at 48 psi at 2.3 mph (Table 1). The initial weed counts occurred on May 15, 2019 using a square meter frame. The primary weeds present were tumble mustard (SSYAL) and Russian-thistle (SASKT). After the weeds were counted, the trial area was sprayed with glyphosate + Spray Prep (1.1 lb ae/A + 2.0 qts/100 gal). After the June 13th counts, Russian-thistle plants were hand rouged since they were in low abundance. After the final rating on July 9th, the trial area was sprayed with glyphosate + 2,4-D + Spray Prep + NIS (2.2 lb ae/A + 0.34 lb ae/A + 2.0 qts/100 gal + 0.25% v/v). All SASKT plants were counted within individual plots on the June 13 and July 9 rating dates and converted to plants per square meter for the results presentation. Count data were log transformed and analyzed with SAS 9.4 PROC GLM. Treatment means were separated using Fisher's protected LSD test when the model was significant at $P \leq 0.05$. Treatment means were back transformed for presentation purposes.

Table 1. Application and soil data.

Location	Smith Farm Lind, Washington	
Application date	November 28, 2018	March 28, 2019
Application type	preemergence	preemergence
Air temperature (F)	50	50
Relative humidity (%)	61	68
Wind (mph, direction)	6, S	5, NE
Cloud cover (%)	0	100
Soil temperature at 6 inch (F)	40	42
pH	5.9	
OM (%)	2.1	
Texture	silt loam	

Russian-thistle was the only broadleaf weed that was uniformly dispersed throughout the trial area for the duration of the trial. We were able to take one rating (May 15th) on the activity of these treatments for control of SSYAL. Carfentrazone/sulfentrazone applied in the late fall provided significantly better control of SSYAL when compared to the nontreated check (Table 2). However, carfentrazone/sulfentrazone applied at either late winter or the split application, provided significantly better control of SSYAL, which was comparable to the remaining treatments evaluated. On the initial May 15th rating date, all treatments were providing excellent control of SASKT, except metribuzin applied in the late fall. Over the next month, carfentrazone + sulfentrazone, flumioxazin + pyroxasulfone applied as a split application and metribuzin applied in late winter continued to provide excellent control of SASKT. On the final rating of July 9th, only the carfentrazone + sulfentrazone treatments, regardless of application time, were providing significantly better control of SASKT than the nontreated check plots. The results of this trial suggest that preemergence herbicides can provide an alternative means of controlling SASKT in chemical fallow and may become necessary as glyphosate-resistant SASKT becomes more prevalent.

Table 2. Preemergence control of SASKT and SSYAL in chemical fallow with herbicides near Lind, Washington in 2019.

Treatment	Rate	Application Timing	SSYAL 5/15/19	----------------SASKT---------------- 5/15/19	6/13/19	7/9/19
	lb ai/A		-------------------No. of plants m^{-2}-------------------			
Nontreated check	--	--	12.33 c	14.64 c	0.20 b	0.39 cd
Carfentrazone/sulfentrazone	0.21	Late Fall	2.78 b	0.00 a	0.00 a	0.01 a
Carfentrazone/sulfentrazone	0.21	Late Winter	0.11 a	0.00 a	0.00 a	0.03 ab
Carfentrazone/sulfentrazone fb	0.11 fb	Late Fall fb	0.11 a	0.00 a	0.00 a	0.00 a
Carfentrazone/sulfentrazone	0.11	Late Winter				
Flumioxazin/pyroxasulfone	0.21	Late Fall	0.00 a	0.22 a	0.16 b	0.52 cd
Flumioxazin/pyroxasulfone	0.21	Late Winter	0.00 a	0.35 a	0.16 b	0.28 bc
Flumioxazin/pyroxasulfone fb	0.11 fb	Late Fall fb	0.00 a	0.00 a	0.08 ab	0.30 c
Flumioxazin/pyroxasulfone	0.11	Late Winter				
Metribuzin	0.49	Late Fall	0.00 a	4.93 b	0.17 b	0.67 d
Metribuzin	0.49	Late Winter	0.00 a	0.22 a	0.12 ab	0.34 cd
Metribuzin fb metribuzin	0.25 fb	Late Fall fb	0.10 a	0.35 a	0.15 b	0.38 cd
	0.25	Late Winter				

Pyraflufen tank mixtures for postemergence weed control in fallow. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research & Extension Center near Garden City, KS to compare pyraflufen tank mixtures for weed control in fallow. Herbicides were applied postemergence using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, environmental, and weed information is shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block with 4 replications. Soil was a Ulysses silt loam with 3.4% organic matter and pH of 7.9. Visual weed control was determined on May 17, May 29, and June 10, 2019. These dates were 4, 16, and 28 days after treatment (DAT), respectively.

Table 1. Application information.

Application timing	Postemergence
Application date	May 23, 2019
Air temperature (F)	75
Relative humidity (%)	56
Soil temperature (F)	60
Wind speed (mph)	3 to 6
Wind direction	Southeast
Soil moisture	Good
Kochia	
Height (inch)	3 to 5
Density (plants/m^2)	100
Pinnate tansymustard	
Height (inch)	10 to 15
Density (plants/m^2)	10
Flixweed	
Height (inch)	15 to 25
Density (plants/m^2)	10

Tank mixtures containing sulfentrazone controlled kochia, pinnate tansymustard, and flixweed better than most other treatments at 4 DAT, but did not exceed 65% (Table 2). Similarly, kochia control at 16 DAT was 97% or more with all treatments containing sulfentrazone, and 93% with the treatment of pyraflufen plus glyphosate and dicamba. Pinnate tansymustard and flixweed control was 96% or more, regardless of treatment, at 16 DAT and did not differ between treatments. By 28 DAT, pyraflufen with glyphosate, glyphosate and 2,4-D, or glyphosate and dicamba controlled kochia 75 to 89%, whereas sulfentrazone-containing treatments controlled kochia 95 to 97%. All herbicide treatments completely controlled pinnate tansymustard and flixweed at 28 DAT.

Table 2. Pyraflufen tank mixtures for postemergence weed control in fallow.

Treatment	Rate	Kochia			Pinnate tansymustard			Flixweed		
		4 DAT[1]	16 DAT	28 DAT	4 DAT	16 DAT	28 DAT	4 DAT	16 DAT	28 DAT
	lb/A	% Visual			% Visual			% Visual		
Pyraflufen	0.00325 ai	43	85	76	40	98	100	35	97	100
Glyphosate	1.0 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Pyraflufen	0.00325 ai	45	88	75	40	98	100	40	97	100
Glyphosate	1.0 ae									
2,4-D amine	0.25 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Pyraflufen	0.00325 ai	65	98	97	53	99	100	50	98	100
Sulfentrazone	0.188 ai									
Glyphosate	1.0 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Sulfentrazone	0.188 ai	60	97	96	53	98	100	50	96	100
Glyphosate	1.0 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Pyraflufen	0.00325 ai	63	97	95	53	98	100	50	97	100
Sulfentrazone	0.188 ai									
2,4-D amine	0.25 ae									
Glyphosate	1.0 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Pyraflufen	0.00325 ai	45	93	89	40	97	100	43	97	100
Glyphosate	1.0 ae									
Dicamba	0.25 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
Pyraflufen	0.00325 ai	65	97	97	53	98	100	50	97	100
Sulfentrazone	0.188 ai									
Dicamba	0.25 ae									
Glyphosate	1.0 ae									
Crop oil concentrate	1 %									
Ammonium sulfate	3.0									
LSD (0.05)		9	4	6	6	NS	NS	5	NS	NS

[1] DAT is days after treatment.

Long-term control of smooth scouringrush with glyphosate in no-till fallow. Mark Thorne[1], Jacob Fischer[1], Derek Appel[1], Dale Whaley[2], and Drew Lyon[1]. ([1]Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420; [2]Douglas County Extension, Washington State Univ., Waterville, WA 98858-0550) This study evaluated herbicides applied in 2018 to control smooth scouringrush and the effects on the population in 2019. In 2018, we compared broadcast and rope wick applications of glyphosate for control of smooth scouringrush (EQULA) in no-till fallow/wheat rotations. Smooth scouringrush is a persistent perennial plant with an extensive root system, making it difficult to control with standard fallow herbicide applications targeted at annual weed populations. One advantage of a rope wick application is that glyphosate can be applied directly to the plant surface at a high concentration, up to 75% v/v. For the broadcast comparison, we applied glyphosate at 3.4 lb ae/A. This rate is consistent with labeled rates for other difficult-to-control perennial weeds. At Reardan, an additional treatment combined an organosilicone non-ionic surfactant (OSNIS) with glyphosate to see if an OSNIS would aid glyphosate efficacy in EQULA control since the stems contain a relatively high concentration of silica and may be difficult to penetrate. MCPA ester was broadcast applied as a burndown check because it quickly turns stems black after application, but does not seem to have much long-term effect.

Treatments were applied May 25, 2018 at a site near Omak, WA, and July 5, 2018 near Reardan, WA (Table 1). Both sites were in no-till fallow with a uniform density of EQULA stems. Plots measured 10 by 30 ft at Omak and 10 by 40 ft at Reardan. At both sites, plots were arranged in a randomized complete block design with four replications per treatment. Broadcast treatments 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 3 mph. Spray output was 15 gpa at 25 psi. Rope wick treatments were applied with a 10-ft by 3-inch wick tube with braided polyester wicking ropes (Rodgers Sales Co. Inc., Lyon, MS) mounted on the front of a four wheeler ATV moving approximately 3 mph. A 3-gal tank, lightly pressurized with CO_2, fed the wick tube to keep the ropes saturated and dripping. Data were analyzed using SAS 9.4 PROC GLIMMIX.

Table 1. Application and soil data.

Location	Omak, WA	Reardan, WA
Application date	May 25, 2018	July 5, 2018
Growth stage, EQULA	stems with strobili, up to 20 inches	stems with strobili, 6 to 20 inches
Crop phase	no-till fallow	no-till fallow
Air temperature	85	79
Relative humidity (%)	23	36
Wind (mph, direction)	4-6, S	3-7, NNE
Cloud cover (%)	60	0
Soil temperature at 6 inches (F)	80	68

Treatments were evaluated in 2018, 45 days after treatment (DAT) at Omak and 33 DAT at Reardan. At the Omak site, EQULA stems were counted in two 0.3-yd^2 quadrats per plot on July 9, 2018. Stems were counted if green living tissue was visible. An accidental cattle-grazing incident removed much of the biomass at this site, so biomass sampling was not practical. At the Reardan site, living portions of stems were collected in two 0.3-yd^2 quadrats/plot on August 7, 2018. Excessive branching on the lower portion of the stems conversely made stem counts impractical. In 2019, percent control compared to the non-treated check plots was visually assessed based on overall abundance (density, mass).

In 2018, the glyphosate treatments at Omak and the MCPA ester and the glyphosate + OSNIS treatments at Reardan were most effective at reducing EQULA stem abundance (Tables 2 and 3); however, at Reardan, glyphosate without OSNIS had very little effect. It is not exactly clear why glyphosate alone worked so well at Omak but not at Reardan, but application timing seems to be a factor. The rope wick application was also more effective at Omak, compared with Reardan, as stem density averaged 73 stems/yd^2 and was three times lower than the non-treated check (Table 2). When glyphosate was visually effective, EQULA stems turned a yellow straw color during several weeks after treatment, but in contrast, MCPA ester treated stems turned black very quickly after treatment. In 2019, it was evident that some of the 2018 treatments had long-term effects on EQULA density. At Omak, stem abundance in plots treated with the rope wick or the broadcast glyphosate applications averaged 78 and 88% control, respectively (Table 2). At Reardan, the rope wick or glyphosate + OSNIS applications averaged 65 and 90% control, respectively, and were both superior to glyphosate alone or MCPA ester (Table 3). These data suggest that long-term control of EQULA is possible with glyphosate, but only if glyphosate visibly discolors the stems. Furthermore, an addition of an OSNIS may be necessary to move the herbicide into the plant. In contrast, quick burndown or blackening of the stems with MCPA ester does very little to effect long-term control.

Table 2. Smooth scouringrush (EQULA) control comparing rope wick with broadcast herbicide treatments at Omak, WA. Stem density in 2018 measured 45 days after treatment in the fallow phase, visual rating in 2019 was on July 12 in the winter wheat phase.

			EQULA control[2]	
			2018	2019
Treatment[1]	Application	Rate	Stem density	Rating[3]
			stems/yd^2	% control
glyphosate	rope wick	75% v/v	73 b	78 a
glyphosate	broadcast	3.4 lb ae/A	20 c	88 a
MCPA ester	broadcast	1.4 lb ae/A	203 a	13 b
non-treated check	-	-	225 a	-

[1] Treatments applied May 25, 2018.
[2] Values in each column followed by the same letter are not different (Pvalue≤0.05).
[3] 2019 ratings are visual assessments of percent control from the 2018 applications.

Table 3. Smooth scouringrush (EQULA) control comparing rope wick with broadcast herbicide treatments at Reardan, WA. Stem biomass in 2018 measured 33 days after treatment in the fallow phase, visual rating in 2019 was on June 28 in the winter wheat phase.

			EQULA control[2]	
			2018	2019
Treatment[1]	Application	Rate	Biomass	Rating
			lb dry mass/yd^2	% control
glyphosate	rope wick	75% v/v	0.42 a	65 a
glyphosate	broadcast	3.4 lb ae/A	0.53 a	16 b
glyphosate + OSNIS	broadcast	3.4 lb ae/A + 0.25% v/v	0.25 b	90 a
MCPA ester	broadcast	1.4 lb ae/A	0.27 b	25 b
non-treated check	-	-	0.55 a	-

[1] Treatments applied July 5, 2018. OSNIS=organosilicone surfactant
[2] Values in each column followed by the same letter are not different (Pvalue≤0.05).
[3] 2019 ratings are visual assessments of percent control from the 2018 applications.

Comparison of terbuthylazine and atrazine preemergence in grain sorghum. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research & Extension Center near Garden City, KS compared terbuthylazine at two rates to competitive standards for preemergence (PRE) weed control in grain sorghum. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with pH of 7.9 and 3.4% organic matter. Weed control ratings were visually estimated on July 16 and July 29, 2019. These dates were 28 and 41 days after herbicide treatment (DAT). Sorghum yields were determined October 15, 2019 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 14.0% moisture.

Table 1. Application information.

Application timing	Preemergence
Application date	June 18, 2019
Air temperature (F)	88
Relative humidity (%)	62
Soil temperature (F)	86
Wind speed (mph)	3 to 6
Wind direction	West-southwest
Soil moisture	Fair

Quinoa and crabgrass control with all herbicides was 95% or more regardless of evaluation date, and did not differ (data not shown). At 28 DAT, kochia and Palmer amaranth control was 80% or more with all herbicides except terbuthylazine or atrazine at 0.75 lb/A (Table 2). By 41 DAT, control of each of these species was best (85%) when the premix of *S*-metolachlor/atrazine at 2.9 lb/A was applied. All herbicides controlled Russian thistle similarly at 28 DAT. *S*-metolachlor/atrazine provided the best Russian thistle control at 41 DAT (88%), and only terbuthylazine or atrazine at 0.75 lb/A were less efficacious. Grain yields were increased 31 to 54% by most herbicide treatments compared to nontreated sorghum. However sorghum treated with atrazine at 0.75 lb/A yielded similarly to the nontreated controls.

Table 2. Terbuthylazine and atrazine comparisons in sorghum.

Treatment	Rate	Timing[1]	Kochia 28 DAT[2]	Kochia 41 DAT	Russian thistle 28 DAT	Russian thistle 41 DAT	Palmer amaranth 28 DAT	Palmer amaranth 41 DAT	Sorghum yield
	lb/A		% Visual		% Visual		% Visual		bu/A
Untreated	---	---	---	---	---	---	---	---	58.6
Terbuthylazine	0.75	PRE	70	63	83	65	68	60	77.7
Terbuthylazine	1.0	PRE	80	78	86	83	80	70	76.9
Atrazine	0.75	PRE	78	73	88	75	73	65	66.9
Atrazine	1.0	PRE	81	75	90	80	81	73	80.9
Terbuthylazine	0.75	PRE	84	75	88	83	80	75	78.9
S-metolachlor	0.96	PRE							
Atrazine	0.75	PRE	84	73	90	78	83	73	83.5
S-metolachlor	0.96	PRE							
S-metolachlor/ Atrazine	2.9	PRE	85	85	93	88	89	85	90.4
LSD (0.05)			6	7	NS	12	11	10	18.0

[1] PRE = preemergence.
[2] DAT is days after treatment.

Residual weed control with preemergence herbicides in grain sorghum. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research & Extension Center near Garden City, KS to compare various preemergence (PRE) herbicides for residual weed control in grain sorghum. One treatment included a postemergence (POST) application of *S*-metolachlor at 25 days after planting. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Ulysses silt loam with a pH of 7.9 and 3.4% organic matter. Visual estimates of weed control were determined on July 16 and August 28, 2019; these dates were 7 and 50 days after the POST treatment (DA-B), respectively. Grain yields were determined on October 15, 2019 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 14.0% moisture.

Table 1. Application information.

Application timing	Preemergence	Postemergence
Application date	June 14, 2019	July 7, 2019
Air temperature (F)	96	74
Relative humidity (%)	41	73
Soil temperature (F)	78	72
Wind speed (mph)	2 to 5	4 to 7
Wind direction	South	South
Soil moisture	Fair	Fair
Grain sorghum		
Height (inch)	0	2 to 3
Leaves (no.)	---	1
Kochia		
Height (inch)	0	2 to 4
Density (plants/m^2)	---	1
Russian thistle		
Height (inch)	0	2 to 4
Density (plants/m^2)	---	1
Quinoa		
Height (inch)	0	2 to 4
Density (plants/m^2)	---	1
Palmer amaranth		
Height (inch)	0	2 to 3
Density (plants/m^2)	---	1
Crabgrass		
Height (inch)	0	0
Density (plants/m^2)	---	---

All herbicides controlled quinoa 88% or more at 7 DA-B and 95% or more at 50 DA-B, and did not differ between treatments. Similarly, crabgrass control was 95% or more regardless of herbicide treatment or rating date (data not shown). Kochia control at 7 DA-B was 93% or more with all herbicides except *S*-metolachlor/glyphosate/mesotrione at 2.15 lb/A plus atrazine PRE and acetochlor/atrazine PRE (Table 2). These treatments, along with *S*-metolachlor/glyphosate/mesotrione at 2.7 lb/A plus atrazine PRE and atrazine/*S*-metolachlor PRE controlled kochia less than 90% at 50 DA-B. *S*-metolachlor/atrazine/mesotrione at 2.48 or 2.78 lb/A PRE were the only treatments to control Russian thistle more than 80% at 7 DA-B. However, no differences between herbicide treatments occurred for Russian thistle control by 50 DA-B. Palmer amaranth control was similar among herbicides at 7 DA-B. At 50 DA-B, *S*-metolachlor/glyphosate/mesotrione at 2.15 or 2.7 lb/A plus atrazine PRE and atrazine/*S*-metolachlor PRE provided less than 90% Palmer amaranth control. Grain yields were 88 to 106 bu/A from herbicide-treated sorghum plots, but did not differ from sorghum receiving no herbicide treatment (83 bu/A) (data not shown).

Table 2. Weed control and grain yield with preemergence herbicides in grain sorghum.

Treatment	Rate	Timing[1]	Kochia 7 DA-B[2]	Kochia 50 DA-B[2]	Russian thistle 7 DA-B	Russian thistle 50 DA-B	Palmer amaranth 7 DA-B	Palmer amaranth 50 DA-B
	lb/A		% Visual		% Visual		% Visual	
S-metolachlor/ Atrazine/ Mesotrione	2.48	PRE	98	95	85	83	100	98
S-metolachlor/ Atrazine/ Mesotrione	2.78	PRE	100	98	90	83	95	95
S-metolachlor/ Glyphosate/ Mesotrione	2.15	PRE	91	88	73	78	93	80
Atrazine	0.65	PRE						
S-metolachlor/ Glyphosate/ Mesotrione	2.7	PRE	93	85	70	80	93	85
Atrazine	0.65	PRE						
Atrazine/ *S*-metolachlor	2.25	PRE	94	85	80	80	85	78
Atrazine/ *S*-metolachlor	2.25	PRE	95	90	80	88	95	95
S-metolachlor	1.24	POST						
Acetochlor/ Atrazine	2.25	PRE	85	83	80	78	93	90
Saflufenacil/ Dimethenamid	0.435	PRE	96	100	75	85	98	98
Dimethenamid	0.47	PRE						
LSD (0.05)			8	10	9	NS	NS	10

[1] PRE = preemergence, POST = 25 days after planting.
[2] DA-B is days after the postemergence treatment.

Efficacy of KFD-365-02 rates and mixtures in imidazolinone-tolerant grain sorghum. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research & Extension Center near Garden City, KS to compare KFD-365-02 at two rates applied preemergence (PRE) or postemergence (POST) to competitive standards for efficacy in imidazolinone-resistant grain sorghum. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 19.4 gpa at 4.1 mph and 30 psi. Application, environmental, and weed information are shown in Table 1. Plots were 10 by 35 feet and arranged in a randomized complete block design with four replications. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual weed control was determined on June 20 and July 10, 2019; these dates were 17 days after the PRE treatments (DA-B) and 19 days after the POST treatments (DA-C). Grain yields were not determined.

Table 1. Application information.

Application timing	20 days preplant	Preemergence	Early postemergence
Application date	May 14, 2019	June 3, 2019	June 21, 2019
Air temperature (F)	65	86	71
Relative humidity (%)	61	45	75
Soil temperature (F)	56	83	73
Wind speed (mph)	1 to 4	8 to 11	5 to 8
Wind direction	South	South-southwest	North
Soil moisture	Good	Good	Good
Grain sorghum			
Height (inch)	0	0	1 to 3
Leaves (no.)	---	---	1 to 3
Palmer amaranth			
Height (inch)	0	0	1 to 5
Density (plants/m^2)	---	---	10
Kochia			
Height (inch)	0	0	1 to 3
Density (plants/m^2)	---	---	8
Puncturevine			
Diameter (inch)	0	0	3 to 6
Density (plants/m^2)	---	---	3
Russian thistle			
Height (inch)	0	0	1 to 3
Density (plants/m^2)	---	---	2
Velvetleaf			
Height (inch)	0	0	0.5 to 2
Density (plants/m^2)	---	---	5
Green foxtail			
Height (inch)	0	0	2 to 3
Density (plants/m^2)	---	---	1

Control of Russian thistle, velvetleaf, and green foxtail was 91% or more regardless of herbicide or evaluation date (data not shown). Palmer amaranth control at 17 DA-B and 19 DA-C was best when *S*-metolachlor/mesotrione was applied 20 days preplant (DPP) followed by KFD-365-02 with atrazine or 2,4-D POST (Table 2). The lack of Palmer amaranth control from POST applications of KFD-365-02 was due to resistance of the weed biotype to imidazolinone herbicides. Most herbicides controlled kochia 88 to 96% at 17 DA-B; KFD-365-02 at 0.047 or 0.07 lb/A PRE followed by atrazine POST did not. By 19 DA-C, no difference occurred among herbicides for kochia control. Similarly, puncturevine control at 17 DA-B was similar among herbicide treatments. By 19 DA-C, puncturevine control was 80% or more with all herbicides except *S*-metolachlor/mesotrione PRE followed by KFD-356-02 POST or KFD-365-02 at 0.047 lb/A plus atrazine PRE followed by 2,4-D POST. No visible crop injury was observed from any treatment, and grain yields could not be determined due to the intense Palmer amaranth pressure.

Table 2. Weed control in imidazolinone-resistant sorghum.

Treatment[1]	Rate	Timing[2]	Palmer amaranth		Kochia		Puncturevine	
			17 DA-B[3]	19 DA-C[3]	17 DA-B	19 DA-C	17 DA-B	19 DA-C
	lb/A							
Glyphosate	0.95	PRE	---	---	---	---	---	---
AMS	1.0%	PRE						
S-metolachlor/ Mesotrione	1.84	20 DPP	86	78	94	90	88	70
KFD-365-02	0.047	POST						
COC	1.0%	POST						
S-metolachlor/ Mesotrione	1.84	20 DPP	95	96	95	95	85	83
KFD-365-02	0.047	POST						
Atrazine	1.0%	POST						
COC	1.0	POST						
S-metolachlor/ Mesotrione	1.84	20 DPP	89	88	96	88	85	80
KFD-365-02	0.047	POST						
2,4-D amine	0.24	POST						
KFD-365-02	0.047	PRE	79	58	95	98	88	75
Atrazine	1.0	PRE						
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
2,4-D amine	0.24	POST						
KFD-365-02	0.07	PRE	76	50	95	93	98	80
Atrazine	1.0	PRE						
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
2,4-D amine	0.24	POST						
KFD-365-02	0.047	PRE	78	65	88	98	95	83
S-metolachlor	0.96	PRE						
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
Atrazine	1.0	POST						
COC	1.0%	POST						
KFD-365-02	0.07	PRE	73	68	88	88	95	85
S-metolachlor	0.96	PRE						
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
Atrazine	1.0	POST						
COC	1.0%	POST						
KFD-365-02	0.047	PRE	78	64	84	88	90	80
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
Atrazine	1.0	POST						
COC	1.0%	POST						
KFD-365-02	0.07	PRE	78	60	80	85	95	81
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
Atrazine	1.0	POST						
COC	1.0%	POST						
S-metolachlor	0.96	PRE	78	60	90	90	98	90
Glyphosate	0.95	PRE						
AMS	1.0%	PRE						
Atrazine	1.0	POST						
COC	1.0%	POST						
S-metolachlor	0.96	PRE	80	64	91	93	100	85
Atrazine	1.0	PRE						
Glyphosate	0.95	PRE						
AMS	1.0	PRE						
KFD-365-02	0.047	POST						
COC	1.0%	POST						

S-metolachlor	0.96	PRE	78	65	98	100	100	90
Atrazine	1.0	PRE						
Glyphosate	0.95	PRE						
AMS	1.0	PRE						
KFD-365-02	0.047	POST						
2,4-D amine	0.24	POST						
S-metolachlor	0.96	PRE	78	48	95	98	93	80
Atrazine	1.0	PRE						
Glyphosate	0.95	PRE						
AMS	1.0	PRE						
2,4-D amine	0.24	POST						
LSD (0.05)			11	17	11	NS	NS	10

[1] AMS is ammonium sulfate, COC is crop oil concentrate.
[2] 20 DPP is 20 days preplant, PRE is preemergence, and POST is early postemergence.
[3] 17 DA-B is 17 days after the preemergence treatments, 19 DA-C is 19 days after the early postemergence applications.

Evaluation of pinoxaden/fenoxaprop for wild oat control in spring wheat. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A field study was conducted at the Meyer Farm near Pullman, WA to evaluate crop safety and wild oat (AVEFA) control with pinoxaden/fenoxaprop. The study area followed winter wheat. 'Whit' spring wheat was seeded on April 26, 2019 at the rate of 117 lb/A with a John Deere 455 double disc drill on a 7-inch row spacing at 1-inch depth. Nitrogen and sulfur were applied prior to planting at a rate of 80 and 20 lb/A, respectively. At planting, nitrogen and phosphorus were applied at 10 and 20 lb/A, respectively. Plots were 10 ft by 35 ft and arranged in a randomized complete block design with four replications. All herbicide treatments were applied on May 28, 2019 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 48 psi at 2.3 mph (Table 1). Wheat was at the two-tiller stage and was 12 inches tall. Wild oat plants were 3 inches tall and there was an average of 12 plants per square yard. However, these wild oat counts only represented a fraction of what was in the study area. There were many AVENA plants within the row that were difficult to distinguish from the spring wheat at the time of application. Data were analyzed with SAS 9.4 PROC GLM. Treatment means were separated using Fisher's protected LSD test when the model was significant at $P \leq 0.05$.

Table 1. Application and soil data.

Location	Meyer Farm Pullman, Washington
Application date	May 28, 2019
Application type	postemergence
Air temperature (F)	80
Relative humidity (%)	36
Wind (mph, direction)	6, W
Cloud cover (%)	30
Soil temperature at 6 inch (F)	58
pH	5.0
OM (%)	4.2
Texture	silt loam

The trial site was uniformly and heavily infested with AVEFA. In general, group 1 herbicides including pinoxaden/fenoxaprop, pinoxaden, fenoxaprop and clodinafop-propargyl, provided better control than group 2 herbicides including flucarbazone-sodium, propoxycarbazone-sodium and fluroxypyr/pyroxsulam (Table 2). None of the treatments provided commercially acceptable (> 80%) control. Pinoxaden/fenoxaprop was the only treatment to come close to this level of control. Propoxycarbazone-sodium- and fluroxypyr/pyroxsulam- treated plots yielded similarly to the nontreated check plots. Yields were increased by all other treatments when compared to the nontreated check. No crop injury was observed with any of the treatments in this study. Some AVEFA populations in Washington, including the population in this study, are now resistant to pinoxaden. Pinoxaden has helped to keep AVEFA under control for many years, but as this study demonstrates, our ability to control AVEFA with pinoxaden is diminishing. The addition of fenoxaprop to pinoxaden provides some additional control of AVEFA, but it may be insufficient for the control of populations already resistant to pinoxaden.

Table 2. Postemergence control of AVEFA in spring wheat with herbicides near Pullman, Washington in 2019.

Treatment	Rate	6/17/19	7/2/19	7/15/19	8/19/19 Yield
		AVEFA control			
	lb ai/A	-------------------0 to 100%-------------------			bu/A
nontreated check	--	--	--	--	27
pinoxaden/fenoxaprop	0.21	58	75	71	46
pinoxaden	0.21	10	38	35	43
fenoxaprop	0.11	40	58	54	42
clodinafop-propargyl[1]	0.21	33	46	49	41
flucarbazone-sodium[2]	0.027	5	35	23	38
propoxycarbazone-sodium[3]	0.039	5	20	15	25
fluroxypyr/pyroxsulam[2]	0.13	5	28	13	29
LSD (0.05)		27	25	22	9

[1]Treatment was applied with 98.1% modified vegetable oil (KALO) at 0.25% v/v.
[2]Treatment was applied with 90% nonionic surfactant (R-11) at 0.5% v/v and 32% urea ammonium nitrate (UAN) at 2 qts/A.
[3]Treatment was applied with 90% nonionic surfactant (R-11) at 0.5% v/v.

Downy brome control in winter wheat. Traci A. Rauch and Joan M. Campbell. (Dept of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Two studies were established to evaluate downy brome control with quizalofop in Co-AXium 'Fusion AX' winter wheat and with mesosulfuron/thiencarbazone combined with pyroxasulfone in 'Brundage96' winter wheat near Moscow, ID. Co-Axium winter wheat was selected by mutagenesis to be tolerant to the non-selective herbicide quizalofop. The plots were arranged in a randomized complete block design with four replications. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer (Table 1). The quizalofop study was oversprayed on May 13, 2019 with pyrasulfotole/bromoxynil at 0.19, florasulam/fluroxypyr at 0.04, and florasulam/MCPA at 0.32 lb ae/A for broadleaf weed control and propiconazole/pyraclostrobin/ fluxapyroxad at 0.3 lb ai/A for stripe rust control. Crop injury and downy brome control were evaluated visually during the growing season. The quizalofop and mesosulfuron/thiencarbazone studies were harvested at crop maturity with a small plot combine on August 5 and 20, 2019, respectively.

Table 1. Application and soil data.

	Quizalofop study		Mesosulfuron/thiencarbazone study	
Winter wheat seeding date	10/12/18		10/16/18	
Application date	4/23/19	5/11/19	10/17/18	5/4/19
Growth stage				
Winter wheat	3 leaf	2 tiller	postplant pre	2 tiller
Downy brome (BROTE)	1 tiller	3 tiller	pre	2 tiller
gpa	15	15	10	10
psi	38	38	34	34
mph	3	3	3	3
Nozzle size	11002	11002	110015	110015
Air temperature (F)	56	82	66	73
Relative humidity (%)	77	25	32	32
Wind (mph, direction)	2, W	3, S	3, W	2, W
Dew present?	yes	no	no	no
Cloud cover (%)	100	10	0	0
Soil moisture	wet	dry	dry	adequate
Soil temperature at 2 inch (F)	50	76	55	68
Next rain occurred	5/17/19	5/17/19	11/2/18	5/17/19
pH	4.5		4.5	
OM (%)	2.6		3.2	
CEC (meq/100g)	13.3		12.5	
Texture	loam		silt loam	

In the quizalofop study, all treatments injured winter wheat 0 to 2% but did not differ among treatments (Table 2). All treatments, except pyroxasulfone alone, controlled downy brome 92 to 99%. Grain yield tended to be lowest for the untreated check but did not differ among all treatments. Grain test weight did not differ among treatments including the untreated check.

In the mesosulfuron/thiencarbazone study, all treatments injured winter wheat 0 to 11% but did not differ among treatments (Table 3). Downy brome control was best with pyroxasulfone combinations and mesosulfuron plus pyrasulfotole/bromoxynil and bromoxynil/MCPA (90 to 99%) but did not differ from pyroxasulfone alone (88%). Grain yield tended to be lowest for the untreated check but did not differ among all treatments. Grain test weight was lowest for the untreated check.

Table 2. Winter wheat response and downy brome control with quizalofop near Moscow, ID in 2019.

Treatment[1]	Rate	Application timing[2]	Downy brome control[3,4]	Winter wheat Injury[3,4]	Winter wheat Yield[4]	Winter wheat Test weight[4]
	lb ai/A		%	%	lb/A	lb/bu
Pyroxasulfone	0.065	2 leaf	56	0	3510	60.4
Quizalofop + NIS	0.055 + 0.25% v/v	2 leaf	99	2	4000	61.0
Pyroxsulam	0.0164	2 leaf	97	2	3829	60.0
Pyroxasulfone +	0.065	2 leaf				
quizalofop +NIS	0.055 + 0.25% v/v	2 tiller	99	0	3715	60.9
Quizalofop + NIS	0.055 + 0.25% v/v	2 tiller	99	1	3604	59.5
Quizalofop + NIS	0.069 + 0.25% v/v	2 tiller	99	0	4087	60.6
Quizalofop + NIS	0.083 + 0.25% v/v	2 tiller	99	0	4124	61.4
Quizalofop + MSO	0.055 + 1% v/v	2 tiller	99	1	3938	60.5
Quizalofop +NIS +	0.055 + 0.25% v/v +					
UAN	20% v/v	2 tiller	99	0	4077	60.9
Pyroxsulam	0.0164	2 tiller	94	0	3950	60.4
Mesosulfuron/thiencarbazone	0.0178	2 tiller	92	0	3744	59.6
Untreated check	--	--	-	--	3239	59.6
LSD (0.05)			10	NS	NS	NS
Density (plants/ft^2)			5			

[1]Pyroxsulam treatments were applied with a non-ionic surfactant at 0.25% v/v and ammonium sulfate at 1.5 lb ai/A. Mesosulfuron/thiencarbazone was applied with a non-ionic surfactant at 0.5% v/v and urea ammonium nitrate at 4 pt/A.

[2]Application timing based on winter wheat growth stage.

[3]Evaluation date June 19, 2019.

[4]Some plots in Rep 4 were not included due to winter flood.

Table 3. Winter wheat response and downy brome control with mesosulfuron/thiencarbazone combined with pyroxasulfone near Moscow, ID in 2019.

Treatment[1]	Rate	Application timing[2]	Downy brome control[3]	Winter wheat Injury[3]	Winter wheat Yield	Winter wheat Test weight
	lb ai/A		%	%	lb/A	lb/bu
Pyroxasulfone	0.08	preemergence	88	0	6852	60.8
Pyroxasulfone +	0.08	preemergence				
mesosulfuron/thiencarbazone	0.0178	2 tiller	99	9	6295	60.6
Pyroxasulfone +	0.08	preemergence				
mesosulfuron/thiencarbazone +	0.0178	2 tiller				
pyrasulfotole/bromoxynil	0.217	2 tiller	98	6	6846	61.3
Pyroxasulfone +	0.08	preemergence				
mesosulfuron/thiencarbazone +	0.0178	2 tiller				
pyrasulfotole/bromoxynil +	0.217	2 tiller				
bromoxynil/MCPA	0.5	2 tiller	98	7	6270	60.5
Pyroxasulfone +	0.08	preemergence				
mesosulfuron +	0.0134	2 tiller				
pyrasulfotole/bromoxynil +	0.217	2 tiller				
bromoxynil/MCPA	0.5	2 tiller	98	5	6486	60.8
Mesosulfuron/thiencarbazone	0.0178	2 tiller	72	2	6418	60.1
Mesosulfuron/thiencarbazone +	0.0178	2 tiller				
pyrasulfotole/bromoxynil	0.217	2tiller	76	5	6829	60.7
Mesosulfuron/thiencarbazone +	0.0178	2 tiller				
pyrasulfotole/bromoxynil +	0.217	2 tiller				
bromoxynil/MCPA	0.5	2 tiller	78	8	6388	60.4
Mesosulfuron +	0.0134	2 tiller				
pyrasulfotole/bromoxynil +	0.217	2 tiller				
bromoxynil/MCPA	0.5	2 tiller	90	11	6462	60.7
Untreated check	--	--	-	-	5634	59.2
LSD (0.05)			11	NS	NS	0.7
Density (plants/ft^2)			5			

[1]All treatments, except pyroxasulfone alone, were applied with a non-ionic surfactant at 0.25% v/v and urea ammonium nitrate at 5% v/v.
[2]Application timing based on winter wheat growth stage.
[3]Evaluation date June 7, 2019.

<u>Evaluation of quizalofop-P herbicide for the control of downy brome in the CoAXium™ wheat production system</u>. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A field study was conducted at the Cochran Farm near Walla Walla, WA to evaluate crop safety and downy brome (BROTE) control with quizalofop-P. LCS Fusion AX winter wheat was direct seeded. Plots were 10 ft by 35 ft and arranged in a randomized complete block design with four replications. All herbicide treatments were applied on April 4, 2019 with a CO_2-powered backpack sprayer set to deliver 15 gpa at 47 psi at 1.5 mph (Table 1). Wheat ranged from the 3- to 8-tiller stage, had an average height of 8 inches and was beginning to grow upright. Downy brome plants ranged in height from 2 to 6 inches tall, most were tillered and there was an average of 40 plants per square foot. Data were analyzed with SAS 9.4 PROC GLM. Treatment means were separated using Fisher's protected LSD test when the model was significant at $P \leq 0.05$.

Table 1. Application and soil data.

Location	Cochran Farm Walla Walla, Washington
Application date	April 4, 2019
Application type	postemergence
Wheat growth stage	3-8 tiller
Downy brome density	40 plants per sq. ft.
Air temperature (F)	59
Relative humidity (%)	36
Wind (mph, direction)	2, SW
Cloud cover (%)	100
Soil temperature at 6 inch (F)	58
Texture	silt loam

The trial site was uniformly and heavily infested with BROTE. There was no crop injury observed among any of the treatments. The level of BROTE control between the three rates of quizalofop-P evaluated was not significantly different (Table 2). Downy brome control with quizalofop-P was not influenced by the addition of NIS, MVO or UAN. On the April 30th rating date, 26 days after application, all quizalofop-P treatments were providing greater than 95% control of BROTE. On the same rating date, mesosulfuron and pyroxsulam were providing approximately 50% control. On the final rating date, June 6th, all quizalofop-P treatments were providing outstanding control of downy brome, whereas mesosulfuron and pyroxsulam essentially were providing no control. Downy brome resistance to Group 2 herbicides like mesosulfuron, pyroxsulam, imazamox, and sulfosulfuron is common in the Walla Walla area. This trial demonstrated the effectiveness of the CoAXium Wheat Production System for the control of BROTE.

Table 2. Postemergence control of BROTE in LCS Fusion AX winter wheat with herbicides near Walla Walla, Washington in 2019.

Treatment	Rate	4/19/19	4/30/19	6/6/19
		BROTE control		
	lb ai/A	-------------------0 to 100%--------------------		
quizalofop-P[1]	0.055	73	96	98
quizalofop-P[1]	0.069	73	100	100
quizalofop-P[1]	0.083	73	99	100
quizalofop-P[2]	0.055	73	98	99
quizalofop-P[3]	0.055	68	95	99
quizalofop-P[3]	0.069	75	100	100
quizalofop-P[4]	0.069	75	100	100
mesosulfuron[5]	0.013	58	53	20
pyroxsulam[5]	0.016	58	48	18
nontreated check	--	--	--	--
LSD (0.05)		8	4	3

[1]Treatment was applied with 90% nonionic surfactant (R-11) at 0.25% v/v.

[2]Treatment was applied with 98.1% modified vegetable oil (KALO) at 1.0% v/v.

[3]Treatment was applied with 90% nonionic surfactant (R-11) at 0.5% v/v and 98.1% modified vegetable oil (KALO) at 0.5% v/v.

[4]Treatment was applied with 90% nonionic surfactant (R-11) at 0.25% v/v and 32% urea ammonium nitrate (UAN) at 3 gal/A.

[5]Treatment was applied with 90% nonionic surfactant (R-11) at 0.5% v/v and 32% urea ammonium nitrate (UAN) at 0.5 gal/A.

Grass and broadleaf weed control in winter wheat with mesosulfuron/thiencarbazone. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established to evaluate rattail fescue, jointed goatgrass, and mayweed chamomile control with mesosulfuron/thiencarbazone alone or in combination in winter wheat 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). Crop injury and weed control were evaluated visually during the growing season.

Table 1. Application and soil data.

Application date	5/13/2019
Growth stage	
Winter wheat	2 tiller
Rattail fescue	3 tiller
Jointed goatgrass	3 tiller
Mayweed chamomile	2 inch
Air temperature (F)	82
Relative humidity (%)	26
Wind (mph, direction)	2, SW
Cloud cover (%)	100
Next moisture occurred	5/17/2019
Soil moisture	dry
Soil temperature at 2 inch (F)	80
pH	4.9
OM (%)	3.0
CEC (meq/100g)	18.1
Texture	silt loam

At 17 DAT, all herbicide combinations with mesosulfuron/thiencarbazone injured winter wheat 5 to 8%, except pyrasulfotole/bromoxynil alone (Table 2). No visual injury was evident by 33 DAT (data not shown). At 17 DAT, mesosulfuron/thiencarbazone combined with pyrasulfotole/bromoxynil and bromoxynil/MCPA controlled rattail fescue 88%. AT 66 DAT, rattail fescue control did not differ among all treatments (94 to 96%). Jointed goatgrass control did not differ among treatments but tended to be better with mesosulfuron/thiencarbazone plus pyrasulfotole/bromoxynil alone or combined with bromoxynil/MCPA. All treatments, except mesosulfuron/thiencarbazone alone, controlled mayweed chamomile 94 to 98%.

Table 2. Weed control and winter wheat response with mesosulfuron/thiencarbazone combinations in 2019.

			Weed control			
		Wheat[2]	Rattail fescue		Jointed[3]	Mayweed[3]
Treatment[1]	Rate	injury	17 DAT	66 DAT	goatgrass	chamomile
	lb ai/A	%	%	%	%	%
Mesosulfuron/thiencarbazone	0.0178	2	75	95	68	81
Mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil	0.0178 0.217	0	80	95	85	94
Mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + bromoxynil/MCPA	0.0178 0.217 0.5	8	88	94	87	97
Mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + florasulam/fluroxypyr	0.0178 0.217 0.092	6	80	96	79	97
Mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + clopyralid/fluroxypyr	0.0178 0.217 0.188	5	80	95	77	98
LSD (0.05)		4	6	NS	NS	6
Density (plants/ft^2)			10		1	1

[1]All treatments were applied with a non-ionic surfactant at 0.25% v/v and urea ammonium nitrate at 5% v/v.
[2]17 days after treatment.
[3]66 days after treatment.

Broadleaf weed control in winter wheat with fluroxypyr/halauxifen. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established to evaluate prickly lettuce and mayweed chamomile control with fluroxypyr/halauxifen compared to standards in winter wheat 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). Crop injury and weed control were evaluated visually during the growing season.

Table 1. Application and soil data.

Application date	5/14/2019
Growth stage	
Winter wheat	2 tiller
Prickly lettuce	2 inch
Mayweed chamomile	2 inch
Air temperature (F)	71
Relative humidity (%)	38
Wind (mph)	0
Cloud cover (%)	100
Next moisture occurred	5/17/2019
Soil moisture	dry
Soil temperature at 2 inch (F)	60
pH	5.1
OM (%)	3.0
CEC (meq/100g)	15.5
Texture	silt loam

No treatment visibly injured winter wheat (data not shown). Pyrasulfotole/bromoxynil and fluroxypyr/clopyralid combined with halauxifen/florasulam controlled prickly lettuce 95% at 34 DAT and mayweed chamomile 92 to 94% at 34 DAT and 95% at 80 DAT (Table 2). The same treatments plus fluroxypyr/halauxifen combined with 2,4-D ester controlled prickly lettuce 90 to 99% at 80 DAT.

Table 2. Prickly lettuce and mayweed chamomile control with fluroxypyr/halauxifen compared to standards in 2019.

		Weed control			
		Prickly lettuce		Mayweed chamomile	
Treatment[1]	Rate	34 DAT	80 DAT	34 DAT	80 DAT
	lb ai/A	%	%	%	%
Fluroxypyr/halauxifen	0.114	68	60	38	64
Fluroxypyr/halauxifen +	0.114				
2,4-D ester	0.344	79	90	73	77
Fluroxypyr/clopyralid	0.188	84	80	79	87
Fluroxypyr/clopyralid +	0.188				
halauxifen/florasulam	0.0096	95	99	94	95
Fluroxypyr/pyroxsulam	0.132	50	62	28	45
Pyrasulfotole/bromoxynil	0.217	95	99	92	95
LSD (0.05)		22	17	17	18
Density (plants/ft^2)		3		3	

[1]All treatments were applied with a non-ionic surfactant at 0.25% v/v, except pyrasulfotole/bromoxynil. Fluroxypyr/pyroxsulam and pyrasulfotole/bromoxynil were applied with ammonium sulfate at 1.56% v/v.

The effect of disturbance on Italian ryegrass control with pyroxasulfone in winter wheat. Traci A. Rauch and Joan M. Campbell. (Dept of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established near Moscow, ID to evaluate winter wheat response and Italian ryegrass (LOLMU) control with pyroxasulfone and pyroxasulfone/carfentrazone in winter wheat applied at four application times: pre-fertilization, post-fertilization, postplant preemergence pre-germination, and postplant preemergence post-germination. Gypsum potash mix was applied and cultivated into the field (post fertilization timing). Anhydrous fertilizer was applied with a shank style applicator during seeding. Pyroxasulfone (0.08 lb ai) and pyroxasulfone/carfentrazone (0.10 lb ai of pyroxasulfone) were applied at the 2015 highest labeled rate for this soil type. 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 study area was oversprayed with glyphosate at 1.25 lb ae/A on September 24, 2018 and thifensulfuron/tribenuron at 0.031 lb ai/A, pyrasulfotole/bromoxynil at 0.193 lb ai/A, and florasulam/fluroxypyr at 0.092 lb ai/A for broadleaf weed control and azoxystrobin/propiconazole at 0.131 lb ai/A for stripe rust control on May 22, 2019. Wheat injury and Italian ryegrass control were evaluated visually during the growing season. Grain was harvested with a small plot combine on August 21, 2019.

Table 1. Application and soil data.

Wheat variety – seeding date	Puma – 10/8/18			
Application date	9/24/18	10/2/18	10/8/18	11/5/18
Application timing	pre-fertilization	post-fertilization	postplant pre- no germ	postplant pre- germ
Wheat	preplant	preplant	no germination	1 in root/ 0.25 in shoot
Italian ryegrass	pre	pre	pre	germinating
Air temperature (F)	48	52	58	45
Relative humidity (%)	68	100 -raining	48	78
Wind (mph, direction)	0	0	0	0
Cloud cover (%)	100	100	100	100
Soil moisture	dry	dry (surface wet)	dry	adequate
Soil temperature at 2 inch (F)	60	51	55	40
Next rain occurred	11/2/18	11/2/18	11/2/18	11/24/18
pH	5.1			
OM (%)	3.0			
CEC (meq/100g)	15.5			
Texture	silt loam			

No winter wheat injury was visible at any evaluation date (data not shown). Italian ryegrass control was best with pyroxasulfone/carfentrazone (89%) at the postplant germination timing but did not differ from pyroxasulfone/carfentrazone postplant no germination or the post fertilization timing and pyroxasulfone alone at the postplant germination or no germination timing (72 to 83%) (Table 2). Flufenacet/metribuzin did not control Italian ryegrass most likely due to a resistant population which will be tested in the greenhouse. Weed control across all application timings was better with pyroxasulfone/carfentrazone compared to pyroxasulfone alone due to a greater amount of active ingredient. Timely adequate rainfall to activate the herbicide was lacking at all application dates; therefore, pyroxasulfone active ingredient rate was critical compared to the effect of disturbance. Italian ryegrass control was 62 versus 76% with 0.08 and 0.10 lb ai/A pyroxasulfone, respectively.

Winter wheat grain yield and test weight did not differ among treatments including the untreated check. Wheat grain yield tended to be lowest with the untreated check. Average grain yield for pyroxasulfone alone was 3719 lb/A and for pyroxasulfone/carfentrazone was 3934 lb/A which was mostly like due to the pyroxasulfone active ingredient rate being higher in the pyroxasulfone/carfentrazone.

Table 2. Winter wheat response and Italian ryegrass control with pyroxasulfone treatments applied at four times near Moscow, ID in 2019.

Treatment	Rate	Application timing[1]	Adequate rainfall[2]	LOLMU control[3]	Wheat	
					Yield	Test weight
	lb ai/A		(DAA)	%	lb/A	lb/bu
Pyroxasulfone	0.08	pre-fert	39	48	3254	61.5
Pyroxasulfone/carfentrazone	0.109	pre-fert	39	60	3188	61.6
Pyroxasulfone	0.08	post-fert	31	54	3623	61.6
Pyroxasulfone/carfentrazone	0.109	post-fert	31	72	3955	61.7
Pyroxasulfone	0.08	postplant-no germ	25	72	4084	61.7
Pyroxasulfone/carfentrazone	0.109	postplant-no germ	25	83	4112	62.0
Pyroxasulfone	0.08	germination	19	76	3916	61.6
Pyroxasulfone/carfentrazone	0.109	germination	19	89	4483	61.6
Flufenacet/metribuzin	0.425	germination	19	40	3688	60.8
Untreated check			--	--	2528	62.1
LSD (0.05)				25	NS	NS
Density (plants/ft^2)				15	--	--

[1]Pre-fert = Before fertilization. Post-fert = After potash/gypsum mixture cultivated. Postplant = Wheat planted but not germinated.

[2]Rainfall over 0.3 inch.

[3]LOLMU = Italian ryegrass. Evaluation date July 15, 2019.

Wheat tolerance to bicyclopyrone/bromoxynil. Traci A. Rauch and Joan M. Campbell. (Weed Science, University of Idaho, Moscow, ID 83844-2333) Fertilizers as a carrie or as an adjuvant with grass herbicides can sometimes cause crop injury when combined with bicyclopyrone/bromoxynil. Application timing is also critical in reducing crop response. Studies were established to evaluate crop tolerance with bicyclopyrone/bromoxynil herbicide combined with fertilizers alone or as an adjuvant with grass herbicides in 'Magic' winter wheat and application timing in 'Ryan' spring wheat at the University of Idaho Plant Science Farm 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 3 mph (Table 1 and 2). Crop injury was evaluated visually during the growing season. Grain was harvested with a small plot combine on August 6 and 21, 2019 in winter and spring wheat, respectively.

Table 1. Application and soil data for winter wheat studies.

	Fertilizer	Grass herbicides
Winter wheat seeding date	10/9/18	10/9/18
Application date	4/25/19	5/4/19
Growth stage		
Winter wheat	2 tiller	2 tiller
Air temperature (F)	69	66
Relative humidity (%)	28	44
Wind (mph)	0	0
Dew present?	no	yes
Cloud cover (%)	90	10
Next rain occurred	5/17/19	5/17/19
Soil		
Moisture	adequate	adequate
Temperature at 2 inch (F)	60	60
pH	4.5	
OM (%)	4.1	
CEC (meq/100g)	14.0	
Texture	silt loam	

Table 2. Application and soil data for spring wheat study.

Application timing (growth stage)	Two tiller	Joint	Swollen boot	Head visible (25%)
Application date	5/30/19	6/12/19	6/18/19	6/22/19
Air temperature (F)	70	85	62	77
Relative humidity (%)	63	40	70	45
Wind (mph), direction	2, E	1, S	1, W	2, S
Cloud cover (%)	0	30	0	40
Next rain occurred	6/6/19	6/20/19	6/20/19	6/27/19
Soil				
Moisture	adequate	adequate	adequate	adequate
Temperature at 2 inch (F)	62	75	63	76
pH	4.6			
OM (%)	3.6			
CEC (meq/100g)	16.5			
Texture	silt loam			

In the bicyclopyrone/bromoxynil plus various fertilizers study, no treatment visibly injured winter wheat (data not shown). Grain yield and test weight did not differ among treatments (Table 3).

In the bicyclopyrone/bromoxynil plus grass herbicides with and without UAN (urea ammonium nitrate) study, bicyclopyrone/bromoxynil alone plus UAN, mesosulfuron/thiencarbazone alone or combined with bicyclopyrone/bromoxynil plus UAN, and imazamox combined with bicyclopyrone/bromoxynil plus UAN injured winter wheat 4 to 11% at 5 DAT (Table 4). At 10 DAT, bicyclopyrone/bromoxynil plus UAN and imazamox combined with bicyclopyrone/bromoxynil plus UAN injured winter wheat 15%. Grain yield and test weight did not differ among treatments (Table 4).

In the application timing study, no treatment visibly injured spring wheat (data not shown). Grain yield did not differ among treatments including the untreated check (Table 5). Grain test weight was greater for the untreated check and the joint application time compared to the swollen boot timing.

Table 3. Winter wheat response with bicyclopyrone/bromoxynil combined with various fertilizers as carriers near Moscow, Idaho in 2019.

Treatment[1]	Rate	Yield	Test weight
	lb ai/A	lb/A	lb/bu
Bicyclopyrone/bromoxynil	0.193	6025	62.1
Bicyclopyrone/bromoxynil +	0.193		
urea ammonium nitrate (URAN 32% -McGregor Co.)	25% v/v	5859	61.4
Bicyclopyrone/bromoxynil +	0.193		
urea nitrogen/methylene urea/triazone urea (NDemand 30L)	25% v/v	5886	62.0
Bicyclopyrone/bromoxynil +	0.193		
urea nitrogen/triazone urea/methylene urea (Maximum N-Pact)	25% v/v	5793	62.1
Bicyclopyrone/bromoxynil +	0.193		
urea nitrogen (Stand 12-0-2)	25% v/v	5838	62.1
Bicyclopyrone/bromoxynil +	0.193		
urea nitrogen/methylene urea/methylene diurea (CoRoN 28-0-0)	25% v/v	5952	62.1
Bicyclopyrone/bromoxynil +	0.193		
liquified urea	30% v/v	6223	61.6
Bicyclopyrone/bromoxynil +	0.193		
liquified urea	50% v/v	6254	62.2
Bicyclopyrone/bromoxynil +	0.193		
liquified urea	85% v/v	6187	62.0
LSD (0.05)		NS	NS

[1]All treatments were applied with a buffer, sodium bicarbonate (CoAct+), at 0.58 lb ai/A w and a nonionic surfactant (R-11) at 0.25% v/v. Trade name of fertilizer is listed in parentheses.

Table 4. Wheat response with bicyclopyrone/bromoxynil combined with grass herbicides and fertilizer near Moscow, ID in 2019.

Treatment[1]	Rate	Wheat injury		Wheat	
		5 DAT	10 DAT	Yield	Test weight
	lb ai/A	%	%	lb/A	lb/bu
Bicyclopyrone/bromoxynil	0.193	0	0	6914	61.9
Bicyclopyrone/bromoxynil +	0.193				
UAN	15% v/v	9	15	6466	61.8
Bicyclopyrone/bromoxynil +	0.193				
pyroxsulam	0.0164	0	0	6557	62.0
Bicyclopyrone/bromoxynil +	0.193				
pyroxsulam +	0.0164				
UAN	15% v/v	1	3	6448	61.9
Bicyclopyrone/bromoxynil +	0.193				
mesosulfuron/thiencarbazone	0.0178	2	0	6964	62.3
Bicyclopyrone/bromoxynil +	0.193				
mesosulfuron/thiencarbazone +	0.0178				
UAN	15% v/v	4	1	6497	61.8
Bicyclopyrone/bromoxynil +	0.193				
imazamox	0.047	2	4	6259	61.8
Bicyclopyrone/bromoxynil +	0.193				
imazamox +	0.047				
UAN	15% v/v	11	15	6632	61.7
Pyroxsulam +	0.0164				
UAN +	15% v/v				
NIS	0.25% v/v	0	0	6827	61.8
Mesosulfuron/thiencarbazone +	0.0134				
UAN +	15% v/v				
NIS	0.25% v/v	5	9	6633	61.9
Imazamox +	0.047				
UAN +	15% v/v				
NIS	0.25% v/v	0	0	7620	62.4
LSD (0.05)		3	1	NS	NS

[1]All treatments were applied with a buffer, sodium bicarbonate (CoAct+), at 0.58 lb ai/A w and a nonionic surfactant (R-11) at 0.25% v/v. UAN is urea ammonium nitrate (fertilizer).

Table 5. Spring wheat response with bicyclopyrone/bromoxynil applied at various timings near Moscow, Idaho in 2019.

Treatment[1]	Rate	Application timing	Yield	Test weight
	lb ai/A		lb/A	lb/bu
Bicyclopyrone/bromoxynil	0.193	2 tiller	5972	63.2
Bicyclopyrone/bromoxynil	0.193	joint	5702	63.4
Bicyclopyrone/bromoxynil	0.193	swollen boot	5850	62.8
Bicyclopyrone/bromoxynil	0.193	visible head (25%)	5716	63.1
Untreated check	--	--	6005	63.4
LSD (0.05)			NS	0.4

[1]All treatments were applied with a buffer, sodium bicarbonate (CoAct+), at 0.58 lb ai/A w and a nonionic surfactant (R-11) at 0.25% v/v.

Broadleaf weed control in chickpea. Joan Campbell and Traci Rauch. (Plant Sciences Department, University of Idaho, Moscow, ID) An experiment was established near Genesee, ID to evaluate combinations of spring preplant, postplant pre-emergence (postplantpre), and postemergence herbicide applications for efficacy and crop tolerance in 'Sierra' chickpea. Treatments consisted of various combinations including linuron, metribuzin, flumioxazin, sulfentrazone, saflufenacil, dimethenamid and pyridate. Plot size was 8 by 25 feet. Herbicides were applied at 20 gpa with a CO_2 pressurized sprayer at 32 psi and 3 mph (Table 1). The randomized complete block experiment had four replications and analysis of variance was used to statistically separate treatment effects. Chickpea was direct seeded May 9, 2019 with a Flexicoil drill equipped with Barton II disc openers. Soil was a silt loam with 5.3 pH, 3.5% organic matter, and 18.9 meq/100 g CEC. Crop injury and weed control were measured throughout the season and chickpea seed was harvested at maturity.

Table 1. Environmental application data.

	Preplant	Postplantpre	Postemergence
Application time	April 13	May 13	June 17
Chickpea stage (inch)	not planted	non-germinated seed	10 to 12
Lambsquarters, common (inch)	-	-	0.5 to 3
Pigweed, redroot (inch)	-	-	0.5 to 1
Air temperature (F)	72	79	70
Relative humidity (%)	44	27	63
Soil temperature (F)	60	62	71
Soil moisture	wet	good	good, dry surface
Next rainfall occurred	April 20	May 15	June 20
Rainfall 1 week after app. (inch)	0.33	1.37	0.25

Common lambsquarters was the main weed present followed by redroot pigweed. Prickly lettuce, sowthistle, shepherd's-purse and field pennycress plants were too sparse to evaluate. On June 2, all treated plots had 1 to 3 common lambsquarters plants and 0 to 2 pigweed plants except sulfentrazone (preplant) followed by metribuzin + saflufenacil (postplantpre) and sulfentrazone (preplant) followed linuron (postplantpre) (Table 2). On August 1, most treatments controlled common lambsquarters 93% or better except sulfentrazone (preplant) followed by metribuzin + saflufenacil (postplantpre) and sulfentrazone (preplant) followed linuron (postplantpre) with 75 and 79% control, respectively.

Chickpea yield was higher than the untreated check (1711 lb/a) with all treatments except sulfentrazone (preplant) followed by metribuzin + saflufenacil (postplantpre) (1896 lb/a). Yield was highest with sulfentrazone + dimethenamid applied postplantpre (2752 lb/a) and was statistically higher than sulfentrazone (preplant) followed by metribuzin + saflufenacil (postplantpre) (1896 lb/a) and metribuzin + saflufenacil (postplantpre) (2234 lb/a).

Table 2. Broadleaf weed control in chickpea near Genesee, Idaho, 2019.

Treatment	Rate	Timing	June 2 Common lambsquarters	June 2 Redroot pigweed	August 1 Common lambsquarters	Chickpea seed yield
	lb ai/a		plants per plot		%	lb/a
Nontreated			213	46	-	1711
Sulfentrazone	0.25	Preplant	18	2	75	1896
Metribuzin	0.375	PostPlantPre				
Saflufenacil	0.0445	PostPlantPre				
Sulfentrazone	0.25	Preplant	2	1	95	2657
Metribuzin	0.375	PostPlantPre				
Saflufenacil	0.0445	PostPlantPre				
Pyridate	1.88	Postemerge				
Sulfentrazone	0.25	Preplant	1	0	97	2420
Pyridate	1.88	Postemerge				
Metribuzin	0.375	PostPlantPre	2	0	94	2234
Saflufenacil	0.0445	PostPlantPre				
Metribuzin	0.375	PostPlantPre	1	1	99	2356
Saflufenacil	0.0445	PostPlantPre				
Linuron	0.625	PostPlantPre				
Flumioxazin	0.064	PostPlantPre	3	1	93	2315
Linuron	0.625	PostPlantPre				
Flumioxazin	0.064	PostPlantPre	1	0	97	2498
Dimethenamid	0.98	PostPlantPre				
Sulfentrazone	0.25	Preplant	15	9	79	2259
Linuron	0.625	PostPlantPre				
Sulfentrazone	0.25	PostPlantPre	1	0	97	2532
Linuron	0.625	PostPlantPre				
Sulfentrazone	0.25	Preplant	1	0	99	2652
Dimethenamid	0.98	PostPlantPre				
Sulfentrazone	0.25	PostPlantPre	1	1	94	2752
Dimethenamid	0.98	PostPlantPre				
Metribuzin	0.375	PostPlantPre	3	0	99	2672
Saflufenacil	0.0445	PostPlantPre				
Pyridate	1.88	Postemerge				
LSD (0.10)			72	20	11	509

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