WESTERN SOCIETY OF WEED SCIENCE

2021 RESEARCH PROGRESS REPORT

ISSN-0090-8142

March 1-4, 2021

FOREWORD

The 2021 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.

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Winter annual grass control with aerial and ground application of indaziflam and imazapic. Georgia R. Harrison, Lisa C. Jones, and Timothy S. Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333). A study was established at Rinker Rock Creek Ranch near Hailey, ID to observe how helicopter, fixed wing airplane, and ground application volumes affect indaziflam efficacy for control of invasive winter annual grasses. Indaziflam and imazapic were applied on September 16 and 19, 2019 (Table 1). Fixed wing airplane and helicopter treatments were of 2.5, 5, 10, and 20 gpa and UTV ground applications were of 10 and 20 gpa of indaziflam alone and indaziflam and imazapic, such that there were eight treatments for each aerial application and four treatments for the ground application. Indaziflam and imazapic were applied at 0.065 lb ai/A and 0.078 lb ai/A, respectively. All treatments were applied with a non-ionic surfactant at 0.25% v/v.

Permanent assessment plots 3 sq m were arranged within treatment areas in locations that were representative of the surrounding plant community assemblages. Pre-treatment plant cover was recorded on October 3, 2019 and post-treatment plant cover was recorded on June 10, 2020. Within each plot, plant foliar cover was recorded using cover classes; data was analyzed using the midpoint of cover classes averaged among treatment groups. Percent control was summarized by summing midpoint cover of both downy brome (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*). Vegetation response within plots will be monitored in summer 2021 to assess long-term treatment efficacy.

Table 1. Application and soil data.

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

All treatments controlled winter annual grass cover 49 to 100% compared to the untreated check (Table 2). The best control was achieved with helicopter application of indaziflam and imazapic at 10 and 20 gpa, and ground application of indaziflam + imazapic at 10 gpa (Table 2). Fixed wing airplane application of both herbicide treatments at 2.5 and 5 gpa had the worse control (Table 2). Helicopter application of indaziflam + imazapic at 2.5 gpa, fixed wing airplane application of indaziflam only at 2.5 and 5 gpa and indaziflam + impazapic at 2.5 gpa, and ground application of indaziflam at 10 and 20 gpa all had significantly less control on winter annual grasses than other treatments (Table 2). Continued monitoring of permanent plots may elucidate any differences related to chemical treatment and application type.

Table 2. Control of winter annual grasses applied at different volumes.

Application type	Treatment[1]	Application volume	Winter annual grass cover[2] Pre-treatment[3]	9 MAT[4]	Average control	
		gpa	----------%		----------	
--	Untreated check	--	45	34	---	
Helicopter	Indaziflam	2.5	45	9	76	abcde
Helicopter	Indaziflam + imazapic	2.5	75	35	56	def
Helicopter	Indaziflam	5	55	10	81	abcd
Helicopter	Indaziflam + imazapic	5	42	8	79	abcde
Helicopter	Indaziflam	10	39	3	93	ab
Helicopter	Indaziflam + imazapic	10	43	0	100	a
Helicopter	Indaziflam	20	55	0	100	a
Helicopter	Indaziflam + imazapic	20	63	0	100	a
Fixed wing airplane	Indaziflam	2.5	49	22	49	fg
Fixed wing airplane	Indaziflam + imazapic	2.5	46	19	67	cedf
Fixed wing airplane	Indaziflam	5	60	23	55	ef
Fixed wing airplane	Indaziflam + imazapic	5	67	9	85	abc
Fixed wing airplane	Indaziflam	10	64	4	94	ab
Fixed wing airplane	Indaziflam + imazapic	10	48	4	88	abc
Fixed wing airplane	Indaziflam	20	63	4	94	ab
Fixed wing airplane	Indaziflam + imazapic	20	74	6	91	abc
UTV ground	Indaziflam	10	20	11	55	g
UTV ground	Indaziflam + imazapic	10	53	1	98	ab
UTV ground	Indaziflam	20	48	14	74	bcdef
UTV ground	Indaziflam + imazapic	20	63	5	92	abc
LSD ($\alpha = 0.05$)					25	

[1]For all treatments, indaziflam and imazapic were applied at 0.065 lb ai/A and 0.078 lb ai/A, respectively, with 0.25% v/v non-ionic surfactant.
[2]Cover represents combined cover of downy brome and Japanese brome within each plot.
[3]Evaluations made October 3, 2019.
[4]Evaluations made June 10, 2020.

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), July 1, 2019 (39 MAT), and June 23, 2020 (51 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 ($p = 0.14$). Plots 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 ($p = 0.27$). Plots 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 ($p = 0.25$). Plots 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 ($p = 0.81$). Plots had an average perennial grass cover of 27 to 50% (data not shown), which was not significantly different compared to prior evaluations.

Fifty-one months after treatment, average control from all treatments dissipated (Table 2). However, in two of three replicates, the high rate of indaziflam/rimsulfuron maintained 100% control. Differences in perennial grass cover between treatments were not statistically significant ($p = 0.27$). Plots had an average perennial grass cover of 18 to 39% (data not shown), which is less than the average cover in 2016 ($p < 0.01$).

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. Notably, the high rate of indaziflam/rimsulfuron provided excellent control in two out of three replicates even four years after treatment. 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]	51 MAT[7]
	oz/A	lb ai/A	%				
Indaziflam + glyphosate	5 + 12	0.065 + 0.516	57 b	94 ab	84 ab	81 a	29 a
Indaziflam + glyphosate	7 + 12	0.092 + 0.516	75 b	94 ab	93 ab	84 a	51 a
Rimsulfuron	3	0.047	97 a	63 b	33 c	25 c	26 a
Rimsulfuron	4	0.063	99 a	89 ab	67 b	84 a	51 a
Indaziflam/rimsulfuron	4.5	0.119	98 a	81 ab	96 ab	81 ab	48 a
Indaziflam/rimsulfuron	6	0.158	100 a	100 a	100 a	91 a	67 a
Imazapic	7	0.109	100 a	90 ab	34 c	21 c	13 a
Glyphosate	12	0.516	13 c	9 c	9 c	30 bc	15 a
LSD (α = 0.05)			22	34	30	52	NA

[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.
[7]Evaluations made June 23, 2020.

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), July 8, 2019 (32 MAT), and June 23, 2020 (43 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). Plots 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). Plots 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). Plots 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.

Forty-three months after treatment, control from all treatments seemingly dissipated (Table 2). However, like in 2019, one replicate of the untreated check had no ventenata, thereby reducing the calculated efficacy of other treatments in that replicate to zero. When disregarding this outlier, all treatments of indaziflam + glyphosate had 100% control 43 months after treatment. Differences in perennial grass cover between treatments were not statistically significant (p = 0.63). Plots had an average perennial grass cover of 28 to 47% upon evaluation on June 23, 2020 (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]	43 MAT[6]
	oz/A	lb ai/A	-----------------	---------%	----------	-----------------
Indaziflam + glyphosate	3 + 6	0.039 + 0.238	99 a	99 a	67 a	67 a
Indaziflam + glyphosate	4 + 6	0.052 + 0.238	100 a	100 a	100 a	67 a
Indaziflam + glyphosate	5 + 6	0.065 + 0.238	100 a	100 a	100 a	67 a
Sulfosulfuron + glyphosate[2]	1.33 + 6	0.002 + 0.238	93 a	33 b	0 b	0 a
Imazapic + glyphosate[2]	6 + 6	0.093 + 0.238	21 b	35 b	0 b	0 a
LSD ($\alpha = 0.05$)			31	39	47	NA

[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.
[6]Evaluations made June 23, 2020.

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), June 5, 2019 (19-21 MAT), and July 14, 2020 (22-24 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 ($p = 0.22$). Plots 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 ($p = 0.49$). Plots 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.

At the July 14, 2020 evaluation, all treatments had reduced control of ventenata compared to the previous evaluation in 2019 (Table 2). Treatments maintaining excellent control (90 to 98%) were the pre-emergent applications of indaziflam and indaziflam/rimsulfuron and the 1-leaf applications of the high rate of indaziflam and indaziflam/rimsulfuron. Other treatments showed high variability in percent control between replicates. For example, the low rate of indaziflam applied at the 1-leaf stage had 79, 13, and 100% control respectively in the three replicates. The low rate of indaziflam + rimsulfuron applied at the 2-leaf stage had 47, 0, and 100% control respectively in the three replicates. The high rate of indaziflam + rimsulfuron applied at the 2-leaf stage had 100% control in replicates two and three, but only 39% control in replicate one. Plots had an average perennial grass cover of 18 to 41% (data not shown) and were not different between treatments ($p = 0.34$), but this was significantly more compared to prior evaluations ($p < 0.01$). No signs of injury to perennial grasses were observed in plots treated with the low and high rates of indaziflam + rimsulfuron, and cover increased to 29% in 2020.

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]	19-21 MAT[4]	22-24 MAT[5]
	oz/A	lb ai/A		--------------------------%--------------------------		
Indaziflam	5	0.065	Sept 19	100 a	100 a	98 a
Indaziflam	7	0.092	Sept 19	100 a	100 a	97 a
Indaziflam/rimsulfuron	4.5	0.119	Sept 19	100 a	100 a	92 ab
Imazapic	7	0.109	Sept 19	23 b	21 b	21 cd
Indaziflam	5	0.065	Oct 10	100 a	100 a	64 abc
Indaziflam	7	0.092	Oct 10	100 a	100 a	96 a
Indaziflam/rimsulfuron	4.5	0.119	Oct 10	100 a	100 a	90 ab
Imazapic	7	0.109	Oct 10	8 c	0 c	0 d
Indaziflam + rimsulfuron	5 + 3	0.065 + 0.047	Nov 9	100 a	98 a	49 bc
Indaziflam + rimsulfuron	7 + 4	0.092 + 0.063	Nov 9	100 a	100 a	80 ab
LSD (α = 0.05)				8	6	46

[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.
[5]Evaluations made July 14, 2020.

Tolerance of western larch to indaziflam application in first or second growing season. Leah T. Dreesmann, Lisa C. Jones, and Timothy Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID, 83844-2333) A study was established near Princeton, Idaho at the University of Idaho Experimental Forest to test the tolerance of western larch (*Larix occidentalis*) to over-the-top applications of indaziflam applied in the spring of the first or second growing season. Plots 8 by 20 ft were arranged in a randomized complete block design with three replications of 16 treatments plus an untreated check. Ten western larch seedlings (5 cu inch plugs) were planted in a straight line in the middle of each plot on April 30, 2019. All herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 15 gpa at 30 psi and 3 mph (Table 1). Prior to application of experimental treatments, the site was prepared with 2 lb ae/gal imazapyr + 5.4 lb ae/gal glyphosate + 0.07 lb ai/a sulfometuron methyl + 0.0375 lb ai/a metsulfuron methyl + 1% v/v MSO in October 2018. Plots received 3 lb ae/gal clopyralid treatment adjacent to, but not over the top of, trees to control prickly lettuce (*Lactuca serriola*) on June 9, 2019. Ground-line diameter and height of trees were evaluated when planted and on July 15, 2020. Phytotoxicity was rated on a scale of 0 to 10 at the plot level, with 0 being no injury and 10 being near death. Dead trees were not included. Phytotoxicity was evaluated on July 9, 2019 and July 15, 2020. Mortality of trees was evaluated on August 5, 2019, May 13, 2020, June 4, 2020, and July 15, 2020.

Table 1. Application and soil data.

Application date	May 13, 2019	May 8, 2020
Western larch growth stage	Seedling, first growing season	Seedling, second growing season
Air temperature (F)	69	64
Relative humidity (%)	34	35
Wind (mph, direction)	1, SSW	1, E
Cloud cover (%)	80	10
Soil temperature at 2 inches (F)	54	48
Soil pH	7.0	
Soil texture	loam	

Each indicator of western larch tolerance–phytotoxicity measurements, mortality after treatment, and change in height and diameter—was explored to investigate differences between application dates and treatments.

Two months after the spring 2019 treatment, there was a difference in phytotoxicity between treated plots ($p = 0.036$) (Table 2). Trees treated with the high rate of indaziflam and clopyralid had higher phytotoxicity (3.3) than untreated trees (2.1) and trees treated with the low rate of indaziflam had lower phytotoxicity (1.3) than untreated trees (Table 2). Other treatments with clopyralid also had high phytotoxicity but were not significantly different from the untreated check. Two months after the spring 2020 treatment, there was a difference in phytotoxicity between application dates ($p = 0.020$) and treatments ($p = 0.029$) (Table 2). On average, the trees sprayed in the first season had lower phytotoxicity ratings (1.5) than trees sprayed in the second season (2.5). An exception was those treated with the high rate of indaziflam with sulfometuron methyl in spring 2019, which had a higher average phytotoxicity rating (3.7) even in the 2020 evaluation (Table 2). From the 2020 evaluation, differences between individual treatments could not be detected, mostly likely due to the small number of replications and high number of treatments, but there were notable trends. For the trees treated in spring 2020, those treated with indaziflam and clopyralid combinations and the high rate of indaziflam with sulfometuron methyl had higher rates of phytotoxicity (3-4.3). Indaziflam at the low rate by itself had a low phytotoxicity (1). Overall, the phytotoxicity of western larch decreased over time after exposure to the herbicides and low levels of indaziflam had little effect on tree health.

Three months after the spring 2019 treatment, the treated seedlings had 2.8 times higher mortality compared to the untreated seedlings ($p = 0.014$; data not shown). The average background mortality of seedlings at this time was 3.7%. One year after the spring 2019 treatment and before the second group of trees was treated, treated seedlings had 2.7 times higher mortality compared to the untreated seedlings ($p = 0.012$; data not shown). The average background mortality of seedlings at this time was 7%. Two months after the spring 2020 treatment, there was still a difference between the overall mortality between the different application times, with higher mortality in trees treated in spring 2019 ($p = 0.014$; data not shown). Mortality rates in summer 2020 were also analyzed by treatment and although no differences were found, trends existed. At this evaluation time, background mortality was 8.1%. Treatments with only indaziflam had lower mortality rates than treatments with indaziflam and another herbicide (Table 2). Sulfometuron methyl seemed to contribute to mortality. The high rate of indaziflam and sulfometuron methyl had the highest mortality (40%), and the only treatments with mortality after the spring 2020 application were those that contained sulfometuron-methyl (Table 2). Overall, herbicide treatment in the first growing season increased mortality of western larch and sulfometuron-methyl also seemed to increase mortality.

There was no difference between the change in ground-line diameter measurements taken in April 2019 and July 2020 for application timings ($p = 0.490$) or individual treatments ($p = 0.101$) (Table 2). There was a difference between the change in tree height taken in April 2019 and July 2020 for application timings ($p < 0.001$), indicating that the seedlings treated in Spring 2019 had grown taller than the seedlings treated in Spring 2020. Seedlings may have experienced decreased competition with weeds after herbicide treatment. There was also a difference for the change in height between the treatments ($p < 0.001$) (Table 2). The treatments that included clopyralid, as well as the low rate of indaziflam alone, had the least impact on growth. All treatments with sulfometuron methyl had the least amount of vertical growth. Overall, treatment with indaziflam or clopyralid (or a combination) did not seem to hinder the height of the tree, and were taller than untreated trees.

Table 2. Indicators of western larch tolerance to herbicides applied at different rates and times.

			Indicator				
Treatment	Rate[1]	Application Timing	Phytotoxicity[2]		Mortality[3]	Height Change[4]	Diameter Change
	lb ai/a		7/9/19	7/15/20	%	inch	inch
Untreated	--		2.1	1.3	8.1	3.7 defg	2.1
Indaziflam	0.065	Spring 2019	1.3*	0.3	10.0	9.0 a	2.2
Indaziflam	0.092	Spring 2019	2.0	1.3	10.0	5.3 bcd	2.3
Clopyralid	0.205	Spring 2019	2.7	1.3	10.0	6.3 bc	2.1
Sulfometuron methyl	0.070	Spring 2019	2.0	1.7	23.3	5.3 bcde	1.7
Indaziflam + clopyralid	0.065 + 0.205	Spring 2019	2.3	1.3	13.3	9.5 a	2.7
Indaziflam + clopyralid	0.092 + 0.205	Spring 2019	3.3*	1.3	26.7	6.1 bcd	2.2
Indaziflam + sulfometuron methyl	0.065 + 0.070	Spring 2019	2.0	1.3	16.7	3.6 defg	1.4
Indaziflam + sulfometuron methyl	0.092 + 0.070	Spring 2019	2.3	3.7	40.0	1.3 g	1.5
Indaziflam	0.065	Spring 2020	--	1.0	16.7	4.7 bcdef	1.8
Indaziflam	0.092	Spring 2020	--	2.7	13.3	2.8 efg	1.5
Clopyralid	0.409	Spring 2020	--	1.7	10.0	6.2 bc	2.2
Sulfometuron methyl	0.070	Spring 2020	--	1.3	10.0	3.9 cdefg	2.0
Indaziflam + clopyralid	0.065 + 0.409	Spring 2020	--	4.3	6.7	4.5 bcdef	1.8
Indaziflam + clopyralid	0.092 + 0.409	Spring 2020	--	3.0	0.0	6.4 b	2.5
Indaziflam + sulfometuron methyl	0.065 + 0.070	Spring 2020	--	2.0	10.0	2.7 fg	1.7
Indaziflam + sulfometuron methyl	0.092 + 0.070	Spring 2020	--	3.7	0.0	2.5 fg	1.7
LSD ($\alpha = 0.05$)			NA	NA	NA	4.0	NS

[1]Cloypralid rate expressed in lb ae/a.
[2]Phytotoxicity was rated on a scale of 0-10: 0 normal growth, 1 fewer than half the trees had needle injury, 2 slight needle injury or nonvertical candle orientation, 3 severe needle injury or nonvertical candle orientation, 4 slight needle injury + nonvertical candle orientation, 5 severe needle injury + nonvertical candle orientation, 6 slight needle injury + candle epinasty, 7 moderate needle injury + candle epinasty, 8 severe needle injury + candle epinasty, 9 severe needle injury + candle epinasty, resulting in partial necrosis, 10 severe needle injury + candle epinasty, nearly dead. Each treatment was compared to the untreated check and an asterisk indicates when a treatment differed from the untreated. LSD cannot be calculated for ordinal data.
[3]Total mortality as measured on July 15, 2020. Untreated mortality includes the background mortality in the spring 2020 plots prior to treatment.
[4]Means followed by the same letter are not statistically significantly different.

Herbicide efficacy against kyllinga in turf. Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). A small plot field experiment was conducted on a driving range with bermudagrass, 'Tifway 419', that was infested with kyllinga at the Kierland Golf Club in Scottsdale, AZ. Treated plots measured 5 ft by 10 ft and were replicated three times in a randomized complete block design. Sprays were applied with a backpack CO_2 sprayer equipped with a hand-held boom with three TurboTeeJet flat fan 11002 nozzles spaced 20 inches apart. The sprays were applied in 40 gpa water pressurized to 35 psi and a non-ionic surfactant, Latron CS-7 at 0.25% v/v was added to the herbicide mix. Pyrimisulfan formulated as a granular was distributed over the plot area using a can with small holes on the bottom and shaken on to the surface. Weed control was evaluated at intervals following the application on 06 August 2020. The weather conditions at the time of application were air temperature at 84°F, clear sky, no measurable wind, and soil temperature was 80°F.

At 11 to 18 days after treatment (DAT), kyllinga exhibited a progressive reduced rate of growth and phytotoxicity responding to all herbicides (Table). At 28 DAT, all treatments gave 94 to 98% control of kyllinga except pyrimisulfan which marginally offered control at 85% and imazosulfuron at 50% showing much less efficacy. At 60 DAT, halosulfuron, imazaquin, trifloxysulfuron, sulfosulfuron, and flazasulfuron eliminated most of the kyllinga and gave 88 to 99% control. Pyrimisulfan reduced kyllinga but there was regrowth that could possibly be controlled with a second application. Imazosulfuron disappointingly did not demonstrate efficacy beyond three weeks after application.

Table. Kyllinga control in turf, Scottsdale, AZ

		KYLBR control					
Treatment	Rate	17 Aug	24 Aug	03 Sep	14 Sep	28 Sep	05 Oct
	(lb a.i./A)	%					
untreated check		0 b	0 c	0 d	0 d	0 c	0 c
halosulfuron	0.062	75 a	85 a	94 a	90 ab	99 a	88 a
imazaquin	0.5	78 a	82 ab	98 a	92 ab	96 ab	92 a
trifloxysulfuron	0.025	80 a	85 a	98 a	99 a	99 a	99 a
sulfosulfuron	0.059	77 a	85 a	98 a	99 a	99 a	96 a
imazosulfuron	0.65	77 a	82 ab	50 c	57 c	17 c	0 c
flazasulfuron	0.047	78 a	85 a	98 a	96 a	96 ab	95 a
pyrimisulfan	4.35	73 a	80 b	85 b	75 b	60 b	60 b

KYLBR = *Kyllinga brevifolia.*
Single treatment applied on 06 August 2020.
Means within a column followed by the same letter are not significantly different by Tukey-Kramer HSD (p=0.05).

Comparison of postemergence herbicides and combinations for goosegrass control. Kai Umeda (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). A small plot field experiment was conducted on a driving range with bermudagrass 'Tifway 419' infested with goosegrass at the Kierland Golf Club in Scottsdale, AZ. Treated plots measured 5 ft by 5 ft and were replicated three times in a randomized complete block design. 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. The sprays were applied in 47 gpa water pressurized to 35 psi. Methylated seed oil at 0.5% v/v was added to topramezone alone, foramsulfuron, and foramsulfuron + halosulfuron + thiencarbazone treatments. The single application was made on 16 July 2020 when the air temperature was 100°F, clear sky, with a slight breeze at 3-4 mph and soil temperature at 88°F. Weed control and turf injury were evaluated at intervals following the application.

At 21 days after treatment (DAT), topramezone alone or in combinations gave acceptable goosegrass control at 82 to 93% (Table). Topramezone at 0.016 lb a.i./A caused significant 40% injury to the turf at 11 DAT and the bleaching injury diminished at 18 DAT. Less injury was observed when $ZnSO_4$, carfentrazone + growth hormone herbicides, or metribuzin were added to topramezone. Single applications of metribuzin and foramsulfuron treatments did not adequately control goosegrass.

Table. Postemergence goosegrass control in turf, Scottsdale, AZ 2020

Treatment and Rate		ELEIN Control		CYNDA Injury
(lb a.i./A)	27 Jul	03 Aug	06 Aug	27 Jul
	----------------------	%	-----------------------	--- % ---
untreated check	0 d	0 b	0 d	0 d
Topramezone 0.011	85 a	85 a	93 a	25 b
Topramezone 0.016	87 a	85 a	88 ab	40 a
Topramezone 0.016 + $ZnSO_4$ 16 lb/A	85 a	83 a	82 abc	12 bcd
Topramezone 0.016 + carfentrazone 0.04 + 2,4-D 1.3 + dicamba 0.12 + MCPP 0.42	87 a	87 a	88 ab	15 bc
Topramezone 0.016 + metribuzin 0.375	83 a	87 a	93 a	8 cd
Foramsulfuron 0.04	65 b	85 a	68 bc	0 d
Foramsulfuron 0.04 + halosulfuron 0.062 + thiencarbazone 0.02	73 ab	83 a	77 abc	0 d
Metribuzin 0.375	50 c	23 b	58 c	0 d

Treatments applied on 16 July 2020.
Methylated seed oil at 0.5% v/v added to topramezone alone, foramsulfuron, and foramsulfuron + halosulfuron + thiencarbazone treatments.
ELEIN = *Eleusine indica* (goosegrass), CYNDA = *Cynodon dactylon* x *C. transvaalensis* (bermudagrass 'Tifway 419')
Means within a column followed by the same letter are not significantly different by Tukey-Kramer HSD at p=0.05.

Amicarbazone sequential postemergence applications for *Poa annua* control in overseeded bermudagrass. Kai Umeda (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040). A small plot field experiment was conducted at the Raven Golf Course, Phoenix, AZ on bermudagrass fairways that were winter overseeded and infested with *Poa annua*. The plots measured 5 ft by 10 ft and treatments were replicated three times in a randomized complete block design. Amicarbazone was applied with a backpack CO_2 sprayer equipped with a hand-held boom with three TurboTeeJet 11002 flat fan nozzles spaced 20 inches apart. The sprays were applied in 40 gpa water pressurized to 35 psi. At the Raven Golf Course treatments were first sprayed on 14 February 2020 with the air temperature at 71°F, clear sky, wind at 2-3 mph, and soil temperature at 58°F. The second application was sprayed on 28 February with the air temperature at 59°F, overcast sky, wind at 2-3 mph, and soil temperature at 56°F. The third sequential application was applied on 20 March with the air temperature at 59°F. clear sky, wind at less than 2 mph, and soil temperature at 60°F.

In mid-March at 3 weeks after treatment of the second application (WAT-2), the amicarbazone at 0.125 + 0.125 and 0.14 +0.14 lb a.i./A provided acceptable and better *P. annua* control than lower rates of 0.094 + 0.094 or 0.125 + 0.063 lb a.i./A with a third application still remaining to be applied (Table). The sequential applications of 0.125 + 0.125 oz/A and 0.094 + 0.094 + 0.094 lb a.i./A were similar in giving 87 and 83% control, respectively, and not significantly different from the 0.14 + 0.14 lb a.i./A treatment.

Table. Amicarbazone split applications for *Poa annua* control, Raven Golf Course, Phoenix, AZ, 2020

amicarbazone rate (lb ai./A)	POANN control (%)			Turf quality*		
	20 Mar	03 Apr	27 Apr	20 Mar	03 Apr	27 Apr
	------------------- % --------------------			--------------------- % --------------------		
Untreated check	0 d	0 c	0 c	7.7 a	7.0 a	4.7 c
0.094 + 0.094 + 0.094	72 c	73 b	83 ab	7.3 a	7.3 a	5.3 bc
0.125 + 0.125	88 a	75 b	87 a	6.0 ab	7.3 a	7.0 a
0.125 + 0.063 + 0.063	80 b	78 ab	75 b	7.3 a	8.0 a	6.3 ab
0.14 + 0.14	90 a	85 a	92 a	5.3 b	7.7 a	7.3 a

amicarbazone application dates: 14 and 28 February and 20 March 2020.
POANN = *Poa annua*
Turf quality 1- 9; 1 = poor, 9 = best
Means followed by the same letter within a column are not significantly different by Tukey-Kramer HSD, p=0.05

Weed control in chickpea with preemergence herbicides and pyridate. Joan M. Campbell and Traci A. Rauch. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Two experiments were conducted to evaluate weed control in chickpea at the University of Idaho Plant Science Farm. One experiment evaluated preemergence herbicides and the second experiment evaluated pyridate rates. The experiments were arranged in a randomized complete block design with four replications and included a non-treated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa (preemergence herbicides) or 20 gpa (pyridate) at 32 psi and 3 mph. The pyridate experiment was over sprayed with clethodim for grass control and both experiments were sprayed with fluxapyroxad/pyraclostrobin fungicide. Crop response and weed control were evaluated visually. Chickpea seed was harvested with a small plot combine on August 31, 2020.

Table 1. Application data and site information.

	Preemergence	Pyridate
Variety and planting date	'Sierra' 4/17/2020	
Application date	4/18/2020	5/30/2020
Growth stage		
Chickpea	postplant pre	6-8 nodes, 8-10 inch
Common lambsquarters	pre	Cotyledon -13 leaves, 0.25-3 inch
Annual ryegrass	pre	-
Air temperature (F)	59	82
Relative humidity (%)	40	50
Wind (mph, direction)	5, W	4, E
Cloud cover (%)	100	80
Next moisture occurred	5/22/2020	5/31/2020
Soil moisture	fair	good
Soil temperature at 2 inch (F)	50	71
pH	4.9	
OM (%)	3.1	
CEC (meq/100g)	17.6	
Texture	silt loam	

Crop response was not observed in either experiment (data not shown).

In the preemergence herbicides experiment, common lambsquarters control was 75 to 90% with pyroxasulfone/sulfentrazone treatments or sulfentrazone/s-metolachlor on July 16 (Table 2). Other treatments did control common lambsquarters. Ryegrass control was 82 to 99% on June 16. This high amount of control likely was due to small ryegrass plants and a high common lambsquarters population masking the ryegrass plants. Ryegrass plants were larger and topped the crop in mid-season. On July 16, ryegrass control was best with treatments containing pyroxasulfone or s-metolachlor. Higher rates of pyroxasulfone tended to result in higher ryegrass control. Saflufenacil alone resulted in no ryegrass control, but the addition of dimethenamid increased control to 59%. Chickpea seed yield was highest with the treatments that controlled common lambsquarters, pyroxasulfone/sulfentrazone treatments or sulfentrazone/s-metolachlor.

In the pyridate experiment, all rates controlled common lambsquarters 95 to 99% (Table 3). Seed yield ranged from 2242 to 2632 lb/a with pyridate treatments and seed yield with all treatments were higher than non-treated at 1208 lb/a.

Table 2. Common lambsquarters and ryegrass control with preemergence herbicides in chickpea near Moscow, Idaho in 2020.

		Weed control				Chickpea seed yield
		Common lambsquarters		Annual ryegrass		
Treatment	Rate	June 16	July 16	June 16	July 16	August 31
	lb ai/a	%	%	%	%	lb/a
Non-treated	-	-	-	-	-	1087 d
Pyroxasulfone/sulfentrazone	0.189	88 ab[1]	75 ab	83 a	84 abc	1756 abc
Pyroxasulfone/sulfentrazone	0.234	97 a	83 a	98 a	63 bc	1922 a
Pyroxasulfone/sulfentrazone	0.5	98 a	90 a	98 a	95 a	2091 a
Sulfentrazone/s-metolachlor	1.17	95 a	85 a	93 a	86 ab	1852 ab
Saflufenacil	0.0445	30 c	29 cd	87 a	0 d	1036 d
Pyroxasulfone/carfentrazone	0.094	57 bc	16 d	82 a	76 abc	1292 d
Pyroxasulfone/carfentrazone	0.14	61 bc	41 cd	95 a	83 abc	1263 d
Pyroxasulfone/carfentrazone	0.28	59 bc	18 d	99 a	96 a	1364 cd
Saflufenacil + dimethenamid	0.0445 0.656	71 ab	49 bc	85 a	59 c	1416 bcd

[1] Means followed by the same letter are not statistically different from one another P=0.05.

Table 3. Common lambsquarters control with pyridate in chickpea near Moscow, Idaho in 2020.

		Common lambsquarters control		Chickpea
Herbicide[1]	Rate	June 13	August 31	seed yield
	lb ai/a	%	%	lb/a
Non-treated	-	-	-	1208 c[3]
Pyridate	0.94	98[2]	97	2511 ab
Pyridate	0.78	98	97	2242 b
Pyridate	0.70	99	99	2632 a
Pyridate	0.625	98	95	2500 ab
Pyridate	0.47	98	95	2282 b

[1] Pyridate was applied with 1% v/v crop oil concentrate (Mor-Act).
[2] Weed control was not statistically different among rates.
[3] Means followed by the same letter are not statistically different from one another P=0.05.

Topramezone and glufosinate rates and mixtures for efficacy in corn. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate topramezone and glufosinate rates alone and in a premix for efficacy in glufosinate-tolerant corn. Herbicides were applied using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. 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 11 and July 1, 2020. These dates were 8 and 28 days after treatment (DAT), respectively. Corn yields were determined on October 3, 2020 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

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

Application timing	Postemergence
Application date	June 3, 2020
Air temperature (F)	97
Relative humidity	24
Soil temperature (F)	84
Wind speed (mph)	2 to 6
Wind direction	North
Soil moisture	Fair
Corn	
Height (inches)	5 to 8
Leaves (no.)	3 to 4
Kochia	
Height (inches)	2 to 6
Density (plants/ft^2)	2
Palmer amaranth	
Height (inches)	1 to 5
Density (plants/ft^2)	3
Russian thistle	
Height (inches)	3 to 6
Density (plants/ft^2)	0.5
Green foxtail	
Height (inches)	1 to 3
Density (plants/ft^2)	1
Crabgrass	
Height (inches)	0.5 to 1
Density (plants/ft^2)	0.3

At 8 DAT, only topramezone/glufosinate at 0.56 lb/A controlled kochia as much as 80% (Table 2). This treatment along with topramezone alone at 0.0219 lb/A and dicamba/diflufenzopyr plus glyphosate controlled kochia best at 28 DAT. No treatment controlled Russian thistle more than 81% at 8 DAT, but the high rate of topramezone alone and dicamba/diflufenzopyr plus glyphosate each provided greater than 90% control at 28 DAT. Likewise, Palmer amaranth control was less than 85% regardless of treatment at 8 DAT. Only dicamba/diflufenzopyr plus glyphosate controlled Palmer amaranth more than 75% at 28 DAT. Topramezone/glufosinate at 0.56 lb/A and dicamba/diflufenzopyr provided the best green foxtail control at 28 DAT. These treatments along with topramezone alone at either rate, were the most efficacious treatments for crabgrass control late in the season. Generally, increasing the rate of topramezone, glufosinate, or topramezone/glufosinate did not improve control of the weed species studied here. All herbicides treatments except topramezone/glufosinate at the low rate resulted in higher grain yields than the untreated control. However, only the treatment of dicamba/diflufenzopyr with glyphosate resulted in yields higher (115.2 bu/A) than 62 bu/A.

Table 2. Weed control and corn yield from the topramezone and glufosinate trial in corn.

Treatment[1]	Rate	Kochia 8 DAT[2]	Kochia 28 DAT	Russian thistle 8 DAT	Russian thistle 28 DAT	Palmer amaranth 8 DAT	Palmer amaranth 28 DAT	Green foxtail 8 DAT	Green foxtail 28 DAT	Crabgrass 8 DAT	Crabgrass 28 DAT	Grain yield
	lb/A	—— % Visual ——		—— % Visual ——		—— % Visual ——		—— % Visual ——		—— % Visual ——		bu/A
Untreated	---	---	---	---	---	---	---	---	---	---	---	8.4
Topramezone MSO AMS	0.0164 1.0% 3.0	70	78	68	83	65	68	63	83	65	88	43.4
Topramezone MSO AMS	0.0219 1.0% 3.0	73	80	73	93	68	75	63	85	63	90	61.2
Glufosinate AMS	0.40 3.0	63	65	68	68	75	65	78	70	65	73	35.7
Glufosinate AMS	0.54 3.0	70	65	75	70	83	68	83	80	80	80	41.1
Topramezone/ Glufosinate MSO AMS	0.42 1.0% 3.0	73	75	73	78	75	65	80	75	78	83	34.1
Topramezone/ Glufosinate MSO AMS	0.56 1.0% 3.0	80	80	81	85	83	75	81	90	80	88	45.0
Dicamba/ Diflufenzopyr Glyphosate NIS AMS	0.175 1.13 0.25% 3.0	60	88	60	95	65	88	78	96	73	91	115.2
LSD (0.05)		7	8	9	8	8	8	9	11	8	7	26.5

[1] MSO is methylated seed oil, AMS is ammonium sulfate, and NIS is nonionic surfactant.
[2] DAT is days after treatment.

Dimethenamid alone and in mixtures for efficacy in corn. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate dimethenamid alone or with various mixtures for efficacy in corn. Herbicides were applied using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, 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 and August 10, 2020. These dates were 5 and 59 days after the postemergence treatment (DAB), respectively. Corn yields were determined on October 6, 2020 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application, environmental, and weed information for the dimethenamid study in corn.

Application timing	Preemergence	Postemergence
Application date	May 14, 2020	June 12, 2020
Air temperature (F)	80	70
Relative humidity	49	41
Soil temperature (F)	64	68
Wind speed (mph)	5 to 9	7 to 10
Wind direction	North-northwest	Southwest
Soil moisture	Good	Good
Corn		
Height (inches)	---	5 to 8
Leaves (no.)	0	3 to 4
Kochia		
Height (inches)	---	---
Density (plants/ft^2)	0	0
Palmer amaranth		
Height (inches)	---	2 to 4
Density (plants/ft^2)	0	0.1
Russian thistle		
Height (inches)	---	3 to 6
Density (plants/ft^2)	0	0.2
Green foxtail		
Height (inches)	---	---
Density (plants/ft^2)	0	0
Shattercane		
Height (inches)	---	3 to 5
Density (plants/ft^2)	0	0.1

Common sunflower control was 83 to 95% at 5 DAB and 80 to 93% control at 59 DAB, and did not differ between herbicide treatments (data not shown). All herbicides controlled kochia more than 90% at 5 DAB except dimethenamid/saflufenacil applied preemergence (PRE) followed by pyroxasulfone postemergence (POST) (Table 2). Dimethenamid/saflufenacil alone, or with a drift control agent-deposition aid (DCA-DA) PRE, and dimethenamid/saflufenacil followed by pyroxasulfone controlled kochia less than 90% at 59 DAT. Pyroxasulfone with saflufenacil and mesotrione or dimethenamid/saflufenacil controlled Russian thistle the best at each rating date. However, no herbicide provided more than 81% Russian thistle control. Dimethenamid alone, or with a DCA-DA PRE, and dimethenamid/saflufenacil plus mesotrione PRE controlled Palmer amaranth 100% at 5 DAB, but no difference occurred among herbicides for Palmer amaranth control at 59 DAB. Similarly, green foxtail control did not differ among herbicides at 5 DAT, and only dimethenamid/saflufenacil alone PRE provided less than 95% foxtail control later in the season. Grain yields were 68 to 108 bu/A higher from herbicide-treated plots than from untreated plots (37.5 bu/A). However, yields were generally lowest when dimethenamid alone or dimethenamid/saflufenacil alone were applied (105 to 108 bu/A).

Table 2. Weed control and grain yield from the dimethenamid in corn trial.

Treatment[1]	Rate	Timing[2]	Kochia 5 DAB[3]	Kochia 59 DAB	Russian thistle 5 DAB	Russian thistle 59 DAB	Palmer amaranth 5 DAB	Palmer amaranth 59 DAB	Green foxtail 5 DAB	Green foxtail 59 DAB	Grain yield
	lb/A		——— % Visual ———		——— % Visual ———		——— % Visual ———		——— % Visual ———		bu/A
Untreated			---	---	---	---	---	---	---	---	37.5
Dimethenamid	0.656	PRE	100	98	70	53	100	85	98	100	108.5
Dimethenamid/ Saflufenacil	0.435	PRE	95	83	68	53	95	88	98	93	105.1
Dimethenamid	0.656	PRE	95	95	73	58	100	90	98	100	137.4
DCA-DA	2.07	PRE									
Dimethenamid/ Saflufenacil	0.435	PRE	95	88	73	55	95	93	98	100	131.4
DCA-DA	2.07	PRE									
Pyroxasulfone	0.108	PRE	98	98	74	63	85	93	93	95	148.8
Mesotrione	0.125	PRE									
Pyroxasulfone	0.143	PRE	100	98	79	70	90	88	100	98	145.1
Mesotrione	0.125	PRE									
Pyroxasulfone	0.108	PRE	100	100	83	73	98	98	100	98	144.3
Saflufenacil	0.045	PRE									
Mesotrione	0.125	PRE									
MSO	1.0%	PRE									
AMS	2.5%	PRE									
Dimethenamid/ Saflufenacil	0.435	PRE	100	98	81	80	100	95	100	100	141.5
Pyroxasulfone	0.108	PRE									
Dimethenamid/ Saflufenacil	0.435	PRE	90	85	70	68	95	88	94	100	136.8
Pyroxasulfone	0.108	POST									
LSD (0.05)			7	8	8	8	8	NS	NS	6	25.4

[1] DCA-DA is a drift control agent/deposition aid, MSO is methylated seed oil, and AMS is ammonium sulfate.
[2] PRE is preemergence, POST is postemergence.
[3] DAB is days after the postemergence treatments.

<u>Single and split applications for weed control in corn.</u> Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate single versus split application of herbicide premixtures for efficacy in corn. Herbicides were applied using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. Application, 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 24 and August 14, 2020. These dates were 34 and 85 days after the postemergence treatments (DAB). Corn yields were determined on October 1, 2020 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application, environmental, and weed information for the single and sequential treatment study in corn.

Application timing	Preemergence	Postemergence
Application date	May 1, 2020	May 21, 2020
Air temperature (F)	59	67
Relative humidity	51	80
Soil temperature (F)	58	66
Wind speed (mph)	3 to 7	6 to 10
Wind direction	Northwest	Southeast
Soil moisture	Fair	Good
Corn		
Height (inches)	---	2 to 5
Leaves (no.)	0	1 to 2
Russian thistle		
Height (inches)	---	4 to 6
Density (plants/ft^2)	0	0.2
Kochia		
Height (inches)	---	1 to 3
Density (plants/ft^2)	0	0.2
Palmer amaranth		
Height (inches)	---	1 to 2
Density (plants/ft^2)	0	0.1
Sunflower		
Height (inches)	---	2 to 3
Density (plants/ft^2)	0	0.1
Green foxtail		
Height (inches)	---	0.5 to 1
Density (plants/ft^2)	0	0.1

Early season control of all weed species was 90% or more with all preemergence (PRE) herbicides, and did not differ between treatments (data not shown). Control of common sunflower and green foxtail remained 90% or more throughout the season regardless of herbicide. *S*-metolachlor/atrazine applied PRE followed by *S*-metolachlor/atrazine/mesotrione POST and *S*-metolachlor/atrazine/mesotrione/bicyclopyrone applied PRE and POST provided less than 90% kochia and Palmer amaranth control at 34 DAB (Table 2). Kochia control was similar among all herbicides at 85 DAB, but Palmer amaranth control remained less than 90% with the above-mentioned treatments as well as with *S*-metolachlor/atrazine PRE followed by *S*-metolachlor/glyphosate/mesotrione POST. All herbicides controlled Russian thistle similarly at 34 DAB, but *S*-metolachlor/atrazine/mesotrione alone PRE was less efficacious than other treatments on Russian thistle at 85 DAB. Grain yields did not differ among herbicide-treated plots. However, yields increased 85 to 104 bu/A with herbicide treated plots compared to the untreated controls (40.9 bu/A).

Table 2. Weed control and corn yield from the single and sequential treatment study in corn.

Treatment[1]	Rate	Timing[2]	Kochia		Russian thistle		Palmer amaranth		Grain yield
			34 DAB[3]	85 DAB[3]	34 DAB	85 DAB	34 DAB	85 DAB	
	lb/A		% Visual		% Visual		% Visual		bu/A
Untreated	---	---	---	---	---	---	---	---	40.9
S-metolachlor/ Atrazine/ Mesotrione	2.48	PRE	95	97	84	77	94	93	138.9
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.58	PRE	100	95	94	95	100	94	132.5
S-metolachlor/ Atrazine/ Mesotrione	1.39	PRE	99	98	98	90	100	98	144.3
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.29	POST							
AMS	1.0%	POST							
S-metolachlor/ Atrazine	2.9	PRE	95	95	94	90	93	88	143.2
S-metolachlor/ Glyphosate/ Mesotrione	1.94	POST							
NIS	0.25%	POST							
AMS	1.0%	POST							
S-metolachlor/ Atrazine	2.06	PRE	89	90	98	93	85	83	140.2
S-metolachlor/ Atrazine/ Mesotrione	1.62	POST							
NIS	0.25%	POST							
AMS	1.0%	POST							
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.29	PRE	86	90	98	93	85	80	125.6

S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.29	POST							
Acetochlor/ Clopyralid/ Mesotrione	2.06	PRE	98	95	90	90	95	95	145.3
Acetochlor/ Clopyralid/ Mesotrione	1.03	PRE	100	98	93	90	100	99	129.6
Acetochlor/ Clopyralid/ Mesotrione	1.03	POST							
Isoxaflutole/ Thiencarbazone	0.115	PRE	100	100	98	98	98	93	142.1
Atrazine	1.0	PRE							
Acetochlor/ Mesotrione	1.2	POST							
Glyphosate	1.2	POST							
AMS	1.0%	POST							
LSD (0.05)			10	NS	NS	10	10	12	30.2

[1] AMS is ammonium sulfate, NIS is nonionic surfactant.
[2] PRE is preemergence, POST is postemergence.
[3] DAB is days after the postemergence treatments.

Evaluation of novel sorghum herbicides for grass control in fallow. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to compare herbicides from three herbicide-tolerant sorghum technologies: imidazolinone-, ALS- and ACCase-tolerant technologies, 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 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 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 16 and August 13, 2020. These dates were 14 days after the early postemergence treatments (14 DAB) and 26 days after the late postemergence treatments (26 DAC), respectively.

Table 1. Application, environmental, and weed data for the sorghum herbicide fallow study.

Application date	Preemergence	Early postemergence	Late postemergence
Air temperature (F)	May 27, 2020	July 2, 2020	July 18, 2020
Relative humidity	64	74	75
Soil temperature (F)	51	87	57
Wind speed (mph)	58	78	74
Wind direction	3 to 6	3 to 7	1 to 5
Soil moisture	North-northwest	East	South
Green foxtail	Dry	Fair	Good
Height (inches)	---	1 to 6	6 to 18
Density (plants/ft^2)	0	2.5	2.0
Shattercane			
Height (inches)	---	3 to 6	8 to 18
Density (plants/ft^2)	0	0.3	0.2
Crabgrass			
Height (inches)	---	0.5 to 1	12 to 20
Density (plants/ft^2)	0	0.1	0.2

Imazamox at 0.047 or 0.07 lb/A applied preemergence (PRE) provided good control of green foxtail, shattercane, and crabgrass, and was among the best treatments for each of these species at both rating dates (Table 2). No postemergence treatment controlled green foxtail more than 78% at 26 DAC. In addition to imazamox PRE, quizalofop applied early postemergence (EPOST) at 0.069 lb/A controlled shattercane more than 90% at 14 DAB. By 26 DAC, shattercane control exceeded 90% with either rate of imazamox PRE or EPOST, nicosulfuron at either rate EPOST, and quizalofop at either rate EPOST or late postemergence (LPOST). Early season crabgrass control was 90% or more with all PRE herbicides, both rates of nicosulfuron EPOST, and the high rate of quizalofop EPOST. However, by 28 DAC, all PRE and EPOST herbicides provided similar crabgrass control, and these treatments were significantly better than nicosulfuron, imazamox or the low rate of quizalofop applied LPOST.

Table 2. Weed control in the sorghum herbicide fallow study.

Treatment[1]	Rate	Timing[2]	Green foxtail		Shattercane		Crabgrass	
			14 DAB[3]	26 DAC[3]	14 DAB	26 DAC	14 DAB	26 DAC
	lb/A		— % Visual —		— % Visual —		— % Visual —	
Imazamox	0.047	PRE	94	88	90	93	93	90
Imazamox	0.07	PRE	98	89	100	98	96	90
S-metolachlor	1.43	PRE	86	70	65	60	94	93
Acetochlor	1.5	PRE	75	58	63	60	90	89
Dimethenamid	0.84	PRE	80	60	73	63	91	90
Imazamox COC	0.047 1.0%	EPOST EPOST	70	70	80	95	85	98
Imazamox COC	0.07 1.0%	EPOST EPOST	80	75	83	95	88	98
Quizalofop COC	0.0413 1.0%	EPOST EPOST	73	65	89	100	83	98
Quizalofop COC	0.069 1.0%	EPOST EPOST	85	78	93	100	94	95
Nicosulfuron COC AMS	0.032 1.0% 4.0	EPOST EPOST EPOST	73	53	88	98	93	100
Nicosulfuron COC AMS	0.048 1.0% 4.0	EPOST EPOST EPOST	80	58	88	90	93	100
Imazamox COC	0.047 1.0%	LPOST LPOST	---	45	---	78	---	70
Imazamox COC	0.07 1.0%	LPOST LPOST	---	48	---	73	---	65
Quizalofop COC	0.0413 1.0%	LPOST LPOST	---	45	---	93	---	70
Quizalofop COC	0.069 1.0%	LPOST LPOST	---	60	---	95	---	83
Nicosulfuron COC AMS	0.032 1.0% 4.0	LPOST LPOST LPOST	---	35	---	55	---	45
Nicosulfuron COC AMS	0.048 1.0% 4.0	LPOST LPOST LPOST	---	38	---	70	---	63
LSD (0.05)			9	14	11	13	7	14

[1] COC is crop oil concentrate, AMS ammonium sulfate.
[2] PRE is preemergence, EPOST is early postemergence, and LPOST is late postemergence.
[3] 14 DAB is 14 days after the early postemergence treatments, 26 DAC is 26 days after the late postemergence treatments.

Glufosinate and 2,4-D tank mixtures and application timing for weed control in fallow. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to compare glufosinate plus 2,4-D choline tank mixtures at various application timings for weed control in fallow. Herbicides were applied using a tractor-mounted, compressed CO_2 sprayer delivering 19.4 gpa at 30 psi and 4.1 mph. 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 July 14, August 3, and August 21, 2020. These dates were 4 and 24 days after the early postemergence treatments (DAB), and 17 days after the late postemergence treatments (DAC), respectively.

Table 1. Application, environmental, weed information for the glufosinate and 2,4-D experiment in fallow.

Application timing	Preemergence	Early postemergence	Late postemergence
Application date	June 24, 2020	July 10, 2020	August 4, 2020
Air temperature (F)	93	73	65
Relative humidity	32	77	66
Soil temperature (F)	83	76	64
Wind speed (mph)	6 to 10	2 to 7	6 to 11
Wind direction	South	East	Southeast
Soil moisture	Good	Good	Good
Palmer amaranth			
Height (inches)	---	2 to 15	2 to 60
Density (plants/ft^2)	0	4	2.5
Shattercane			
Height (inches)	---	2 to 6	2 to 16
Density (plants/ft^2)	0	0.2	0.1
Crabgrass			
Height (inches)	---	0.5 to 1	1 to 6
Density (plants/ft^2)	0	1	0.1

Only four treatments controlled Palmer amaranth 90% or throughout the season: glufosinate plus 2,4-D and metribuzin preemergence (PRE) followed by glufosinate plus 2,4-D late postemergence (LPOST), glufosinate plus 2,4-D and pyroxasulfone PRE followed by glufosinate plus 2,4-D LPOST, and pyroxasulfone plus imazethapyr/saflufenacil and glyphosate PRE followed by glufosinate alone or with 2,4-D LPOST (Table 2). Conversely, the only treatments that did not control shattercane 90% or more, regardless of rating date, were glyphosate PRE followed by glyphosate LPOST and glufosinate plus 2,4-D PRE followed by glufosinate plus 2,4-D LPOST. Crabgrass control at 4 DAB was excellent (98 to 100%) when the PRE treatments included pyroxasulfone, metribuzin, pyroxasulfone plus imazethapyr/saflufenacil, chlorimuron/flumetsulam/metribuzin, or sulfentrazone/cloransulam. At 17 DAC, crabgrass was controlled 89 to 98% by glufosinate plus 2,4-D and metribuzin PRE followed by glufosinate plus 2,4-D LPOST, pyroxasulfone plus imazethapyr/saflufenacil and glyphosate PRE followed by glufosinate alone or with 2,4-D, and glufosinate plus glyphosate alone or with 2,4-D PRE followed by glufosinate plus glyphosate alone or with 2,4-D LPOST.

Table 2. Weed control with glufosinate and 2,4-D mixtures in fallow.

Treatment[1]	Rate	Timing[2]	Palmer amaranth 4 DAB[3]	Palmer amaranth 24 DAB[3]	Palmer amaranth 17 DAC[3]	Shattercane 4 DAB	Shattercane 24 DAB	Shattercane 17 DAC	Crabgrass 4 DAB	Crabgrass 24 DAB	Crabgrass 17 DAC
	lb/A		% Visual			% Visual			% Visual		
Glyphosate	1.13	PRE	0	0	33	0	0	80	0	0	83
AMS	3.0	PRE									
Glyphosate	1.13	LPOST									
AMS	3.0	LPOST									
Glufosinate	0.575	PRE	40	23	28	0	0	78	0	0	80
2,4-D choline	0.95	PRE									
AMS	3.0	PRE									
Glufosinate	0.575	LPOST									
2,4-D choline	0.95	LPOST									
AMS	3.0	LPOST									
Glufosinate	0.575	PRE	97	91	90	98	95	95	100	95	83
2,4-D choline	0.95	PRE									
Pyroxasulfone	0.098	PRE									
AMS	3.0	PRE									
Glufosinate	0.575	LPOST									
2,4-D choline	0.95	LPOST									
AMS	3.0	LPOST									
Glufosinate	0.575	PRE	97	84	86	99	95	94	98	88	75
2,4-D choline	0.95	PRE									
Sulfentrazone/ Cloransulam	0.219	PRE									
AMS	3.0	PRE									
Glufosinate	0.575	LPOST									
2,4-D choline	0.95	LPOST									
AMS	3.0	LPOST									
Glufosinate	0.575	PRE	90	74	79	96	100	100	99	83	70
2,4-D choline	0.95	PRE									
Chlorimuron/ Flumioxazin/ Metribuzin	0.23	PRE									
AMS	3.0	PRE									
Glufosinate	0.575	LPOST									
2,4-D choline	0.95	LPOST									
AMS	3.0	LPOST									

Glufosinate 2,4-D choline Metribuzin AMS Glufosinate 2,4-D choline AMS	0.575 0.95 0.5 3.0 0.575 0.95 3.0	PRE PRE PRE PRE LPOST LPOST LPOST	99	93	91	100	100	100	100	96	90
Pyroxasulfone Imazethapyr/ Saflufenacil Glyphosate Glufosinate 2,4-D choline AMS	0.08 0.063 1.13 0.575 0.95 3.0	PRE PRE PRE LPOST LPOST LPOST	98	95	93	100	100	98	100	99	96
Pyroxasulfone Imazethapyr/ Saflufenacil Glyphosate Glufosinate AMS	0.08 0.063 1.13 0.575 3.0	PRE PRE PRE LPOST LPOST	98	96	93	99	99	99	100	99	98
Saflufenacil Metribuzin Glyphosate AMS Glufosinate 2,4-D choline AMS	0.022 0.5 1.13 3.0 0.575 0.95 3.0	PRE PRE PRE PRE LPOST LPOST LPOST	98	81	86	98	93	100	99	85	73
Glufosinate AMS Glufosinate AMS	0.575 3.0 0.575 3.0	EPOST EPOST LPOST LPOST	88	69	45	90	98	100	91	83	73
Glufosinate 2,4-D choline AMS Glufosinate 2,4-D choline AMS	0.575 0.95 3.0 0.575 0.95 3.0	EPOST EPOST EPOST LPOST LPOST LPOST	91	71	68	94	100	98	93	85	65
Glufosinate *S*-metolachlor	0.575 0.955	EPOST EPOST	93	81	70	93	100	100	94	88	85

AMS	3.0	EPOST								
Glufosinate	0.575	LPOST								
AMS	3.0	LPOST								
Glufosinate	0.575	EPOST	91	85	85	94	99	100	91	83	83
2,4-D choline	0.95	EPOST								
S-metolachlor	0.955	EPOST								
AMS	3.0	EPOST								
Glufosinate	0.575	LPOST								
2,4-D choline	0.95	LPOST								
AMS	3.0	LPOST								
Glufosinate	0.575	EPOST	93	74	78	94	100	100	89	85	91
Glyphosate	1.13	EPOST								
AMS	3.0	EPOST								
Glufosinate	0.575	LPOST								
Glyphosate	1.13	LPOST								
AMS	3.0	LPOST								
Glufosinate	0.575	EPOST	94	81	71	95	93	95	93	93	89
2,4-D choline	0.95	EPOST								
Glyphosate	1.13	EPOST								
AMS	3.0	EPOST								
Glufosinate	0.575	LPOST								
2,4-D choline	0.95	LPOST								
Glyphosate	1.13	LPOST								
AMS	3.0	LPOST								
LSD (0.05)			6	6	10	5	9	11	4	8	10

[1] AMS is ammonium sulfate.

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

[3] 4 DAB is 4 days after early postemergence treatment, 24 DAB is 24 days after early postemergence treatment, and 17 DAC is 17 days after late postemergence treatment.

Halauxifen/fluroxypyr alone and in combinations for weed control in fallow. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to compare halauxifen/fluroxypyr alone or with competitive standards for weed control in fallow. All 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 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 estimates were determined on May 15, May 27, and June 10, 2020. These dates were 9, 21, and 35 days after herbicide treatment (DAT).

Table 1. Application, environmental, and weed data for the halauxifen/fluroxypyr study in fallow.

Application date	May 6, 2020
Air temperature (F)	55
Relative humidity	40
Soil temperature (F)	59
Wind speed (mph)	1 to 4
Wind direction	North-northeast
Soil moisture	Dry
Kochia	
Height (inches)	2 to 4
Density (plants/ft^2)	10
Flixweed	
Height (inches)	8 to 12
Density (plants/ft^2)	2

This trial was conducted under severe drought conditions, with only 25% of normal precipitation received from the time of application until the final evaluation date. Kochia control with halauxifen/fluroxypyr alone was equal to or better than dicamba, fluroxypyr, or glyphosate alone at each rating date. At 35 DAT, halauxifen/fluroxypyr alone provided 80% kochia control, whereas the tank mixtures of dicamba plus glyphosate, fluroxypyr plus dicamba and glyphosate, and halauxifen/fluroxypyr plus dicamba and glyphosate controlled kochia 94 to 98%. Halauxifen/fluroxypyr alone controlled flixweed similarly to dicamba, fluroxypyr, and glyphosate alone early in the season. The addition of dicamba and/or glyphosate to halauxifen/fluroxypyr alone improved flixweed control at 21 DAT, but all herbicides provided complete flixweed control by 35 DAT. More research is needed to test halauxifen/fluroxypyr for efficacy under favorable growing conditions.

Table 2. Halauxifen/fluroxypyr comparisons for efficacy in fallow.

Treatment[1]	Rate	Kochia			Flixweed		
		9 DAT[2]	21 DAT	35 DAT	9 DAT	21 DAT	35 DAT
	lb ae/A	% Visual			% Visual		
Halauxifen/ Fluroxypyr NIS	0.114 0.25%	28	63	80	20	85	100
Dicamba NIS	0.119 0.25%	10	55	75	20	78	100
Halauxifen/ Fluroxypyr Dicamba NIS	0.114 0.119 0.25%	33	73	91	28	91	100
Fluroxypyr NIS	0.14 0.25%	25	63	75	20	70	100
Fluroxypyr Dicamba NIS	0.14 0.119 0.25%	23	75	93	28	85	100
Glyphosate NIS AMS	0.77 0.25% 1.0%	0	45	55	23	85	100
Halauxifen/ Fluroxypyr Glyphosate NIS AMS	0.114 0.77 0.25% 1.0%	30	73	89	25	91	100
Fluroxypyr Glyphosate NIS AMS	0.14 0.77 0.25% 1.0%	28	73	88	28	94	100
Dicamba Glyphosate NIS AMS	0.119 0.77 0.25% 1.0%	33	68	94	30	90	100
Fluroxypyr Dicamba Glyphosate NIS AMS	0.14 0.119 0.77 0.25% 1.0%	35	81	98	35	96	100
Halauxifen/ Fluroxypyr Dicamba Glyphosate NIS AMS	0.114 0.119 0.77 0.25% 1.0%	38	81	98	35	96	100
LSD (0.05)		7	6	5	7	6	NS

[1] NIS is nonionic surfactant, AMS is ammonium sulfate.
[2] DAT is days after herbicide treatment.

Pyraflufen tank mixtures for weed control in fallow. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to compare pyraflufen tank mixed with various herbicides for control of glyphosate-resistant kochia 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 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 3.4% organic matter and pH of 7.9. Visual weed control was determined on May 13, May 19, and June 2, 2020. These dates were 8, 14, and 28 days after treatment (DAT), respectively.

Table 1. Application, environmental, and weed data for the pyraflufen tank mix study in fallow.

Application date	May 5, 2020
Air temperature (F)	67
Relative humidity	28
Soil temperature (F)	62
Wind speed (mph)	7 to 10
Wind direction	Northeast
Soil moisture	Dry
Kochia	
Height (inches)	1 to 4
Density (plants/ft^2)	2.5
Flixweed	
Height (inches)	8 to 12
Density (plants/ft^2)	0.3

The trial was conducted under severe drought conditions, such that less than 25% of normal precipitation was received from the time of herbicide application until the final evaluation date. Pyraflufen plus glyphosate alone or with 2,4-D controlled kochia less than 40% at 8 DAT (Table 2). The combination of pyraflufen with glyphosate, 2,4-D and sulfentrazone provided 50% kochia control at this date. By 14 DAT, kochia control was best when pyraflufen was mixed with sulfentrazone (68 to 73%). At 28 DAT, only those treatments containing sulfentrazone provided more than 75% kochia control. Kochia control reached a high point at 28 DAT, and plants soon began to recover (data not shown). Pyraflufen tank mixed with glyphosate, 2,4-D and sulfentrazone controlled flixweed 70% by 8 DAT. Pyraflufen plus glyphosate and sulfentrazone, with or without 2,4-D, controlled flixweed 90% at 14 DAT. However, all herbicides completely controlled flixweed at 28 DAT. More research is needed to test these herbicides under more favorable growing conditions.

Table 2. Weed control with pyraflufen tank mixtures in fallow.

Treatment[1]	Rate	Kochia			Flixweed		
		8 DAT[2]	14 DAT	28 DAT	8 DAT	14 DAT	28 DAT
	lb/A	% Visual			% Visual		
Pyraflufen	0.00325	35	50	70	38	65	100
Glyphosate	1.03						
COC	1.0 %						
AMS	3.0						
Pyraflufen	0.00325	30	45	68	48	75	100
Glyphosate	1.03						
2,4-D amine	0.25						
COC	1.0 %						
AMS	3.0						
Pyraflufen	0.00325	45	68	83	55	90	100
Glyphosate	1.03						
Sulfentrazone	0.188						
COC	1.0 %						
AMS	3.0						
Glyphosate	1.03	40	63	78	48	83	100
Sulfentrazone	0.188						
COC	1.0 %						
AMS	3.0						
Pyraflufen	0.00325	50	73	80	70	90	100
Glyphosate	1.08						
2,4-D amine	0.25						
Sulfentrazone	0.188						
COC	1.0 %						
AMS	3.0						
LSD (0.05)		5	8	9	7	7	NS

[1] COC is crop oil concentrate, AMS is ammonium sulfate.
[2] DAT is days after herbicide treatment.

Precision and broadcast spray applications of picloram for rush skeletonweed control in fallow. Mark Thorne, Jacob Fischer, Henry Wetzel, and Drew Lyon (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A multi-year study was initiated in 2019 comparing applications of picloram for rush skeletonweed (*Chondrilla juncea*) control in a winter wheat/no-till fallow rotation. Standard broadcast applications were compared with applications made using a precision sprayer (WEED-IT, Hoge Wesselink 8, 7221 CJ Steenderen, The Netherlands) at three different picloram rates. Picloram is effective for control of rush skeletonweed at the labeled rate is 0.25 lb ai/A; however, rush skeletonweed is a spreading perennial and it is not known if a precision spray application that only covers the area directly associated with the above-ground stems and rosettes will be effective.

Treatments were applied October 3, 2019 at a site near Hay, WA (Table 1), which was in standing winter wheat stubble following the 2019 harvest. Picloram was applied at 0.125, 0.25, and 0.5 lb ai/A rates. The precision sprayer was calibrated to apply 29.4 gpa at 50 psi moving 5 mph if all nozzles were spraying continuously. Ten TeeJet® 3003E nozzles were spaced at 8 inches approximately 18 inches above the ground. The broadcast applications were applied with a 10-ft hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with CO_2 moving 3 mph. Spray output was 15 gpa at 25 psi. The plots measured 10 by 35 ft, but the precision applicator only sprayed a width of 6.7 ft in each plot. The field site was managed in no-till fallow through 2020 and fall-seeded to winter wheat. Treatment efficacy was evaluated with plant density counts in a 6.7- by 33-ft area in each plot on April 15, 2020 in fallow, and October 22, 2020 in the newly emerged winter wheat crop.

Table 1. Application and soil data.

Location	Hay, WA
Application date	October 3, 2019
Rush skeletonweed growth stage	post-flowering stems and rosettes
Crop phase	no-till fallow
Air temperature (°F)	50
Relative humidity (%)	54
Wind (mph, direction)	4, W
Cloud cover (%)	100
Soil temperature at 2 inches (F)	48
Soil texture	Walla Walla silt loam
Soil organic matter 0-6 inches (%)	2.1
Soil pH	6.1

Rush skeletonweed density differed across the site, therefore, each precision spray application volume would reflect the density in each plot. The percentage of area sprayed by the precision sprayer in relation to the total potential area, was 51, 26, and 28%, for the 0.125, 0.25, and 0.5 lb ai/A rates, respectively, which translates to 0.06, 0.07, and 0.14 lb ai/A of active ingredient for each respective rate. (Table 2). None of the precision sprayer applications exceeded the labeled rate of 0.25 lb ai/A.

Table 2. Area sprayed and amount of picloram applied with a precision sprayer compared with a standard broadcast application.

Active ingredient applied using the broadcast rate	Percent of total area sprayed with the precision sprayer at each rate[1]	Active ingredient applied using the precision sprayer at each rate
lb ai/A	%	lb ai/A
0.125	52	0.06
0.25	27	0.07
0.50	29	0.17

[1]Percent of total area sprayed is based on the amount of area sprayed with the precision sprayer in relation to the potential area covered (6.7 by 35 ft/plot). The percentage reflects the density of rush skeletonweed.

By April 2020, all treatments had fewer plants than the nontreated check, which averaged 1.5 plants/yd^2, and no differences were found between the precision sprayer and broadcast applications (Table 3). By October, density in the nontreated check had increased to 2.5 plants/yd^2 but was not different from either the precision sprayer or broadcast application of picloram at 0.125 lb ai /A. Rush skeletonweed densities at the 0.25 and 0.50 lb ai/A rates were not different from each other and were more effective than the 0.125 lb ai/A rate. No difference was found between the precision sprayer and broadcast applications at any of the three rates (Table 3).

This study indicates that applications of picloram with a precision sprayer can be equally effective compared with broadcast applications for control of rush skeletonweed through the fallow phase of the wheat/fallow rotation. Furthermore, the labeled 0.25 lb ai/A rate appears to be as effective as a 0.50 lb ai/A rate; however, the 0.125 lb ai/A rate does not control rush skeletonweed completely through the fallow year. These treatments will be evaluated in 2021 for effect on winter wheat yield.

Table 3. Effect of picloram applications in no-till fallow on rush skeletonweed density during the fallow year.

		Rush skeletonweed density[2]	
Application method[1]	Rate	April 15, 2020	October 22, 2020
	lb ai/A	--------------------plants/yd^2--------------------	
nontreated check	0	1.5 a	2.5 a
precision sprayer	0.125	0.2 b	1.9 a
broadcast	0.125	0.1 b	3.2 a
precision sprayer	0.25	0.1 b	0.8 b
broadcast	0.25	0.0 b	0.7 b
precision sprayer	0.50	0. 1 b	0.4 b
broadcast	0.50	0.0 b	0.2 b

[1]Treatments were applied October 3, 2019.
[2]Means followed by the same letter in each column are not different (α=0.05).

Control of smooth scouringrush with sulfonylurea herbicides and non-ionic surfactants. Mark Thorne and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) Three sulfonylurea herbicides and two surfactants were compared for control of smooth scouringrush (*Equisetum laevigatum*) in a wheat/fallow system. Chlorsulfuron is known to be effective on smooth scouringrush but has a long soil-active period and can limit crop rotation options. Other sulfonylurea herbicides have shorter plantback intervals, but their efficacy on smooth scouringrush may be lower. We compared efficacy of chlorsulfuron/metsulfuron, triasulfuron, and thifensulfuron/tribenuron for control of smooth scouringrush, applied in fallow, using either an organosilicone nonionic surfactant (OSNIS) or a standard nonionic surfactant (NIS). All herbicides were applied in 2019 during the no-till fallow phase of the rotation and evaluated in the 2020 winter wheat crop just prior to harvest.

The study site was in a three-year rotation of no-till fallow/winter wheat/spring wheat located near Steptoe, WA. Smooth scouringrush density in 2019 averaged 468 stems/yd^2. Plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. All herbicide treatments were applied on June 12, 2019 (Table 1) with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with CO_2 moving 3 mph. Spray output was 15 gpa at 25 psi.

Table 1. Application and soil data.

Application date	6/12/2019
Rotation phase	no-till fallow
Smooth scouringrush stage	stems with strobili
Air temperature (F)	85
Relative humidity (%)	28
Wind (mph, direction)	3, N
Cloud cover (%)	40
Soil temperature at 2 inches (F)	80
Soil texture	Palouse-Thatuna silt loam
Soil OM 0-6 inches (%)	2.2
Soil pH	5.0

In the 2020 winter wheat crop, smooth scouringrush in the nontreated check treatment averaged 239 stems/yd^2 but was not different from the triasulfuron or thifensulfuron/tribenuron treatments (Table 2). Chlorsulfuron/metsulfuron treatments reduced density substantially compared with all other treatments. Chlorsulfuron/metsulfuron with OSNIS was more effective than chlorsulfuron/metsulfuron with NIS, which averaged 1 and 5 stems/yd^2, respectively. Triasulfuron or thifensulfuron/tribenuron may lack the soil persistence needed to give long-term control of smooth scouringrush. Adding OSNIS improves efficacy of chlorsulfuron/metsulfuron compared with NIS and has been shown in other research to aid uptake of herbicides through open stomates.

Table 2. Herbicide and surfactant effect on smooth scouringrush in winter wheat following application in the previous fallow year.

Treatment	Rate	Smooth scouringrush density[1]
	oz ai/A + % v/v	stems/yd^2
nontreated check		239 a
chlorsulfuron/metsulfuron + NIS	0.31/0.06 + 0.25	5 b
chlorsulfuron/metsulfuron + OSNIS	0.31/0.06 + 0.25	1 c
triasulfuron + NIS	0.42 + 0.25	265 a
triasulfuron + OSNIS	0.42 + 0.25	211 a
thifensulfuron/tribenuron + NIS	0.38/0.38 + 0.25	216 a
thifensulfuron/tribenuron + OSNIS	0.38/0.38 + 0.25	186 a

[1]Means followed by the same letter are not different (α=0.05).

Smooth scouringrush control with glyphosate and an organosilicone surfactant no-till fallow. Mark Thorne and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A study was initiated in 2019 and evaluated in 2020 to test timing of application of glyphosate with an organosilicone nonionic surfactant (OSNIS) for control of smooth scouringrush (*Equisetum laevigatum*). Trial locations were at the Palouse Conservation Field Station (PCFS) near Pullman, WA, and farms near Steptoe and Edwall, WA. Each site was in no-till fallow in 2019 and in winter wheat in 2020. Initial densities in 2019 averaged 67, 125, and 370, stems/yd^2 at Edwall, PCFS, and Steptoe, respectively.

All treatments were applied in 2019 near the end of each month from May through August, except for the first application at Steptoe, which was applied June 11, 2019 (Table 1). Experimental design was a split-plot randomized complete block, with three sub-plot treatments per main plot, and four application times. Main plots were the application times and sub-plots were the herbicide treatments of glyphosate alone (with no added surfactant), glyphosate with OSNIS, and no herbicide. Main-plots at Steptoe and Edwall measured 10 by 30 ft with sub-plots measuring 10 by 10 ft. Due to limited area, PCFS main plots were 6.7 by 15 ft with 6.7- by 5-ft sub-plots. Herbicides were applied with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with CO_2 moving 3 mph. Spray output was 15 gpa at 25 psi.

Table 1. Application and soil data.

PCFS, Pullman, WA				
Application date	5/28/2019	7/2/2019	7/25/2019	8/29/2019
Air temperature (°F)	72	72	86	67
Relative humidity (%)	42	32	26	43
Wind (mph, direction)	2-4, W	0	0-1, W	2, E
Cloud cover (%)	20	3-5, W	0	100
Soil temperature at 2 inches (F)	75	76	90	64
Soil texture	Caldwell silt loam			
Soil organic matter 0-6 inches (%)	3.3			
Soil pH	5.1			
Steptoe, WA				
Application date	6/11/2019	7/2/2019	7/25/2019	8/28/2019
Air temperature (°F)	77	74	82	88
Relative humidity (%)	34	32	28	18
Wind (mph, direction)	1-3, E	3-5, W	2-3, SE	3, W
Cloud cover (%)	1	10	0	0
Soil temperature at 2 inches (F)	72	72	74	62
Soil texture	Palouse-Thatuna silt loam			
Soil organic matter 0-6 inches (%)	2.7			
Soil pH	5.0			
Edwall, WA				
Application date	5/23/2019	7/2/2019	7/25/2019	8/29/2019
Air temperature (°F)	73	71	78	75
Relative humidity (%)	22	28	27	33
Wind (mph, direction)	2, E	3-5, SW	1-2, SW	3, SE
Cloud cover (%)	0	2	0	100
Soil temperature at 2 inches (F)	61	72	76	62
Soil texture	Broadax silt loam			
Soil organic matter 0-6 inches (%)	2.9			
Soil pH	5.0			

In July 2020, all treatments were assessed in the winter wheat crop, approximately a year after herbicide applications, by counting stems in sample quadrats in each sub-plot. Smooth scouringrush density at each location differed in response to herbicide treatment and timing of application (Table 2). Furthermore, each location differed in its topography and aspect. The PCFS location had a southern exposure and was located at the bottom of a gentle slope. This location was the warmest of the three and had warmer soil temperatures at each application time (Table 1). The Edwall site was in a northwest-facing draw with a gentle slope and moist soil much of the year. The Steptoe site was on a steep north-facing slope. These differences likely had an impact on the growth of the plants, and possibly the efficacy of the treatments.

Applications of glyphosate + OSNIS resulted in fewer stems than glyphosate alone at all locations and application times, except for the May application at PCFS (Table 2). The May PCFS applications of glyphosate alone and glyphosate + OSNIS resulted in 8 and 2 stems/yd^2, respectively, compared with 63 stems/yd^2 for the nontreated check. Furthermore, the glyphosate alone application only reduced stem density, compared with the nontreated check, at the July applications at Edwall and Steptoe, and the August application at Steptoe (Table 2). In addition, the response of the glyphosate alone treatment was much more variable than the glyphosate + OSNIS treatment (data not shown). The poor response of glyphosate alone is consistent with previous research and grower reports and is likely due to the inability of smooth scouringrush to uptake enough of the herbicide to make a difference the following year. This barrier is diminished by adding OSNIS. The application of glyphosate + OSNIS could be a good alternative to using long residual herbicides containing chlorsulfuron, which are known to control smooth scouringrush, but cannot be applied for at least 36 months prior to planting susceptible crops such as pulses or non-sulfonylurea resistant canola.

Table 1. Smooth scouringrush density in 2020 winter wheat crops following herbicide applications in the previous fallow year at three locations in eastern Washington.

			Smooth scouringrush density[2]		
Time	Treatments[1]	Rates	Edwall	PCFS	Steptoe
		lb ai/A + % v/v	-----------stems per square yard-----------		
May	none	-	339 a	63 a	280 a
May	glyphosate alone	3.38	209 a	8 b	143 a
May	glyphosate + OSNIS	3.38 + 0.25	79 b	2 b	12 b
June	none	-	276 a	54 a	241 a
June	glyphosate alone	3.38	189 a	13 a	91 a
June	glyphosate + OSNIS	3.38 + 0.25	38 b	0 b	16 b
July	none	-	184 a	146 a	260 a
July	glyphosate alone	3.38	89 b	67 a	165 b
July	glyphosate + OSNIS	3.38 + 0.25	40 c	2 b	67 c
August	none	-	134 a	133 a	263 a
August	glyphosate alone	3.38	73 a	99 a	158 b
August	glyphosate + OSNIS	3.38 + 0.25	29 b	8 b	38 c

[1]OSNIS=organosilicone nonionic surfactant

[2]Numbers followed by the same letter in each column for each time are not different (α=0.05).

Annual bluegrass control with tank mixtures in established tall fescue. Andreia K. Suzukawa[1], Kyle C. Roerig[2], Andrew G. Hulting[1], and Caio A. C. G. Brunharo[1]. ([1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331; [2]Pratum Co-op, Salem, OR 97305). Herbicide resistance in weeds has been a recurrent and evolving problem in agriculture. One of the main strategies for avoiding and managing herbicide resistance is to rotate herbicides. The objective of this study was to evaluate the efficacy of post emergence herbicides in tank mixtures for annual bluegrass (*Poa annua* L.) control in established tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort.) grown for seed. Tall fescue was sown in the fall of 2018. The study was conducted in a randomized complete block design with four replications and each plot was 2.4 by 10.6 m. Treatments were applied when annual bluegrass plants were in the 2-leaf to 2-tiller growth stage with a compressed air pressurized boom mounted on a bicycle sprayer calibrated to deliver 187 L ha^{-1}. Further information on application is presented in Table 1. Annual bluegrass control and crop injury were assessed in a 0 to 100 scale, where 0 represents no control or no crop injury and 100 complete weed control or crop injury. Plant growth regulators and broadleaf herbicides were applied according to grower standards. The crop was swathed on July 1 and harvested on July 15, 2020.

Table 1. Herbicide application data.

Application date	October 17, 2019
Temperature (ºC)	22
Relative humidity (%)	68
Wind speed (m s^{-1})	0
Cloud cover (%)	30

Pyroxasulfone/flumioxazin + glufosinate + metribuzin provided 85% annual bluegrass control, the greatest among all herbicide treatments (Table 2). The two EPTC rates tested (3430 and 4909 g ha^{-1}) in tank mixtures with glufosinate + dimethenamid-P, S-metolachlor, metribuzin, or oxyfluorfen did not result in differences in annual bluegrass control (68 and 69%). The addition of oxyfluorfen or dimethenamid-P in the pendimethalin + glufosinate tank mixture also did not result in differences in weed control or crop injury. All herbicide treatments resulted in crop injury. However none of the treatments resulted in reduction in seed yield in comparison to the untreated control.

Table 2. Annual bluegrass control, crop injury and seed yield for different herbicide treatments in established tall fescue, Corvallis, Oregon, 2019-20

Treatments	Rate	Annual bluegrass[1] 22 DAA[2]	Crop injury 22 DAA	Seed yield[ns]
	g ai ha^{-1}	---------------------------%---------------------		kg ha^{-1}
untreated control	--	0 d	0 e	2213
Flufenacet/metribuzim + glufosinate + metribuzin	616 257 157	69 c	15 d	2360
Pyroxasulfone/flumioxazin + glufosinate + metribuzin	160 257 157	85 a	21 a	2184
EPTC + glufosinate + dimethenamid-P	3430 257 1098	69 c	20 ab	2244
EPTC + glufosinate + dimethenamid-P	4909 257 1098	69 c	19 abc	2273
EPTC + glufosinate + S-metolachlor	3430 257 1423	69 c	20 ab	2185
EPTC + glufosinate + S-metolachlor	4909 257 1423	69 c	20 ab	2206
EPTC + glufosinate + metribuzin	3430 257 157	71 bc	18 bcd	2166
EPTC + glufosinate + metribuzin	4909 257 157	73 bc	16 cd	2270
EPTC + glufosinate + oxyfluorfen	3430 257 53	74 bc	21 a	2068
EPTC + glufosinate + oxyfluorfen	4909 257 53	76 b	21 a	2107
Pendimethalin + glufosinate + oxyfluorfen	1121 257 53	68 c	19 abc	2160
Pendimethalin + glufosinate + dimethenamid-P	1121 257 1098	73 bc	19 abc	2229
EPTC + dimethenamid-P + ethalfluralin + glufosinate	3430 1098 841 257	73 bc	20 ab	2065
CV		7.62	10.11	5.46

[1]Means within a column followed by the same letter are not significantly different at the 5% level as determined by the t (LSD) test;
[2]DAA: Days after application;
ns: not significant among means.

Annual bluegrass control with post emergence herbicides in established tall fescue. Andreia K. Suzukawa[1], Kyle C. Roerig[2], Andrew G. Hulting[1], and Caio A. C. G. Brunharo[1]. ([1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331, [2]Pratum Co-op, Salem, OR 97305). A study was conducted in established tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort.) to assess efficacy of pyroxasulfone/carfentrazone, flufenacet/metribuzin, pyroxasulfone/flumioxazin and indaziflam in tank mixture with glufosinate (G) and metribuzin (M). Plots were 2.4 by 10.6 m arranged in a randomized complete block design with four replications. Tall fescue was sown in the fall of 2018. Treatments were applied with a compressed air pressurized boom mounted on a bicycle sprayer calibrated to deliver 187 L ha^{-1} at the 2-leaf to 2-tiller growth stage of annual bluegrass plants (Table 1). All treatments included glufosinate at 257 g ai ha^{-1} and metribuzin at 157 g ai ha^{-1} (G+M). Annual bluegrass and volunteer tall fescue control and crop injury were assessed using a 0 to 100 scale, where 0 represents no control or no crop injury and 100 complete weed control or crop injury. Plant growth regulators and broadleaf herbicides were applied according to grower standards. The crop was swathed on July 1 and harvested on July 15, 2020.

Table 1. Application data.

Application date	October 7, 2019
Temperature (ºC)	22
Relative humidity (%)	68
Wind speed (m s^{-1})	0
Cloud cover (%)	30

All herbicide treatments tested resulted in some crop injury (up to 24%) 32 days after application. However, approximately one month later crop injury was no longer visible (Table 2). The herbicide treatments pyroxasulfone/flumioxazin, flufenacet/metribuzim and pyroxasulfone/carfentrazone (256 g ai ha^{-1}) in tank mixture with glufosinate and metribuzin resulted in >95% control of annual bluegrass; however, the latter treatment caused a reduction in yield. At lower rates (96 or 128 g ai ha^{-1}) pyroxasulfone/carfentrazone + G+M did not result in tall fescue seed yield loss and were not significantly different in annual bluegrass control. The higher indaziflam rate (29 g ai ha^{-1}) + G+M provided greater control of annual bluegrass (85%) than the treatment containing indaziflam at 15 g ai ha^{-1}. Tall fescue seed yield ranged from 2159 to 2263 kg ha^{-1}. The only treatment to reduce tall fescue seed yield was pyroxasulfone/carfentrazone (256 g ai ha^{-1}) + G+M.

Table 2. Annual bluegrass control, crop injury and seed yield after herbicide treatments in established tall fescue, Corvallis, Oregon, 2019-20.

Treatments	Rate	Crop injury[1]		Annual bluegrass control		Seed yield
		32 DAA[2]	67 DAA	32 DAA	67 DAA	
	g ai ha^{-1}	-------------------%-------------------				kg ha^{-1}
Untreated control	--	0	0	0 d	0 e	1982 b
Flufenacet-metribuzin +	616	16 de	0	71 b	95 a	2263 a
glufosinate +	257					
metribuzin	157					
Pyroxasulfone-flumioxazin +	160	30 a	3	89 a	97 a	2159 a
glufosinate +	257					
metribuzin	157					
Pyroxasulfone-carfentrazone +	96	19 cd	0	64 c	86 bc	2175 a
glufosinate +	257					
metribuzin	157					
Pyroxasulfone-carfentrazone +	128	20 c	0	70 bc	91 ab	2167 a
glufosinate +	257					
metribuzin	157					
Pyroxasulfone-carfentrazone +	256	24 b	0	69 bc	95 a	1947 b
glufosinate +	257					
metribuzin	157					
Indaziflam +	15	18 cde	0	69 bc	76 d	2231 a
glufosinate +	257					
metribuzin	157					
Indaziflam +	29	15 e	0	69 bc	85 c	2180 a
glufosinate +	257					
metribuzin	157					

[1]Means within a column followed by the same letter are not significantly different at the 5% level as determined by the t (LSD) test;
[2]DAA: days after application.

Preemergence herbicides for annual bluegrass control in perennial ryegrass. Andreia K. Suzukawa[1], Kyle C. Roerig[2], Andrew G. Hulting[1], and Caio A. C. G. Brunharo[1]. ([1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331, [2]Pratum Co-op, Salem, OR 97305). The objective of this study was to evaluate the efficacy of preemergence herbicides for annual bluegrass control in carbon-seeded perennial ryegrass. Perennial ryegrass was sown on October 2, 2019, at 0.9 cm of depth, with row spacing of 25 cm. A 2.5-cm wide band of activated carbon at 336 kg ha^{-1} was sprayed on top of the seed rows. The study was conducted in a randomized complete block design, with four replications and each plot was 2.4 by 10.6 m. Treatments were applied with a bicycle sprayer calibrated to deliver 187 L ha^{-1}. The study area received 16 mm of precipitation three days following the application. Further information on application is presented in Table 1. Annual bluegrass (*Poa annua* L.) control and crop injury were assessed in a 0 to 100 scale, where 0 represents no control or no crop injury and 100 complete weed control or crop injury. The crop was swathed on July 8 and harvested on July 17, 2020.

Table 1. Application data.

Application date	October 2, 2019
Temperature (ºC)	14
Relative humidity (%)	84
Wind speed (m s^{-1})	0
Soil temperature at 5 cm (ºC)	11
Cloud cover (%)	100

All herbicide treatments provided control of annual bluegrass, ranging from 80 to 100%, except for pronamide alone, which had 68% control (Table 2). Pyroxasulfone/carfentrazone at the highest rate (256 g ai ha^{-1}) caused 10% crop injury 72 days after application. Little to no visible symptoms ($\leq$ 5%) were observed close to harvest. Pyroxasulfone/carfentrazone applied at 96 or 128 g ai ha^{-1}, caused 0 and 1 % visual injury. Perennial ryegrass had seed yield greater than the untreated control in the herbicide treatments pyroxasulfone/carfentrazone at 96 and 128 g ai ha^{-1}, pyroxasulfone/flumioxazin, rimsulfuron, rimsulfuron+pronamide and diuron+pronamide. Lowest yield was found with the higher rate of indaziflam.

Table 2. *Poa annua* L. (POANN) control, crop injury, and seed yield after herbicide treatments in carbon-seeded perennial ryegrass, Corvallis, Oregon, 2019-20.

Treatments	Rate	POANN 72 DAA[1,2]	Crop injury 72 DAA	Crop injury 252 DAA	Yield
	g ai ha^{-1}	--------------------%-------------------			kg ha^{-1}
untreated	--	0 d	0 b	0 c	2754 cd
pyroxasulfone/carfentrazone	96	99 a	0 b	0 c	2911 ab
pyroxasulfone/carfentrazone	128	100 a	0 b	1 bc	2930 ab
pyroxasulfone/carfentrazone	256	100 a	10 a	5 a	2806 bcd
pyroxasulfone/flumioxazin	80	98 a	3 b	0 c	2970 a
indaziflam	15	80 b	0 b	0 c	2857 abc
indaziflam	29	80 b	0 b	3 b	2694 d
rimsulfuron	53	96 a	3 b	0 c	2920 ab
rimsulfuron + pronamide	53 + 145	100 a	0 b	0 c	2924 ab
pronamide	289	68 c	0 b	0 c	2875 abc
diuron + pronamide	2242 + 289	99 a	0 b	0 c	2957 a

[1]Means within a column followed by the same letter are not significantly different at the 5% level as determined by the t (LSD) test;
[2]DAA: Days after application.

Crop safety evaluation of florauxifen-benzyl/2,4-D formulations in annual and perennial ryegrass grown for seed. Seth Abugho[1], Kyle Roerig[2], Andrew Hulting[1], and Caio A. C. G. Brunharo.[1] ([1]Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331; [2]Pratum Co-op, Salem, OR 97305). The goal of this experiment was to assess the injury in annual and perennial ryegrass grown for seed caused by formulations of florpyrauxifen-benzyl in mixture with 2 ,4 dichlorophenoxy acetic acid (2, 4-D) or 2, 4 dimethylamine (2, 4-DMA). Perennial ryegrass was sown at the Hyslop Field Research Center, Corvallis, OR, on October 2, 2019. Seeds were planted at 0.9 cm depth with 25 cm row spacing using a conventional drill. Annual ryegrass was a volunteer crop. The experimental design was a randomized complete block with 4 replications. Plot size was 2.4 m × 10.6 m. Plots were kept weed-free using a broadcast application of florasulam (21 g ha^{-1}). Treatments were applied at three different crop stages. Perennial ryegrass was applied at 1 node, mid-boot and heading. Annual ryegrass was applied at 2 nodes, mid-boot and flowering. Thirteen herbicide treatments (Table 1) were applied using a bicycle sprayer calibrated to deliver 187 L ha^{-1} fitted with Greenleaf AM11003 nozzles. Methylated seed oil (1% V/V) was used as an adjuvant for all herbicide treatments. Crop injury was visually assessed on a 1 to 10 scale (1=no injury; 10=crop death). Visual assessments were made at 1 and 2 weeks after application (WAA). Plots were harvested by swathing on July 8, 2020) and combining on July 17, 2020. The harvested seed was then cleaned on an air screen cleaner and clean seed yield recorded.

Crop safety on perennial ryegrass. Florpyrauxifen-benzyl/2, 4-D applied at 0.57 kg ai ha^{-1} and 1.14 kg ai ha^{-1} at first node stage caused 5.25 to 5.63 and 6.00 to 6.12 crop injury to perennial ryegrass at 1 and 2 WAA , respectively (Table 1). At mid-boot stage, florpyrauxifen-benzyl/2, 4-D at 1.14 kg ai ha^{-1} caused 4.50 to 5.25 injury to perennial ryegrass at 1 to 2 WAA, respectively. Florpyrauxifen-benzyl/2, 4-DMA formulations caused minimal injury to perennial ryegrass at 1 to 2 WAA regardless of the rates (0.56 to 1.12 kg ai ha^{-1}). At the start of heading of the crop, herbicide treatments caused <2.00 injury to perennial ryegrass at 1 and 2 WAA regardless of the florpyrauxifen-benzyl/2, 4-D rates.

Crop safety on annual ryegrass. The high rate of florpyrauxifen-benzyl/2, 4-D (1.14 kg ai ha^{-1}) applied at 2 node stage caused 6.63 to 7.13 annual ryegrass injury at 1 or 2 WAA, respectively (Table 2). At mid-boot stage, florpyrauxifen-benzyl/2, 4-D at 0.56 kg ai ha^{-1} caused 3.00 injury to annual ryegrass compared to other herbicide treatments at 1 WAA. Minimal injury was observed in annual ryegrass at 2 WAA regardless of herbicide treatments. At flowering, higher rates of florpyrauxifen-benzyl mixed with either 2,4-D or 2, 4-DMA applied at 1 WAA caused 3.38 to 3.63 injury, respectively, to annual ryegrass. Annual ryegrass did not have significant injury at 2 WAA (Table 2).

Crop yield. Untreated perennial ryegrass check plots yielded 2865 kg ha^{-1} clean seed. Florpyrauxifen-benzyl/2, 4-D DMA (0.56 kg ai ha^{-1}) applied at 30 and 15 days before boot stage of perennial ryegrass had 2660 kg ha^{-1} and 2698 kg ha^{-1} yield, respectively (Table 1). Florpyrauxifen-benzyl/2, 4-D at 1.14 kg ha^{-1} applied at boot stage of perennial ryegrass yielded 2147 kg ha^{-1}, the least among all herbicide treatments. Untreated annual ryegrass check plots yielded 1639 kg ha^{-1}, the highest among all treatments. Both rates of florpyrauxifen-benzyl/2, 4-DMA applied at 30 and 15 days before boot stage of annual ryegrass yielded 1423 kg ha^{-1} to 1642 kg ha^{-1}. Florpyrauxifen-benzyl/2, 4-D applied at 30 days before boot stage had 1495 kg ha^{-1} annual ryegrass yield. Boot stage applications of florpyrauxifen-benzyl/2, 4-D at 0.57 and 1.14 kg ai ha-1, including florpyrauxifen-benzyl/2, 4-DMA yielded 903 kg ha^{-} to 1133 kg ha^{-1}.

Regardless of the rates, florpyrauxifen-benzyl/2, 4- D applied at 1- node stage can cause more injury to perennial ryegrass compared to mid-boot and heading stage. Florpyrauxifen/2, 4-D DMA formulations cause less injury to perennial ryegrass applied at heading stage. Annual ryegrass is more sensitive to florpyrauxifen-benzyl in mixture with either 2, 4-D or 2, 4-D DMA compared to perennial ryegrass. Nevertheless, these formulations do possess value for use as a tool in perennial ryegrass or annual ryegrass systems. Further investigation on time of application at earlier crop stages could be done to reduce crop injury

Table 1. Crop safety and seed yield of perennial ryegrass to the application of florpyrauxifen-benzyl/2, 4-D formulations, Corvallis, OR 2020

Treatments	Rate	Crop stage	Perennial ryegrass injury[a]		Seed Yield
	kg ai ha^{-1}		1 WAA[b]	2 WAA	kg ha^{-1}
Untreated check	--	--	1.00 c	1.00 b	2865 a
2, 4-D/florpyrauxifen-benzyl	0.57	1-node	5.25 a	6.12 a	2512 de
2, 4-D/ florpyrauxifen-benzyl	1.14	1-node	5.63 a	6.00 a	2402 f
2, 4-D DMA/florpyrauxifen-benzyl	0.56	1-node	1.87 c	2.00 b	2660 bc
2, 4-D DMA/florpyrauxifen-benzyl	1.12	1-node	2.87 b	4.75 a	2430 ef
2, 4-D/florpyrauxifen-benzyl	0.57	Mid-boot	4.00 ab	2.13 b	2513 de
2, 4-D/florpyrauxifen-benzyl	1.14	Mid-boot	5.25 a	4.50 a	2294 g
2, 4-D DMA/florpyrauxifen-benzyl	0.56	Mid-boot	1.25 c	1.75 b	2698 b
2, 4-D DMA/florpyrauxifen-benzyl	1.12	Mid-boot	2.50 bc	1.25 b	2532 de
2, 4-D/florpyrauxifen-benzyl	0.57	Heading	1.75 c	1.00 b	2530 de
2, 4-D/florpyrauxifen-benzyl	1.14	Heading	1.50 c	1.00 b	2147 h
2, 4-D DMA/florpyrauxifen-benzyl	0.56	Heading	1.00 c	1.00 b	2587 cd
2, 4-D DMA/florpyrauxifen-benzyl	1.12	Heading	1.50 c	1.00 b	2448 ef

[a]Means within a column followed by the same letter are not significantly different using Fisher's Protected LSD at P=0.05.
[b]WAA:weeks after application.

Table 2. Crop safety and seed yield of annual ryegrass to the application of florpyrauxifen-benzyl/2, 4-D formulations, Corvallis, OR 2020

Treatments	Rate	Crop stage	Annual ryegrass injury[a]		Seed Yield
	kg ai ha^{-1}		1 WAA[b]	2 WAA	kg ha^{-1}
Untreated check	--	--	1.00 c	1.00 c	1639 a
2, 4-D/florpyrauxifen-benzyl	0.57	2-nodes	5.75 a	3.75 bc	1495 ab
2, 4-D/ florpyrauxifen-benzyl	1.14	2-nodes	6.63 a	7.13 a	1264 bcd
2, 4-D DMA/florpyrauxifen-benzyl	0.56	2-nodes	4.63 ab	3.38 bc	1642 a
2, 4-D DMA/florpyrauxifen-benzyl	1.12	2-nodes	4.88 ab	4.38 ab	1423 abc
2, 4-D/florpyrauxifen-benzyl	0.57	Mid-boot	3.00 b	2.25 a	1295 bcd
2, 4-D/florpyrauxifen-benzyl	1.14	Mid-boot	2.75 b	1.75 c	1238 cd
2, 4-D DMA/florpyrauxifen-benzyl	0.56	Mid-boot	1.75 c	1.75 c	1464 abc
2, 4-D DMAflorpyrauxifen-benzyl	1.12	Mid-boot	1.50 c	1.50 c	1495 ab
2, 4-D/florpyrauxifen-benzyl	0.57	Flowering	2.50 b	2.50 c	1133 de
2, 4-D/florpyrauxifen-benzyl	1.14	Flowering	3.38 b	2.75 c	903 e
2, 4-D DMA/florpyrauxifen-benzyl	0.56	Flowering	2.25 bc	1.25 c	1338 bcd
2, 4-D DMA/florpyrauxifen-benzyl	1.12	Flowering	3.63 ab	1.25 c	904 e

[a]Means within a column followed by the same letter are not significantly different using Fisher's Protected LSD at P=0.05.
[b]WAA:weeks after application.

Imazamox rates and timings for weed control in herbicide-tolerant grain sorghum. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to evaluate imazamox (KFD-356-02) rates, application timings, and tank mix partners for efficacy in imazamox-resistant grain sorghum. 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 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 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 6 and August 11, 2020. These dates were six days after the preemergence treatments (6 DAB) and 35 days after the late postemergence treatments (35 DAD), respectively. Crop injury ratings were taken on July 6 and July 14, 2020, and these dates were 6 days after the early postemergence treatments (6 DAB) and 7 DAD, respectively.

Table 1. Application, environmental, and weed data for the imazamox grain sorghum study.

Application timing	14 Days preplant	Preemergence	Early postemergence	Late postemergence
Application date	May 18, 2020	June 3, 2020	June 30, 2020	July 7, 2020
Air temperature (F)	81	75	73	76
Relative humidity	36	44	41	62
Soil temperature (F)	81	73	74	77
Wind speed (mph)	0 to 4	3 to 7	3 to 6	3 to 7
Wind direction	South	Northwest	South	South
Soil moisture	Dry	Dry	Fair	Fair
Grain sorghum				
Height (inches)	---	---	6 to 8	7 to 9
Leaves (no.)	0	0	3 to 5	4 to 6
Palmer amaranth				
Height (inches)	---	---	3 to 6	3 to 7
Density (plants/ft^2)	0	0	0.5	2
Velvetleaf				
Height (inches)	---	---	2 to 4	2 to 6
Density (plants/ft^2)	0	0	0.1	0.2
Puncturevine				
Diameter (inches)	---	---	6	8
Density (plants/ft^2)	0	0	0.1	0.2
Green foxtail				
Height (inches)	---	---	2 to 5	---
Density (plants/ft^2)	0	0	0.2	0
Shattercane				
Height (inches)	---	---	3 to 6	3 to 5
Density (plants/ft^2)	0	0	0.1	0.2

Common sunflower control was complete with all herbicides regardless of rating date (data not shown). Early season Palmer amaranth control was similar among all herbicides except KFD-365-02 plus atrazine preemergence (PRE) followed by 2,4-D early postemergence (EPOST) and KFD-365-02 PRE followed by atrazine EPOST (Table 2). These treatments, along with KFD-365-02 plus *S*-metolachlor PRE followed by atrazine EPOST were the least effective on Palmer amaranth at 7 DAD as well. However, since the Palmer amaranth biotype in the study is resistant to several herbicide modes-of-actions, no herbicide treatment provided more than 80% control late in the season. Velvetleaf control was 93% or more with all herbicides except *S*-metolachlor/atrazine PRE at 6 DAC.

Similarly, velvetleaf control was best (93 to 100%) with all herbicides except *S*-metolachlor/mesotrione PRE followed by KFD-365-02 alone, or with atrazine EPOST and *S*-metolachlor plus atrazine PRE followed by 2,4-D EPOST at 7 DAD. Treatments of *S*-metolachlor/mesotrione 10 days preplant (10 DPP) followed by KFD-365-02 EPOST or KFD-365-02 PRE provided greater than 90% green foxtail control early, but only the 0.07 lb/A rate of KFD-365-02 applied PRE controlled foxtail more than 90% at 35 DAD. Similarly, only the high rate of KFD-365-02 applied PRE provided adequate puncturevine control at 35 DAD. Shattercane control was good with all herbicides except *S*-metolachlor/atrazine PRE followed by fluroxypyr/2,4-D/bromoxynil. Most herbicide treatments caused 8 to 14% sorghum necrosis at 6 DAC; however, injury did not persist (data not shown).

Table 2. Weed control with imazamox in imazamox-tolerant grain sorghum.

Treatment[1]	Rate	Timing[2]	Palmer amaranth 6 DAB[3]	Palmer amaranth 35 DAD[3]	Velvetleaf 6 DAB	Velvetleaf 35 DAD	Green foxtail 6 DAB	Green foxtail 35 DAD	Shattercane 6 DAB	Shattercane 35 DAD	Puncturevine 35 DAD
	lb/A		% Visual		% Visual		% Visual		% Visual		% Visual
S-metolachlor/ Mesotrione	1.84	14 DPP	89	75	98	88	93	85	99	95	40
KFD-356-02	0.047	EPOST									
COC	1.0%	EPOST									
S-metolachlor/ Mesotrione	1.84	14 DPP	91	70	96	90	91	80	98	98	55
KFD-356-02	0.047	EPOST									
Atrazine	1.0	EPOST									
COC	1.0%	EPOST									
S-metolachlor/ Mesotrione	1.84	14 DPP	91	70	100	100	90	70	100	100	43
KFD-356-02	0.047	EPOST									
2,4-D amine	0.238	EPOST									
KFD-356-02	0.07	PRE	70	35	100	100	100	100	100	100	90
Atrazine	1.0	PRE									
2,4-D amine	0.238	EPOST									
KFD-356-02	0.07	PRE	91	80	100	100	100	95	100	100	90
S-metolachlor	1.0	PRE									
Atrazine	1.0	EPOST									
COC	1.0%	EPOST									
KFD-356-02	0.047	PRE	86	63	100	100	98	85	98	100	75
S-metolachlor	1.0	PRE									
Atrazine	1.0	EPOST									
COC	1.0%	EPOST									
KFD-356-02	0.07	PRE	71	20	100	100	100	95	100	100	93
Atrazine	1.0	EPOST									
COC	1.0%	EPOST									
S-metolachlor	1.0	PRE	86	68	98	100	88	83	96	100	30
Atrazine	1.0	PRE									
KFD-356-02	0.047	EPOST									
COC	1.0%	EPOST									
S-metolachlor	1.0	PRE	89	73	96	98	83	73	100	100	33
Atrazine	1.0	PRE									
KFD-356-02	0.047	EPOST									

2,4-D amine	0.238	EPOST									
S-metolachlor Atrazine 2,4-D amine	1.0 1.0 0.238	PRE PRE EPOST	88	73	93	83	85	60	93	95	30
S-metolachlor/ Atrazine Fluroxypyr/ 2,4-D ester/ Bromoxynil	2.9 0.75	PRE LPOST	90	80	78	93	86	63	88	85	48
LSD (0.05)			10	15	8	10	9	8	6	7	16

[1] COC is crop oil concentrate.
[2] 14 DPP is 14 days preplant, PRE is preemergence, EPOST is early postemergence, and LPOST is late postemergence.
[3] 6 DAB is days after 6 days after the preemergence treatments, 35 DAD is 35 days after the late postemergence treatments.

Nicosulfuron application timings for efficacy in grain sorghum. Randall S. Currie and Patrick W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted to compare nicosulfuron at two rates and two application timings for efficacy in acetolactase synthase-tolerant grain sorghum. 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 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 3.4% organic matter and pH of 7.9. Visual weed control was determined on July 6, 2020, which was 10 days after the early postemergence treatments (10 DAB) and again on August 4, 2020, which was 28 days after the late postemergence treatments (28 DAC).

Table 1. Application, environmental, and weed data for the nicosulfuron in sorghum trial.

Application timing	Preemergence	Early postemergence	Late postemergence
Application date	June 3, 2020	June 26, 2020	July 7, 2020
Air temperature (F)	73	84	76
Relative humidity	44	41	62
Soil temperature (F)	73	72	77
Wind speed (mph)	3 to 7	2 to 6	3 to 7
Wind direction	Northwest	West-southwest	South
Soil moisture	Dry	Good	Good
Grain sorghum			
Height (inches)	---	4 to 6	6 to 9
Leaves (no.)	0	3 to 5	4 to 6
Palmer amaranth			
Height (inches)	---	1 to 4	2 to 7
Density (plants/ft^2)	0	2	1
Velvetleaf			
Height (inches)	---	5 to 5	4 to 6
Density (plants/ft^2)	0	0.5	0.1
Green foxtail			
Height (inches)	---	1 to 3	1 to 4
Density (plants/ft^2)	0	0.5	0.3
Shattercane			
Height (inches)	---	3 to 5	4 to 6
Density (plants/ft^2)	0	0.3	0.2

Sunflower control was similar among all herbicides tested, and was 90% or more regardless of rating date (data not shown). Late-season Palmer amaranth control was best when *S*-metolachlor/atrazine applied preemergence (PRE) was followed by nicosulfuron plus atrazine late postemergence (LPOST), but did not exceed 75% (Table 2). The poor control of Palmer amaranth from the postemergence treatments was due to the weed biotype being resistant to both acetolactase synthase-inhibiting and triazine herbicides. Nicosulfuron plus atrazine applied early postemergence (EPOST) or LPOST controlled velvetleaf 88 to 93% regardless of rate at 28 DAC. Green foxtail control at 10 DAB was best when *S*-metolachlor/atrazine PRE was applied alone or followed by nicosulfuron at 0.0623 lb/A plus atrazine EPOST. Either rate of nicosulfuron applied EPOST and nicosulfuron at 0.0623 lb/A applied LPOST were the only treatments to control green foxtail more than 90% at 28 DAC. *S*-metolachlor/atrazine applied PRE controlled shattercane the best at 10 DAB. However, nicosulfuron at both rates and application timings provided complete shattercane control later in the season.

Table 2. Weed control with nicosulfuron in grain sorghum.

			Palmer amaranth		Velvetleaf		Green foxtail		Shattercane	
Treatment[1]	Rate	Timing[2]	10 DAB[3]	28 DAC[3]	10 DAB	28 DAC	10 DAB	28 DAC	10 DAB	28 DAC
	lb/A		——— % Visual ———		——— % Visual ———		——— % Visual ———		——— % Visual ———	
S-metolachlor/ Atrazine	1.38	PRE	79	55	85	78	85	73	95	88
S-metolachlor/ Atrazine	1.38	PRE	68	75	75	88	78	93	75	100
Nicosulfuron	0.0314	LPOST								
Atrazine	0.75	LPOST								
COC	2.0%	LPOST								
AMS	1.94%	LPOST								
S-metolachlor/ Atrazine	1.38	PRE	75	65	83	93	80	91	83	100
Nicosulfuron	0.0623	LPOST								
Atrazine	0.75	LPOST								
COC	2.0%	LPOST								
AMS	1.94%	LPOST								
Nicosulfuron	0.0314	EPOST	55	23	61	88	70	83	73	100
Atrazine	0.75	EPOST								
COC	2.0%	EPOST								
AMS	1.94%	EPOST								
Nicosulfuron	0.0623	EPOST	55	35	70	95	70	98	73	100
Atrazine	0.75	EPOST								
COC	2.0%	EPOST								
AMS	1.94%	EPOST								
LSD (0.05)			9	9	14	11	6	7	14	4

[1] COC is crop oil concentrate, AMS is ammonium sulfate.
[2] PRE is preemergence, EPOST is early postemergence, and LPOST is late postemergence.
[3] 10 DAB is 10 days after the early postemergence treatments and 28 DAC is 28 days after the late postemergence treatments.

Control of common lambsquarters and mayweed chamomile with pyrasulfotole/bromoxynil/fluoxypyr 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 Cook Agronomy Farm near Pullman, WA to evaluate the efficacy of a premixture of pyrasulfotole/bromoxynil/fluroxypyr on common lambsquarters (CHEAL) and mayweed chamomile (ANTCO) in spring wheat. On March 26, 2020, 'Ryan' spring wheat was planted with a Horsch direct-seed air drill with row openers on a 12-inch spacing. Plots were 10 ft by 35 ft and arranged in a randomized complete block design with four replications. On May 16th, herbicides were applied with a hand-held spray boom, equipped with six, TeeJet® XR80015 nozzles on a 20-inch spacing, using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 50 psi (Table 1). Visual ratings of CHEAL and ANTCO control were assessed on June 4th and 16th. Wheat seed was harvested with a small plot combine on August 26th.

Table 1. Application and soil data.

Location	Cook Agronomy Farm, Pullman, Washington
Application date	May 16, 2020
Wheat growth stage	First node detected
Common lambsquarters	2.5-inch diam. and 2.5-inch tall
Common lambsquarters density	21 plants per ft^2
Mayweed chamomile	1.5-inch diam. and 1.5 -inch tall
Mayweed chamomile density	8 plants per ft^2
Air temperature (F)	60
Relative humidity (%)	47
Wind (mph, direction)	6, east
Cloud cover (%)	100
Soil temperature at 6 in (F)	56
pH	5.3
OM (%)	2.5
Texture	silt loam

The next five days following application, the trial area received 2.21 inches of rainfall. Another 1.89 inches of rainfall was received prior to the last weed control ratings on June 16th. The mean maximum and minimum air temperatures were 67 and 46°F, over this 32-day period, respectively The environmental conditions, well above average soil moisture and moderate air temperatures, suggest that the broadleaf weeds may have had some ability to resist the herbicide treatments. The wheat stand was thin and did not add significant crop competition to the weeds. There was no crop injury observed among any of the treatments in this study. Pyrasulfotole/bromoxynil and pyrasulfotole/bromoxynil/fluroxypyr provided a similar level of control of CHEAL and ANTCO (Table 2). Pyrasulfotole/bromoxynil and pyrasulfotole/bromoxynil/fluroxypyr provided better control of CHEAL than ANTCO. Bicyclopyrone/bromoxynil provided similar control of CHEAL to pyrasulfotole/bromoxynil and pyrasulfotole/bromoxynil/fluroxypyr, but better control of ANTCO. Bromoxynil + MCPA Ester + thifensulfuron/tribenuron provided the best CHEAL control and comparable ANTCO control to bicyclopyrone/bromoxynil. Bromoxynil + fluroxypyr provided poor control of CHEAL and a similar level of control of ANTCO to pyrasulfotole/bromoxynil and pyrasulfotole/bromoxynil/fluroxypyr. Yield data are not presented due to a significant infestation of Italian ryegrass (LOLMU).

Table 2. Common lambsquarters and mayweed chamomile control in 'Ryan' spring wheat with herbicides near Pullman, Washington in 2020.

Treatment	Rate	6/4 19 DAT	6/16 31 DAT	6/4 19 DAT	6/16 31 DAT
		CHEAL control		ANTCO control	
	lb ae/a	------------%----------		------------%----------	
nontreated check	--	--	--	--	--
pyrasulfotole/bromoxynil/fluroxypyr[1]	0.30	78	76	50	46
pyrasulfotole/bromoxynil[1]	0.22	84	76	52	53
bicyclopyrone/bromoxynil[2]	0.19	63	73	64	79
bromoxynil + MCPA ester + thifensulfuron/tribenuron[3]	0.5 + 0.46 + (0.03 lb ai/a)	94	89	63	78
bromoxynil + fluroxypyr[3]	0.62	50	45	53	48
LSD (0.05)		9	13	11	23

[1]Treatment was applied with ammonium sulfate (APF S-Sul) at 0.5 lb per acre

[2]Treatment was applied with sodium bicarbonate (CoAct+) at 2.75 fl oz/A and crop oil concentrate (Agri-Dex) at 1.0% v/v.

[3]Treatment was applied with a 98% nonionic surfactant (Rainier EA) at 0.25% v/v.

Broadleaf weed control in timothy with bicyclopyrone. Traci A. Rauch and Joan M. Campbell. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was conducted to evaluate broadleaf weed control with bicyclopyrone in seedling timothy at the University of Idaho Plant Science Farm. 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. Crop response and broadleaf weed control were evaluated visually. Timothy was swathed on August 17 and harvested with a small plot combine on August 24, 2020.

Table 1. Application data and site information.

Variety and planting date	'Titan' 10/11/19	
Application date	10/11/19	5/24/20
Growth stage		
Timothy	postplant pre	3 tiller
Willowherb sp. (EPISS)	pre	3 inch
Prickly lettuce (LACSE)	pre	2 inch
Air temperature (F)	55	64
Relative humidity (%)	36	49
Wind (mph, direction)	2, E	1, SW
Cloud cover (%)	0	50
Next moisture occurred	10/27/19	5/31/20
Soil moisture	dry	wet
Soil temperature at 2 inch (F)	60	60
pH	5.5	
OM (%)	2.8	
CEC (meq/100g)	17.6	
Texture	silt loam	

All spring applied bicyclopyrone treatments and saflufenacil injured timothy 12 to 26% (Table 2). Willowherb control tended to be better with fall bicyclopyrone plus spring fluroxypyr, spring bicyclopyrone high rate alone, spring bicyclopyrone combinations, and pyrasulfotole/bromoxynil treatments All spring bicyclopyrone treatments, pyrasulfotole/bromoxynil alone or with saflufenacil controlled prickly lettuce 99%. Willowherb and prickly lettuce control did not differ among treatments most likely due to non-uniform populations. Crop lodging occurred after June 10 and limited visual injury and weed control ratings. Seed yield did not differ among treatments including the untreated check but tended to be lowest with saflufenacil combination which displayed the greatest visual injury. In general, broadleaf weed control was better with bicyclopyrone applied in the spring.

Table 2. Timothy response and broadleaf weed control with bicyclopyrone near Moscow, ID in 2020.

Treatment[1]	Rate	Application timing	Timothy injury[2]	EPISS control[2]	LACSE control[2]	Timothy yield
	lb ai/A		%	%	%	lb/A
Bicyclopyrone	0.045	fall	2	75	87	1445
Bicyclopyrone	0.09	fall	4	70	84	1205
Bicyclopyrone +	0.045	fall				
bromoxynil	0.25	spring	4	80	92	1377
Bicyclopyrone +	0.045	fall				
fluroxypyr	0.105	spring	4	94	89	1147
Bicyclopyrone	0.045	spring	18	76	99	1158
Bicyclopyrone	0.09	spring	21	99	99	1258
Bicyclopyrone +	0.045					
bromoxynil	0.25	spring	12	99	99	1135
Bromoxynil	0.25	spring	0	83	89	1220
Bicyclopyrone +	0.045					
fluroxypyr	0.105	spring	15	98	99	1239
Fluroxypyr	0.105	spring	2	87	90	1254
Pyrasulfotole/bromoxynil	0.24	spring	0	99	99	1375
Saflufenacil +	0.044					
pyrasulfotole/bromoxynil +	0.21					
2,4-D amine	0.5	spring	26	99	99	1039
Untreated check	--	--	--	--	--	1328
LSD (0.05)			5	NS	NS	NS
Density (plants/ft^2)				2	1	

[1]A nonionic surfactant at 0.25% and ammonium sulfate at 2.5% v/v were applied with all spring treatments except the saflufenacil treatment. The saflufenacil treatment was combined with a methylated seed oil (Super Spread MSO) at 1% v/v.
[2]Evaluation date June 10, 2020.

Downy brome and rattail fescue control in winter wheat with pyroxasulfone combinations. Traci A. Rauch and Joan M. Campbell. (Dept of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Two studies were established in winter wheat to evaluate grass weed control with flumioxazin/pyroxasulfone preplant combined with pyroxsulam postemergence and pyroxasulfone postplant preemergence with mesosulfuron/thiencarbazone postemergence near Moscow, ID. 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). Both studies were oversprayed on April 24, 2020 with pyrasulfotole/bromoxynil at 0.19 and thifensulfuron/tribenuron at 0.0.25 lb ai/A for broadleaf weed control and propiconazole/pyraclostrobin/ fluxapyroxad at 0.3 lb ai/A for stripe rust control. Grass weed control was evaluated visually during the growing season. The mesosulfuron/thiencarbazone and flumioxazin/pyroxasulfone studies were harvested at crop maturity with a small plot combine on August 10 and 19, 2020, respectively.

Table 1. Application and soil data.

	Flumioxazin/pyroxasulfone study		Mesosulfuron/thiencarbazone study	
Variety and seeding date	'Castle CL+' 10/16/19		'Brundage 96 CL' 10/7/19	
Application date	10/10/19	4/20/20	10/7/19	4/17/20
Growth stage				
Winter wheat	preplant	2 tiller	postplant pre	2 tiller
Downy brome (BROTE)	pre	1 tiller	pre	2 tiller
Rattail fescue (VLPMY)	--	--	pre	3 tiller
Volume (gpa)	20	20	10	10
Pressure (psi)	38	38	34	34
Speed (mph)	3	3	3	3
TeeJet nozzle size	11003	11003	110015	110015
Air temperature (F)	51	63	72	67
Relative humidity (%)	38	50	25	26
Wind (mph, direction)	1, ESE	2, E	2, NE	3, WSW
Cloud cover (%)	10	10	75	0
Soil moisture	dry	adequate	dry	dry
Next rain occurred	10/19/19	5/3/20	10/19/19	5/3/20
Soil temperature at 2 inch (F)	46	60	58	68
pH	5.1			
OM (%)	2.9			
CEC (meq/100g)	15.3			
Texture	silt loam			

In the flumioxazin/pyroxasulfone study, no treatment injured winter wheat at any evaluation time (data not shown). Downy brome control was 96 to 98% with flumioxazin/pyroxasulfone with or without GA preplant followed by pyroxsulam postemergent (Table 2). Grain yield was lowest for the untreated check. Grain yield with flumioxazin alone was lower than all herbicide treatments except pyroxasulfone alone. Grain test weight did not differ among treatments including the untreated check.

In the mesosulfuron/thiencarbazone study, no treatment injured winter wheat at any evaluation time (data not shown). Downy brome control was best with pyroxasulfone combined with mesosulfuron/thiencarbazone plus pyrasulfotole/bromoxynil (92%) but did not differ from pyroxasulfone plus mesosulfuron/thiencarbazone (89%) (Table 3). All pyroxasulfone treatments controlled rattail fescue 99%. Grain yield was lowest for the untreated check but did not differ from non-pyroxasulfone treatments.

Table 2. Winter wheat response and downy brome control with flumioxazin/pyroxasulfone combined with pyroxsulam near Moscow, ID in 2020.

Treatment[1]	Rate	Application timing[2]	BROTE control[3]	Winter wheat Yield	Winter wheat Test weight
	lb ai/A		%	lb/A	lb/bu
Pyroxasulfone	0.08	preplant	51	5858	62.3
Flumioxazin	0.064	preplant	48	5214	62.3
Flumioxazin/pyroxasulfone	0.143	preplant	84	6386	61.9
Flumiox/pyrox/metri	0.33	preplant	80	5991	61.5
Pyroxsulam	0.0164	2 tiller	79	6060	61.7
Flucarbazone +	0.031	preplant			
pyroxsulam	0.0164	2 tiller	81	6021	61.6
Flumioxazin/pyroxasulfone +	0.143	preplant			
pyroxsulam	0.0164	2 tiller	97	6278	61.3
Flumioxazin/pyroxasulfone/metribuzin +	0.33	preplant			
pyroxsulam	0.0164	2 tiller	98	6243	61.5
Flumioxazin/pyroxasulfone + GA +	0.143 + 0.025	preplant			
pyroxsulam	0.0164	2 tiller	96	6133	61.7
Flumiox/pyrox/metri + GA +	0.33 + 0.025	preplant			
pyroxsulam	0.0164	2 tiller	97	6194	61.5
Untreated check	--	--	-	4329	62.5
LSD (0.05)			17	701	NS
Density (plants/ft^2)			5		

[1]All treatments included glyphosate at 1.13 lb ae/A, a non-ionic surfactant at 0.25% v/v and dry ammonium sulfate at 2.5 lb ai/A applied preplant. Flumiox/pyrox/metri = flumioxazin/pyroxasulfone/metribuzin.
[2]Application timing based on winter wheat growth stage.
[3]Evaluation date July 13, 2020.

Table 3. Winter wheat response and downy brome and rattail fescue control with pyroxasulfone combined with mesosulfuron/thiencarbazone near Moscow, ID in 2020.

Treatment[1]	Rate	Application timing[2]	BROTE control[3]	VLPMY control[4]	Winter wheat yield
	lb ai/A		%	%	lb/A
Pyroxasulfone	0.08	preemergence	76	99	4041
Pyroxasulfone +	0.08	preemergence			
mesosulfuron/thiencarbazone	0.0178	2 tiller	89	99	4268
Pyroxasulfone +	0.08	preemergence			
mesosulfuron/thiencarbazone +	0.0178	2 tiller			
pyrasulfotole/bromoxynil	0.217	2 tiller	92	99	4109
Mesosulfuron/thiencarbazone	0.0178	2 tiller	45	65	2207
Mesosulfuron/thiencarbazone +	0.0178	2 tiller			
pyrasulfotole/bromoxynil	0.217	2tiller	52	72	2135
Mesosulfuron/thiencarbazone +	0.0178	2 tiller			
pyrasulfotole/bromoxynil +	0.217	2 tiller			
bromoxynil/MCPA	0.5	2 tiller	66	72	2072
Untreated check	--	--	-	-	1713
LSD (0.05)			5	9	554
Density (plants/ft^2)			25	10	

[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 July 13, 2020.
[4]Evaluation date June 8, 2020.

Evaluation of triallate herbicide for the control of downy brome and Italian ryegrass in winter wheat. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A field study was conducted on land owned and farmed by the late Mark James near Dixie, WA. The objective of this study was to evaluate triallate in combination with pyroxasulfone, imazamox or pyroxsulam for the control of downy brome (BROTE) and Italian ryegrass (LOLUM). Winter wheat was the previous crop. Crop residue remaining after harvest was burned just prior to planting. The field was sprayed with glyphosate on October 6, 2019 and triallate was applied with a 50-ft-wide Valmar applicator on October 7th at 1.5 lb ai/A to half of the trial area. Two, 50 ft by 200 ft strips received triallate and two strips did not. Plots were 10 ft by 50 ft and arranged in a randomized complete block design with four replications within the respective strips. On October 8th, the trial area received 0.47 inch of rainfall that aided in the activation and incorporation of the triallate. Mechanical incorporation of the triallate occurred at planting on October 10th with a Horsch high disturbance direct-seed drill with paired rows on a 15-inch row spacing. The cultivar 'UI Magic CL+' was seeded at a depth of 1.5 inches and a rate of 110 lb seed/A. Preemergence herbicides were applied with a hand-held spray boom, equipped with six, TeeJet® AIXR80015 nozzles on a 20-inch spacing, using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 52 psi (Table 1). Postemergence herbicides were applied with a hand-held spray boom, equipped with six, TeeJet® XR80015 nozzles on a 20-inch spacing, using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 50 psi. Visual ratings of BROTE and LOLMU control were assessed on June 5th when the contrast of BROTE and LOLUM seedheads against the wheat were at their best. Wheat seed was harvested with a small plot combine on July 18th.

Table 1. Application and soil data.

Location	James Farm Dixie, Washington			
Application date	October 7, 2019	October 10, 2019	November 19, 2019	February 28, 2020
Application type	preplant	preemergence	postemergence	postemergence
Wheat growth stage	--	beginning of imbibition	two-leaf	2-tiller
Wheat height	--	--	4 inch	8 inch
Annual grass growth stage	--	--	1-2 leaf	3 leaf to 5 tiller
Annual grass height	--	--	2-3 inch	2-3 inch
Air temperature (F)	66	59	61	65
Relative humidity (%)	23	29	85	32
Wind (mph, direction)	7, west	4, west	6, southwest	4, southwest
Cloud cover (%)	50	0	10	10
Soil temperature at 6 inch (F)	50	50	47	41
pH	5.2			
OM (%)	2.9			
Texture	silt loam			

Annual grass identification was difficult when the postemergence applications were made. In the early spring, it became easier to distinguish that there was a good density of both BROTE and LOLUM plants in the trial area. None of the herbicides applied caused any crop injury. Triallate and pyroxasulfone each provided some control of BROTE and LOLUM (Table 2). Triallate provided slightly better BROTE control, whereas pyroxasulfone provided slightly better LOLUM control. Neither product provided commercially acceptable control of either annual grass weed when applied alone. The combination of triallate plus pyroxasulfone provided the best control of BROTE and LOLUM and increased yield by 18 bu/A when compared to the nontreated check. The addition of metribuzin to pyroxasulfone did not increase the control of either annual grass weed when compared to pyroxasulfone alone or in combination with triallate. The group 2 herbicides (imazamox and pyroxsulam) provided very little control of either BROTE or LOLUM when applied on their own. However, when combining imazamox or pyroxsulam with triallate, BROTE control was better than LOLUM control. This study demonstrated that as resistance to the postemergence group 2 herbicides increases in both BROTE and LOLUM, it will be important to use preplant and preemergence herbicides with at least two different sites of action to control these two troublesome annual grass weeds in wheat.

Table 2. Downy brome and Italian ryegrass control in ‘UI Magic CL+’ winter wheat with herbicides near Dixie, Washington in 2020.

Treatment	Rate	Application date	BROTE control 6/5	LOLUM control 6/5	Yield 7/18
	lb ai/A		---------------%---------------		bu/A
Nontreated check	--	--	--	--	99
triallate	1.5	10/7/19	60	48	113
triallate fb pyroxasulfone	1.5 fb 0.08	10/7/19 fb 10/11/19	90	88	117
triallate fb pyroxasulfone + metribuzin	1.5 fb 0.08 + 0.09	10/7/19 fb 10/11/19	83	83	113
triallate fb imazamox[1]	1.5 fb 0.04	10/7/19 fb 11/8/19	85	54	115
triallate fb pyroxsulam[2]	1.5 fb 0.016	10/7/19 fb 11/8/19	78	53	110
triallate fb imazamox[1]	1.5 fb 0.04	10/7/19 fb 2/28/20	74	55	112
triallate fb pyroxsulam[2]	1.5 fb 0.016	10/7/19 fb 2/28/20	68	48	108
pyraxosulfone	0.08	10/11/19	44	60	108
pyroxasulfone + metribuzin	0.08 + 0.09	10/11/19	46	61	110
imazamox[1]	0.04	11/8/19	33	15	104
pyroxsulam[2]	0.016	11/8/19	15	24	105
imazamox[1]	0.04	2/28/20	26	15	105
pyroxsulam[2]	0.016	2/28/20	5	13	100
LSD (0.05)			24	14	7

[1]Imazamox was applied with urea ammonium nitrate at 1 qt/a and a 98% nonionic surfactant (Rainier EA®) at 0.25% v/v.

[2] Pyroxsulam was applied with urea ammonium nitrate at 2 qt/a and a 98% nonionic surfactant (Rainier EA®) at 0.5% v/v.

Rattail fescue and prickly lettuce control in winter wheat with mesosulfuron/thiencarbazone combinations. 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 and prickly lettuce 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). Entire plot area was treated with fluxapyroxad/pyraclostrobin/propiconazole at 0.16 lb ai/A for stripe rust control on May 1, 2020. Crop injury and weed control were evaluated visually during the growing season.

Table 1. Application and soil data.

Application date	4/8/2020
Growth stage	
Winter wheat	2 tiller
Rattail fescue	4 tiller
Prickly lettuce	2 inch
Air temperature (F)	66
Relative humidity (%)	28
Wind (mph, direction)	3, NW
Cloud cover (%)	0
Next moisture occurred	5/3/2020
Soil moisture	dry
Soil temperature at 2 inch (F)	54
pH	5.1
OM (%)	3.1
CEC (meq/100g)	16.8
Texture	silt loam

No winter wheat injury was visible at any evaluation date (data not shown). At 50 DAT, rattail fescue control did not differ among all treatments, but tended to be better with mesosulfuron/thiencarbazone combined with pyrasulfotole/bromoxynil and clopyralid/fluroxypyr (91%) (Table 2). AT 96 DAT, no treatment adequately controlled rattail fescue due to an extremely dense population (47 to 75%). At 50 DAT, only mesosulfuron/thiencarbazone alone did not control prickly lettuce. By 96 DAT, prickly lettuce control was greater than 90% with mesosulfuron/thiencarbazone plus pyrasulfotole/bromoxynil combined with bromoxynil/MCPA or clopyralid/fluroxypyr.

Table 2. Rattail fescue and prickly lettuce control with mesosulfuron/thiencarbazone combinations in 2020.

		Weed control			
		Rattail fescue		Prickly lettuce	
Treatment[1]	Rate	50 DAT	96 DAT	50 DAT	96 DAT
	lb ai/A	%	%	%	%
Mesosulfuron/thiencarbazone	0.0178	76	47	22	0
Mesosulfuron/thiencarbazone +	0.0178				
pyrasulfotole/bromoxynil	0.217	77	60	87	57
Mesosulfuron/thiencarbazone +	0.0178				
pyrasulfotole/bromoxynil +	0.217				
bromoxynil/MCPA	0.5	85	68	98	91
Mesosulfuron/thiencarbazone +	0.0178				
pyrasulfotole/bromoxynil +	0.217				
florasulam/fluroxypyr	0.092	84	71	94	75
Mesosulfuron/thiencarbazone +	0.0178				
pyrasulfotole/bromoxynil +	0.217				
clopyralid/fluroxypyr	0.188	91	75	98	91
LSD (0.05)		NS	11	15	24
Density (plants/ft^2)		25		1	

[1]All treatments were applied with a non-ionic surfactant at 0.25% v/v and urea ammonium nitrate at 5% 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. Anhydrous fertilizer was applied with a shank style applicator prior to seeding. 'Trident' winter wheat blend was seeded with a single disk drill plus liquid ammonium phosphate (10-34-0). 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 30, 2019 and clopyralid/fluroxypyr/MCPA ester at 0.36 lb ai/A for broadleaf weed control and propiconazole at 0.028 lb ai/A for stripe rust control on April 24, 2020. Wheat injury and Italian ryegrass control were evaluated visually during the growing season.

Table 1. Application and soil data.

Wheat variety – seeding date	Trident – 10/4/19			
Application date	9/30/19	10/3/19	10/5/19	10/14/19
Application timing	pre-fertilization	post-fertilization	postplant pre- no germ	postplant pre- germ
Wheat	preplant	preplant	no germination	0.5 in root/ 0.25 in shoot
Italian ryegrass	pre	pre	pre	germinating
Air temperature (F)	51	56	64	60
Relative humidity (%)	55	49	29	37
Wind (mph, direction)	1, W	3, W	2, SE	2, W
Cloud cover (%)	100	100	20	10
Soil moisture	dry	dry	dry	dry
Next rain occurred	10/19/19	10/19/19	10/19/19	10/19/19
Soil temperature at 2 inch (F)	45	45	53	54
pH	5.2			
OM (%)	3.1			
CEC (meq/100g)	13.7			
Texture	silt loam			

No winter wheat injury was visible at any evaluation date (data not shown). On May 29, Italian ryegrass control did not differ among treatments and ranged from 68 to 92%. By June 25, Italian ryegrass control was best with pyroxasulfone/carfentrazone (93%) at the postplant germination timing but did not differ from all other application timings and treatments, except the pre-fertilization time for pyroxasulfone/carfentrazone and pyroxasulfone alone and flufenacet/metribuzin (75 to 77%) (Table 2). Pre-fertilization disturbance level is highest compared to all other timings. In previous years (2016, 2018, and 2019), adequate rainfall after application time has been the driving force determining level of Italian ryegrass control and not the effect of disturbance. Weed control across all application timings was slightly better with pyroxasulfone/carfentrazone compared to pyroxasulfone alone due to a greater amount of active ingredient. Italian ryegrass control was 83 versus 87% with 0.08 and 0.10 lb ai/A pyroxasulfone, respectively.

Table 2. Italian ryegrass control with pyroxasulfone treatments applied at four times near Moscow, ID in 2020.

Treatment	Rate	Application timing[1]	Adequate rainfall[2]	Italian ryegrass control[3] 5/29/20	6/25/20
	lb ai/A		(DAA)	%	%
Pyroxasulfone	0.08	pre-fert	19	73	76
Pyroxasulfone/carfentrazone	0.109	pre-fert	19	81	77
Pyroxasulfone	0.08	post-fert	16	77	83
Pyroxasulfone/carfentrazone	0.109	post-fert	16	88	88
Pyroxasulfone	0.08	postplant-no germ	13	82	88
Pyroxasulfone/carfentrazone	0.109	postplant-no germ	13	88	90
Pyroxasulfone	0.08	germination	5	88	85
Pyroxasulfone/carfentrazone	0.109	germination	5	92	93
Flufenacet/metribuzin	0.425	germination	5	68	75
LSD (0.05)				NS	10
Density (plants/ft^2)				15	

[1]Pre-fert = Before fertilization. Post-fert = After anhydrous fertilizer injected. Postplant = Wheat planted but not germinated.

[2]Rainfall over 0.3 inch.

[3]Replication 4 excluded due to non-uniform Italian ryegrass distribution.

Italian ryegrass control with pyroxasulfone combinations 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 combinations in winter wheat. 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 30, 2019 and clopyralid/fluroxypyr/MCPA ester at 0.36 lb ai/A for broadleaf weed control and propiconazole at 0.028 lb ai/A for stripe rust control on April 24, 2020. Wheat injury and Italian ryegrass control were evaluated visually during the growing season.

Table 1. Application and soil data.

Wheat variety – seeding date	Trident – 10/4/19	
Application date	10/6/19	4/9/20
Application timing	postplant pre	post
Wheat	no germination	2 tiller
Italian ryegrass	pre	1 leaf
Air temperature (F)	64	62
Relative humidity (%)	30	41
Wind (mph, direction)	2, SE	2, SE
Cloud cover (%)	25	10
Soil moisture	dry	adequate
Next rain occurred	10/19/19	5/3/20
Soil temperature at 2 inch (F)	63	48
pH	5.2	
OM (%)	3.1	
CEC (meq/100g)	13.7	
Texture	silt loam	

No winter wheat injury was visible at any evaluation date (data not shown). On June 10, all treatments controlled Italian ryegrass 90% or better except flufenacet/metribuzin applied postplant preemergence followed by pyroxasulfone postemergence and pyroxasulfone at 0.07 lb ai/A postplant preemergence followed by pyroxasulfone at 0.06 lb ai/A postemergence (82 and 88%). By June 25, Italian ryegrass control was best with pyroxasulfone postplant preemergence followed by flufenacet/metribuzin postemergence (92%) but did not differ from any metribuzin treatment or pyroxasulfone postplant preemergence at 0.13 lb ai/A.

Table 2. Italian ryegrass control with pyroxasulfone combinations near Moscow, ID in 2020.

Treatment	Rate	Application timing[1]	Italian ryegrass control 6/10/20	6/25/20
	lb ai/A		%	%
Pyroxasulfone	0.11	postplant pre	91	86
Pyroxasulfone	0.13	postplant pre	93	91
Pyroxasulfone +	0.07	postplant pre		
pyroxasulfone	0.06	2 tiller	88	83
Pyroxasulfone +	0.10	postplant pre		
pyroxasulfone	0.03	2 tiller	93	87
Flufenacet/metribuzin +	0.34	postplant pre		
pyroxasulfone	0.11	2 tiller	82	76
Pyroxasulfone +	0.11	postplant pre		
flufenacet/metribuzin	0.34	2 tiller	97	92
Pyroxasulfone +	0.11	postplant pre		
metribuzin	0.07	postplant pre	94	89
Pyroxasulfone +	0.11	postplant pre		
metribuzin	0.09	postplant pre	96	90
LSD (0.05)			7	5
Density (plants/ft^2)			15	

[1]Based on wheat growth stage. Postplant pre is after planting wheat but before emergence.

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KEYWORD INDEX