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FOREWORD

The 2018 Research Progress Report of the Western Society of Weed Science (WSWS) is a compilation of research investigations contributed by weed scientists in the western United States of America. The objective of the Research Progress Report is to provide an avenue for presentation and exchange of on-going research to the weed science community. The information in this report is preliminary; therefore, it is not for the development of endorsements or recommendations.

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

Traci Rauch
Research Progress Report Editor
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Table 1. Application and soil data.

Application date	November 7, 2016
Annual grass growth stage	1 leaf for all species
Air temperature (F)	54
Relative humidity (%)	64
Wind (mph, direction)	1, SSE
Cloud cover (%)	100
Soil temperature at 4 inches (F)	44
Soil pH	6.9
Soil texture	silt loam

All treatments except propoxycarbazone provided some level of control (68 to 100%) of annual grasses compared to the untreated check (Table 2). Weed control of 89% and higher was achieved with indaziflam, rimsulfuron, indaziflam + propoxycarbazone, indaziflam + rimsulfuron, and indaziflam + glyphosate. Weed control and high bluebunch wheatgrass (*Pseudoroegneria spicata*) cover was achieved with indaziflam, rimsulfuron, and indaziflam + propoxycarbazone. While propoxycarbazone performed poorly when considering control of all annual grass weeds, it was noticeably superior at controlling Japanese brome (93% control on average) compared to downy brome (0% control; data not shown). Indaziflam + rimsulfuron caused approximately 30% injury to bluebunch wheatgrass, resulting in a reduction in foliar cover to 0% and 3% in two of the three replicates. In contrast, adjacent plots maintained 13% and 28% cover of bluebunch wheatgrass.

Table 2. Annual grass control and bluebunch wheatgrass cover following applications of indaziflam with different tank mixtures.[1]

Treatment[2]	Rate		Annual grass control	Bluebunch wheatgrass cover
	oz/A	lb ai/A	%	%
Indaziflam	7	0.092	89 ab	32 a
Propoxycarbazone	1.2	0.044	6 d	5 cd
Rimsulfuron	4	0.063	97 ab	20 abc
Imazapic	7	0.109	68 c	20 abc
Glyphosate	12	0.420	80 bc	17 abcd
Indaziflam + propoxycarbazone	7 + 1.2	0.092 + 0.044	94 ab	27 ab
Indaziflam + rimsulfuron	7 + 4	0.092 + 0.063	100 a	8 bcd
Indaziflam + imazapic	7 + 7	0.092 + 0.109	85 abc	19 abcd
Indaziflam + glyphosate	8 + 12	0.105 + 0.420	100 a	0 d
LSD (α = 0.05)			19	19

[1]Evaluations made July 6, 2017. 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.

Invasive annual grass control with 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 in a grassland to examine weed control of winter annual grasses near Lewiston, ID. In order of decreasing abundance, the site was invaded by ventenata, Japanese brome, and downy brome. Plots 10 by 20 ft were arranged in a randomized complete block design with three replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi and 3 mph (Table 1). Perennial grasses were dormant at the time of treatment application. Perennial plant cover and injury and weed control were visually evaluated on July 7, 2017 (242 DAT).

Table 1. Application and soil data.

Application date	November 7, 2016
Annual grass growth stage	1 leaf for all species
Air temperature (F)	64
Relative humidity (%)	48
Wind (mph, direction)	3, WNW
Cloud cover (%)	20
Soil temperature at 4 inches (F)	44
Soil pH	6.9
Soil texture	silt loam

All treatments provided some level of control (43 to 100%) in annual grasses compared to the untreated check (Table 2). Weed control of over 90% was achieved with both rates of indaziflam + glyphosate, both rates of rimsulfuron, and both rates of indaziflam + rimsulfuron. Control levels at or near 100% were achieved with the high rate of indaziflam + glyphosate, the high rate of rimsulfuron, and indaziflam + rimsulfuron at both rates. However, these same treatments also had the lowest cover of perennial grasses: 2 to 10%. In contrast, perennial grass cover of 25% and 34% was observed with the low rate of rimsulfuron and the low rate of indaziflam + glyphosate, respectively. In comparison, the untreated check had 15% average cover of perennial grasses. Per visual evaluation, indaziflam + rimsulfuron at both the low and high rates caused 70 to 100% injury (symptom: chlorosis) in perennial grasses, primarily bluebunch wheatgrass (*Pseudoroegneria spicata*), which ultimately survived. The high rate of rimsulfuron and the high rate of indaziflam + glyphosate injured or killed tall oatgrass (*Arrhenatherum elatius*; data not shown). Glyphosate and both rates of indaziflam applied alone were least effective in controlling Japanese brome compared to control rates for ventenata and downy brome (data not shown).

Table 2. Annual grass control and perennial grass cover following applications of indaziflam and rimsulfuron at different rates[1].

Treatment[2]	Rate		Annual grass control[3]	Perennial grass cover[4]
	oz/A	lb ai/A	%	%
Indaziflam + glyphosate	5 +12	0.065 + 0.420	92 ab	34 a
Indaziflam + glyphosate	7 + 12	0.092 + 0.420	100 a	6 bc
Rimsulfuron	3	0.047	91ab	25 ab
Rimsulfuron	4	0.063	99 a	10 bc
Indaziflam + rimsulfuron	5 + 3	0.065 + 0.047	100 a	2 c
Indaziflam + rimsulfuron	7 + 4	0.092 + 0.063	100 a	10 bc
Imazapic	7	0.109	68 bcd	26 ab
Glyphosate	12	0.420	43 d	34 a
Indaziflam	5	0.065	61 cd	13 bc
Indaziflam	7	0.092	74 abc	10 bc
LSD			28	21

[1]Evaluations made July 7, 2017. 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]$\alpha = 0.05$
[4]$\alpha = 0.08$

Herbicide application with a pulse width modulation sprayer for leafy spurge and Canada thistle control. Rodney G. Lym. (Department of Plant Sciences, North Dakota State University, Fargo, ND 58108-6050). Pulse Width Modulation (PWM) technology has been developed to improve precision application of pesticides. PWM involves rapidly switching an electrically-actuated solenoid on and off (duty cycle) in order to control the flow rate of the nozzle. This cycling takes place so quickly the flow appears to be constant and the coverage remains reasonably uniform. Controlling flow rate by adjusting duty cycle and cycling frequency of an electric nozzle while maintaining a constant pressure provides advantages over controlling flow by adjusting pressure. Normally, increasing spray pressure results in increased flow rate. However, increased pressure also changes the spray angle and droplet size which may result in increased spray particle drift. PWM flow control provides an extremely wide range of flow rates from a single nozzle, maintaining a consistent spray angle and droplet size without adjusting pressure.

The PWM technology has yet to be adapted for weed control in pasture, rangelands, and wildlands. Use of a PWM sprayer would allow both drift reduction and more precise application at the variable speeds required when driving in uneven and rugged terrain. The PWM sprayer will reduce the duty cycle (percent of time a nozzle is open) when the applicator slowed to avoid obstacles and then increase the cycle as the speed increased. The pressure and droplet size remain the same, so application rate is unaffected by changes in speed.

Five experiments were established to evaluate leafy spurge and Canada thistle control using the PWM sprayer. The first series of studies evaluated the effect of droplet size on weed control. Various nozzles and pressures were used with the PWM sprayer to apply herbicides so that the spray pattern consisted of 150, 300, 450, 600, 750, or 900 micron droplets at 10 gpa. Application speed was 10 mph and a NIS at 0.25% was included with all treatments(Induce). A tractor mounted boom sprayer with XR8002 nozzles calibrated to apply treatments at 17 gpa and 35 psi was included as the standard. Picloram plus 2,4-D at 4 + 16 oz/A was applied to leafy spurge while aminopyralid at 1.25 oz/A was applied for Canada thistle control. Separate spring or fall studies were established on June 23, 2016 or September 14, 2016 for each weed species. Leafy spurge was in the true flower or fall-regrowth stage, at the time of the spring or fall treatment, respectively. Canada thistle was in the rosette to bolting stage when the spring treatments were applied and in the rosette growth stage in the fall. Plots were 15 by 40 feet and treatments were replicated three times in all studies.

Leafy spurge and Canada thistle control was similar when herbicides were applied with the PWM system in the spring compared to a standard boom sprayer at all droplet sizes except 150 microns (Table 1). Leafy spurge control averaged 96% 1 month after treatment (MAT) with all droplet sizes except 150 microns which only averaged 60%. *Aphthona* spp. (leafy spurge biological control agents) established in the western side of the research plots during the summer resulting in better than expected control.

Canada thistle control averaged 98% 12 MAT with all spring applied treatments except when application was made with nozzles that applied primarily 150 micron droplets which only averaged 63% (Table 2). Control averaged 96% 14 MAT regardless of droplet size with the exception of the 150 micron droplet treatment which declined to 55%.

Leafy spurge control averaged 92% 9 MAT when picloram plus 2,4-D was applied in the fall with the PWM sprayer using droplet sizes of 600 to 900 microns compared to 89% with a standard boom sprayer equipped with XR8002 nozzles (Table 3). Treatments applied using droplet sizes of 450 microns or less did not provide satisfactory leafy spurge control. Fall Canada thistle control with aminopyralid averaged 100% 9 MAT when droplet size was 450 microns or greater (Table 4). Canada thistle control averaged 95 and 10% when aminopyralid was applied using 300 and 150 micron droplets, respectively.

The fifth study evaluated leafy spurge control with quinclorac applied at 12 oz/A with the PWM sprayer at three application speeds. The droplet size was held constant at 550 microns and 10 gpa for all applications with duty cycles of 30, 60, and 90% at 5, 10 and 15 mph speeds, respectively. The study was established on the Sheyenne National Grassland near Anselm, ND on June 20, 2017 when leafy spurge was in the flowering growth stage. Plots were 30 by 150 feet. Leafy spurge control averaged 95% 2 MAT regardless of application speed (Table 5).

In summary, herbicides applied with the PWM system provided similar leafy spurge and Canada thistle control compared to traditional boom sprayer with XR8002 nozzles as long as the average droplet size exceeded 150 microns. The only exception was the fall treatment of leafy spurge when control was best with droplet sizes of 600 microns or more. Initial results from a single study found no difference in leafy spurge control with quinclorac at application speeds from 5 to 15 mph. The PWM sprayer can be used to apply herbicides in pasture and rangeland at a variety of travel speeds while maintaining medium sized spray droplets resulting in reduced drift and uniform coverage.

Table 1. Leafy spurge control with picloram plus 2,4-D applied on June 23, 2016 with a pulse width modulation (PWM) sprayer using various nozzles compared to a tractor mounted boom sprayer at Fargo, ND.

Treatment					Months after treatment.			
				Rate	1	2	12[a]	14[a]
		Nozzle	Droplet	—— oz/A ——	—— % control ——			
Picloram + 2,4-D + NIS[b]	PWM	ER110015	150	4 + 16 + 0.25%	60	44	83	50
Picloram + 2,4-D + NIS	PWM	SR11002	300	4 + 16 + 0.25%	95	56	62	39
Picloram + 2,4-D + NIS	PWM	MR11004	450	4 + 16 + 0.25%	97	71	70	28
Picloram + 2,4-D + NIS	PWM	DR11005	600	4 + 16 + 0.25%	96	71	50	55
Picloram + 2,4-D + NIS	PWM	DR11006	750	4 + 16 + 0.25%	95	47	53	32
Picloram + 2,4-D + NIS	PWM	UR11006	900	4 + 16 + 0.25%	96	72	93	42
Picloram + 2,4-D + NIS	CO_2	XR8002	Medium[c]	4 + 16 + 0.25%	98	51	56	30
LSD (0.05)					17	NS	NS	NS

[a]*Aphthona* spp. flea beetles established in western half of plot area resulting in much better leafy spurge control than expected in those plots and increased plot to plot variation.
[b]Surfactant at 0.25% applied with all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.

[c]Medium-size droplet range is 281 - 429 microns.

Table 2. Canada thistle control with aminopyralid applied on June 23, 2016 with a pulse width modulation (PWM) sprayer using various nozzles compared to a tractor mounted boom sprayer at Fargo, ND.

					Months after treatment			
Treatment				Rate	1	2	12	14
		Nozzle	Droplet	oz/A	% control			
Aminopyralid + NIS[a]	PWM	ER110015	150	1.25 + 0.25%	75	83	63	55
Aminopyralid + NIS	PWM	SR11002	300	1.25 + 0.25%	89	99	98	99
Aminopyralid + NIS	PWM	MR11004	450	1.25 + 0.25%	92	100	99	99
Aminopyralid + NIS	PWM	DR11005	600	1.25 + 0.25%	98	100	96	91
Aminopyralid + NIS	PWM	DR11006	750	1.25 + 0.25%	96	100	98	98
Aminopyralid + NIS	PWM	UR11006	900	1.25 + 0.25%	95	99	100	95
Aminopyralid + NIS	CO_2	XR8002	Medium[b]	1.25 + 0.25%	94	99	94	96
LSD (0.05)					11	12	25	29

[a]Surfactant at 0.25% applied with all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Medium-size droplet range is 281 - 429 microns.

Table 3. Leafy spurge control with picloram plus 2,4-D applied on September 14, 2016 with a pulse width modulation (PWM) sprayer using various nozzles compared to a tractor mounted boom sprayer at Fargo, ND.

Treatment				Rate	Months after treatment	
					9	12
		Nozzle	Droplet	—— oz/A ——	——% control——	
Picloram + 2,4-D + NIS[a]	PWM	ER80015	150	8 + 16 + 0.25%	5	0
Picloram + 2,4-D + NIS	PWM	SR8002	300	8 + 16 + 0.25%	5	5
Picloram + 2,4-D + NIS	PWM	MR8004	450	8 + 16 + 0.25%	62	28
Picloram + 2,4-D + NIS	PWM	DR8005	600	8 + 16 + 0.25%	90	30
Picloram + 2,4-D + NIS	PWM	DR8006	750	8 + 16 + 0.25%	93	48
Picloram + 2,4-D + NIS	PWM	UR8006	900	8 + 16 + 0.25%	93	52
Picloram + 2,4-D + NIS	CO_2	XR8002	Medium[b]	8 + 16 + 0.25%	89	28
LSD (0.05)					28	25

[a]Surfactant at 0.25% applied with all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Medium-size droplet range is 281 - 429 microns applied with tractor sprayer.

Table 4. Canada thistle control with aminopyralid applied on September 14, 2016 with a pulse width modulation (PWM) sprayer using various nozzles compared to a tractor mounted boom sprayer at Fargo, ND.

Treatment		Nozzle	Droplet	Rate	Months after treatment 9	12
				—— oz/A ——	—— % control ——	
Aminopyralid + NIS[a]	PWM	ER80015	150	1.25 + 0.25%	10	8
Aminopyralid + NIS	PWM	SR8002	300	1.25 + 0.25%	95	92
Aminopyralid + NIS	PWM	MR8004	450	1.25 + 0.25%	100	100
Aminopyralid + NIS	PWM	DR8005	600	1.25 + 0.25%	99	99
Aminopyralid + NIS	PWM	DR8006	750	1.25 + 0.25%	100	98
Aminopyralid + NIS	PWM	UR8006	900	1.25 + 0.25%	100	98
Aminopyralid + NIS	CO_2	XR8002	Medium[b]	1.25 + 0.25%	100	97
LSD (0.05)					3	15

[a]Surfactant at 0.25% applied with all treatments - Induce by Helena Chemical Co., 225 Schilling Blvd, Collierville, TN 38017.
[b]Medium-size droplet range is 281 - 429 microns.

Table 5. Leafy spurge control with quinclorac applied on June 20, 2017 with a pulse width modulation (PWM) sprayer using compared to a tractor mounted boom sprayer at Fargo, ND.

Treatment/application speed	MPH[a]	Rate	Months after treatment 2
		—— oz/A ——	—— % control ——
Quinclorac + MSO[b]	5	12 + 1 pt	95
Quinclorac + MSO	10	12 + 1 pt	92
Quinclorac + MSO	15	12 + 1 pt	97
LSD (0.05)			NS

[a]Application speed in miles per hour with a Wilger DR11006 nozzle and an average of 550 micron droplet size applied at 10 gpa.
[b]MSO - methylated seed oil 13064 by Winfield United 4001 Lexington Ave. N., Arden Hills, MN 55126.

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 in a grassland 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 and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 30 psi and 3 mph (Table 1). Perennial grasses were dormant at the time of treatment application. Perennial plant cover and weed control were visually evaluated on June 15, 2016 (86 DAT) and July 11, 2017 (477 DAT).

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

At 86 DAT, 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 was not statistically significant (p = 0.18). Treatments had an average perennial grass cover of 21 to 65% (data not shown).

At 477 DAT, 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 = 0.12). Treatments had an average perennial grass cover of 20 to 58% (data not shown).

Percent control from the indaziflam + glyphosate treatments increased from the evaluation 86 DAT to the evaluation 477 DAT. Conversely, percent control from the low rate of rimsulfuron and the low rate of the indaziflam/rimsulfuron premixture decreased between the two evaluation times.

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

			Ventenata control	
Treatment[2]	Rate		86 DAT	477 DAT
	oz/A	lb ai/A	----------------------- % -----------------------	
Indaziflam + glyphosate	5 + 12	0.065 + 0.420	57 b	94 ab
Indaziflam + glyphosate	7 +12	0.092 + 0.420	75 b	94 ab
Rimsulfuron	3	0.047	97 a	63 b
Rimsulfuron	4	0.063	99 a	89 ab
Indaziflam/rimsulfuron	4.5	0.119	98 a	80 ab
Indaziflam/rimsulfuron	6	0.158	100 a	100 a
Imazapic	7	0.109	100 a	90 ab
Glyphosate	12	0.420	13 c	9 c
LSD (α = 0.05)			20	32

[1]Evaluations made July 11, 2017. 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.

Ventenata control with different rates of indaziflam at natural sites. Lisa C. Jones and Timothy Prather. (Department of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) A study was established in a grassland 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 and included 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 were dormant at the time of treatment application. Perennial plant cover and weed control were visually evaluated on July 11, 2017 (246 DAT).

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

All treatments except imazapic + glyphosate controlled ventenata 93 to 100% compared to the untreated check (Table 2). Differences in perennial grass cover between treatments was not statistically significant (p = 0.26). Treatments had an average perennial grass cover of 38 to 70% upon evaluation on July 11, 2017 (data not shown).

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

Treatment	Rate		Ventenata control
	oz/A	lb ai/A	%
Indaziflam + glyphosate	3 + 6	0.039 + 0.210	99 a
Indaziflam + glyphosate	4 + 6	0.052 + 0.210	100 a
Indaziflam + glyphosate	5 + 6	0.065 + 0.210	100 a
Sulfosulfuron + glyphosate[2]	1.33 + 6	0.002 + 0.210	93 a
Imazapic + glyphosate[2]	6 + 6	0.093 + 0.210	21 b
LSD (α = 0.05)			27

[1]Evaluations made July 11, 2017. 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.

Timing of preemergence herbicides for liverseedgrass control in turf. Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040) Two small plot field experiments were conducted in dormant common bermudagrass turf at Greenwood Cemetery in Phoenix, AZ. The first experiment was initiated on 19 December 2016 with treatments applied in plots measuring 5 ft x 10 ft and replicated three times in a randomized complete block design. A second experiment with the same treatments and design was initiated on 24 February 2017 in an adjacent area. Indaziflam, flumioxazin, dithiopyr, and dimethenamid were applied with a backpack CO_2 sprayer with a hand-held boom with three 8003LP flat fan nozzles spaced 20 inches apart that delivered 50 gpa water pressurized to 30 psi. Pendimethalin, pendimethalin plus dimethenamid, oxadiazon, and prodiamine were spread as granules with a shaker jar on to the plots. Prodiamine was formulated on to a 18-5-0 fertilizer. During the first application on 19 December, the air temperature was 69°F, clear sky, slight breeze at 3-4.5 mph, soil temperature at 54°F at 2-inch depth, and the straw-colored bermudagrass was completely dormant. On 24 February, the air temperature was 64°F, wind at less than 3 mph, and soil temperature at 58°F, with dormant bermudagrass showing slight greenup. The first appearance of liverseedgrass was 10 March 2017 with plants at the cotyledon to 2-½ leaf stages. Weed control was evaluated at intervals after liverseedgrass appeared and through the early summer.

On 28 March 2017, at 99 days after application (DAA-1) of the early timing, all treatments provided acceptable control of better than 80% of the liverseedgrass (Table 1). On 18 April at 3 weeks later, dimethenamid and oxadiazon did not satisfactorily control liverseedgrass. On 04 May at 136 DAA-1, dithiopyr was not effective against liverseedgrass. Flumioxazin gave 77% control for up to 5 months, indaziflam and the combination of pendimethalin plus dimethenamid were effective for another 3 weeks into June. Prodiamine at 88% and pendimethalin at 83% continued to offer acceptable liverseedgrass control beyond 6 months after application made in mid-December.

Following the later timing application, most of the herbicides exhibited acceptable liverseedgrass at 32 DAA-2 on 28 March (Table 2). Between 50 – 70 DAA-2, indaziflam, flumioxazin, dithiopyr, dimethenamid, and oxadiazon did not provide acceptable liverseedgrass control. Prodiamine, pendimethalin, and pendimethalin plus dimethenamid controlled liverseedgrass longer than 3 months into June. Prodiamine continued to give very acceptable liverseedgrass control at 85% for over 4 months after the application in February while pendimethalin and pendimethalin plus dimethenamid were marginally effective at 73 and 75% control, respectively.

Most effective liverseedgrass control was achieved with prodiamine and pendimethalin, each applied at 3.0 lb a.i./A in mid-December when bermudagrass was dormant and control lasted over 6 months. Both herbicides and the pendimethalin plus dimethenamid pre-mix combination can be applied into February when there is slight bermudagrass greenup before liverseedgrass emergence to give control for over 4 months. Shorter duration liverseedgrass control was given by all of the herbicides with December applications being more effective than February applications.

Table 1. Early winter preemergence herbicide application for liverseedgrass control.

Treatment	Rate (lb a.i./A)	UROPA control 28 Mar	18 Apr	04 May	22 May	08 Jun	12 Jul
		---------- % ----------					
Untreated check		0 b	0 b	0 c	0 b	0 c	0 b
Indaziflam[1]	0.05	96 a	90 a	85 a	87 a	50 abc	8 b
Flumioxazin[1]	0.38	88 a	85 a	82 ab	77 a	50 abc	48 ab
Dithiopyr[1]	0.5	93 a	90 a	73 ab	75 a	20 bc	27 ab
Dimethenamid[1]	1.5	81 a	57 a	63 ab	68 a	23 bc	20 ab
Pendimethalin[2]	3.0	99 a	95 a	95 a	90 a	85 ab	83 a
Prodiamine[3]	3.0	99 a	95 a	95 a	90 a	90 a	88 a
Oxadiazon[2]	4.0	96 a	78 a	40 bc	17 b	0 c	0 b
Dimethenamid + Pendimethalin[2]	1.5 + 2.0	98 a	93 a	90 a	87 a	77 ab	33 ab

Early winter applications on 19 December 2016.
UROPA (liverseedgrass) control rated during spring 2017.
[1]Treatments sprayed in 50 gpa water.
[2]Treatments spread as granules.
[3]Treatment spread as granule coated fertilizer.
Means followed by the same letter are not significantly different by Tukey-Kramer HSD.

Table 2. Late winter preemergence herbicide application for liverseedgrass control.

Treatment	Rate (lb a.i./A)	UROPA control 28 Mar	18 Apr	04 May	22 May	08 Jun	12 Jul
		---------- % ----------					
Untreated check		0 c	0 c	0 c	0 d	0 b	0 b
Indaziflam[1]	0.05	82 ab	73 ab	65 ab	65 ab	20 b	0 b
Flumioxazin[1]	0.38	90 ab	77 ab	75 a	17 cd	13 b	0 b
Dithiopyr[1]	0.5	75 b	80 ab	75 a	50 bc	30 b	5 b
Dimethenamid[1]	1.5	85 ab	82 ab	73 a	65 ab	30 b	17 b
Pendimethalin[2]	3.0	85 ab	77 ab	88 a	85 a	80 a	73 a
Prodiamine[3]	3.0	97 a	92 a	92 a	90 a	85 a	85 a
Oxadiazon[2]	4.0	82 ab	57 b	33 bc	0 d	0 b	0 b
Dimethenamid + Pendimethalin[2]	1.5 + 2.0	96 ab	93 a	93 a	92 a	87 a	75 a

Late winter applications on 24 February 2017.
UROPA (liverseedgrass) control rated during spring 2017.
[1]Treatments sprayed in 50 gpa water.
[2]Treatments spread as granules.
[3]Treatment spread as granule coated fertilizer.
Means followed by the same letter are not significantly different by Tukey-Kramer HSD.

Comparison of postemergence herbicides for purple nutsedge control in turf. Kai Umeda. (University of Arizona Cooperative Extension, Phoenix, AZ 85040). A small plot field experiment was conducted on hybrid bermudagrass cv. Tifway 419 infested with purple nutsedge at the Raven Golf Club in Phoenix, AZ. The treated plots measured 5 ft x 10 ft and treatments were replicated four times in a randomized complete block design. Sprays were applied using a backpack CO_2 sprayer equipped with a hand-held boom with three 8002 flat fan nozzles spaced 20 inches apart. Treatments were mixed and sprayed in 40 gpa water that included a surfactant, Latron CS-7, at 0.25% v/v, and pressurized to 35 psi. The first of the sequential applications was made on 06 July 2017 with the air temperature at 97°F, clear sky and calm air, soil temperature was 82°F, turf was mowed the day prior to application and nutsedge was 0.5 to 1 inch taller than turf. The sequential application was made on 25 August at 7 weeks after the first application. The air temperature was 95°F, clear sky with slight breeze at less than 2 mph, and soil temperature was 88°F.
Halosulfuron, imazaquin, trifloxysulfuron, sulfosulfuron, flazasulfuron and halosulfuron plus foramsulfuron plus thiencarbazone gave better than 91% control of nutsedge within 3 weeks after the first treatment date (WAT-1) (Table). At 5 WAT-2, trifloxysulfuron, sulfosulfuron, flazasulfuron, and halosulfuron plus foramsulfuron plus thiencarbazone continued to provide better than 90% and approached near complete reduction of nutsedge. Halosulfuron, imazaquin, and sulfentrazone plus imazethapyr demonstrated acceptable control up to 4 WAT-2. Sulfentrazone alone was not effective in this experiment due to the expired age of the product. An additional treatment, imazasulfuron applied only on 25 August exhibited 95% nutsedge control after 5 WAT.

Table. Comparison of herbicides for purple nutsedge control in turf.

Treatment	Rate (lb a.i./A)	25 Jul	25 Aug	CYPRO Control 13 Sep	22 Sep	29 Sep
		------------------	------------------	%	------------------	------------------
Untreated check		0 b	0 d	0 b	0 b	0 b
Halosulfuron	0.062	91 a	63 bc	90 a	86 a	74 a
Imazaquin	0.5	93 a	70 abc	90 a	86 a	74 a
Trifloxysulfuron	0.025	98 a	85 abc	98 a	95 a	99 a
Sulfosulfuron	0.059	97 a	88 a	99 a	95 a	94 a
Flazasulfuron	0.047	93 a	80 abc	98 a	91 a	90 a
Halosulfuron + Foramsulfuron + Thiencarbazone	0.062 + 0.04 + 0.02	97 a	86 ab	98 a	94 a	94 a
Sulfentrazone + Imazethapyr	0.188 + 0.038	79 a	83 abc	88 a	81 a	70 a
Sulfentrazone	0.188	5 b	61 c	13 b	0 b	0 b
Imazasulfuron*	0.66			95	93	95

Sequential applications of herbicides applied on 06 July and 25 August 2017.
All treatments included surfactant Latron CS-7 at 0.25% v/v.
*Imazasulfuron applied to 2 replicates plots on only 25 August.
CYPRO = *Cyperus rotundus* = purple nutsedge
Means followed by the same letter within a column are not significantly different by Tukey-Kramer HSD.

Amicarbazone formulations comparison for *Poa annua* control in turf. Kai Umeda. (University of Arizona Cooperative Extension, Maricopa County, Phoenix, AZ 85040) Two small plot field experiments were conducted at the Raven Golf Course in Phoenix, AZ and at Encanterra Golf Club in San Tan Valley, AZ on dormant bermudagrass fairways overseeded with perennial ryegrass. Herbicide treatments were applied sequentially at 2 week intervals at both locations using a backpack CO_2 sprayer equipped with a hand-held boom with three flat fan 8002 nozzles spaced 20 inches apart. Sprays were applied in 23 gpa water that included a surfactant, Latron CS-7, at 0.25% v/v and pressurized to 50 psi. The treatment plots measured 5 ft by 10 ft and were arranged in a randomized complete block design with 4 replicates. At Raven Golf Course, initial sprays were applied on 6 March 2017 with the air temperature at 54°F, clear sky, slight breeze at 3-6 mph, soil temperature near the surface at 54°F, *P. annua* flowering, and the turf mowed at 0.5 inch. The sequential sprays were applied on 20 March when the air temperature was 74°F, clear sky with a slight breeze at 2-4 mph, and soil temperature at 64°F. At Encanterra Golf Club, the first sprays were applied on 7 March 2017 when the air temperature was 55°F, wind was less than 3 mph, clear sky, and soil temperature was 52°F, with flowering *P. annua*. The sequential sprays were applied on 21 March with air temperature at 72°F, negligible wind at less than 2 mph, clear sky, and soil temperature at 64°F. *P. annua* control and ryegrass quality were evaluated at intervals after the sequential applications.

At Raven Golf Course and at Encanterra Golf Club, at all rating dates following the sequential applications, amicarbazone 2SC exhibited a rate response with a trend of improved *P. annua* control from low to middle to high rate. Amicarbazone 2SC at 0.094 lb a.i./A did not provide acceptable *P. annua* control at both locations. Amicarbazone 2SC at 0.14 and 0.188 lb a.i./A were comparable to amicarbazone 70W at 0.175 lb a.i./A to control *P. annua* at acceptable levels. The high rate of amicarbazone 2SC caused slight chlorosis of the treated perennial ryegrass. Most of the amicarbazone treatments caused severe injury and thinning of the ryegrass where the sprays were started and ended at the front and back of the plots.

Table 1. Efficacy and safety of amicarbazone formulations at Raven Golf Course, Phoenix, AZ, 2017

Treatment	Rate (lb a.i./A)	POANN Control				Ryegrass quality		
		29 Mar	10 Apr	1 May	12 May	10 Apr	1 May	12 May
		---------------------- % ----------------------						
Untreated check		0 d	0 c	0 d	0 c	7.3 a	6.5 a	6.5 a
Amicarbazone 2SC	0.094	60 c	71 b	75 c	68 b	7.0 a	6.3 a	6.3 a
Amicarbazone 2SC	0.14	76 ab	86 a	90 ab	89 a	6.8 ab	6.3 a	6.8 a
Amicarbazone 2SC	0.188	83 a	91 a	95 a	93 a	5.8 b	6.3 a	6.8 a
Amicarbazone 70W	0.175	65 bc	81 ab	85 b	89 a	6.3 ab	6.0 a	6.3 a

POANN = *Poa annua*; Ryegrass quality rated 1-9, 1 is poor and 9 is good
Treatments applied on 06 March and 20 March 2017.
Means followed by the same letter not significantly different at p=0.05 using students t-test.

Table 2. Efficacy and safety of amicarbazone formulations at Encanterra Golf Club, San Tan Valley, AZ, 2017

Treatment	Rate (lb a.i./A)	POANN Control				Ryegrass quality
		29 Mar	6 Apr	19 Apr	04 May	10 Apr
		--------------------------- % ------------------------------				
Untreated check		0 d	0 c	0 c	0 c	7.3 a
Amicarbazone 2SC	0.094	55 c	58 b	63 b	69 b	7.0 a
Amicarbazone 2SC	0.14	69 b	69 b	83 a	83 a	6.8 ab
Amicarbazone 2SC	0.188	80 ab	83 a	88 a	88 a	5.8 b
Amicarbazone 70W	0.175	83 a	84 a	88 a	84 a	6.3 ab

POANN = *Poa annua;* Ryegrass quality rated 1-9 scale, 1 is poor and 9 is good
Treatments applied on 07 March and 21 March 2017.
Means followed by the same letter not significantly different at p=0.05 using students t-test.

Safener-regulated tolerance to herbicides in sugar beet. Elizabeth M. Buescher[1], Don Morishita[2], and Rong Ma[1] ([1]Department of Plant Sciences, University of Idaho, Moscow, ID USA and [2]Department of Plant Sciences, University of Idaho, Kimberly, ID USA)

Herbicide-resistant weeds are present in nearly every major crop, with 252 herbicide-resistant weed species reported globally. Weeds are developing resistance to nearly all classes of herbicides including glyphosate-resistant common lambsquarters and kochia in sugar beets production, however, there are no novel mode of action herbicides developed in the past 20 years. Weeds can cause major crop loss, which may have serious economic and food security consequences. In Idaho, sugar beets account for fifty-five percent of the sugar produced in the United States with profits totaling nearly $3 billion in 2015/2016. Pre-emergence herbicide such as ethofumesate can effectively control broadleaf weeds, however, sugar beets can be damaged by these herbicides. Herbicide safeners which induce herbicide tolerance in monocots can increase the range of herbicides usage in crop species. However, safener usage has not been explored extensively in dicots. We therefore propose sugar beets may benefit from safener seed treatment and experience less or no damage with herbicide pre-emergence treatment (PRE).

Six sugar beet varieties (A-F; Betaseed) were seed-treated with the safener fluxofenim (Syngenta; 0.25 g/kg seeds) and planted at a depth of two centimeter in potting mix. Seven different herbicides were applied on sugar beets, which represented different modes of action. Herbicides used are as follows: pyroxasulfone (Zidua), *S*-metolachlor (Dual Magnum), dimethenamid-p (Outlook), saflufenacil (Sharpen), ethofumesate (Nortron), imazamox (Beyond), and pendimethalin (Prowl). Treatments for each variety were carried out as follows: untreated control (80% ethanol-treated seeds, water PRE); safener only (safener-treated seeds, water PRE); herbicide only (80% ethanol-treated seeds, herbicide PRE); and herbicide + safener (safener-treated seeds, herbicide PRE). Eighty percent ethanol was used for the solvent to dissolve safener. All pots were arranged in a randomized complete block design in the greenhouse. The above-ground tissue was harvested and dried for total biomass at 21 days after herbicide treatment. This experiment has been repeated twice, one replicate in late September and the second replicate in December. A standard least square model (JMP) examining genotype, treatment, and replicate as model effects indicates there is an environmental effect on the variation in our dry biomass results.

Preliminary greenhouse results indicate that fluxofenim induces tolerance in a genotype-specific manner to three herbicides: pendimethalin, *S*-metolachlor, and ethofumesate. Pendamethalin + fluxofenim showed an increase in dry biomass for varieties A (+ 49%) and C (+23%) compared with untreated control. Additionally, varieties A and B showed induced tolerance to *S*-metolachlor with fluxofenim treatment on seeds. Their dry biomass were the same as untreated control and significantly higher than herbicide only treated plants. Varieties E and F showed significantly improved dry biomass with *S*-metolachlor + fluxofenim compared to herbicide only treatment, although still less than untreated control. Ethofumesate caused slight damage to all sugar beet varieties, however, variety E showed increased dry biomass when safener was seed-applied. Saflufenacil-treated sugar beets germinated but immediately perished, regardless of safener presence. Both imazamox and dimethenamid-p suffered significant herbicide damage during the herbicide only treatment with 70% and 50% decreased biomass compared with control, respectively. Interestingly, safener only treatment significantly improved plant growth for three varieties, A (+40%), B (+26%) and C (+35%) compared with untreated control. Future directions for this work is to examine these results in a large-scale field experiment.

Interrupted windgrass control in Kentucky bluegrass. Traci A. Rauch and Joan M. Campbell. (Crop and Weed Science Division, University of Idaho, Moscow, ID 83844-2333) A study was conducted to evaluate interrupted windgrass control in established Kentucky bluegrass near Melrose, Idaho. Studies were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph. Crop response and weed control were evaluated visually.

Table 1. Application and soil data.

Variety and stand age	'Palouse'- 12 years	
Application date	10/10/2016	10/24/2016
Growth stage		
Kentucky bluegrass	1 inch regrowth	3 inch regrowth
Interrupted windgrass (APEIN)	pre	spike
Air temperature (F)	49	53
Relative humidity (%)	93	76
Wind (mph, direction)	4, NW	0
Cloud cover (%)	95	100
Next moisture occurred	10/17/2016	10/29/2016
Soil moisture	adequate	wet
Soil temperature at 2 inch (F)	50	47
pH	5.0	
OM (%)	5.0	
CEC (meq/100g)	20.9	
Texture	silt loam	

On April 28, flufenacet/metribuzin, pyroxasulfone and dimethenamid treatments injured Kentucky bluegrass 15 to 25% (Table 2). By June 6, Kentucky bluegrass injury ranged from 0 to 10% but did not differ among treatments. Flufenacet/metribuzin, dimethenamid and pyroxasulfone treatments controlled interrupted windgrass 84 to 99%.

Table 2. Interrupted windgrass control in Kentucky bluegrass near Melrose, ID in 2017.

Treatment	Rate	Application timing	Kentucky bluegrass injury April 28	Kentucky bluegrass injury June 6	APEIN control[1]
	lb ai/A		%	%	%
Dimethenamid	0.98	Oct 10	25	2	84
Pendimethalin	2.38	Oct 10	6	0	45
Dimethenamid +	0.98	Oct 10			
pendimethalin	2.38	Oct 10	24	8	94
Pendimethalin +	2.38	Oct 10			
diuron	0.625	Oct 24	11	0	57
Pyroxasulfone	0.106	Oct 10	22	2	92
Pyroxasulfone	0.213	Oct 10	15	10	99
Pyroxasulfone +	0.106	Oct 10			
diuron	0.625	Oct 24	19	0	99
Pyroxasulfone +	0.106	Oct 10			
dimethenamid	0.98	Oct 10	25	7	99
Diuron	1	Oct 24	9	0	32
Diuron +	1	Oct 24			
metribuzin	0.188	Oct 24	6	0	35
Flufenacet/metribuzin	0.55	Oct 10	18	4	93
LSD (0.05)			12	NS	22
Density (plants/ft^2)					10

[1]Evaluation date June 13, 2017.

Weed control in chickpea affected by incorporation. Joan Campbell and Traci Rauch. (Plant Sciences Department, University of Idaho, Moscow, ID 83844-2333) A study was initiated at the University of Idaho Parker Farm east of Moscow, Idaho to evaluate herbicides for control of broadleaf weeds and the effect of rolling after application. Incorporation by rainfall is required for the activation of most soil applied herbicides. This study was to determine if mechanical incorporation might be substituted for rainfall. Herbicides were applied May 5, 2016 the day after planting Billy Bean chickpea. Herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 20 gpa at 39 psi and 3 mph. Relative humidity, air and soil temperature were 60%, 69 F, and 59 F, respectively. Soil was a silt loam with 22% sand, 22% clay and 58% silt. Soil pH was 5.6 and cation exchange capacity was 16 meq/100g. Half the plot was incorporated with a roller packer after herbicide application. The study was arranged in a split block design with four replications. Common lambsquarters was evaluated visually on June 7 and 27, and plants were counted on July 5. Chickpea seed was harvested at maturity.

Weed control and chickpea yield were lower with saflufenacil + metribuzin compared to other treatments (Table 1). Weed control on June 27 was highest with linuron + sulfentrazone although not statistically different from other herbicide treatment combinations with linuron.

Incorporation with rolling reduced weed control and did not affect chickpea yield (Table 2). Mechanical herbicide incorporation is not recommended at this time to improve herbicide performance.

Table 1. Common lambsquarters control and chickpea seed yield averaged over rolling treatment, Moscow, 2016.

	Common lambsquarters control			
Herbicide treatment[1]	Visual June 6	Visual June 27	Plant number	Chickpea seed yield
	%	%	plant/m^2	lb/A
Untreated	-	-	213 ab[2]	1722 a
saflufenacil + metribuzin	72 a	53 a	45 b	3697 b
linuron + flumioxazin	95 b	88 bc	3 b	5295 c
linuron + imazethapyr	97 b	88 bc	10 b	5273 c
dimethenamid + sulfentrazone	95 b	83 b	6 b	5420 c
linuron + sulfentrazone	98 b	93 c	3 b	5938 c

[1]Herbicide rates are linuron 0.625, imazethapyr 0.031, saflufenacil 0.044, metribuzin 0.375, flumioxazin 0.064, dimethenamid 0.984, and sulfentrazone 0.25 expressed as lb ai/A.
[2] Means followed by the same letter within a column are not statistically different $P<0.05$.

Table 2. Lambsquarters control and chickpea seed yield averaged over herbicide treatment, Moscow, 2016.

	Common lambsquarters control[1]			
Treatment	Visual May	Visual June	Plant number[2,3]	Chickpea seed yield[3]
	%	%	plant/m^2	lb/A
Rolled	87 a	75 a	19 a	4858 a
Non-rolled	96 b	86 b	8 b	5177 a

[1] Means followed by the same letter within a column are not statistically different $P<0.05$.
[2] Data was square root transformed for statistical analysis.
[3] Nontreated plots not included.

Crop safety of diuron applied to seedling red clover grown for seed. Kyle C. Roerig, Andrew G. Hulting, Daniel W. Curtis, and Carol Mallory-Smith. (Crop and Soil Science, Oregon State University, Corvallis, OR 97331) Current diuron labels require that applications to red clover must be between October 15 and December 15. Additionally, red clover must be established 9 months prior to application and no crop may be replanted within one year. Because of these restrictions it is very difficult to use diuron in red clover. This trial was designed evaluate crop safety in seedling red clover (established less than 9 months) outside of the application dates specified.

Red clover was planted during the first week of October, 2016. The trial was a randomized complete block with four replications. Treatments were applied using a bicycle-wheeled plot sprayer calibrated to deliver 20 GPA. Diuron was applied at a rate of 1.6 lb ai/a on February 13, 2017, to 1 trifoliate red clover, March 31, 2017, to 1-2 trifoliate red clover, and May 3, 2017, to clover with 3-5 inches of growth (Table). Seed yield was equivalent to the untreated when diuron was applied February 13 (p-value 0.05). This result suggests that applications can be made to seedling clover and later than the currently allowed application window without reducing seed yield. However, when diuron was applied March 31 or May 3, yield was lower. The growth stage at the February 13 and March 31 applications were similar, yet only the March 31 application reduced yield. In the three days surrounding the February 13 and March 31 application the average high temperatures were 53 and 69, respectively. Weather conditions at the time of application that promote active growth may play a larger role in determining crop safety than growth stage.

The results from this trial support the addition of seedling red clover to diuron labels and increasing the application window. Additional studies are being conducted in the 2017-2018 growing season in seedling and established red clover to confirm the results of this trial.

Table. Seedling red clover seed yield with diuron applied at three dates.

			Red clover[1]	
Treatment	Rate	Application	injury[2]	Seed yield[3]
	lb ai/a	date	-----%-----	-----lb/a-----
untreated			0 c	468 a
diuron	1.6	2/13/2017	8 c	433 a
diuron	1.6	3/31/2017	80 a	296 b
diuron	1.6	5/3/2017	65 b	278 b

[1]Means followed by same letter within a column are not significantly different at p-value = 0.05 by Fisher's Protected LSD
[2]Evaluated 6/12/2017
[3]Harvested 8/4/2017

Control of dock species in seedling red clover grown for seed. Kyle C. Roerig, Andrew G. Hulting, Daniel W. Curtis, and Carol Mallory-Smith. (Crop and Soil Science, Oregon State University, Corvallis, OR 97331) In the Pacific North West curly dock and broadleaf dock are problematic in red and white clover grown for seed. Curly dock and broadleaf dock are competitive perennials with large taproots that thrive in wet areas. The presence of dock can reduce seed yield through competition. In a survey of Western Oregon seed cleaners dock was a common contaminant found in seed lots and is very difficult to clean out of clover seed (Anderson and Hulting, 2013) resulting in further seed yield loss. Previous research efforts to control dock have focused on the use of 2,4-DB and asulam in established clover. These data indicate excellent crop safety and acceptable dock control with 2,4-DB and excellent dock control and mixed crop safety with asulam (Roerig et al., 2016). Flumetsulam was observed to control dock with preemergent and early post emergent applications in New Zealand (Anderson, personal communication).The present study evaluated control of seedling dock with 2,4-DB and preemergent and seedling dock control with flumetsulam.

This trial was conducted in seedling red clover planted during the first week of October, 2016 at the Hyslop Research Farm near Corvallis, Oregon. A mixture of broadleaf and curly dock was planted in two rows running across the plots. The trial was a randomized complete block with four replications. Treatments were applied using a bicycle-wheeled plot sprayer calibrated to deliver 20 GPA. Flumetsulam was applied at 0.067 and 0.133 lb ai/a to red clover shortly after planting (preemergent), at the first trifoliate stage (early postemergent) and when clover 3-5 inches (Table 1). Preemergent and early postemergent applications provided 99% or greater control of dock at both rates. Injury was observed with both the higher and lower rates. At the higher rate, injury was visually assessed at 75-80% and yield was reduced (p-value 0.05) compared to the untreated plot. At the lower rate, injury was observed, but yield was equivalent to the untreated plot (p-value 0.05). Although not statistically significant, yield in plots receiving these treatments were lower and further evaluation is warranted. These treatments and reduced rates are being repeated in the 2017-2018 season to provide a better assessment of crop safety. Flumetsulam applied to clover with 3-5 inches of growth exhibited excellent crop safety, but failed to provide adequate dock control (Table 2). 2,4-DB was applied at two timings and three rates. Control at these rates and timings was variable, but tended to be better at higher rates and later timings, with the highest rate providing 74% control at the later timing. Although 100% control is ideal, 74% control is better than any options currently available. At all rates and timings of 2,4-DB tested, crop safety was excellent and yield was not affected. The addition of bromoxynil did not improve dock control.

Table 1. Crop and weed stage at each application

Species	Date		
	10/6/2016	11/4/2016	5/3/2017
Dock	Preemergent	Cotyledons to first leaf	6 inch diameter
Red clover	Preemergent	First trifoliate	3-5 inches of growth

Table 2. Control of dock spp. in red clover preemergent and seedling applications of flumetsulam and 2,4-DB.

Treatment	Rate	Application	Dock[1] Control		Red clover[1] Injury		Red clover[1] Yield	
	lb ai/a	date	-------------%[2]		-------------		lb/a[3]	
untreated			0	f	0	d	389	ab
flumetsulam	0.067	10/6/2016	100	a	43	b	339	abc
flumetsulam	0.133	10/6/2016	100	ab	75	a	225	d
flumetsulam[4]	0.067	11/4/2016	99	ab	20	c	326	bc
flumetsulam[4]	0.133	11/4/2016	100	a	80	a	252	cd
2,4-DB	0.500	11/4/2016	53	cd	0	d	367	ab
2,4-DB	1.000	11/4/2016	50	cd	5	d	369	ab
2,4-DB	1.500	11/4/2016	68	bc	20	c	347	ab
2,4-DB	0.500	11/4/2016	43	cde	53	b	314	bc
+ bromoxynil	0.250	11/4/2016						
flumetsulam[4]	0.067	5/3/2017	30	def	20	c	416	a
flumetsulam[4]	0.133	5/3/2017	43	cde	20	c	382	ab
2,4-DB	0.500	5/3/2017	23	def	0	d	362	ab
2,4-DB	1.000	5/3/2017	71	abc	3	d	423	a
2,4-DB	1.500	5/3/2017	74	abc	3	d	329	bc
2,4-DB	0.500	5/3/2017	13	ef	4	d	391	ab
+ bromoxynil	0.250	5/3/2017						

[1]Means followed by same letter within a column are not significantly different at p-value = 0.05 by Fisher's Protected LSD
[2]Evaluated 6/12/2017
[3]Harvested 8/4/2017
[4]Applied with 0.25% v/v NIS

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Control of prickly lettuce in white clover grown for seed. Kyle C. Roerig, Andrew G. Hulting, Daniel W. Curtis, and Carol Mallory-Smith. (Crop and Soil Science, Oregon State University, Corvallis, OR 97331) Following spring forage harvest or the cessation of winter grazing, Western Oregon clover seed fields often become infested with prickly lettuce. In addition to impacting yield through competition, the milky latex of prickly lettuce can cause harvest difficulties. This study was conducted in an established commercial white clover seed field near Shedd, Oregon, with an infestation of prickly lettuce to evaluate registered and non-registered herbicide options for prickly lettuce control. The trial was a randomized complete block with four replications. Treatments were applied using a bicycle-wheeled plot sprayer calibrated to deliver 20 GPA.

Prickly lettuce control of 98% or greater was achieved when MCPA amine either at the 0.231 or 0.463 lb ae/a rate was followed by a second application of MCPA amine eight days later at the same rate (Table). Single applications of MCPA amine provided 65 and 87% control of prickly lettuce at 0.231 and 0.463 lb ae/a respectively. Plots treated with 0.463 lb ae/a MCPA amine, either once or twice, had the lowest numerical yield. This difference is not significant from the untreated (p-value 0.05), however, it does warrant further evaluation of crop safety. All other treatments included in this trial failed to provide adequate control of prickly lettuce.

Table. Prickly lettuce control and crop safety in established white clover.

Treatment	Rate	Application	Prickly lettuce[1] Control		White clover[1] Injury		Seed yield	
	lb ai/a[2]	date	-----------------%[3]----------------				lb/a[4]	
untreated			0	e	0	a	202	bc
bentazon	1.0000	5/9/2017	13	de	0	a	275	a
bentazon	1.0000	5/9/2017	61	bc	0	a	238	abc
+ bentazon	1.0000	5/17/2017						
imazamox	0.0390	5/9/2017	29	cd	0	a	272	a
+ bentazon	0.6250	5/9/2017						
imazethapyr	0.0940	5/9/2017	8	de	0	a	235	abc
imazethapyr	0.0940	5/9/2017	31	cd	0	a	237	abc
+ bentazon	0.6250	5/9/2017						
MCPA amine	0.2310	5/9/2017	65	bc	0	a	196	bc
MCPA amine	0.2310	5/9/2017	98	a	10	a	217	abc
+ MCPA amine	0.2310	5/17/2017						
MCPA amine	0.4630	5/9/2017	87	ab	3	a	186	c
MCPA amine	0.4630	5/9/2017	100	a	8	a	188	c
+ MCPA amine	0.4630	5/17/2017						
2,4-DB	1.5000	5/9/2017	66	bc	3	a	252	ab
fluthiacet	0.0064	5/9/2017	4	de	0	a	220	abc

[1]Means followed by same letter within a column are not significantly different at p-value = 0.05 by Fisher's Protected LSD

[2]Or lb ae/a

[3]Evaluated 7/20/2017

[4]Harvested 8/9/2017

<u>Crop safety of PPO inhibitors applied to white clover grown for seed.</u> Kyle C. Roerig, Andrew G. Hulting, Daniel W. Curtis, and Carol Mallory-Smith. (Crop and Soil Science, Oregon State University, Corvallis, OR 97331) Paraquat is frequently used in dormant clover grown for seed to burn down small, recently emerged weeds. Because of the undesirable mammalian toxicity of paraquat, suitable alternatives are desired. PPO (protoporphyyrinogen oxidase) inhibitors have been shown to have crop safety when applied to dormant clover grown for seed (Roerig et al., 2016). This study was conducted to evaluate the crop safety of three PPO inhibitor herbicides at three timings.

The trial was conducted on an established stand of white clover grown at the Hyslop Research Farm near Corvallis, Oregon. The trial was a randomized complete block with four replications. Treatments were applied using a bicycle-wheeled plot sprayer calibrated to deliver 20 GPA. Applications of flumioxazin, carfentrazone, and saflufenacil were made in December, February, and May at the rates show in Table. Flumioxazin and carfentrazone were applied with 0.25% v/v NIS and saflufenacil was applied with 1% v/v MSO and 1% w/v AMS. Foliage was chopped and removed April 19, 2017. Because PPO inhibitors effect foliage and seed production differently, visually estimated injury evaluations focused on the relative number of clover flower heads.

Visual evaluations of percent flower reduction closely correlated with harvested seed yield. These results indicate that flumioxazin can be applied safely at all three timings tested. Carfentrazone can be applied safely in December and February, but not in May. Yield was not impacted by saflufenacil only when it was was applied in December. These results indicate that all three herbicides can be used safely during the dormant season. Additionally, flumioxazin and carfentrazone can be used in +-clover transitioning out of dormancy (February 29) and flumioxazin can be used on actively growing clover shortly after foliage removal.

Table. White clover seed yield and visual evaluation of percent reduction in flower head number when treated with PPO inhibitors.

Treatment	Rate	Application	White clover[1] Flower reduction[2]		Seed yield[3]	
	lb ai/a	date	-------%-------		lb/a	
untreated			0	e	373	bc
flumioxazin	0.128	12/29/2016	0	e	423	a
carfentrazone	0.039	12/29/2016	3	de	383	abc
saflufenacil	0.045	12/29/2016	5	de	384	abc
flumioxazin	0.128	2/28/2017	3	de	413	ab
carfentrazone	0.039	2/28/2017	10	d	380	abc
saflufenacil	0.045	2/28/2017	70	a	261	de
flumioxazin	0.128	5/5/2017	0	e	366	c
carfentrazone	0.039	5/5/2017	23	c	295	d
saflufenacil	0.045	5/5/2017	55	b	242	e

[1]Means followed by same letter within a column are not significantly different at p-value = 0.05 by Fisher's Protected LSD
[2]Evaluated 6/12/2017
[3]Harvested 8/7/2017

Reference:

Roerig, K. C., A. G. Hulting, D. W. Curtis, and C. A. Mallory-Smith. 2016. Evaluation of carfentrazone, flumioxazin and saflufenacil for crop safety and weed control in clovers grown for seed. West Soc. Weed Sci. Res. Prog. Rep. p 48-49

Premix herbicides for split application efficacy in corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated sequential applications of premix herbicides for efficacy in corn. The experimental area was overseeded with kochia, Palmer amaranth, crabgrass, quinoa, and domesticated sunflower prior to corn planting. Quinoa and domesticated sunflower were used as surrogates for common lambsquarters and common sunflower. Herbicides were applied either preemergence (PRE) alone or PRE followed by postemergence (POST). All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi when corn was 5 to 8 inches tall. Application, environmental, crop, and weed information is shown in Table 1. Plot size was 10 by 35 feet and arranged in a randomized complete block with four replicates. Soil for the experiment was a Beeler silt loam with pH 7.6 and 2.4% organic matter. Visual weed control was determined on June 23 and September 5, 2017, which was 7 and 81 days after postemergence applications (DA-B), respectively. Corn yields were determined on October 23, 2017 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Postemergence
Application date	May 24, 2017	June 16, 2017
Air temperature (F)	66	77
Relative humidity (%)	30	56
Soil temperature (F)	54	75
Wind speed (mph)	2	8
Wind direction	West	South
Soil moisture	Fair	Good
Corn		
Height (inch)	---	8 to 13
Leaves (no.)	0	4 to 5
Common sunflower		
Height (inch)	---	4 to 8
Density (plants/m^2)	0	1
Palmer amaranth		
Height (inch)	---	4 to 6
Density (plants/m^2)	0	2
Green foxtail		
Height (inch)	---	8 to 12
Density (plants/m^2)	0	2
Kochia		
Height (inch)	---	10 to 15
Density (plants/m^2)	0	2
Quinoa		
Height (inch)	---	6 to 10
Density (plants/m^2)	0	1
Crabgrass		
Height (inch)	---	2 to 4
Density (plants/m^2)	0	3

Control of kochia, green foxtail, quinoa, and Palmer amaranth was 96 to 100%, regardless of herbicide or evaluation date, and did not differ among treatments (data not shown). Although common sunflower control was slightly less with *S*-metolachlor/atrazine/mesotrione/bicyclopyrone plus atrazine applied PRE compared to other treatments at 7 DA-B (Table 2), no differences for sunflower control occurred by 81 DA-B. Crabgrass control was 95 to 100% regardless of treatment early in the season, and remained high with all herbicides except isoxaflutole plus atrazine PRE followed by dicamba plus atrazine and glyphosate POST (88%). All herbicide treatments resulted in grain yields that were 67 to 101 bu/A greater than the untreated controls. The best yields were achieved when *S*-metolachlor/atrazine/mesotrione/bicyclopyrone plus atrazine was applied alone PRE and when acetochlor/mesotrione/clopyralid plus atrazine PRE was followed by acetochlor/mesotrione/clopyralid plus atrazine and glyphosate POST (133 to 128 bu/A). These yields were better than yields from corn receiving isoxaflutole plus atrazine PRE followed by dicamba plus atrazine and glyphosate POST (99 bu/A).

Table 2. Split-application herbicide efficacy in corn.

Treatment	Rate	Timing[a]	Common sunflower 7 DA-B[b]	Common sunflower 81 DA-B	Crabgrass 7 DA-B	Crabgrass 81 DA-B	Corn yield
	per A		% Visual		% Visual		bu/A
Untreated	---		0	0	0	0	31.5
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.5 qt	PRE	96	100	98	97	132.9
Atrazine	0.4 qt	PRE					
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.25 qt	PRE	100	100	100	99	124.2
Atrazine	0.3 qt	PRE					
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.25 qt	POST					
Atrazine	0.3 qt	POST					
Dicamba/ Diflufenzopyr	2.5 oz	POST					
Glyphosate	31 oz	POST					
Ammonium sulfate	2.0%	POST					
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.5 qt	PRE	100	100	100	100	125.0
Atrazine	0.3 qt	PRE					
S-metolachlor/ Glyphosate/ Mesotrione	4.0 pt	POST					
Atrazine	0.5 qt	POST					
Dicamba/ Diflufenzopyr	2.5 oz	POST					
Nonionic surfactant	0.5%	POST					
Ammonium sulfate	2.0%	POST					
Acetochlor/ Mesotrione/ Clopyralid	1.25 qt	PRE	100	100	95	100	127.6
Atrazine	0.5 qt	PRE					
Acetochlor/ Mesotrione/ Clopyralid	1.25 qt	POST					
Atrazine	0.5 qt	POST					
Glyphosate	31 oz	POST					
Ammonium sulfate	2%	POST					
Isoxaflutole	3.0 oz	PRE	100	100	96	88	98.8
Atrazine	0.5 qt	PRE					
Dicamba	32 oz	POST					
Atrazine	0.5 qt	POST					
Glyphosate	31 oz	POST					
Ammonium sulfate	2%	POST					
Pyroxasulfone	3.0 oz	PRE	100	100	100	100	120.2
Atrazine	0.5 qt	PRE					
Topramezone/ Dimethenamid	16 oz	POST					
Atrazine	0.5 qt	POST					
Glyphosate	31 oz	POST					
Crop oil concentrate	1%	POST					
Ammonium sulfate	2%	POST					

S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.5 qt	PRE	100	100	99	100	121.5
Atrazine	0.3 qt	PRE					
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.5 qt	POST					
Atrazine	0.3 qt	POST					
Dicamba/ Diflufenzopyr	2.5 oz	POST					
Glyphosate	31 oz	POST					
Ammonium sulfate	2%	POST					
LSD (0.05)			3	NS	4	3	28.0

[a] PRE is preemergence, POST is postemergence.
[b] DA-B is days after postemergence applications.

Preemergence and early postemergence weed control in irrigated corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated residual weed control with herbicides applied preemergence (PRE) or early postemergence (EPOST) when corn had one to two true leaves. The experimental area was overseeded with Palmer amaranth, kochia, crabgrass, quinoa, and domesticated sunflower seed prior to corn planting. Quinoa and domesticated sunflower were used as surrogates for common lambsquarters and common sunflower. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi. Application, environmental, crop, and weed information is shown in Table 1. Plot size was 10 by 35 feet and arranged in a randomized complete block with four replicates. Soil was a Beeler silt loam with pH 7.6 and 2.4% organic matter. Weed control was visually determined on June 16 and August 17, 2017, which was 11 and 73 days after the early postemergence treatments (DA-B), respectively. Corn yields were determined by mechanical harvest of the two center rows of each plot on October 19, 2017, and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Early postemergence
Application date	May 16, 2017	June 5, 2017
Air temperature (F)	93	91
Relative humidity (%)	22	26
Soil temperature (F)	73	83
Wind speed (mph)	4	5
Wind direction	South	East
Soil moisture	Good	Good
Corn		
Height (inch)	---	4 to 6
Leaves (no.)	0	1 to 2
Common sunflower		
Height (inch)	---	1 to 2
Density (plants/m^2)	0	1
Palmer amaranth		
Height (inch)	---	0.5 to 2
Density (plants/m^2)	0	10
Green foxtail		
Height (inch)	---	0.25 to 1
Density (plants/m^2)	0	2
Kochia		
Height (inch)	---	1 to 2
Density (plants/m^2)	0	2
Quinoa		
Height (inch)	---	0.5 to 2
Density (plants/m^2)	0	1
Crabgrass		
Height (inch)	---	0.25 to 1
Density (plants/m^2)	0	2

Palmer amaranth, kochia, quinoa, common sunflower, and green foxtail control was 97% or more regardless of herbicide or evaluation date, and did not differ between any treatments (data not shown). Crabgrass was controlled 94% or more by all treatments except rimsulfuron/mesotrione plus atrazine, dicamba, and glyphosate at 11 and 73 DA-B, and isoxaflutole/thiencarbazone plus atrazine, dicamba and glyphosate at 73 DA-B (Table 2). The exceptional weed control with these herbicides resulted in grain yields that were 108 to 125 bu/A greater than in the untreated plots. However, no differences occurred among herbicide treatments for corn yield.

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

Treatment	Rate	Timing[a]	Crabgrass		Corn
			11 DA-B[b]	73 DA-B	yield
	per A		% Visual		bu/A
Untreated	---		0	0	63.7
Rimsulfuron	1.0 oz	PRE	99	94	172.1
Mesotrione	5.0 oz	PRE			
S-metolachlor/ Atrazine	2 qt	PRE			
Glyphosate	22 oz	PRE			
Nonionic surfactant	0.25%	PRE			
Ammonium sulfate	2%	PRE			
Rimsulfuron/ Mesotrione	4.0 oz	EPOST	94	88	183.4
Atrazine	32 oz	EPOST			
Dicamba	4.0 oz	EPOST			
Glyphosate	22 oz	EPOST			
Crop oil concentrate	1%	EPOST			
Ammonium sulfate	2%	EPOST			
Isoxaflutole/ Thiencarbazone	5.6 oz	EPOST	98	91	188.7
Atrazine	32 oz	EPOST			
Dicamba	4.0 oz	EPOST			
Glyphosate	22 oz	EPOST			
Nonionic surfactant	0.25%	EPOST			
Ammonium sulfate	2%	EPOST			
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	3.0 qt	EPOST	100	97	183.5
Glyphosate	22 oz	EPOST			
Nonionic surfactant	0.25%	EPOST			
Acetochlor/ Mesotrione/ Clopyralid	2.5 qt	EPOST	99	97	186.8
Atrazine	32 oz	EPOST			
Glyphosate	22 oz	EPOST			
Nonionic surfactant	0.5%	EPOST			
LSD (0.05)			3	6	29.2

[a] PRE is preemergence, EPOST is early postemergence when corn was in the two leaf stage.
[b] DA-B is days after early postemergence applications.

Dicamba/tembotrione compared to standards for postemergence weed control in corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated the premix of dicamba/tembotrione with tank mixtures for postemergence efficacy compared to standards in corn. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi when corn was 5 to 8 inches tall. Application, environmental, crop, and weed information is shown in Table 1. Plot size was 10 by 35 feet and arranged in a randomized complete block with four replicates. Soil for the experiment was a Beeler silt loam with pH 7.6 and 2.4% organic matter. Visual weed control was evaluated on June 7 and August 16, 2017, which was 8 and 78 days after treatment (DAT), respectively. Corn yields were determined on October 18, 2017 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Postemergence
Application date	May 30, 2017
Air temperature (F)	71
Relative humidity (%)	54
Soil temperature (F)	64
Wind speed (mph)	5
Wind direction	West
Soil moisture	Good
Corn	
Height (inch)	5 to 8
Leaves (no.)	3 to 4
Common sunflower	
Height (inch)	6 to 10
Density (plants/m^2)	3
Palmer amaranth	
Height (inch)	1 to 6
Density (plants/m^2)	20
Green foxtail	
Height (inch)	3 to 6
Density (plants/m^2)	5
Kochia	
Height (inch)	4 to 6
Density (plants/m^2)	3
Quinoa	
Height (inch)	4 to 8
Density (plants/m^2)	5
Crabgrass	
Height (inch)	3 to 5
Density (plants/m^2)	20

Control of kochia, quinoa, and green foxtail was complete with all herbicides evaluated at 8 and 78 DAT (data not shown), and was 97% or more for Palmer amaranth, common sunflower, and crabgrass at 8 DAT (Table 2). By 78 DAT, common sunflower control was complete with all herbicides. On the same date, only the premix of tembotrione/thiencarbazone plus glyphosate and atrazine controlled Palmer amaranth less than 94%. Crabgrass control at 78 DAT was greatest with any herbicide treatment except when dicamba/tembotrione at 24 oz/A plus atrazine was mixed with glyphosate or glufosinate (85 to 86%). All herbicide-treated corn yielded 111 to 126 bu/A more grain than the untreated controls, but no difference occurred among herbicide treatments for yield.

Table 2. Dicamba/tembotrione postemergence comparisons in corn.

Treatment	Rate	Palmer amaranth 8 DAT[a]	Palmer amaranth 78 DAT	Common sunflower 8 DAT	Common sunflower 78 DAT	Crabgrass 8 DAT	Crabgrass 78 DAT	Corn Yield
	oz/A	% Visual		% Visual		% Visual		bu/A
Untreated	---	0	0	0	0	0	0	46.2
Dicamba/ Tembotrione	32	100	96	100	100	97	90	170.6
Glyphosate	32							
Atrazine	16							
Ammonium sulfate	1%							
Dicamba/ Tembotrione	32	100	99	99	100	97	91	158.5
Atrazine	16							
Crop oil concentrate	1%							
Ammonium sulfate	1%							
Dicamba/ Tembotrione	24	100	96	98	100	98	86	159.2
Glyphosate	32							
Atrazine	16							
Ammonium sulfate	1%							
Dicamba/ Tembotrione	24	100	94	97	100	97	85	161.4
Glufosinate	32							
Atrazine	16							
Ammonium sulfate	1%							
Tembotrione/ Thiencarbazone	3.0	100	91	99	100	98	93	168.5
Glyphosate	32							
Atrazine	16							
Ammonium sulfate	1%							
S-metolachlor/ Glyphosate/ Mesotrione	3.6 pt	100	98	99	100	97	88	169.0
Atrazine	16							
Nonionic surfactant	0.25%							
Ammonium sulfate	1%							
Topramezone	0.57	100	98	98	100	97	94	168.3
Dimethenamid	14							
Glyphosate	32							
Atrazine	16							
Ammonium sulfate	1%							
Topramezone	0.57	99	100	97	100	98	88	156.9
Dicamba/ Diflufenzopyr	3.0							
Glyphosate	32							
Atrazine	16							
Ammonium sulfate	1%							
Acetochlor/ Atrazine	3.0 qt	100	100	100	100	98	93	164.8
Dicamba/ Tembotrione	32							
Glyphosate	32							
Ammonium sulfate	1%							
S-metolachlor/ Atrazine	1.6 qt	100	100	100	100	98	93	171.7
Dicamba/ Tembotrione	32							
Glyphosate	32							
Ammonium sulfate	1%							
LSD (0.05)		NS	6	2	NS	NS	7	25.4

[a] DAT is days after herbicide treatment.

Glufosinate rates and tank mix partners for weed control in corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated glufosinate rates and tank mix partners for postemergence weed control in corn. The experimental area was overseeded with a mixture of kochia, Palmer amaranth, crabgrass, quinoa, and domesticated sunflower seed prior to corn planting. Quinoa and domesticated sunflowers were used as surrogates for common lambsquarters and common sunflower, respectively. All postemergence treatments were preceded by a preemergence application of isoxaflutole at 3.0 oz/A plus atrazine at 32 oz/A. All herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi. Application, environmental, crop, and weed information is shown in Table 1. Plot size was 10 by 35 feet and arranged in a randomized complete block with four replicates. Soil for the experiment was a Beeler silt loam with pH 7.6 and 2.4% organic matter. Weed control was visually rated on June 12 and August 16, 2017, which was 7 and 72 days after postemergence application (DA-B), respectively. Corn yields were determined on October 18, 2017 by mechanically harvesting the center two rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Postemergence
Application date	April 20, 2017	June 5, 2017
Air temperature (F)	54	90
Relative humidity (%)	56	29
Soil temperature (F)	60	90
Wind speed (mph)	8	5
Wind direction	North-northwest	Southeast
Soil moisture	Good	Good
Corn		
Height (inch)	---	8 to 10
Leaves (no.)	0	3 to 4
Common sunflower		
Height (inch)	---	4 to 6
Density (plants/m^2)	0	3
Palmer amaranth		
Height (inch)	---	3 to 7
Density (plants/m^2)	0	3
Green foxtail		
Height (inch)	---	2 to 3
Density (plants/m^2)	0	2
Kochia		
Height (inch)	---	3 to 7
Density (plants/m^2)	0	15
Russian thistle		
Height (inch)	---	3 to 6
Density (plants/m^2)	0	2
Crabgrass		
Height (inch)	---	2 to 4
Density (plants/m^2)	0	10

Control of quinoa, green foxtail, and kochia was 98% or more regardless of herbicide treatment or evaluation date (data not shown) as was common sunflower control (Table 2). Palmer amaranth and crabgrass control was 95% or more regardless of herbicide treatment at 7 DA-B. Postemergence applications of glufosinate at any rate alone controlled Palmer amaranth 85 to 88% at 72 DA-B, whereas tank mixing any herbicide with glufosinate increased control 7 to 15%. Crabgrass control was 89 to 96% at 72 DA-B with all treatments except when glufosinate at 22 oz/A was applied with dicamba at 10 oz/A (84%). Corn yields did not differ among herbicide-treated plots, but each herbicide treatment increased yield 118 to 149 bu/A relative to the untreated controls.

Table 2. Glufosinate rates and tank mixtures in corn.

Treatment	Rate	Timing[a]	Palmer amaranth 7 DA-B[b]	Palmer amaranth 72 DA-B	Common sunflower 7 DA-B	Common sunflower 72 DA-B	Crabgrass 7 DA-B	Crabgrass 72 DA-B	Corn Yield
	oz/A		% Visual		% Visual		% Visual		bu/A
Untreated	---		0	0	0	0	0	0	52.1
Isoxaflutole	3.0	PRE	99	88	100	100	97	95	176.9
Atrazine	32	PRE							
Glufosinate	32	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	99	86	100	100	95	93	183.1
Atrazine	32	PRE							
Glufosinate	36	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	98	85	100	100	97	89	186.7
Atrazine	32	PRE							
Glufosinate	43	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	98	100	100	98	91	173.5
Atrazine	32	PRE							
Glufosinate	32	POST							
Atrazine	16	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	96	99	100	97	93	188.8
Atrazine	32	PRE							
Glufosinate	36	POST							
Atrazine	16	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	95	100	100	98	94	201.5
Atrazine	32	PRE							
Glufosinate	43	POST							
Atrazine	16	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	100	100	100	97	90	170.4
Atrazine	32	PRE							
Glufosinate	22	POST							
Tembotrione	3.0	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	99	100	100	97	94	185.4
Atrazine	32	PRE							
Glufosinate	32	POST							
Tembotrione	3.0	POST							
AMS	3.0 lb	POST							
Isoxaflutole	3.0	PRE	98	95	100	100	96	84	184.7
Atrazine	32	PRE							
Glufosinate	22	POST							
Dicamba	10	POST							
Ammonium sulfate	3.0 lb	POST							

Isoxaflutole	3.0	PRE	100	99	97	100	96	89	179.6
Atrazine	32	PRE							
Glufosinate	32	POST							
Dicamba	10	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	100	100	98	99	90	181.8
Atrazine	32	PRE							
Glufosinate	22	POST							
Thiencarbazone/ Tembotrione	3.0	POST							
Atrazine	16	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	98	99	100	99	94	188.8
Atrazine	32	PRE							
Glufosinate	22	POST							
S-metolachlor/ Glyphosate/ Mesotrione	3.6 pt	POST							
Ammonium sulfate	3.0 lb	POST							
Isoxaflutole	3.0	PRE	100	100	100	100	99	96	198.3
Atrazine	32	PRE							
S-metolachlor/ Glyphosate/ Mesotrione	3.6 pt	POST							
Diflufenzopyr/ Dicamba	5.0	POST							
Ammonium sulfate	1.7 lb	POST							
LSD (0.05)			2	6	3	2	3	7	32.9

[a] PRE is preemergence, POST is postemergence.
[b] DA-B is days after postemergence treatments.

Application timing and tank mixture evaluation for efficacy in irrigated field corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated various herbicides premixes and tank mixtures for efficacy at various application timings. Herbicides were applied 28 days early preplant (EPP) followed by postemergence (POST), preemergence (PRE) only, PRE followed by POST, or early postemergence (EPOST) only. Application, environmental, crop, and weed information is given in Table 1. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi. Plot size was 10 by 35 feet, and the experiment was a randomized complete block with four replications. Soil was a Beeler silt loam with pH 7.6 and 2.4% organic matter. Weed control ratings for all species were visually determined on June 19 and August 16, 2017, which was 10 and 68 days after the POST treatments (DA-D), respectively. Corn yields were determined October 18, 2017 by mechanically harvesting the two center rows of each plot and adjusting grain weights to 15.5% moisture.

Table 1. Application information.

Application timing	28 days preplant	Preemergence	Early Postemergence	Postemergence
Application date	April 12, 2017	May 9, 2017	May 30, 2017	June 9, 2017
Air temperature (F)	62	76	74	67
Relative humidity (%)	45	47	41	66
Soil temperature (F)	52	46	72	67
Wind speed (mph)	10	3	5	7
Wind direction	South	Southeast	West	South
Soil moisture	Good	Good	Good	Good
Corn				
Height (inch)	---	---	4 to 7	7 to 10
Leaves (no.)	0	0	2 to 3	4 to 5
Common sunflower				
Height (inch)	---	---	2 to 4	2 to 4
Density (plants/m^2)	0	0	3	1
Palmer amaranth				
Height (inch)	---	---	1 to 3	2 to 4
Density (plants/m^2)	0	0	1 to 5	1 to 5
Green foxtail				
Height (inch)	---	---	1 to 3	1 to 4
Density (plants/m^2)	0	0	3	3
Kochia				
Height (inch)	---	---	4 to 8	2 to 4
Density (plants/m^2)	0	0	3	1
Russian thistle				
Height (inch)	---	---	6 to 12	6 to 15
Density (plants/m^2)	0	0	5	3
Quinoa				
Height (inch)	---	---	1 to 3	1 to 3
Density (plants/m^2)	0	0	3	1

Overall weed control was good with most herbicides, such that kochia, Russian thistle, and quinoa control was 98% or more regardless of treatment of rating date (data not shown). Common sunflower control at 10 DA-D was 95% when pyroxasulfone/fluthiacet plus pyroxasulfone/mesotrione plus atrazine and glyphosate were applied EPOST, while green foxtail control was 94% with the same treatment at 68 DA-D (Table 2). Palmer amaranth and green foxtail control at 68 DA-D was 93 and 91%, respectively, when acetochlor/flumetsulam/clopyralid plus atrazine and glyphosate were applied PRE followed by glyphosate POST. All herbicide-treated corn yielded 34 to 69 bu/A more grain than the untreated control. Yields among herbicide-treated corn were lowest when no EPOST or POST application was included.

Table 2. Application timing and tank mixture evaluation in corn.

Treatment[a]	Rate	Timing[b]	Common sunflower 10 DA-D[c]	Common sunflower 68 DA-D	Palmer amaranth 10 DA-D	Palmer amaranth 68 DA-D	Green foxtail 10 DA-D	Green foxtail 68 DA-D	Corn Yield
	oz/A		% Visual		% Visual		% Visual		bu/A
Untreated	---		0	0	0	0	0	0	103.7
Pyroxasulfone/ Fluthiacet	4.0	PRE	100	100	100	100	100	99	172.6
Atrazine	32	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
Fluthiacet/ Mesotrione	2.5	POST							
Atrazine	16	POST							
Glyphosate	22	POST							
COC	1%	POST							
AMS	1%	POST							
Pyroxasulfone/ Fluthiacet	4.0	PRE	100	100	100	100	100	99	165.3
Mesotrione	4.0	PRE							
Atrazine	32	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
Fluthiacet/ Mesotrione	2.5	POST							
Atrazine	16	POST							
Glyphosate	22	POST							
COC	1%	POST							
AMS	1%	POST							
Pyroxasulfone/ Fluthiacet	4.0	PRE	100	100	100	100	100	98	161.9
Isoxaflutole	3.0	PRE							
Atrazine	32	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
Fluthiacet/ Mesotrione	2.5	POST							
Atrazine	16	POST							
Glyphosate	22	POST							
COC	1%	POST							
AMS	1%	POST							

Pyroxasulfone/ Fluthiacet	4.0	PRE	100	100	100	99	100	100	166.1
Flumetsulam/ Clopyralid	4.0	PRE							
Atrazine	32	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
Fluthiacet/ Mesotrione	2.5	POST							
Atrazine	16	POST							
Glyphosate	22	POST							
COC	1%	POST							
AMS	1%	POST							
Pyroxasulfone/ Fluthiacet	2.0	EPOST	95	98	100	100	100	94	164.9
Pyroxasulfone/ Mesotrione	2.5	EPOST							
Atrazine	32	EPOST							
Glyphosate	22	EPOST							
COC	1%	EPOST							
AMS	1%	EPOST							
Pyroxasulfone/ Fluthiacet	4.0	EPOST	100	100	100	100	100	98	151.0
Mesotrione	3.0	EPOST							
Atrazine	32	EPOST							
Glyphosate	22	EPOST							
COC	1%	EPOST							
AMS	1%	EPOST							
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.25 qt	PRE	100	100	100	99	100	100	169.9
Atrazine	10	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	1.25 qt	POST							
Atrazine	10	POST							
Dicamba/ Diflufenzopyr	2.5	POST							
Glyphosate	28	POST							
AMS	1%	POST							

S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.5 qt	PRE	100	100	100	100	100	97	138.0
Atrazine	13	PRE							
Glyphosate	22	PRE							
AMS	1%	PRE							
Acetochlor/ Mesotrione/ Clopyralid	2.5 qt	EPP	100	100	100	98	98	96	161.3
Atrazine	32	EPP							
Glyphosate	32	EPP							
2,4-D ester	16	EPP							
AMS	2.5%	EPP							
Glyphosate	32	POST							
AMS	2.5%	POST							
Acetochlor/ Atrazine	2.1 qt	PRE	100	100	100	98	100	96	164.3
Flumetsulam/ Clopyralid	4.0	PRE							
Glyphosate	32	PRE							
AMS	2.5%	PRE							
Glyphosate	32	POST							
AMS	2.5%	POST							
Acetochlor/ Flumetsulam/ Clopyralid	2.0 pt	PRE	100	100	100	93	100	91	160.5
Atrazine	32	PRE							
Glyphosate	32	PRE							
AMS	2.5%	PRE							
Glyphosate	32	POST							
AMS	2.5%	POST							
Acetochlor/ Mesotrione/ Clopyralid	2.5 qt	PRE	100	100	100	100	100	97	167.1
Atrazine	32	PRE							
Glyphosate	32	PRE							
AMS	2.5%	PRE							
Glyphosate	32	POST							
AMS	2.5%	POST							
Acetochlor/ Mesotrione/ Clopyralid	1.25 qt	PRE	100	100	100	100	100	97	171.6
Atrazine	32	PRE							
Glyphosate	32	PRE							
AMS	2.5%	PRE							
Acetochlor/	1.25 qt	POST							

Mesotrione/ Clopyralid									
Atrazine	32	POST							
Glyphosate	32	POST							
AMS	2.5%	POST							
LSD (0.05)			4	2	1	4	2	4	31.7

[a] AMS is ammonium sulfate, COC is crop oil concentrate.
[b] EPP is 28 days before planting, PRE is preemergence, EPOST is early postemergence , and POST is postemergence.
[c] DA-D is days after postemergence treatment.

Dicamba-tolerant volunteer soybean control in irrigated field corn. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment at the Kansas State University Southwest Research-Extension Center near Garden City, KS evaluated preemergence (PRE) and postemergence (POST) herbicides for control of dicamba-tolerant soybean in field corn. Application, environmental, and weed information is given in Table 1. The experimental area was overseeded with dicamba-tolerant soybean seed prior to planting corn, whereas the Palmer amaranth and green foxtail populations were naturally occurring. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi. Plot size was 10 by 35 feet arranged in a randomized complete block design with four replications. Soil for the experiment was a Beeler silt loam with 2.4% organic matter and pH 7.6. Visual weed control ratings were determined on June 20 and September 5, 2017, which was 5 and 82 days after the POST applications (DA-B), respectively. Grain yields were determined by mechanically harvesting the center two rows of each plot on October 20, 2017, and adjusting weights to 15.5% moisture.

Table 1. Application information.

Application timing	Preemergence	Postemergence
Application date	May 16, 2017	June 15, 2017
Air temperature (F)	93	77
Relative humidity (%)	22	58
Soil temperature (F)	73	74
Wind speed (mph)	4	5
Wind direction	South	South-Southeast
Soil moisture	Good	Good
Volunteer soybean		
Height (inch)	---	5
Density (plants/m^2)	0	25
Palmer amaranth		
Height (inch)	---	5
Density (plants/m^2)	0	25
Green foxtail		
Height (inch)	---	4
Density (plants/m^2)	0	3

Dicamba-tolerant soybean control at 5 DA-B was best when topramezone was applied POST with atrazine, glyphosate, and dimethenamid or with dicamba plus diflufenzopyr, atrazine and glyphosate (Table 2). These treatments, along with PRE treatments of topramezone plus dimethenamid and atrazine, completely controlled soybean at 82 DA-B. Similarly, control of Palmer amaranth and green foxtail was generally best with topramezone plus dimethenamid and atrazine applied PRE or any herbicide combination applied POST, regardless of evaluation date. Corn receiving PRE treatment of any herbicide yielded 41 to 120 bu/A more than the weedy checks, however, corn treated POST with any herbicide yielded 117 to 145 bu/A more grain than the untreated corn.

Table 2. Control of dicamba-tolerant soybean in corn.

Treatment[a]	Rate	Timing[b]	Soybean		Palmer amaranth		Green foxtail		Corn
			5 DA-B[c]	82 DA-B	5 DA-B	82 DA-B	5 DA-B	82 DA-B	Yield
	oz/A		——— % Visual ———		——— % Visual ———		——— % Visual ———		bu/A
Untreated	---		0	0	0	0	0	0	48.3
Topramezone	0.5	PRE	74	70	67	52	77	57	89.0
Atrazine	16	PRE							
Topramezone	0.75	PRE	80	81	78	63	84	73	118.8
Atrazine	16	PRE							
Topramezone/ Dimethenamid	16	PRE	70	100	93	85	100	98	168.5
Atrazine	16	PRE							
Topramezone/ Dimethenamid	20	PRE	83	100	90	85	98	100	156.2
Atrazine	16	PRE							
Topramezone	0.5	POST	95	100	91	88	95	98	187.1
Atrazine	16	POST							
Glyphosate	32	POST							
MSO	1%	POST							
AMS	2%	POST							
Topramezone	0.75	POST	95	100	93	87	98	100	191.3
Atrazine	16	POST							
Glyphosate	32	POST							
MSO	1%	POST							
AMS	2%	POST							
Topramezone/ Dimethenamid	16	POST	95	100	94	87	100	100	174.5
Atrazine	16	POST							
Glyphosate	32	POST							
Superb HC	0.5%	POST							
AMS	2%	POST							
Topramezone/ Dimethenamid	20	POST	95	100	94	78	100	100	165.5
Atrazine	16	POST							
Glyphosate	32	POST							
Superb HC	0.5%	POST							
AMS	2%	POST							
Dicamba/ Diflufenzopyr	5	POST	95	100	93	89	100	100	192.9
Atrazine	16	POST							
Glyphosate	32	POST							
MSO	1%	POST							
AMS	2%	POST							
LSD (0.05)			7	6	9	11	5	5	25.0

[a] AMS is ammonium sulfate, MSO is methylated seed oil. [b] PRE = preemergence, EPOST = early postemergence, POST = postemergence. [c] DA-B is days after postemergence application.

Pyraflufen alone and in tank mixtures for spring kochia control in fallow. R. S. Currie, P. W. Geier, G. W. Boyer, and P. W. Stahlman. (Kansas State University Southwest Research-Extension Center and Agricultural Research Center – Hays) Two experiments were conducted in Western Kansas to evaluate pyraflufen alone and in tank mixtures for early spring kochia control in fallow. Locations included the Kansas State University Agricultural Research Center near Hays, KS and the Southwest Research-Extension Center near Garden City, KS. Application, environmental, and weed information are given in Table 1. Herbicides were applied using a tractor-mounted sprayer delivering 20 gpa at 30 psi at Garden City or a backpack sprayer at Hays delivering 15 gpa at 32 psi. Soil at Hays was a Roxbury silt loam with 2.7% organic matter and pH 7.9 at Hays and a Ulysses silt loam with 3.4% organic matter and pH 7.9 at Garden City. Plots were 10 by 32 feet (Hays) or 10 by 35 feet (Garden City) and arranged in randomized complete blocks with four replications. Visual kochia control was determined on May 17, June 2, and June 16, 2017 at Garden City, which was 5, 21, and 35 days after treatment (DAT), respectively. At Hays, visual kochia control was determined on June 9, June 23, and July 7, 2017, which was 7, 21, and 35 DAT, respectively.

Table 1. Application information.

Location	Garden City, KS	Hays, KS
Application date	May 12, 2017	June 2, 2017
Air temperature (F)	64	71
Relative humidity (%)	43	72
Soil temperature (F)	55	70
Wind speed (mph)	5	5
Wind direction	North	South
Soil moisture	Good	Excellent
Kochia:		
Height (inch)	2 to 8	1 to 9
Density (plants/m^2)	100	600

By 7 DAT, no herbicide treatment provided more than 50% kochia control at Garden City or 80% kochia control at Hays (Table 2). At Garden City, treatments of pyraflufen plus glyphosate and 2,4-D or dicamba, glyphosate alone, or glyphosate plus 2,4-D or dicamba provided the best kochia control at 21 and 35 DAT (89 to 97%). Glyphosate alone or with 2,4-D, and pyraflufen plus dicamba alone or with glyphosate controlled kochia 85 to 91% at Hays by 21 DAT, and only pyraflufen plus dicamba with or without glyphosate controlled kochia more than 80% by 35 DAT.

Table 2. Pyraflufen alone and in tank mixtures for spring kochia control in fallow at two Kansas locations.

		Garden City			Hays		
		5 DAT[b]	21 DAT	35 DAT	7 DAT[b]	21 DAT	35 DAT
Treatment[a]	Rate						
	oz/A	% Visual			% Visual		
Untreated	---	0	0	0	0	0	0
Pyraflufen	2.0	33	53	45	70	60	40
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	33	94	83	63	73	48
Glyphosate	22						
AMS	2%						
Pyraflufen	2.0	48	58	50	63	55	23
2,4-D amine	4.0						
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	45	96	89	55	58	45
Glyphosate	22						
2,4-D amine	4.0						
AMS	2%						
Glyphosate	22	19	97	90	48	85	68
AMS	2.0%						
Glyphosate	22	25	97	90	55	88	73
2,4-D amine	4.0						
AMS	2.0%						
2,4-D amine	4.0	---[c]	---	---	3	0	0
AMS	2.0%						
Pyraflufen	2.0	50	91	93	80	90	83
Dicamba	4.0						
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	48	96	97	73	91	83
Glyphosate	22						
Dicamba	4.0						
AMS	2.0%						
Dicamba	4.0	21	55	70	50	70	73
AMS	2.0%						
Dicamba	4.0	38	97	97	---[c]	---	---
Glyphosate	22						
AMS	2.0%						
LSD (0.05)		7	6	8	8	8	8

[a] AMS is ammonium sulfate, COC is crop oil concentrate.
[b] DAT = days after treatment.
[c] --- = treatment not included at that location.

Pyraflufen alone and in tank mixtures for summer weed control in fallow. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center) An experiment at the Kansas State University Southwest Research-extension Center near Garden City, KS evaluated pyraflufen alone and in tank mixtures for late summer weed control in fallow. All herbicides were applied using a tractor-mounted; compressed-CO_2 sprayer calibrated to deliver 20 gpa at 30 psi and 4.2 mph. Application, environmental, and weed information is given in Table 1. The experiment was conducted on a Beeler silt loam soil with pH 7.6 and 2.4% organic matter. Plots were 10 by 35 feet and arranged in a randomized complete block with four replications. Visual control of kochia and Russian thistle was determined on September 15, September 29, and October 12, 2017, which corresponded to 8, 22, and 35 days after herbicide treatment (DAT).

Table 1. Application information.

Application date	September 7, 2017
Air temperature (F)	62
Relative humidity (%)	53
Soil temperature (F)	64
Wind speed (mph)	5
Wind direction	South
Soil moisture	Very dry
Kochia:	
Height (inch)	8 to 15
Density (plants/m^2)	35
Russian thistle:	
Height (inch)	8 to 14
Density (plants/m^2)	50

Kochia control at 8 DAT was best when pyraflufen was tank mixed with glyphosate, 2,4-D amine, and/or dicamba (Table 2), and this trend continued through 35 DAT. However, no pyraflufen treatment controlled kochia more than 60% at 35 DAT. Treatments containing glyphosate, 2,4-D, and/or dicamba without pyraflufen did not control kochia more than 33% at 35 DAT. Similarly, Russian thistle control was best regardless of evaluation date when pyraflufen was applied alone or tank mixed with another herbicide, and pyraflufen treatments provided 90 to 94 Russian thistle control at 35 DAT. Treatments without pyraflufen controlled Russian thistle no more than 63%.

Table 2. Pyraflufen alone and in tank mixtures for late summer weed control in fallow.

		Kochia			Russian thistle		
Treatment[a]	Rate	8 DAT[b]	22 DAT	35 DAT	8 DAT	22 DAT	35 DAT
	oz/A	% Visual			% Visual		
Untreated	---	0	0	0	0	0	0
Pyraflufen	2.0	30	53	48	50	85	90
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	35	55	60	53	85	90
Glyphosate	22						
AMS	2%						
Pyraflufen	2.0	35	50	55	48	91	91
2,4-D amine	4.0						
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	33	58	58	50	91	94
Glyphosate	22						
2,4-D amine	4.0						
AMS	2%						
Glyphosate	22	18	28	30	20	53	55
AMS	2.0%						
Glyphosate	22	23	33	33	28	55	63
2,4-D amine	4.0						
AMS	2.0%						
2,4-D amine	4.0	18	28	25	23	33	30
AMS	2.0%						
Pyraflufen	2.0	33	53	58	50	95	94
Dicamba	4.0						
COC	1.0%						
AMS	2.0%						
Pyraflufen	2.0	38	55	55	53	89	91
Glyphosate	22						
Dicamba	4.0						
AMS	2.0%						
Dicamba +	4.0	15	28	28	25	35	30
AMS	2.0%						
Dicamba	4.0	23	33	33	30	55	55
Glyphosate	22						
AMS	2.0%						
LSD (0.05)		7	9	10	7	7	8

[a] AMS is ammonium sulfate, COC is crop oil concentrate.
[b] DAT = days after treatment.

Broadleaf weed control in fallow with bicyclopyrone/bromoxynil. Traci A. Rauch and Joan M. Campbell. (Plant Sciences Department, University of Idaho, Moscow, ID 83844-2333) A study was established in fallow to evaluate broadleaf weed control with bicyclopyrone/bromoxynil as a preemergence herbicide near Genesee, Idaho. The study was arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). The entire study area was oversprayed with glyphosate at 1.12 lb ae/A on May 10, 2017. Weed control were evaluated visually for 60 days after treatment (DAT). Only three replications were analyzed due to a nonuniform weed population.

Table 1. Application and soil data.

Application date	5/22/17
Growth stage	
Common lambsquarters (CHEAL)	pre
Prickly lettuce (LACSE)	pre
Redroot pigweed (AMARE)	pre
Air temperature (F)	74
Relative humidity (%)	49
Wind (mph), direction	1, NW
Next moisture occurred	6/5/17
Cloud cover (%)	0
Soil moisture	adequate
Soil temperature at 2 inch (F)	65
pH	5.6
OM (%)	4.4
CEC (meq/100g)	18.4
Texture	silt loam

Total weeds included common lambsquarters, prickly lettuce, and redroot pigweed. At 30 DAT, total weed count did not differ among treatments except from the untreated check (Table 2). At 38 DAT, the high rate of pyrasulfotole/bromoxynil reduced total weed count by 52% while the low rate of bicyclopyrone/bromoxynil reduced the total weed count by 80% compared to the untreated check. Bicyclopyrone/bromoxynil treatments controlled total weeds 97% compared to pyrasulfotole/bromoxynil treatments at 92% at 30 DAT. At 53 DAT, only the high rate of bicyclopyrone/bromoxynil controlled total weeds better than 90%.

Table 2. Broadleaf weed control in fallow with bicyclopyrone/bromoxynil near Genesee, ID in 2017.

		Total weed count[2]		Total weed control[2]	
Treatment[1]	Rate	DAT 30	DAT 38	DAT 30	DAT 53
	lb ai/A	Plant number		% of untreated check	
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate	0.058	4	9	97	82
Bicyclopyrone/bromoxynil +	0.225				
sodium bicarbonate	0.068	2	10	97	93
Pyrasulfotole/bromoxynil	0.177	6	14	92	83
Pyrasulfotole/bromoxynil	0.217	8	24	92	73
Untreated check	--	35	50	--	--
LSD (0.05)		13	14	4	11

[1]Sodium bicarbonate was used as a buffer. Ammonium sulfate (AMS) at 1 lb ai/A and nonionic surfactant (NIS) at 0.25% v/v were applied with all treatments.
[2]Only three replications were analyzed due to a nonuniform weed population.

Evaluation of herbicide crop safety and weed control in quinoa. Kyle C. Roerig and R. Ed Peachey (Crop and Soil Science and Horticulture, Oregon State University, Corvallis, OR 97331) Consumption of quinoa has greatly increased in the US over the last decade. Most quinoa consumed in the US is imported. As consumption has increased, so has interest in domestic production. However, one of the primary barriers to US production has been the lack of herbicide options for weed control in quinoa. This study evaluated herbicides that may control problem weeds and have adequate crop safety in quinoa.

The trial was a randomized complete block with four replications. Treatments were applied using a bicycle-wheeled plot sprayer calibrated to deliver 20 GPA. Cycolate treatments were applied before planting and incorporated within 15 minutes of application by a rotary power harrow. Crop injury and weed control with cycolate was rate dependent. All three rates controlled ivy-leaf speedwell and witchgrass. Control of shepherd’s purse ranged from 15-85% and mayweed chamomile ranged from 4-71% depending on rate. Crop injury with cycolate was observed as a reduction in emergence. Injury in the plots treated with 4 lb ai/a was equivalent to the untreated plots and in the plots treated with 16 lb ai/a injury was 68%. When 8 lb ai/a was applied injury was 12%. Clethodim provided control of witchgrass without injuring quinoa. Preemergent S-metolachlor provided excellent control of all weed species present. A reduction in stand in plots treated with s-metolachlor resulted in a 12% injury rating. Based on these results further evaluation of cycolate, clethodim, and S-metolachlor is warranted. Application of Ethofumesate, imazamox, halosulfuron, and asulam all resulted in unacceptable injury. Yield data was not collected because no seed was produced. This may have been due to high temperatures or excessive irrigation during pollination.

Table. Weed control and crop safety of herbicides applied to quinoa.

			Control[1]								Injury[1]	
table	Rate	Applied	Shepherd's purse		Mayweed chamomile		Ivyleaved speedwell		Witchgrass		Quinoa	
	lb ai/a	date	%[2]									
untreated			0	f	0	e	0	c	0	c	0	e
cycolate	4.0000	5/9/2017	15	e	4	de	100	a	99	a	1	e
cycolate	8.0000	5/9/2017	62	c	42	bcd	100	a	99	a	12	d
cycolate	16.0000	5/9/2017	85	bc	71	b	100	a	100	a	68	bc
ethofumesate	2.0000	5/10/2017	53	cd	47	bc	100	a	100	a	50	c
s-metolachlor	1.6000	5/10/2017	99	ab	100	a	100	a	100	a	12	d
imazamox	0.0313	6/6/2017	100	a	38	bcd	100	a	99	a	99	a
imazamox	0.0625	6/6/2017	99	ab	66	bc	100	a	100	a	100	a
halosulfuron	0.0234	6/26/2017	80	bc	69	bc	56	b	1	c	80	b
asulam	1.5000	6/26/2017	20	de	20	cde	18	c	59	b	22	d
clethodim	0.2500	6/26/2017	4	ef	31	bcd	25	c	100	a	1	e

[1]Means followed by same letter within a column are not significantly different at p-value = 0.05 by Fisher's Protected LSD

[2]Evaluated 7/14/2017

Weed management in carbon-seeded perennial ryegrass with preemergence herbicides. Daniel W. Curtis, Kyle C. Roerig, Andrew G. Hulting and Carol Mallory-Smith. (Department of Crop and Soil Science, Oregon State University, Corvallis OR, 97331) A study conducted in perennial ryegrass grown for seed, evaluated crop safety and control of diuron resistant annual bluegrass (*Poa annua*) and roughstalk bluegrass (*Poa trivialis*) following applications of preemergence herbicides. 'APR 2190' perennial ryegrass was planted in 12-inch rows, 0.25 inches deep with a 1-inch wide band of activated carbon sprayed over the seed rows at 300 lb/A on October 3, 2016. Study design was a randomized complete block design with four replications. Plots were 8 x 35 ft with 24 rows of carbon-seeded perennial ryegrass and had two rows of diuron resistant *Poa annua* grower screenings, two rows of *Poa annua* grower screenings of unknown susceptability, and two rows of grower screenings of *Poa trivialis* planted without carbon in a fallow area in the front of each plot. Seedbed preparation included use of a heavy roller to compact the surface to help obtain shallow, uniform seed placement. A bicycle sprayer with output of 20 GPA at 20 psi was used to apply the herbicide treatments on October 4, 2016, and on November 29, 2016 (Table 1). The study, comprised of 10 treatments, included a grower standard of diuron plus pronamide followed by ethofumesate and an untreated check (Table 2). Treatments with glufosinate plus ethofmesate and glufosinate plus oxyfluorfen were included to evaluate safety of treatments intended for removing weed species emerging from within the carbon treated band. The study area received 0.11 inches of rain the afternoon following the application, and 1.46 inches for the first week following application. During the week of grass seed emergence (week 2), rainfall was 5.7 inches. The heavy rainfall combined with field preparation led to standing water on the surface at plant emergence and for several days following. The crop was swathed on July 7, and threshed with a small plot combine on July 19. Seed was cleaned with a Clipper Cleaner and yields were quantified (Table 2).

Table 1. Application and soil data

Planting date	October 3, 2016	
Application date	October 4, 2016	November 29,2016
Crop growth stage	preemergence	5 leaf + 1 tiller
Poa annua growth stage	preemergence	1-2 tiller
Poa trivialis growth stage	preemergence	1-2 tiller
Air temperature (F)	61	52
Relative humidity (%)	78	57
Wind (mph, direction)	0-4, S	2, E
Cloud cover (%)	90	70
First moisture (inches)	October 4 (0.11)	November 29 (0.12)
Soil temperature at 2 inches (F)	60	50
Soil pH	5.7	
Soil OM (%)	4.0	
Soil CEC (meq/100g)	8.1	
Soil texture	silt loam	

October rainfall at the study site was 12.15 inches. The twenty-year rainfall average for the site is 3.17 inches. Severe crop injury, 60% and greater, was observed in all the indaziflam treatments and with the high rate of pyroxasulfone/flumioxazin. This injury resulted in clean seed yield reductions. Extreme rainfall amounts as the emerging seed was germinating probably caused dissipation of the carbon band allowing herbicides to move into the seed row and inhibit root growth thus preventing plant establishment. Control of the *Poa* species with all herbicide treatments was 89 – 100%. Clean seed yields with the lower rate of pyroxasulfone/flumioxazin including treatments followed by glufosinate plus ethofumesate were equivalent to the untreated check and the grower standard treatment. There is a risk of severe crop injury indaziflam in wetter than normal years.

Table 2. Control of two populations of *Poa annua*, *Poa trivialis*, crop injury and seed yield with herbicide treatments in carbon-seeded perennial ryegrass.

Rate		*Poa annua*	DR[1]*Poa annua*	*Poa trivialis*	Crop injury	Clean seed yield
	lb ai/A	------- % control[2] ------			%	lb/A
untreated check	0	0	0	0	0	1091
pyroxasulfone/flumioxazin	0.07	96	99	98	26	1296
pyroxasulfone/flumioxazin	0.14	100	100	100	78	472
indaziflam	0.01	99	100	100	60	533
indaziflam	0.03	100	100	100	93	26
pyroxasulfone/flumioxazinm fb[3]	0.07	100	100	98	41	1126
glufosinate + ethofumesate	0.18 + 1					
pyroxasulfone/flumioxazin fb	0.07	100	100	100	40	1209
glufosinate + oxyfluorfen	0.18 + 0.02					
indaziflam fb	0.01	100	100	100	63	516
glufosinate + ethofumesate	0.18 + 1.0					
indaziflam fb	0.01	99	100	100	75	451
glufosinate + oxyfluorfen	0.18 + 0.02					
diuron + pronamide fb	1.6 + 0.25	89	90	95	5	1244
ethofumesate	1.0					
LSD (P = 0.05)		4	4	3	24	228
CV		3	3	3	175	20

[1]DR = diuron resistant

[2] control and crop injury evaluated May 15, 2017

[3]fb = followed by

Crop tolerance and *Poa* species weed control with fall herbicides applied in established perennial ryegrass grown for seed. Daniel W. Curtis, Kyle C. Roerig, Andrew G. Hulting and Carol A. Mallory-Smith. (Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331) Major weed problems in grass seed production include competition from volunteer crop from previous harvests and *Poa* species, which are seed contamination threats to production. Fall and winter applications of pre and post emergence herbicides in a study conducted in an established perennial ryegrass grown for seed were made with the objectives of measuring potential differences in efficacy and clean seed yield. Plots were 8 x 35 ft arranged in a randomized complete block design with three replications. 'Silver Dollar' perennial ryegrass was carbon seeded in 12-inch rows on October 7, 2015. The planting then received an application of 1 lb ai/A of diuron on October 9, 2015. The plot area was swathed and harvested in July 2016. A forage chopper removed straw residue following the 2016 harvest. Treatments consisted of 18 herbicides or combinations of herbicides applied October 12, 2016 and an untreated check. Sequential treatments were applied on December 1, 2016. Environmental conditions and soil conditions are summarized in Table 1. Herbicide treatments were applied with a compressed air pressurized boom mounted on a unicycle frame calibrated to deliver 20 gpa at 20 psi. Final visual evaluations for crop injury to the perennial ryegrass and percent control of *Poa annua* and *Poa trivialis* were made on May 9, 2017 (Table 2). The perennial ryegrass was swathed on July 7, 2017, and seed threshed with a small plot combine on July 19, 2017. Seed was cleaned with a Clipper cleaner and yields quantified (Table 2).

Table 1. Application information and soil data, Hyslop Research Farm, Corvallis, OR

Application date	October 11, 2016		December 1, 2016
Crop growth stage	4 tillers		4-6 tillers
Poa anna growth stage	pre		1-2 leaf
Air temperature (F)	53		45
Relative Humidity (%)	75		100
Wind (mph, direction)	calm		calm
Cloud cover (%)	100		100
First rainfall (inches)	October 11, 0.01 inches		December 1, 0.01 inches
Soil temperature at 2 in (F)	48		42
Soil pH		5.7	
Soil OM (%)		2.83	
Soil CEC (meq/100g)		14.9	
Soil Texture		silty clay loam	

Clean seed yields from indaziflam and pyroxasulfone/flumioxazin treatments were comparable to yields from the flufenacet/metribuzin treatment, an industry standard. The addition of metribuzin did not affect yields when applied with indaziflam or pyroxasulfone/flumioxazin. Yields in sequential treatments with glufosinate, a registered treatment, are comparable to the yields from the untreated control. Pyroxasulfone/flumioxazin is in the IR-4 program for registration in grasses grown for seed. Bayer Crop Science is considering Indaziflam for registration in grasses grown for seed.

Table 2. Control of *Poa* species, crop injury and grass seed yield with fall herbicide treatments in established perennial ryegrass grown for seed, Corvallis, 2016-2017.

Treatment	Rate	*Poa annua*	*Poa trivialis*	Crop injury	Clean seed yield
	lb ai/A	% control[1]	% control	%	lb/A
Untreated check	0	0	0	0	818
Flufenacet/metribuzin	0.425	93	83	0	916
Indaziflam	0.02	100	100	5	983
Pyroxasulfone/flumioxazin	0.14	83	73	0	844
Flufenacet/metribuzin + metribuzin	0.425 + 0.28	83	83	0	944
Indaziflam + metribuzin	0.02 + 0.28	98	100	3	1036
Pyroxasulfone/flumioxazin + metribuzin	0.14 + 0.28	90	87	0	978
S-metolachlor + metribuzin	0.95 + 0.28	27	0	0	943
Dimethenamid-P + metribuzin	0.98 + 0.28	63	53	0	948
Oxyfluorfen + metribuzin	0.125 + 0.28	83	70	0	936
Flufenacet/metribuzin + metribuzin fb[2]	0.143 + 0.07	97	83	2	944
glufosinate + ethofumesate	0.3 + 1				
Indaziflam/metribuzin fb	0.02 + 0.28	97	100	7	1017
glufosinate + ethofumesate	0.3 + 1				
Pyroxasulfone/flumioxazin + metribuzin fb	0.14 + 0.28	93	80	0	932
glufosinate + ethofumesate	0.3 + 1				
Flufenacet/metribuzin + metribuzin fb	0.425 + 0.28	100	100	5	1010
glufosinate + indaziflam	0.3 + 1				
Flufenacet/metribuzin + metribuzin fb	0.425 + 0.28	100	100	2	941
glufosinate + pyroxasulfone/flumioxazin	0.3 + 0.14				
indaziflam + metribuzin fb	0.02 + 0.28	100	100	8	900
glufosinate + pyroxasulfone/flumioxazin	0.3 + 0.14				
pyroxasulfone/flumioxazin + metribuzin fb	0.14 + 0.28	100	100	7	979
glufosinate + indaziflam	0.3 + 0.02				
s-metolachlor + metribuzin fb	0.95 + 0.28	97	93	3	858
glufosinate + pyroxasulfone/flumioxazin	0.3 + 0.14				
dimethenamid-P + metribuzin fb	0.98 + 0.28	90	100	0	964
glufosinate + pyroxasulfone/flumioxazin	0.3 + 0.14				
LSD (P = 0.05)		32	28	4	NS
CV		23	22	118	8

[1] % control and crop injury evaluated May 9, 2017.

[2] Abbreviations: fb, (followed by). Applications made October 12, 2106 and December 1, 2016.

Efficacy of single and sequential herbicides in irrigated acetolactase synthase (ALS)-resistant grain sorghum. R. S. Currie and P. W. Geier. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846) An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City to evaluate weed control and crop response with acetolactase-synthase (ALS) inhibiting herbicides in irrigated ALS-resistant grain sorghum. Herbicides were applied preemergence (PRE), early postemergence (EPOST), or PRE followed by postemergence (POST). The experimental area was overseeded with crabgrass and Rox orange (to simulate shattercane) to supplement naturally occurring weed pressure prior to planting sorghum. Application, environmental, and weed information is shown in Table 1. A tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi was used to apply all herbicides. Plot size was 10 by 35 feet, arranged in a randomized complete block design with four replicates. Soil was a Beeler silt loam with 2.4% organic matter and pH of 7.6. Visual weed control was determined on July 17 and August 30, 2017, which was 6 and 50 days after the POST treatment (DA-C), respectively. Grain yields were determined on November 1, 2017 by mechanically harvesting the center two rows of each plot and adjusting weights to 14% moisture.

Table 1. Application information.

Application timing	Preemergence	Early postemergence	Postemergence
Application date	June 14, 2017	July 7, 2017	July 11, 2017
Air temperature (F)	68	74	75
Relative humidity (%)	41	51	49
Soil temperature (F)	72	71	71
Wind speed (mph)	5	4	4
Wind direction	North-northwest	East	South
Soil moisture	Good	Good	Excellent
Palmer amaranth			
Height (inch)	---	2	4
Density (plants/m^2)	0	35	35
Crabgrass			
Height (inch)	---	1	2
Density (plants/m^2)	0	25	15
Shattercane			
Height (inch	---	3	3
Density (plants/m^2)	0	5	5

Palmer amaranth control at 50 DA-C was best when *S*-metolachlor was applied PRE followed by nicosulfuron plus atrazine POST or when the premix of *S*-metolachlor and atrazine was applied EPOST with nicosulfuron and atrazine (Table 2). Most herbicides provided 95 to 100% crabgrass control at 6 DA-C, and control was complete regardless of herbicide by 50 DA-C. Shattercane control at 50 DA-C was 95% or more with all herbicides except the premix of atrazine plus *S*-metolachlor applied PRE (50%). Minor sorghum stunting and chlorosis (11 to 15%) was observed when atrazine/*S*-metolachlor was applied EPOST with nicosulfuron and atrazine at three days after application, but sorghum had completely recovered within seven days (data not shown). No other visible sorghum injury was observed. Herbicide-treated grain sorghum yielded 48 to 93 bu/A more grain than non-treated sorghum. Sorghum yields were best (96 to 105 bu/A) when *S*-metolachlor alone or with atrazine was applied PRE followed by nicosulfuron and atrazine POST, or when the premix of atrazine and *S*-metolachlor was applied with nicosulfuron and atrazine EPOST.

Table 2. Efficacy of single and sequential herbicides in acetolactase synthase-resistant grain sorghum.

Treatment[a]	Rate	Timing[b]	Palmer amaranth		Crabgrass		Shattercane		Sorghum
			6 DA-C[a]	50 DA-C	6 DA-C	50 DA-C	6 DA-C	50 DA-C	Yield
			% Visual		% Visual		% Visual		bu/A
Untreated	---		0	0	0	0	0	0	11.8
Atrazine/ *S*-metolachlor	3.2 pt	PRE	93	85	95	100	60	50	80.8
Rimsulfuron	0.25 oz	PRE	98	55	73	100	85	95	66.1
Thifensulfuron	0.125 oz	PRE							
Atrazine	24 oz	PRE							
Nicosulfuron	0.67 oz	POST							
Atrazine	24 oz	POST							
COC	2%	POST							
AMS	2 lb	POST							
S-metolachlor	1.3 pt	PRE	73	58	100	100	100	100	60.0
Rimsulfuron	0.25 oz	PRE							
Thifensulfuron	0.125 oz	PRE							
Nicosulfuron	0.67 oz	POST							
COC	2%	POST							
AMS	2 lb	POST							
Atrazine/ *S*-metolachlor	2.0 pt	PRE	78	86	95	100	85	100	97.2
Nicosulfuron	0.67 oz	POST							
Atrazine	24 oz	POST							
COC	2%	POST							
AMS	2 lb	POST							
S-metolachlor	1.0 pt	PRE	75	88	100	100	73	100	105.2
Nicosulfuron	0.67 oz	POST							
Atrazine	24 oz	POST							
COC	2%	POST							
AMS	2 lb	POST							
Atrazine/ *S*-metolachlor	3.2 pt	EPOST	98	100	99	100	98	100	96.4
Nicosulfuron	0.67 oz	EPOST							
Atrazine	24 oz	EPOST							
COC	2%	EPOST							
AMS	2 lb	EPOST							
LSD (0.05)			7	12	9	NS	10	12	22.2

[a] AMS is ammonium sulfate, COC is crop oil concentrate.

[b] PRE = preemergence, EPOST = early postemergence, POST = postemergence.

[c] DA-C is days after postemergence application.

Novel preplant herbicides for efficacy and crop tolerance in grain sorghum. R. S. Currie, P. W. Geier, and W. Keeling. (Kansas State University Southwest Research-Extension Center, 4500 E. Mary Street, Garden City, KS 67846 and Texas Agrilife Research Center, 1102 E. FM 1294, Lubbock, TX 79403) An experiment was conducted at the Kansas State University Southwest Research-Extension Center near Garden City, KS and at the Texas Agrilife Research Center near Lubbock, TX to evaluate preplant, non-labelled herbicides for residual weed control and crop tolerance in grain sorghum. Herbicides were applied using a tractor-mounted, compressed-CO_2 sprayer delivering 20 gpa at 30 psi at Garden City and a backpack sprayer delivering 10 gpa at 32 psi at Lubbock. Application, environmental, crop, and weed information is shown in Table 1. Plot size was 10 by 35 feet at Garden City and 10 by 25 feet at Lubbock. Plots were arranged in randomized complete blocks replicated four times at both locations. Soil for the experiments was a Beeler silt loam with pH 7.6 and 2.4% organic matter at Garden City and an Acuff loam with 0.8% organic matter and pH 7.8 at Lubbock. Weed control was visually rated on August 4 and August 18, 2017 at Lubbock and Garden City and these dates were 66 and 67 days after planting (DAP), respectively. Visual sorghum injury was determined on June 13 and July 11, 2017 at Lubbock (14 and 42 DAP), and on June 29 and August 18, 2017 at Garden City (17 and 67 DAP). Sorghum yields were determined on October 19 and November 1, 2017 at Lubbock and Garden City, respectively.

Table 1. Application information.

Application timing	Garden City, KS	Lubbock, TX
Application date	May 29, 2017	May 19, 2017
Sorghum planting date	June 12, 2017	May 30, 2017
Air temperature (F)	53	78
Relative humidity (%)	66	50
Soil temperature (F)	57	76
Wind speed (mph)	2	8
Wind direction	North	Southwest
Soil moisture	Fair	Good

Palmer amaranth control at Garden City was 90% or more when *S*-metolachlor/atrazine/mesotrione/bicyclopyrone at 2.0 or 2.5 qt/A and *S*-metolachlor/atrazine/mesotrione at 2.7 qt/A (Table 2). At Lubbock, Palmer amaranth control exceeded 96% with all herbicides except acetochlor/flumetsulam/clopyralid at 1.5 qt/A and flumioxazin at 1.0 oz/A. Acetochlor/flumetsulam/clopyralid at 1.5 qt/A and flumioxazin at 1.0 oz/A controlled kochia less than 90% at Garden City, and these herbicides along with the 2 oz/A rate of flumioxazin provided less than 90% Russian thistle control at Garden City. No visible sorghum injury was observed at Garden City, and sorghum yields did not differ between herbicide-treated and nontreated sorghum. Very dry conditions during the experiment at Garden City likely minimized sorghum injury and limited sorghum yields. At Lubbock, minor sorghum injury was observed early with *S*-metolachlor/atrazine/mesotrione/bicyclopyrone at either rate or flumioxazin at 2 oz/A. By 42 DAP, only acetochlor/flumetsulam/clopyralid showed sorghum injury at Lubbock. The injury with this treatment at Lubbock was also evident in sorghum yields. Sorghum receiving acetochlor/flumioxazin/clopyralid yielded 36 bu/A less grain than the highest yielded treatment of *S*-metolachlor/atrazine. However, all herbicide-treated sorghum at Lubbock yielded 28 to 65 bu/A more grain than nontreated sorghum.

Table 2. Preplant herbicides in grain sorghum.

Treatment	Rate	Palmer amaranth Garden City 67 DAP[a]	Palmer amaranth Lubbock 66 DAP	Kochia Garden City 67 DAP	Russian thistle Garden City 67 DAP	Sorghum injury Lubbock 14 DAP	Sorghum injury Lubbock 42 DAP	Sorghum Yield Garden City	Sorghum Yield Lubbock
	per A	% Visual		% Visual		% Visual		bu/A	
Untreated	---	---	---	---	---	0	0	14.8	16.3
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.0 qt	90	97	99	98	5	0	23.7	72.0
S-metolachlor/ Atrazine/ Mesotrione/ Bicyclopyrone	2.5 qt	96	97	98	100	5	0	23.7	62.2
S-metolachlor/ Atrazine/ Mesotrione	2.7 qt	90	100	100	93	0	0	21.1	71.5
Acetochlor/ Flumetsulam/ Clopyralid	1.5 qt	78	92	75	73	0	33	22.3	44.7
Flumioxazin	1.0 oz	79	59	85	70	0	0	17.3	59.0
Flumioxazin	2.0 oz	80	97	90	73	8	0	18.9	80.5
S-metolachlor/ Atrazine	1.5 qt	80	97	98	94	0	0	21.1	80.9
Acetochlor/ Atrazine	2.25 qt	83	99	94	95	0	0	19.9	74.2
LSD (0.05)		11	7	13	12	2	2	NS	15.6

[a] DAP is days after planting.

Broadleaf weed control in wheat with halauxifen/florasulam. Traci A. Rauch and Joan M. Campbell. (Crop and Weed Science Division, University of Idaho, Moscow, ID 83844-2333) Two studies were established to evaluate broadleaf weed control and crop response with halauxifen/florasulam combined with pyroxsulam in winter wheat near Culdesac and in spring wheat near Moscow, Idaho. These studies were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). At Culdesac, the study was oversprayed with propiconazole/azoxystrobin at 0.24 lb ai/A to control stripe rust and pinoxaden at 0.54 lb ai/A to control grass weeds on May 2, 2017. The study was resprayed with fluxapyroxad/pyraclostrobin at 0.10 lb ai/A and propiconazole at 0.11 lb ai/ for stripe rust control on June 5 by the grower. At Moscow, the study was oversprayed with pinoxaden at 0.54 lb ai/A to control grass weeds and azoxystrobin/propiconazole at 0.24 lb ai/A for stripe rust control on June 17, 2017. Crop response and weed control were evaluated visually during the growing season.

Table 1. Application and soil data.

Location	Culdesac	Moscow
Application date	4/21/17	6/2/17
Winter variety	Magic	WB 6121
Growth stage		
Spring wheat		4 leaf
Winter wheat	4 tiller	--
Catchweed bedstraw	4 node	--
Common lambsquarters	--	4 to 6 leaf
Air temperature (F)	63	67
Relative humidity (%)	61	58
Wind (mph), direction	3, W	4, W
Next moisture occurred	4/26/17	6/4/17
Cloud cover (%)	50	30
Soil moisture	wet	adequate
Soil temperature at 2 inch (F)	60	66
pH	5.0	4.9
OM (%)	5.1	3.9
CEC (meq/100g)	21.9	16.7
Texture	silt loam	silt loam

At Culdesac, all treatments injured winter wheat 0 to 12% but did not differ among treatments at 32 DAT (Table 2). All treatments controlled catchweed bedstraw 84 to 98% at 18 DAT. By 32 DAT, halauxifen/florasulam treatments and pyroxsulam/clopyralid/fluroxypyr controlled catchweed bedstraw 94 to 99%.

At Moscow, halauxifen/florasulam plus pyroxsulam/clopyralid/fluroxypyr injured spring wheat 5% (Table 3). By 12 DAT, spring wheat was not injured visually by any treatment (data not shown). All treatments, except halauxifen/florasulam alone, controlled common lambsquarters 80% or better at 12 DAT. By 46 DAT, all treatments controlled common lambsquarters 95 to 99%.

Table 2. Catchweed bedstraw control in winter wheat with halauxifen/florasulam near Culdesac, ID in 2017.

Treatment[1]	Rate	Wheat injury[2]	Catchweed bedstraw control	
			18 DAT	32 DAT
	lb ai/A	%	%	%
Halauxifen/florasulam +	0.0096			
pyroxsulam	0.0163	12	92	96
Halauxifen/florasulam +	0.0096			
pyroxsulam +	0.0163			
clopyralid/fluroxypyr	0.188	0	97	99
Halauxifen/florasulam +	0.0096			
pyroxsulam +	0.0163			
2,4-D ester	0.344	1	95	94
Halauxifen/florasulam +	0.0096			
pyroxsulam +	0.0163			
bicyclopyrone/bromoxynil	0.19	6	98	98
Pyroxsulam +	0.0163			
pyrasulfotole/bromoxynil	0.217	5	84	90
Mesosulfuron +	0.0134			
clopyralid/fluroxypyr	0.188	11	95	90
Pyroxsulam/clopyralid/fluroxypyr	0.252	9	96	98
LSD (0.05)		NS	NS	5
Density (plants/ft^2)			15	

[1]All treatments were applied with and ammonium sulfate at 1.52 lb ai/A, except the bicyclopyrone/bromoxynil treatment, and nonionic surfactant at 0.5% v/v. Sodium bicarbonate was applied at 0.058 lb ai/A with bicyclopyrone/bromoxynil.
[2]Evaluation 32 DAT.

Table 3. Common lambsquarters control in spring wheat with halauxifen/florasulam near Moscow, ID in 2017.

Treatment[1]	Rate	Wheat injury[2]	Common lambsquarters control	
			12 DAT	46 DAT
	lb ai/A	%	%	%
Halauxifen/florasulam	0.0096	0	66	95
Halauxifen/florasulam +	0.0096			
clopyralid/fluroxypyr	0.188	1	85	99
Halauxifen/florasulam +	0.0096			
clopyralid/fluroxypyr	0.25	1	94	99
Halauxifen/florasulam +	0.0096			
2,4-D ester	0.0163	1	92	98
Halauxifen/florasulam +	0.0096			
MCPA ester	0.0163	0	86	99
Halauxifen/florasulam +	0.0096			
clopyralid/MCPA	0.69	0	94	99
Halauxifen/florasulam +	0.0096			
pyroxsulam/clopyralid/fluroxypyr	0.201	5	80	99
Halauxifen/florasulam +	0.0096			
pyrasulfotole/bromoxynil	0.217	1	99	99
Halauxifen/florasulam +	0.0096			
MCPA/bromoxynil	0.5	2	99	99
LSD (0.05)		2	11	NS
Density (plants/ft^2)			20	

[1]All treatments were applied with ammonium sulfate at 1.52 lb ai/A and nonionic surfactant at 0.25% v/v.
[2]Evaluation 6 DAT.

Rattail fescue and downy brome control in winter wheat. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2339) A study was established to evaluate rattail fescue and downy brome control with pyroxasulfone containing herbicides alone or in combination in 'WB 1529' winter wheat at University of Idaho Parker Plant Science Farm near Moscow, ID. The plots were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). The site was oversprayed with pyrasulfotole/bromoxynil at 0.19 lb ai/A and thifensulfuron/tribenuron at 0.031 lb ai/A for broadleaf weed control and with fluxapyroxad/pyraclostrobin at 0.13 lb ai/A for stripe rust control on May 2, 2017. Crop injury and grass weed control were evaluated visually during the growing season. Grain was harvested with a small plot combine on August 9, 2017.

Table 1. Application and soil data.

Winter wheat seeding date	10/19/16	
Application date	10/23/16	4/29/17
Growth stage		
Winter wheat	1/16th inch root/ no shoot	2 tiller
Rattail fescue	pre	4 tiller
Downy brome	pre	3 tiller
Air temperature (F)	56	56
Relative humidity (%)	88	72
Wind (mph, direction)	0	3, W
Cloud cover (%)	100	100
Next rain occurred	10/27/16	5/6/17
Soil moisture	wet	wet
Soil temperature at 2 inch (F)	53	58
pH	4.6	
OM (%)	3.5	
CEC (meq/100g)	14.2	
Texture	silt loam	

All treatments containing flufenacet/metribuzin visibly injured winter wheat 16 to 39% on June 5, 2017 (Table 2). Rattail fescue was controlled 94 to 99% by all treatments containing flufenacet/metribuzin or pyroxasulfone. Flucarbazone, pyroxsulam, or sulfosulfuron applied alone postemergence did not controlled rattail fescue (60 to 66%). In the past, flucarbazone has suppressed rattail fescue averaging 76% control over 9 observations, but it performed poorly in 2017 most likely due to poor crop competition from nonuniform wheat stand. Pyroxasulfone/fluthiacet and all fall/spring sequential combinations, except flufenacet/metribuzin followed by sulfosulfuron, controlled downy brome 91% or better. Flufenacet/metribuzin, flucarbazone or sulfosulfuron alone did not control downy brome (45 to 70%). Grain yield was lower in the untreated check compared to all other treatments except sulfosulfuron alone and mostly likely confounded by nonuniform gravelly soil. Winter wheat test weight was lower in the untreated check and plots treated with pyroxasulfone/fluthiacet plus pyroxsulam compared to all other herbicide treated plots.

Table 2. Rattail fescue and downy brome control and winter wheat response with pyroxasulfone combinations in 2017.

Treatment[1]	Rate	Application timing[2]	Weed control		Winter wheat		
			Rattail fescue[3]	Downy brome[3]	Injury[3]	Yield	Test weight
	lb ai/A		%	%	%	bu/A	lb/bu
Flufenacet/metribuzin	0.425	pre	99	70	39	53	62.3
Pyroxasulfone	0.08	pre	99	81	0	63	61.9
Pyroxasulfone/fluthiacet	0.091	pre	94	95	2	68	61.5
Flucarbazone	0.027	2 tiller	66	45	4	54	61.1
Pyroxsulam	0.016	2 tiller	64	76	0	58	61.4
Sulfosulfuron	0.031	2 tiller	60	48	5	51	61.0
Flufenacet/metribuzin +	0.34	pre					
flucarbazone	0.027	2 tiller	94	91	19	58	62.5
Flufenacet/metribuzin +	0.34	pre					
pyroxsulam	0.016	2 tiller	99	95	16	56	62.2
Flufenacet/metribuzin +	0.34	pre					
sulfosulfuron	0.031	2 tiller	99	85	20	55	61.3
Pyroxasulfone +	0.08	pre					
flucarbazone	0.027	2 tiller	99	93	2	58	61.3
Pyroxasulfone +	0.08	pre					
pyroxsulam	0.016	2 tiller	99	99	0	64	61.6
Pyroxasulfone +	0.08	pre					
sulfosulfuron	0.031	2 tiller	99	93	0	59	61.2
Pyroxasulfone/fluthiacet +	0.091	pre					
flucarbazone	0.027	2 tiller	99	94	6	58	61.1
Pyroxasulfone/fluthiacet +	0.091	pre					
pyroxsulam	0.016	2 tiller	99	98	0	59	61.0
Pyroxasulfone/fluthiacet +	0.091	pre					
sulfosulfuron	0.031	2 tiller	99	98	0	61	61.7
Untreated check	--	--	-	--	--	44	60.0
LSD (0.05)			14	27	10	8	0.9
Density (plants/ft^2)			10	5			

[1]All postemergence treatments were applied with a non-ionic surfactant at 0.25% v/v and ammonium sulfate at 1 lb ai/A.
[2]Application timing based on winter wheat growth stage.
[3]Evaluation date June 5, 2017.

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Broadleaf weed control in winter wheat with bicyclopyrone/bromoxynil. Traci A. Rauch and Joan M. Campbell. (Crop and Weed Science Division, University of Idaho, Moscow, ID 83844-2333) Two studies were established in winter wheat to evaluate broadleaf weed control and crop response with bicyclopyrone/bromoxynil alone near Culdesac and bicyclopyrone/bromoxynil plus other herbicides near Moscow, Idaho. These studies were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). At Culdesac, the study was oversprayed with propiconazole/azoxystrobin at 0.24 lb ai/A to control stripe rust and pinoxaden at 0.54 lb ai/A to control grass weeds on May 2, 2017. The study was resprayed with fluxapyroxad/pyraclostrobin at 0.10 lb ai/A and propiconazole at 0.11 lb ai/ for stripe rust control on June 5. At Moscow, the study was oversprayed with pinoxaden at 0.54 lb ai/A to control grass weeds and fluxapyroxad/pyraclostrobin at 0.13 lb ai/A for stripe rust control. The study was resprayed on June 2 with propiconazole/azoxystrobin at 0.21 lb ai/A to control stripe rust. Wheat response and weed control were evaluated visually during the growing season. Grain from both studies was harvested with a small plot combine on August 8.

Table 1. Application and soil data.

Location	Culdesac	Moscow
Application date	4/21/17	5/11/17
Winter wheat variety	Magic	WB 1529
Growth stage		
Winter wheat	4 tiller	3 tiller
Catchweed bedstraw (GALAP)	4 whorl	--
Mayweed chamomile (ANTCO)	--	3 inch diameter
Air temperature (F)	60	69
Relative humidity (%)	63	64
Wind (mph), direction	3, NW	3, E
Next moisture occurred	4/26/17	5/12/17
Dew present?	yes	yes
Cloud cover (%)	50	80
Soil moisture	wet	wet
Soil temperature at 2 inch (F)	60	58
pH	5.0	4.7
OM (%)	5.1	2.8
CEC (meq/100g)	21.9	16.3
Texture	silt loam	silt loam

At Culdesac, no treatment visually injured winter wheat (data not shown). At 18 DAT, pyrasulfotole/bromoxynil and thifensulfuron/tribenuron plus MCPA ester did not control catchweed bedstraw (60 and 20%) (Table 2). Catchweed bedstraw control was best with fluroxypyr treatments (86 to 91%) but did not differ from bicyclopyrone/bromoxynil plots (76 to 80%). AT 32 DAT, only fluroxypyr treatments controlled catchweed bedstraw (90 and 91%). Grain yield did not differ for all treatments including the untreated check. Grain test weight was lowest in the untreated check.

At Moscow, only bicyclopyrone/bromoxynil plus mesosulfuron combined with a basic blend injured winter wheat 6% (Table 3). The addition of the basic blend most likely caused the injury and is not recommended with mesosulfuron in the Pacific Northwest. Mayweed chamomile control tended be greater with fluroxypyr/clopyralid but did not differ from any treatments. Grain yield and test weight did not differ from the untreated check for all treatments.

Table 2. Catchweed bedstraw control and wheat response with bicyclopyrone/bromoxynil near Culdesac, ID in 2017.

Treatment[1]	Rate	GALAP control[2]		Wheat	
		18 DAT	32 DAT	Yield	Test weight
	lb ai/A	%	%	bu/A	lb/bu
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
COC	1% v/v	76	71	131	65.3
Bicyclopyrone/bromoxynil +	0.225				
sodium bicarbonate +	0.067				
COC	1% v/v	76	71	132	65.4
Bicyclopyrone/bromoxynil +	0.256				
sodium bicarbonate +	0.076				
COC	1% v/v	80	75	132	65.2
Pyrasulfotole/bromoxynil +	0.177				
NIS	0.25% v/v	62	61	131	65.1
Fluroxypyr/clopyralid	0.188	90	91	123	65.6
Fluroxypyr/clopyralid +	0.188				
thifensulfuron/tribenuron	0.0188	90	90	127	65.8
Thifensulfuron/tribenuron +	0.0188				
MCPA ester	0.347	20	0	124	65.0
Fluroxypyr/florasulam	0.092	86	90	129	65.3
Untreated check	--	--	--	122	64.5
LSD (0.05)		16	14	NS	0.4
Density (plants/ft^2)		22			

[1]Sodium bicarbonate was used as a buffer. COC is a crop oil concentrate. NIS is nonionic surfactant.
[2]GALAP = catchweed bedstraw.

Table 3. Mayweed chamomile control and wheat response with bicyclopyrone/bromoxynil combined with other herbicides near Moscow, ID in 2017.

Treatment[1]	Rate	Wheat injury	ANTCO control	Wheat Yield	Wheat Test weight
	lb ai/A	%	%	bu/A	lb/bu
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
COC	1% v/v	0	75	116	58.4
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
florasulam/MCPA +	0.355				
pinoxaden	0.054	0	84	108	57.7
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
prosulfuron +	0.0143				
pinoxaden	0.054	0	81	112	58.6
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
pinoxaden/florasulam	0.147	0	71	106	57.1
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
flucarbazone +	0.027				
NIS	0.25% v/v	0	60	111	58.2
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
mesosulfuron +	0.034				
basic blend	1% v/v	6	79	107	57.6
Bicyclopyrone/bromoxynil +	0.193				
sodium bicarbonate +	0.058				
pyroxsulam +	0.0163				
NIS	0.25% v/v	0	75	117	58.1
Fluroxypyr/clopyralid	0.188	0	92	115	58.2
Untreated check	--	--	--	111	58.6
LSD (0.05)		1	NS	6	NS
Density (plants/ft^2)			10		

[1]Sodium bicarbonate was used as a buffer. COC is a crop oil concentrate. NIS is nonionic surfactant. Basic blend is nonionic surfactant, pH buffer, and ammonium salt.

[2]ANTCO = mayweed chamomile.

Evaluation of flufenacet plus metribuzin and mesosulfuron plus thiencarbazone for the control of 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 at the Cook Agronomy Farm near Pullman, WA to evaluate the control of Italian ryegrass (LOLMU) in winter wheat with flufenacet plus metribuzin and mesosulfuron plus thiencarbazone. On September 29, 2016, 'Puma' winter wheat was seeded at 90 lb seed per acre with a John Deere 9400 hoe drill on a seven-inch row spacing. Plots were 10 ft by 33 ft and arranged in a randomized complete block design with four replications. On October 4, 2016, delayed preemergence herbicides were applied using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 45 psi (Table 1). On April 11, 2017, postemergence herbicides were applied using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 44 psi (Table 1). A visual ratings of LOLMU control was assessed on June 14th when LOLMU seedheads were clearly visible above the crop canopy. Wheat seed was harvested with a small plot combine on August 7th.

Table 1. Application and soil data.

Location	Cook Agronomy Farm Pullman, Washington	
Application date	October 4, 2016	April 11, 2017
Application type	delayed preemergence	postemergence
Wheat growth stage	coleoptile emerged	3-tillers
Wheat height	--	7 inches
Italian ryegrass growth stage	--	fully tillered
Italian ryegrass height	--	2 inches
Air temperature (F)	52	56
Relative humidity (%)	64	38
Wind (mph, direction)	2, east	7, east
Cloud cover (%)	100	100
Soil temperature at 6 in (F)	54	48
pH	5.2	
OM (%)	3.9	
Texture	silt loam	

October was an extremely wet month with 22 days receiving rainfall and totaling 4.78 inches. Initial counts of LOLMU plants in the nontreated check occurred on October 12th. A significant portion of LOLMU germinated in the fall and survived the winter due to prolonged snow cover. In the spring, it was difficult to get back into the field from all the fall precipitation, snow melt and continued rains in late winter/early spring. On April 11th, when the postemergence application was made, wheat was at three tillers and seven to eight inches tall and the LOLMU was fully tillered at a height of two to three inches. The density of LOLMU in the nontreated checks was so high that it seemed unlikely that additional plants were going to emerge in the spring. Treatments that included a delayed preemergence application of carfentrazone/pyroxasulfone or pyroxasulfone provided good to excellent control of LOLMU. Treatments that included a delayed preemergence application of flufenacet/metribuzin provided fair control of LOLMU. The addition of a spring application of either mesosulfuron/thiencarbazone or pyroxsulam added to fall-applied treatments did not improve LOLMU control when compared to the fall applications alone. Spring applications of either mesosulfuron/thiencarbazone or pyroxsulam alone did not provide commercially acceptable control of LOLMU. The lack of efficacy from the spring applications might be partially explained by the lack of a spring germinating cohort of LOLMU. The fall germinating cohort of LOLMU may have been too large for effective control with spring herbicide applications. Another possible explanation is that the LOLMU population in this field may have been resistant to Group 2 herbicides. Fall herbicide applications led to the best LOLMU control, which in turn led to the highest yields, when compared to spring applied mesosulfuron/thiencarbazone, pyroxsulam or the nontreated check treatments. Test weight was not influenced by any treatments and the mean was 57.5 lb/bu.

Table 2. Italian ryegrass control in 'Puma' winter wheat with herbicides near Pullman, Washington in 2017.

Treatment	Rate	Application Date	LOLMU control 6/14	Yield 8/16
	lb ai/A		0-100%	bu/a
Nontreated check	--	--	--	58
flufenacet/metribuzin	0.425	10/4/16	77	92
pyroxasulfone	0.08	10/4/16	89	111
carfentrazone/pyroxasulfone	0.109	10/4/16	92	103
flufenacet/metribuzin fb mesosulfuron/thiencarbazone[1]	0.425 fb 0.018	10/4/16 fb 4/11/17	79	99
pyroxasulfone fb mesosulfuron/thiencarbazone[1]	0.08 fb 0.018	10/4/16 fb 4/11/17	91	107
carfentrazone/pyroxasulfone fb mesosulfuron/thiencarbazone[1]	0.109 fb 0.018	10/4/16 fb 4/11/17	95	116
mesosulfuron/thiencarbazone[1]	0.018	4/11/17	15	66
flufenacet/metribuzin fb pyroxsulam[1]	0.425 fb 0.016	10/4/16 fb 4/11/17	80	107
pyroxasulfone fb pyroxsulam[1]	0.08 fb 0.016	10/4/16 fb 4/11/17	94	120
carfentrazone/pyroxasulfone fb pyroxsulam[1]	0.109 fb 0.016	10/4/16 fb 4/11/17	95	116
pyroxsulam[1]	0. 016	4/11/17	24	76
LSD (0.05)			8	18

[1]Treatment was applied with urea ammonium nitrate at 2 qt/a and a 90% nonionic surfactant (R-11) at 0.5% v/v.

Rush skeletonweed control in winter wheat. Mark E. Thorne[1], John F. Spring[2], Henry C. Wetzel[1], Ian C. Burke[1], and Drew J. Lyon[1]. ([1]Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420; [2]Colorado State University Extension, Julesburg CO, 80737) Rush skeletonweed (*Chondrilla juncea* L.) is a deep-rooted perennial plant that has persisted on farmland across eastern Washington since the land was taken out of the Conservation Reserve Program (CRP) and put back into winter wheat production. Wheat yield is reduced where dense stands of rush skeletonweed deplete seed zone moisture during the fallow phase of the winter wheat/fallow rotation resulting in failed emergence of fall-seeded winter wheat. During the crop phase, rush skeletonweed flourishes and proliferates in areas where the wheat stand is thin or absent. Herbicide control in the crop phase is one part of an overall strategy to reduce or eradicate skeletonweed from these production areas.

We repeated an herbicide trial initially conducted in 2015-16 on land near LaCrosse, WA evaluating five different synthetic auxin herbicides for control of rush skeletonweed in winter wheat. Herbicides were applied on October 29, 2016 when the wheat was tillering, and on April 5, 2017 when the wheat was well tillered with nodes present 1 inch above the crown (Table 1). The land had been in CRP until October 2013 and the first post-CRP crop was harvested in 2014. In 2016, the field was in summer fallow and was seeded to 'ORCF-102' winter wheat at 60 lb/A on September 2 with a John Deere HZ616® grain drill. The field had been fertilized prior to seeding with 85 lb nitrogen, 10 lb phosphorus, 10 lb sulfur, and 10 lb chloride per acre. At both treatment dates, herbicides were applied with a CO_2 pressurized backpack sprayer and 10-foot spray boom delivering 15 gpa spray volume. Boom pressure was 25 psi and ground speed was 3 mph. For maintenance of the plot area, a blanket treatment of 0.018 lb ai/A of thifensulfuron/tribenuron was applied on April 11, 2017 to control a dense population of tumble mustard. On May 8, 2017, the plot area was sprayed with 0.11 lb ai/A of propiconazole fungicide to control stripe rust. Experimental design was a randomized complete block with four replicated blocks and a factorial arrangement of herbicides and timing. Plot dimension was 10 by 30 feet.

Table 1. Application and soil data.

Location	LaCrosse, WA	
Application date	October 29, 2016	April 5, 2017
Wheat growth stage	3 to 7 tillers	2 to 19 tillers, nodes present
Rush skeletonweed stage	rosette	rosette
Rush skeletonweed size	1 to 9 inch diameter	2 to 8 inch diameter
Air temperature (F)	59	68
Relative humidity (%)	55	40
Wind (mph, direction)	0 to 4, NE	0 to 3, E
Cloud cover (%)	50	100
Soil temperature at 0 to 6 in (F)	48	52
pH	5.5	
OM (%)	2.09	
Texture	silt loam	

Rush skeletonweed density was somewhat variable across the plot site where dense patches coincided with thin wheat stands. For consistency with the 2015-16 trial, two one-meter quadrats per plot were flagged on October 19, 2016 and all rush skeletonweed plants in each quadrat were counted to establish baseline initial densities in which to monitor until harvest. Rush skeletonweed densities were recounted in all quadrats on April 4, just prior to the spring herbicide applications, on April 20, two weeks following spring applications, June 12, when the wheat was in the soft-dough stage and again on July 19, prior to crop harvest. Additionally, herbicide control was evaluated visually on a whole-plot basis as percent of the non-treated check plots. Visual ratings on April 4, 2016 evaluated fall-applied herbicides and were prior to the spring-applied treatments. April 20 ratings evaluated control two weeks following spring applications as well as a second evaluation of the fall applications. Follow-up ratings were also made on June 12 and July 19. The plots were harvested on July 26 with a Kincaid® plot combine and grain samples were bagged from each plot and sub-sampled for grain moisture and test weight. In about 50% of the plots, blank or thin patches of wheat existed where fall emergence was poor. Visual estimations of the percent area affected in each plot were made prior to harvest (data not shown) and were used to standardize wheat yield to reduce variability from the initial stand density. Standardized wheat yields were converted to bu/A and reported on a 12% moisture basis.

Rush skeletonweed densities prior to fall applications were similar across plots and averaged between 7 to 13 plants/m^2 (Table 2). By the April 4 census, fall-applied aminopyralid and clopyralid had reduced rush skeletonweed density to less than 1 plant/m^2, but no reduction was seen with the other herbicides tested. At this census, the spring treatments had not yet been applied. At the June 12 census, fall-applied clopyralid was most effective in controlling rush skeletonweed with only 0.4 plants/m^2 remaining. Spring-applied clopyralid and aminopyralid were equally effective with densities of 1.3 and 1.4 plants/m^2. Results were mixed for aminocyclopyrachlor, dicamba, and 2,4-D ester. Fall-applied aminocyclopyrachlor resulted in 2.8 plants/m^2 and was not different from aminopyralid; however, spring-applied aminocyclopyrachlor was less effective than aminopyralid and not different than the non-treated check (Table 2). Dicamba, and 2,4-D ester were the least effective fall-applied treatments, but spring-applied dicamba was better than the non-treated check. By the July 19 pre-harvest census, no differences in density was found between any of the treatments. By harvest, the dense wheat canopy was up to 52 inches tall and had shaded out many of the rush skeletonweed plants (Table 2). This reduced the number of plants in denser colonized plots, including the non-treated checks, and diminished differences between all treatments.

Table 2. Rush skeletonweed density in winter wheat in response to herbicide applications.

Treatments[1]	Rate	Rush skeletonweed census dates[2] 19 Oct	4 Apr	12 Jun	19 Jul
	(lb ae/A)	--------------------------------(plants/m^2)------------------------------			
Fall-applied herbicides					
non-treated	-	9.1 a	14.2 a	12.2 a	1.6 a
aminopyralid	0.0093	11.3 a	0.8 b	2.4 d	1.3 a
clopyralid	0.1875	7.4 a	0.6 b	0.4 e	0.3 a
aminocyclopyrachlor	0.013	9.4 a	9.4 a	2.8 cd	0.7 a
dicamba	0.125	7.6 a	8.3 a	5.5 bc	2.1 a
2,4-D ester	0.375	11.1 a	12.2 a	6.0 b	1.3 a
Spring-applied herbicides					
non-treated	-	12.8 a	15.5 a	17.3 a	2.5 a
aminopyralid	0.0093	9.0 a	12.7 a	1.4 c	0.5 a
clopyralid	0.1875	9.5 a	12.5 a	1.3 c	0.8 a
aminocyclopyrachlor	0.013	9.1 a	9.5 a	7.9 ab	0.8 a
dicamba	0.125	10.3 a	11.0 a	4.4 b	0.6 a
2,4-D ester	0.375	8.1 a	10.0 a	9.0 ab	1.0 a

[1]All herbicide applications included a non-ionic surfactant at 0.25% v/v rate. Fall treatments were applied on October 29, 2016; spring treatments were applied on April 5, 2017. The October 19, 2016 census established baseline density and was prior to herbicide applications.

[2] Means in each column, within each application time, followed by the same letter are not different at $p \leq 0.05$.

Visual control ratings made over the whole plot area gave similar results to the density measurements. Fall-applied aminopyralid and clopyralid resulted in the greatest control, between 90 and 100%, at the April 4 and April 20 ratings (Table 3). By June 12, control with aminopyralid had declined to 80% compared with 97% control with clopyralid. At this time, aminopyralid control was not different than aminocyclopyrachlor, but control was greater than with dicamba or 2,4-D ester. The decline in control from aminopyralid was due to plants bolting that had previously appeared dead. Injury or control from the spring-applied herbicides was only slightly evident two weeks after application on April 20 as only minor curling or burning could be seen on the rush skeletonweed leaves (Table 3). By June 12, the spring-applied aminopyralid and clopyralid treated plants exhibited the greatest injury. For plants treated with aminocyclopyrachlor, dicamba, or 2,4-D ester, only slight suppression of bolting plants was the most common injury. At the July 19 pre-harvest rating, nearly all remaining plants had bolted and were nearing flowering, and heavy competition by the wheat crop made these ratings more variable than earlier ratings. No difference in control was found between fall-applied aminopyralid, clopyralid, or aminocyclopyrachlor; however, control with clopyralid was still greater than 90% (Table 3). Dicamba and 2,4-D ester gave the least amount of control at 48 and 55%, respectively. No difference was found between any of the spring-applied treatments.

Table 3. Rush skeletonweed visual control ratings in winter wheat.

		Visual control ratings[2]			
Treatments[1]	Rate	04 Apr	20 Apr	12 Jun	19 Jul
	(lb ae/A)	(%)			
Fall-applied herbicides					
non-treated	-	0 -	0 -	0 -	0 -
aminopyralid	0.0093	95 a	96 ab	80 b	82 abc
clopyralid	0.1875	97 a	100 a	97 a	96 a
aminocyclopyrachlor	0.013	72 b	63 c	67 bc	85 ab
dicamba	0.125	79 b	81 bc	35 d	48 c
2,4-D ester	0.375	81 b	80 bc	55 cd	55 bc
Spring-applied herbicides					
non-treated	-	0 -	0 -	0 -	0 -
aminopyralid	0.0093	0 -	4 a	88 a	91 a
Clopyralid	0.1875	0 -	6 a	85 a	90 a
aminocyclopyrachlor	0.013	0 -	4 a	40 b	81 a
Dicamba	0.125	0 -	7 a	57 b	80 a
2,4-D ester	0.375	0 -	6 a	40 b	68 a

[1] See Table 2 for application details.

[2] April 4 ratings were prior to spring applications; April 20 ratings were 2 weeks following spring applications; June 12 ratings were at wheat soft dough stage; July 19 ratings were just prior to harvest. Means in each column, within each application time, followed by the same letter are not different at $p \leq 0.05$.

The wheat stand was exceptionally heavy across most of the plot area with the highest yields averaging 40 bu/A more than the long-term average for this area. Fall-applied herbicides had no effect on test weight; however, spring-applied aminocyclopyrachlor reduced test weight nearly 1.5 lb/bu compared with all other treatments (Table 4). Both fall and spring applications of aminocyclopyrachlor reduced crop yield with the spring application causing a substantial amount of kernel abortion that reduced yield up to 75%. Wheat yield was also reduced by 2,4-D ester applied in the fall, but not in the spring (Table 4). Clopyralid applied in the spring had lower yield than the highest yielding treatments, but was not different than aminopyralid or the non-treated check. Dicamba had no apparent effect on yield applied in either fall or spring.

Overall, aminopyralid or clopyralid applied in fall or spring were superior in controlling rush skeletonweed in winter wheat compared with aminocyclopyrachlor, 2,4-D ester, or dicamba. Clopyralid is currently labeled for winter wheat, however, aminopyralid is not yet labeled in the U.S. The experimental herbicide aminocyclopyrachlor can injure wheat and reduce yield, especially when applied in the spring. These results are similar to results from the 2015-16 trial.

Table 4. Winter wheat test weight and yield following fall- and spring-applied herbicides applications to control rush skeletonweed.

Treatments[1]	Rate	Winter wheat[2] Test weight	Winter wheat[2] Crop yield
	(lb ae/A)	lb/bu	bu/A
Fall-applied herbicides			
non-treated	-	62.9 a	106 a
aminopyralid	0.0093	62.9 a	93 ab
clopyralid	0.1875	62.8 a	105 a
aminocyclopyrachlor	0.013	62.8 a	77 b
dicamba	0.125	62.8 a	101 a
2,4-D ester	0.375	63.0 a	79 b
Spring-applied herbicides			
non-treated	-	62.8 a	91 bc
aminopyralid	0.0093	62.8 a	91 bc
clopyralid	0.1875	62.8 a	88 c
aminocyclopyrachlor	0.013	61.3 b	28 d
dicamba	0.125	62.6 a	104 ab
2,4-D ester	0.375	62.7 a	109 a

[1] See Table 2 for application details.
[2] Means in each column, within each application time, followed by the same letter are not different at $p \leq 0.05$.

Evaluation of mesosulfuron plus thiencarbazone for the postemergence control of rattail fescue in direct-seeded hard red winter wheat. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A field study was conducted at Wolf Farms near Uniontown, WA to evaluate the efficacy of mesosulfuron plus thiencarbazone on rattail fescue (VLPMY) in directed seeded hard red winter wheat. On October 24, 2016, 'Rimrock/Keldin' hard red winter wheat blend was seeded at 1 x 10^6 seeds per acre with a Cross Slot® drill on a 10-inch row spacing. Plots were 10 ft by 33 ft and arranged in a randomized complete block design with four replications. On April 21, 2017, herbicides were applied using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 43 psi (Table 1). Visual ratings of VLPMY control was assessed on May 19th and Jun 13th. Wheat seed was harvested with a small plot combine on August 16th.

Table 1. Application and soil data.

Location	Wolf Farms, Uniontown, Washington
Application date	April 21, 2017
Wheat growth stage	3 tillers
Wheat height	6 to 8 inches
Rattail fescue growth stage	2 tillers
Rattail fescue height	0.75 inch
Air temperature (F)	58
Relative humidity (%)	44
Wind (mph, direction)	3, northeast
Cloud cover (%)	80
Soil temperature at 6 in (F)	44
pH	4.7
OM (%)	3.4
Texture	silt loam

Most likely, the majority of VLPMY germinated in the fall in part due to above average precipitation at planting. The trial area experienced prolonged snow cover and it was very unlikely that the ground froze. Mesosulfuron/thiencarbazone provided better control of VLPMY than the current mesosulfuron formulation. VLPMY control was not improved by tank mixing one or two EC concentrate herbicide formulations (i.e., pyrasulfotole/bromoxynil, bromoxynil/MCPA ester or clopyralid/fluroxypyr) with mesosulfuron/thiencarbazone. Mesosulfuron + pyrasulfotole/bromoxynil + bromoxynil/MCPA ester provided comparable control to mesosulfuron/thiencarbazone. Test weight was not influenced by any treatments and the mean was 59.2 lb/bu. Yield was negatively impacted by the presence of rattail fescue. Mesosulfuron/thiencarbazone-, mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil-, mesosulfuron + pyrasulfotole/bromoxynil + bromoxynil/MCPA ester- and mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + clopyralid/fluroxypyr-treated plots exhibited an increase in yield compared to the nontreated check.

Table 2. Rattail fescue control in 'Rimrock/Keldin' hard red winter wheat with herbicides near Uniontown, Washington in 2017.

Treatment	Rate	Rattail fescue control 5/19	6/13	Yield 8/16
	lb ai/A	---------0-100%--------		bu/a
Nontreated check	--	--	--	71
mesosulfuron[1]	0.013	55	44	76
mesosulfuron/thiencarbazone[1]	0.018	72	72	87
mesosulfuron + pyrasulfotole/bromoxynil [2]	0.013 + 0.22	57	57	80
mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil[2]	0.018 + 0.22	75	75	85
mesosulfuron + pyrasulfotole/bromoxynil + bromoxynil/MCPA ester[2]	0.013 + 0.22 + 0.5	67	62	84
mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + bromoxynil/MCPA ester[2]	0.018 + 0.22 + 0.5	76	80	80
mesosulfuron + pyrasulfotole/bromoxynil + clopyralid/fluroxypyr[2]	0.013 + 0.22 + 0.19	52	37	78
mesosulfuron/thiencarbazone + pyrasulfotole/bromoxynil + clopyralid/fluroxypyr[2]	0.018 + 0.22 + 0.19	67	70	83
LSD (0.05)		14	18	9

[1]Treatment was applied with urea ammonium nitrate at 2 qt/a and a 90% nonionic surfactant (R-11) at 0.5% v/v.
[2]Treatment was applied with urea ammonium nitrate at 2 qt/a and a 90% nonionic surfactant (R-11) at 0.25% v/v.

Mayweed chamomile control in winter wheat with bicyclopyrone plus bromoxynil. Henry Wetzel and Drew Lyon. (Dept. of Crop & Soil Sciences, Washington State Univ., Pullman, WA 99164-6420) A field study was conducted on Mike Nelson's Farm near Albion, WA to evaluate the efficacy of bicyclopyrone plus bromoxynil on mayweed chamomile (ANTCO) in winter wheat. On September 28, 2016, 'ORCF-102' winter wheat was conventionally planted using a John Deere 455 disk drill with a 7.5-inch row spacing. Plots were 10 ft by 33 ft and arranged in a randomized complete block design with four replications. On May 2, 2017, herbicides were applied using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 42 psi (Table 1). Visual ratings of ANTCO control was assessed on May 15th, June 13th and July 28th. Wheat seed was harvested with a small plot combine on August 3rd.

Table 1. Application and soil data.

Location	Cook Agronomy Farm, Pullman, Washington
Application date	May 2, 2017
Wheat growth stage	First node detected
Mayweed chamomile	3 inch diam. and 3 inch tall
Mayweed chamomile density	34 plants per ft^2
Air temperature (F)	48
Relative humidity (%)	75
Wind (mph, direction)	calm
Cloud cover (%)	75
Soil temperature at 6 in (F)	48
pH	5.7
OM (%)	4.3
Texture	silt loam

The trial area experienced above average precipitation and moderate temperatures in the fall which lead to ANTCO germination. Plants survived the winter under a prolonged period of snow cover in part since it was unlikely that the ground froze. ANTCO was uniformly distributed across the trial area and plants were continuing to germinate at the time of application. Crop injury was not noted with any treatments in this study (data not shown). Thirteen days after treatment (DAT) (May 15th), clopyralid/fluroxypyr -, clopyralid/fluroxypyr + thifensulfuron/tribenuron - and clopyralid/fluroxypyr + MCPA ester-treated plots exhibited the best control of ANTCO. By 42 DAT, all three rates of bicyclopyrone/bromoxynil + A20916A were providing a similar level of control as the aforementioned treatments. The addition of florasulam + MCPA ester at 17 fl oz/A to bicyclopyrone/bromoxynil + A20916A (13.7 + 2.75 fl oz/A) did not improve efficacy against ANTCO when compared to bicyclopyrone/bromoxynil + A20916A applied alone. Pyrasulfotole/bromoxynil did not provide the level of control that the bicyclopyrone/bromoxynil + A20916A and clopyralid/fluroxypyr based treatments did. Pyrasulfotole/bromoxynil is only labeled for partial control of ANTCO in winter wheat. Thifensulfuron/tribenuron + MCPA ester provided a similar level of control as the pyrasulfotole/bromoxynil treatments. There were no significant differences among yield or test weight (data not shown) between herbicide treatments, including the nontreated check. The average yield and test weight were 136 bu/A (range 129 to 143 bu/A, CV = 8) and 60 lb/bu (range 60 to 61 lb/bu, CV = 2), respectively.

Table 2. Mayweed chamomile control in 'ORCF-102' winter wheat with herbicides near Albion, Washington in 2017.

Treatment	Rate	Mayweed chamomile control 5/15	6/13	7/28
	lb ae/A	--------------0-100%---------------		
Nontreated check	--	--	--	--
bicyclopyrone/bromoxynil + A20916A[1]	0.19 + (2.75 fl oz/A)	60	82	99
bicyclopyrone/bromoxynil + A20916A[1]	0.22 + (3.2 fl oz/A)	67	84	97
bicyclopyrone/bromoxynil + A20916A[1]	0.25 + (3.6 fl oz/A)	65	85	99
bicyclopyrone/bromoxynil + florasulam/MCPA ester + A20916A[1]	0.19 + 0.31 + (2.75 fl oz/A)	72	82	95
pyrasulfotole/bromoxynil[2]	0.18	50	71	76
pyrasulfotole/bromoxynil[3]	0.22	57	57	60
pyrasulfotole/bromoxynil[3]	0.24	57	64	60
clopyralid/fluroxypyr	0.19	82	85	94
thifensulfuron/tribenuron + clopyralid/fluroxypyr[2]	(0.02 lb ai/A) + 0.19	81	90	100
clopyralid/fluroxypyr + MCPA ester	0.19 + 0.35	82	91	99
thifensulfuron/tribenuron + MCPA ester[2]	(0.02 lb ai/A) + 0.35	47	60	66
LSD (0.05)		10	15	29

[1]Treatment was applied with crop oil concentrate (Agri-Dex) at 1.0% v/v.
[2]Treatment was applied with a 90% nonionic surfactant (R-11) at 0.25% v/v.
[3]Treatment was applied with ammonium sulfate at 1.0 lb/A and a 90% nonionic surfactant (R-11) at 0.25% v/v.

Winter wheat tolerance to fluxapyroxad/pyraclostrobin/propiconazole fungicide combined with various herbicides. Traci A. Rauch and Joan M. Campbell. (Dept. of Plant Sciences, University of Idaho, Moscow, ID 83844-2333) Fungicides combined with herbicides can sometimes cause crop injury. A study was established to evaluate 'Magic' winter wheat tolerance with fluxapyroxad/pyraclostrobin/propiconazole fungicide combined with various herbicides near Genesee, ID. The plots were arranged in a randomized complete block design with four replications and included an untreated check. All herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 10 gpa at 32 psi and 3 mph (Table 1). The site was oversprayed with pyrasulfotole/bromoxynil at 0.21 lb ai/A for broadleaf weed control and with fluxapyroxad/pyraclostrobin at 0.06 lb ai/A for stripe rust control on May 15, 2017. On May 19, the study was oversprayed with propiconazole at 0.11 lb ai/A and fluxapyroxad/pyraclostrobin at 0.13 lb ai/A again for stripe rust control. Crop injury was evaluated visually during the growing season. Grain was harvested with a small plot combine on August 11, 2017.

Table 1. Application and soil data.

Winter wheat seeding date	10/12/16
Application date	5/2/17
Growth stage	
Winter wheat	5 tiller
Air temperature (F)	67
Relative humidity (%)	63
Wind (mph)	0
Cloud cover (%)	80
Next rain occurred	5/6/17
Soil	
Moisture	wet
Temperature at 2 inch (F)	60
pH	6.1
OM (%)	5.3
CEC (meq/100g)	19.7
Texture	silt loam

Mesosulfuron plus pyrasulfotole/bromoxynil with or without fluxapyroxad/pyraclostrobin/propiconazole injured winter wheat 10 to 11% and 11 to 14% at 7 and 14 DAT, respectively (Table 2). AT 14 DAT, pyroxsulam and clopyralid/fluroxypyr combined with MCPA ester injured wheat 8% without fluxapyroxad/pyraclostrobin/propiconazole compared to 2% with it. By 36 DAT, no treatment visibly injured winter wheat (data not shown). Grain yield did not differ among treatments including the untreated check. Winter wheat test weight was lower in plots treated with fluxapyroxad/pyraclostrobin/propiconazole plus pyroxsulam plus clopyralid/fluroxypyr and MCPA ester than the untreated check.

Table 2. Winter wheat response with fluxapyroxad/pyraclostrobin/propiconazole fungicide combined with various herbicides in 2017.

Treatment[1]	Rate	Injury 7 DAT	Injury 14 DAT	Yield	Test weight
	lb ai/A	%	%	bu/A	lb/bu
Fluxapyroxad/pyraclostrobin/propiconazole +	0.12				
NIS	0.25% v/v	0	1	102	62.3
Fluxapyroxad/pyraclostrobin/propiconazole +	0.12				
pyroxsulam +	0.016				
clopyralid/fluroxypyr +	0.25				
MCPA ester +	0.23				
NIS	0.25% v/v	8	2	101	61.7
Pyroxsulam +	0.016				
clopyralid/fluroxypyr+	0.25				
MCPA ester +	0.23				
NIS	0.25% v/v	6	8	104	62.0
Fluxapyroxad/pyraclostrobin/propiconazole +	0.12				
mesosulfuron +	0.0134				
pyrasulfotole/bromoxynil +	0.24				
NIS	0.25% v/v	10	11	105	61.9
Mesosulfuron +	0.0134				
pyrasulfotole/bromoxynil +	0.24				
NIS	0.25% v/v	11	14	108	62.2
Fluxapyroxad/pyraclostrobin/propiconazole +	0.12				
imazamox +	0.094				
bromoxynil/MCPA +	0.5				
MSO	1% v/v	0	0	105	63.0
Imazamox +	0.094				
bromoxynil/MCPA +	0.5				
MSO	1% v/v	0	0	104	62.8
Imazamox +	0.094				
bicyclopyrone/bromoxynil +	0.256				
sodium bicarbonate +	0.076				
COC	1% v/v	0	0	106	62.7
Untreated check	--	-	--	98	62.3
LSD (0.05)		5	4	NS	0.5

[1]All treatments, except fluxapyroxad/pyraclostrobin/propiconazole alone, were applied with urea ammonium nitrate at 10% v/v. NIS = nonionic surfactant. MSO = methylated seed oil. COC = crop oil concentrate.

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