

2016 WSU Weed Control Report

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Partial Research Support Provided by:

The Washington Grain Commission, The USA Dry Pea & Lentil Council and The
Mel & Donna Camp Endowment Fund

Additional Support Provided by:

Arysta Life Science, BASF Corporation, Bayer Crop Science, Dow AgroSciences,
DuPont Crop Protection, FMC Corporation, NuFarm, Syngenta Crop Protection,
TKI NovaSource & Two Rivers Terminal, LLC

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Disclaimer

Some of the pesticides discussed in this presentation were tested under an experimental use permit granted by WSDA. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties up to \$7,500. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.

Evaluation of Everest® 2.0 for the control of rattail fescue in direct-seeded winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Wolf Farms near Uniontown, WA to generate rattail fescue control data with Everest 2.0 in winter wheat. Rattail fescue is a significant problem in direct-seed systems.

The soil at this site is a Athena silt loam with 4.8% organic matter and a pH of 4.4. WB1529 was seeded at a rate of 98 lb seed/A on September 25, 2015 with a direct-seed Cross Slot® drill with row openers on 12-inch centers. Fall fertility consisted of 60:30:20 lb/A of nitrogen:phosphorus:sulfur. Spring fertility consisted of 30 lb nitrogen and 1 lb phosphorus per acre. An early spring post emergence application took place on March 21th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 55°F, relative humidity of 43% and the wind out of the SE at 5 mph. Wheat growth stage was variable, anywhere from 3-leaf to fully tillered. Rattail fescue distribution was not uniform across the trial area. Rattail fescue ranged anywhere from four leaves to four tillers. A typical spring post-emergence application took place on April 18th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 73°F, relative humidity of 30% and the wind out of the NE at 5 mph. Wheat growth stage was anywhere from fully tillered to first joint detected and plant height was 4 to 17 inches. The high variability in wheat size and development was due to incomplete fall emergence resulting from dry soil conditions in the fall of 2015. Rattail fescue ranged anywhere from two to eight tillers.

No crop injury was observed among all treatments evaluated. Eleven hours after the treatments were applied on March 21th, rain began to fall and the trial received 1.26 inches of precipitation through the 22nd. The initial rating on May 5th suggested that Everest 2.0 + PowerFlex® HL (0.98 fl oz + 1.0 oz/A) and Everest 2.0 + ARY-0922-001 (0.98 fl oz + 0.31 oz/A) that were applied on March 21st were providing the best control. However, on the final rating of June 27th, there were no significant differences among treatments, but these two treatments were the only ones that provided commercial acceptable, although only fair, control of rattail fescue. Yield data was not collected within the trial area.

Treatment	Rate	Application Date	Rattail fescue control		
			5/5	5/24	6/27
	fl oz/A		-----%		
Nontreated Check	--	--	--	--	--
Everest 2.0 ¹	0.98	3/21	57 b-d ²	49 a	46 a
Everest 2.0	0.98	4/18	57 b-d	59 a	40 a
Everest 2.0 + Audit [®] 1:1	0.98 + 0.6 oz	3/21	50 cd	15 a	27 a
Everest 2.0 + Audit 1:1	0.98 + 0.6 oz	4/18	57 b-d	62 a	42 a
Everest 2.0 + PowerFlex HL	0.98 + 1 oz	3/21	74 ab	59 a	66 a
Everest 2.0 + PowerFlex HL	0.98 + 1 oz	4/18	62 b-d	65 a	40 a
Everest 2.0 + PowerFlex HL	0.98 + 0.5 oz	3/21	65 bc	37 a	45 a
Everest 2.0 + PowerFlex HL	0.98 + 0.5 oz	4/18	66 bc	54 a	45 a
Everest 2.0 + ARY-0922-001	0.98 + 0.31 oz	3/21	85 a	77 a	77 a
Everest 2.0 + ARY-0922-001	0.98 + 0.31 oz	4/18	55 cd	70 a	52 a
Everest 2.0 + ARY-0922-001	0.98 + 0.15 oz	3/21	62 b-d	44 a	49 a
Everest 2.0 + ARY-0922-001	0.98 + 0.15 oz	4/18	59 b-d	72 a	56 a
PowerFlex HL	2 oz	3/21	45 d	45 a	46 a
PowerFlex HL	2 oz	4/18	60 b-d	56 a	32 a

¹ All treatments were tank mixed with 0.25% v/v NIS and 1.0 lb AMS/A

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by LSMEANS test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Evaluation of Everest® 2.0 and tank mix partners for the control of rattail fescue in direct-seeded winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Wolf Farms near Uniontown, WA to generate rattail fescue control data with Everest 2.0, PowerFlex® HL, Osprey®, Varro® and Audit® 1:1 in winter wheat. All of these products fall in the acetolactate synthase (ALS) inhibitor class (Group 2). Rattail fescue is a significant problem in direct-seed systems.

The soil at this site is an Athena silt loam with 4.8% organic matter and a pH of 4.4. WB1529 was seeded at a rate of 98 lb seed/A on September 25, 2015 with a direct-seed Cross Slot® drill with row openers on 12-inch centers. Fall fertility consisted of 60:30:20 lb/A of nitrogen:phosphorus:sulfur. Spring fertility consisted of 30 lb nitrogen and 1 lb phosphorus per acre. An early spring post-emergence application took place on April 1th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 43 psi at 2.3 mph. Conditions were an air temperature of 64°F, relative humidity of 32% and the wind out of the SE at 3 mph. Wheat growth stage was quite variable within the trial area ranged from 3 to 9 tillers and height ranged from 3 to 9 inches. The high variability in wheat size and development was due to incomplete fall emergence resulting from dry soil conditions in the fall of 2015. Rattail fescue distribution was not uniform across the trial area. Rattail fescue ranged from four to five tillers.

No crop injury was observed among all treatments evaluated. At approximately one month after application, it appeared that all treatments were having a positive effect on rattail fescue control. However, by the final rating on June 27th, products including Osprey and PowerFlex HL when applied alone did not provide acceptable control of rattail fescue. The addition of Audit 1:1 (0.6 oz/A) to Everest 2.0 (0.98 fl oz/A) reduced rattail fescue control when compared to Everest 2.0 (0.98 fl oz/A) applied alone. Audit 1:1 (0.6 oz/A) reduced control when added to Everest 2.0 (0.75 fl oz/A) plus Osprey (4.75 oz/A), when compared to Everest plus Osprey applied together. Everest 2.0 (0.75 fl oz/A) plus Osprey (4.75 oz/A) or Osprey (4.75 oz/A) plus Varro (2.95 fl oz/A) are treatments to consider for the post-emergence control of rattail fescue in direct-seed winter wheat. Yield data was not collected within the trial area.

Treatment	Rate	Rattail fescue control		
		5/5	5/24	6/27
	fl oz/A	-----%-----		
Nontreated Check	--	--	--	--
Osprey + Varro ¹	4.75 oz + 2.95	88 ab ²	88 a	92 a
Everest 2.0 + Osprey + Varro	0.5 + 4.75 oz + 2.95	90 a	92 a	88 ab
Everest 2.0 + Osprey	0.75 + 4.75 oz	90 a	85 a	88 ab
Everest 2.0 + Osprey	0.5 + 4.75 oz	85 a-c	85 a	80 ab
Everest 2.0 + Osprey	0.98 + 4.75 oz	78 b-d	77 ab	73 a-c
Everest 2.0 + Audit 1:1 + Osprey	0.75 + 0.6 oz + 4.75 oz	83 a-c	75 ab	73 a-c
Everest 2.0	0.98	87 ab	77 ab	68 a-c
Everest 2.0 + Audit 1:1 + PowerFlex HL	0.98 + 0.6 oz + 1 oz	78 b-d	65 b	62 b-d
Everest 2.0 + Audit 1:1	0.98 + 0.6 oz	82 a-c	67 b	47 c-e
PowerFlex HL	2 oz	75 cd	62 bc	37 de
Osprey	4.75 oz	70 d	45 c	32 e

¹ All treatments were tank mixed with 0.25% v/v NIS and 1.0 lb AMS/A

² Means, based on three replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Evaluation of crop safety with tank mixtures of Beyond[®] plus Talinor[™] herbicides on WB1376 CL+ winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted on the WSU Cook Agronomy Farm near Pullman, WA to evaluate crop safety with tank mixtures of Beyond plus Talinor herbicides on WB1376 CL+ winter wheat. Talinor is in development as a broadleaf herbicide for use in cereals by Syngenta Crop Protection Inc. Talinor combines two modes of action, bicyclopyrone which inhibits 4-HPPD and bromoxynil which inhibits photosynthesis at photosystem II. These same two herbicide



mechanism of action classes are in Huskie[®]. Talinor was tested, and upon commercialization will be tank mixed, with CoAct+[™], a safener which provides optimum performance of the two active ingredients. Seed was sown at a rate of 86 lb/A on October 28, 2015 with a John Deere 9400 hoe drill with row openers on a 7-inch spacing. Plot area was fertilized with dry urea on April 11th at the rate of 100 lb N per acre. Soil at the site is a Naff silt loam with 3.2% organic matter and a pH of 5.1. On May 3rd, treatments were applied with a CO₂-powered backpack sprayer set to deliver 10 gpa at 45 psi at 2.3 mph. Wheat primarily had 2 nodes and was 12.5 inches tall. The air temperature was 79 F, relative humidity was 29% and wind was out of the south at 5 to 7 mph.

The week following application, average high and low temperatures were 71 and 46 F, respectively. During that same period, 0.05 inch of rain fell on May 5th, two days after application. Symptoms of chlorosis, bleaching that appeared to streak across the leaf and leaf tip necrosis were evident shortly after application in the Beyond + Talinor + CoAct+ regardless of MSO or NIS in the mixture. Evaluating these plots over time did not suggest that this herbicide combination moved with any significance in the xylem, as only the leaves that were present at the day of application exhibited symptoms. Even though significant injury was observed in the Beyond + Talinor + CoAct+-treated plots, there was no difference in yield and test weight when compared to the non-treated check.

Treatment	Rate	Crop Injury						8/13	
		5/12	5/19	5/26	6/2	6/9	6/23	Yield	Test weight
		9 DAT	16 DAT	23 DAT	30 DAT	37 DAT	51 DAT		
	fl oz/A	-----%						bu/A	lb/bu
Nontreated Check	--	--	--	--	--	--	--	85 a	61 a
Beyond ¹	6	0 a ³	0 a	0 a	0 a	0 a	0 a	83 a	61 a
Brox [®] M + Beyond ¹	32 + 6	0 a	0 a	0 a	0 a	0 a	0 a	75 a	61 a
Talinor + CoAct+ + Beyond ²	18.2 + 3.6 + 6	62 b	21 b	16 b	15 b	4 b	4 b	77 a	61 a
Talinor + CoAct+ + Beyond ¹	18.2 + 3.6 + 6	57 b	17 b	12 b	14 b	3 b	4 b	77 a	61 a

¹ Tank mixed with 1.0% v/v MSO and 20% v/v UAN32

² Tank mixed with 0.25% v/v NIS and 20% v/v UAN32

³ Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Mayweed chamomile control in winter wheat with Talinor™

Henry Wetzel and Drew Lyon

A field study was conducted at the WSU Palouse Conservation Field Station near Pullman, WA to generate broadleaf weed control data with Syngenta's Talinor herbicide in winter wheat. Talinor is a premixture of bromoxynil (Group 6) and bicyclopyrone (Group 27) herbicides. Talinor is tank mixed with CoAct+™, which is a safener. Huskie® contains pyrasulfotole, which is also a Group 27 herbicide, and bromoxynil, and is why it is used as a comparison treatment against this new active ingredient combination.



The soil at this site is a Thatuna silt loam with 4.6% organic matter and a pH of 5.0. On November 13, 2015, 'Puma' winter wheat was planted using a Horsch air drill with 12-inch row spacing. Post emergence treatments were applied on April 21th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 43 psi at 2.3 mph. Conditions were an air temperature of 75°F, relative humidity of 42% and the wind out of the SW at 4 mph. The majority of the wheat was at the four-tiller stage and was 12 inches tall. Mayweed chamomile distribution was not uniform across the trial area. Mayweed chamomile was 1.5 inches tall at the time of application and at a density of 21, 6 and 7 plants per square foot in nontreated check plots in replications 1, 2 and 3, respectively.

Crop injury was noted on May 6th (14 DAT) only in the Talinor treatments that were tank mixed with Axial® Star. There was bleaching at the leaf tips of which the plants grew out of quickly. Talinor alone, Talinor plus the tank mix partners tested, and Huskie alone provided greater control of mayweed chamomile 15 days after application than the Affinity® Tankmix and WideMatch® treatments. On June 17th, 57 DAT, Talinor treatments exhibited better control of mayweed chamomile than the Huskie treatments. The exception was Talinor + CoAct+ + Axial Star, which provided similar mayweed chamomile control to Huskie at 15 fl oz/A. There did not appear to be a rate response for Talinor treatments like there were with the Huskie treatments. When the final rating was taken on July 5th, 75 DAT, all treatments were providing good to excellent control of mayweed chamomile except Huskie at 11 fl oz/A. There were no significant differences in yield or test weight among treatments when compared to the nontreated check. Talinor is an effective herbicide for mayweed chamomile control in winter wheat.

		Mayweed chamomile control				
		5/6	5/12	5/24	6/17	7/5
Treatment	Rate	15 DAT	21 DAT	33 DAT	57 DAT	75 DAT
	fl oz/a	-----%-----				
Nontreated Check		--	--	--	--	--
Talinor + CoAct + ¹	13.7 + 2.74	73 ab ⁴	92 a	85 a-c	98 a	95 ab
Talinor + CoAct + ¹	16.0 + 3.2	63 a-c	77 ab	82 a-c	98 a	98 ab
Talinor + CoAct + ¹	18.3 + 3.6	63 a-c	93 a	90 ab	98 a	97 ab
Huskie ²	11	50 c	68 b	63 e	68 c	70 c
Huskie ³	13.5	47 c	70 ab	63 e	78 c	88 ab
Huskie ³	15	57 bc	78 ab	77 cd	82 bc	85 a-c
WideMatch	16	27 d	43 c	78 b-d	100 a	98 ab
WideMatch + Rhonox [®] MCPA Ester	16 + 12	27 d	73 ab	83 a-c	100 a	100 a
Affinity Tankmix + Rhonox MCPA Ester	0.6 oz + 12	27 d	77 ab	67 de	77 c	83 bc
Talinor + CoAct + + Orion ^{®1}	13.7 + 2.74 + 17	70 ab	88 ab	83 a-c	97 a	92 ab
Talinor + CoAct + + Peak ^{®1}	13.7 + 2.74 + 0.4 oz	67 ab	90 ab	92 a	98 a	98 ab
Talinor + CoAct + + Axial Star	13.7 + 2.74 + 16.4	70 ab	85 ab	80 a-c	93 ab	92 ab
Talinor + CoAct + + Orion + Axial Star	13.7 + 2.74 + 17 + 16.4	77 a	90 ab	85 a-c	98 a	92 ab
Talinor + CoAct + + Peak + Axial Star	13.7 + 2.74 + 0.4 oz + 16.4	70 ab	87 ab	83 a-c	100 a	95 ab

¹ Treatments were tank mixed with 1.0% v/v crop oil concentrate

² Treatment was tank mixed with 0.25% v/v NIS

³ Treatments were tank mixed with 0.25% v/v NIS and 1.0 lb AMS/A

⁴ Means, based on three replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Catchweed bedstraw control in winter wheat with Sentrallas™ and Travallas™

Henry Wetzel and Drew Lyon

A field study was conducted at the WSU Palouse Conservation Field Station near Pullman, WA to generate weed control data with two new herbicide premixtures, Sentrallas™ and Travallas™. Each product contains one or two active ingredients in the sulfonyleurea family within the acetolactate synthase (ALS) inhibitor group (Group 2) and fluroxypyr a product in the synthetic auxin group (Group 4).

The soil at this site is a Thatuna silt loam with 5.9% organic matter and a pH of 5.2. On November 13, 2015, 'Puma' winter wheat was planted using a Horsch air drill with 12-inch row spacing. Post-emergence treatments were applied on April 27th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 64°F, relative humidity of 33% and the wind out of the NW at 6 mph. Wheat was at the first node stage and was 20 inches tall. Catchweed bedstraw was 3 inches tall at the time of application and at a density of 12 plants per square foot.

Both min. and max. air temperatures were above average while precipitation was slightly below average. This resulted in significant wheat growth and plants were much taller and further along in their development than typical at the time of application. The vigorous wheat growth likely contributed to the excellent weed control observed in this study. No crop injury was observed. In general, when Sentrallas or Travallas were tank mixed with either Huskie® or Brox®-M, control symptoms were seen sooner than when the two compounds were tank mixed with Starane® Flex. The treatment of Travallas + Starane Flex + Axial® Star was the exception. On the final evaluation date, all treatments provided excellent control of catchweed bedstraw. Huskie Complete and Sentrallas alone were the only treatments to provide less than 95% visual control.

		Catchweed bedstraw control		
		5/12	5/24	6/15
Treatment ¹	Rate	15 DAT	27 DAT	49 DAT
	fl oz/a	-----%-----		
Nontreated Check	--	--	--	--
Travallas + Huskie + Axial Star	10 + 13.5 + 16.4	88 a ²	90 a	100 a
Sentrallas + Huskie	10 + 13.5	84 ab	89 a	100 a
Travallas + Huskie + PowerFlex [®] HL	10 + 13.5 + 2 oz	84 ab	89 a	100 a
Sentrallas + Brox-M	10 + 24	84 ab	86 a	100 a
Travallas + Starane Flex + Axial Star	10 + 13.5 + 16.4	82 a-c	90 a	100 a
Travallas + Brox-M	10 + 24	82 a-c	85 a-c	100 a
Travallas + Huskie + Osprey [®]	10 + 13.5 + 4.75 oz	81 a-c	84 a-c	97 bc
Travallas + Huskie	10 + 13.5	80 a-c	86 a	99 ab
Sentrallas + Starane Flex	10 + 13.5	76 b-d	83 a-d	100 a
Travallas + Starane Flex	10 + 13.5	74 b-d	86 ab	100 a
Travallas + Starane Flex + PowerFlex HL	10 + 13.5 + 2 oz	74 b-d	84 a-c	99 ab
Huskie Complete + AMS	13.7 + 1 lb	74 b-d	75 e	91 e
Travallas + Starane Flex + Osprey	10 + 13.5 + 4.75 oz	72 c-e	86 ab	100 a
Travallas	10	72 c-e	85 a-c	100 a
Sentrallas	10	67 d-f	80 b-e	92 de
WideMatch [®]	16	63 ef	77 c-e	95 c
Goldsky [®] + AMS	16 + 1.5 lb	60 f	76 de	97 bc

¹ All treatments except WideMatch included 0.25% v/v NIS

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Catchweed bedstraw control in winter wheat with GF-3122

Henry Wetzel and Drew Lyon

A field study was conducted at the WSU Palouse Conservation Field Station near Pullman, WA to generate weed control data with an herbicide premixture, GF-3122. The product contains pyroxsulam (Group 2) and halauxifen-methyl (Group 4).

The soil at this site is a Thatuna silt loam with 5.9% organic matter and a pH of 5.2. On November 13, 2015, 'Puma' winter wheat was planted using a Horsch air drill with 12-inch row spacing. Post-emergence treatments were applied on April 27th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 64°F, relative humidity of 33% and the wind out of the NW at 6 mph. Wheat was at the first node stage and was 20 inches tall. Catchweed bedstraw was 5 inches tall at the time of application and at a density of 6 plants per square foot.

No crop injury was observed. Both min. and max. air temperatures were above average while precipitation was slightly below average. This resulted in significant wheat growth and plants were much taller and further along in their development than typical at the time of application. At the initial rating, GF-3122 exhibited better catchweed bedstraw control than PowerFlex[®] HL. Over time, all treatments except Olympus[®] and Osprey[®], provided very good control of catchweed bedstraw.

Treatment ¹	Rate	Catchweed bedstraw control		
		5/12	5/24	6/15
		15 DAT	27 DAT	49 DAT
	fl oz/a	-----%-----		
Nontreated Check	--	--	--	--
GF-3122 + Huskie	1.0 oz + 13.5	86 a ²	84 a	100 a
GF-3122 + Starane [®] Flex	1.0 oz + 13.5	82 a	86 a	100 a
GF-3122 + WideMatch [®]	1.0 oz + 16.0	79 ab	85 a	100 a
GF-3122	1.0 oz	72 b	80 a	99 a
Osprey	4.75 oz	47 c	52 b	66 b
Olympus	0.6 oz	40 cd	62 b	76 b
PowerFlex HL	2.0 oz	37 d	76 a	95 a

¹ Treatments were tank mixed with 0.5% NIS and 1.52 lb AMS/A, except Olympus was tank mixed only with 0.5% NIS

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Rush skeletonweed control in winter wheat following CRP takeout

Mark Thorne, Henry Wetzel and Drew Lyon

Rush skeletonweed is a deep-rooted perennial species that has become well established on thousands of acres across eastern Washington while the land was out of wheat production in the Conservation Reserve Program (CRP). Recent changes to the CRP have resulted in many acres coming back into production and most often without prior skeletonweed control. Uncontrolled



skeletonweed in the fallow phase of the rotation reduces seed-zone moisture and leaves inadequate soil moisture for germination of winter wheat in the fall. Areas where wheat fails to emerge are either late-seeded after fall rains replenish soil moisture or are left blank. In either case, crop yield is reduced. Herbicide control in the crop phase is one part of an overall strategy to reduce or eradicate skeletonweed from these production areas.

We applied five different synthetic auxin herbicides to rush skeletonweed infested winter wheat on November 12, 2015 as the wheat was tillering and again prior to stem jointing on March 17, 2016, at a field site near LaCrosse, WA. The land had been in CRP until October 2013 and the first post-CRP crop was harvested in 2014. In 2015, the field was in summer fallow and was seeded to 'ORCF-102' winter wheat at 60 lb/A on September 11 with a John Deere HZ616 grain drill. The field had been fertilized prior to seeding with 80 lb nitrogen, 10 lb sulfur, and 10 lb chloride per acre. At both treatment dates, herbicides were applied with a CO₂ pressurized backpack sprayer and 10-ft spray boom delivering 15 gal/A spray volume. Boom pressure was 25 psi and ground speed was 3 mph. Experimental design was a randomized complete block with four replicated blocks and a factorial arrangement of herbicides and timing. Plot dimension was 10 by 35 feet.

Rush skeletonweed density was highly variable across the plot site. The infestation was patchy and non-uniform and difficult to objectively assess for herbicide efficacy on a plant population basis. Therefore, two 1-meter quadrats per plot were flagged on April 6, 2016 and all skeletonweed plants, dead or alive, were counted to establish baseline initial densities to follow until crop harvest. Plants that had been killed by the fall applications were still visible and were

included in the count. Skeletonweed densities were recounted in all quadrats on June 2 when the wheat was in the soft-dough stage and again on July 20 at crop harvest.

Additionally, herbicide control/injury of skeletonweed was evaluated visually on a whole-plot basis as a percent of the non-treated check plots. Visual ratings on March 8, 2016 evaluated fall-applied herbicides and were taken prior to the spring-applied treatments. March 31 ratings evaluated control two weeks following spring applications as well as the fall applications. Follow-up ratings were made on June 2 and July 20.

The plots were harvested on July 20 with a Kincaid plot combine. All grain samples were analyzed for moisture with a Foss grain analyzer. Wheat yield was converted to bu/A and reported on a 12% moisture basis.

Milestone[®] and Stinger[®] applied either in the fall or spring were most effective at reducing skeletonweed density. Both herbicides reduced original densities to less than one plant/m² by the June 2 census (Table 1). Although, we reported fall-applied Milestone and Stinger treatments averaging 6.9 and 4.8 plants/m² at the April 6 census, most of these plants were dead and were included to represent the initial density in November when treatments were applied (data not shown). In contrast, DPX-MAT28-128, was only effective in reducing skeletonweed density when applied in spring with a 56% reduction by July 20. Currently, Milestone and DPX-MAT28-128 are not labeled in wheat and appropriate rates and timing have not yet been established. Each has herbicidal activity similar to clopyralid, the active ingredient in Stinger, which is labeled in wheat. Both Clarity[®] and 2,4-D LV6 are also synthetic auxin herbicides, but Clarity was not effective at reducing skeletonweed density at either application date. In contrast, 2,4-D LV6 did reduce plant numbers by 64% when applied in the fall, and 55% when applied in the spring (Table 1).

Skeletonweed visual control ratings on March 8 were variable and were confounded by winter injury symptoms observed on the rosettes. The majority of plants in the Milestone and Stinger plots were completely dead and thus clearly controlled (Table 2); however, it was difficult to assess efficacy of the other three herbicides. By March 31, clear differences were observed in the fall-treated plots between dead plants and live rosettes that were recovering from winter stress and producing new leaves. Milestone and Stinger control were each around 90% while DPX-MAT28-128 and 2,4-D LV6 only showed 10 and 15% control, respectively (Table 2). For the spring-applied treatments, the March 31 ratings were two weeks following spring applications and very few herbicide injury symptoms could be detected.

Herbicide control was visually greatest by the June 2 rating and approached 100% for fall-applied Milestone and Stinger and Stinger applied in the spring, while control for the other herbicides only averaged 37 to 53% (Table 2). By this time, skeletonweed had begun to bolt in the non-treated check plots and in a few of the herbicide-treated plots (data not shown). By the July 20 harvest census, flowers were observed on a few skeletonweed plants, primarily in the non-treated check plots. At this census, fall-applied Milestone and Stinger had maintained nearly the same level of control observed at the June 2 census (Table 2); however, control in the spring-applied plots averaged only 76 and 78%, respectively, and was not different from the 66%

control by 2,4-D LV6. This reduction in control rating was due to the presence of bolting stems originating from rosettes that previously appeared nearly or completely dead (data not shown).

Wheat yield was variable across the study site due to poor emergence following the September 2015 seeding. This resulted from inadequate soil moisture in the seed zone likely caused by a combination of low rainfall in 2015 and moisture depletion by skeletonweed in the denser patches. Rosette density in the non-treated check plots ranged from 1.4 to 89 plants/m² at the beginning of the trial in November 2015. At harvest the low-density plot yielded 89 bu/A and the high-density plot yielded 75 bu/A. In spite of stand variability, differences were seen in wheat yield in relation to the herbicide treatments. Plots treated with Milestone, Stinger, and Clarity averaged the highest yields in both the fall and spring applications and were not different from the fall-applied non-treated check (Table 2). In contrast, DPX-MAT28-128 and 2,4-D LV6 plots were the lowest yielding fall-applied treatments averaging 76 bu/A, each. These two herbicides also resulted in the lowest yields for the spring-applied treatments. The 2,4-D LV6 treatment averaged 76 bu/A, and the DPX-MAT28-128 applied in the spring caused kernel abortion and blank heads resulting in a wheat yield of only 48 bu/A (Table 2.)

In this trial, fall applications of Milestone or Stinger substantially controlled rush skeletonweed in the crop phase of the rotation without reducing grain yield. The experimental DPX-MAT28-128 and 2,4-D LV6 did not control skeletonweed well and appeared to reduce yield. Clarity did not lower yield, but also did not control skeletonweed.

Table 1. Rush skeletonweed density over time in relation to each individual treatment following fall and spring applications to winter wheat.

Treatments ¹	Rate (oz/A)	Rush skeletonweed census dates ²		
		April 6	June 2	July 20
		----- (plants/m ²) -----		
<i>Fall-applied herbicides</i>				
Non-treated	-	9.6 a	9.3 a	7.9 a
Milestone	0.6	6.9 a	0.1 b	1.0 b
Stinger	8.0	4.8 a	0.1 b	0.3 b
DPX-MAT28-128	1.7	4.4 a	3.1 a	2.6 a
Clarity	4.0	5.5 a	4.4 a	4.4 a
2,4-D LV6	8.7	8.3 a	4.6 b	3.0 b
<i>Spring-applied herbicides</i>				
Untreated	-	8.8 a	8.5 a	9.0 a
Milestone	0.6	6.5 a	0.6 b	1.3 b
Stinger	8.0	4.8 a	0.0 b	0.5 b
DPX-MAT28-128	1.7	9.4 a	4.0 b	4.1 b
Clarity	4.0	4.6 a	3.3 a	3.4 a
2,4-D LV6	8.7	13.0 a	10.1 b	5.8 c

¹All herbicide applications included a non-ionic surfactant (R-11) at 0.25% v/v rate. Fall treatments were applied on November 12, 2015; spring treatments were applied on March 17, 2016. DPX-MAT28-128 is an experimental product containing the synthetic auxin aminocyclopyrachlor as the active ingredient.

²Counts on April 6, 2016 represent initial density present at the fall application and included all plants, dead or alive, in two 1-meter permanent quadrats per plot. Counts on subsequent dates are of living plants, only. Numbers (LSMeans) in each row followed by the same letter are not different at $p \leq 0.05$ and measure change in density for each treatment over the course of the trial.

Table 2. Visually rated control of rush skeletonweed, and wheat grain yield in relation to herbicide applications in winter wheat.¹

Treatments ²	Rate	Visual control ratings ³				Wheat yield
		March 8	March 31	June 2	July 20	
	(oz/A)	-----(% of non-treated check)-----				(bu/A)
<i>Fall-applied herbicides</i>						
Non-treated	-	0 -	0 -	0 -	0 -	84 ab
Milestone	0.6	83 a	88 a	98 a	89 a	90 a
Stinger	8.0	87 a	92 a	98 a	96 a	87 a
DPX-MAT28-128	1.7	50 a	10 c	40 b	47 b	76 b
Clarity	4.0	63 a	58 b	37 b	45 b	92 a
2,4-D LV6	8.7	42 a	15 c	48 b	37 b	76 b
<i>Spring-applied herbicides</i>						
Non-treated	-	0 -	0 -	0 -	0 -	79 bc
Milestone	0.6	0 -	6 a	94 a	76 a	87 ab
Stinger	8.0	0 -	10 a	100 a	78 a	90 a
DPX-MAT28-128	1.7	0 -	3 a	53 b	35 b	48 d
Clarity	4.0	0 -	5 a	50 b	32 b	83 a-c
2,4-D LV6	8.7	0 -	5 a	53 b	66 a	76 c

¹Numbers (LSMeans) in each column followed by the same letter are not different at $p \leq 0.05$.

²All herbicide applications included a non-ionic surfactant (R-11) at 0.25% v/v rate. Fall treatments were applied on November 12, 2015; spring treatments were applied on March 17, 2016. DPX-MAT28-128 is an experimental product containing the synthetic auxin aminocyclopyrachlor as the active ingredient.

³March 8 ratings were prior to spring applications; March 31 ratings were 2 weeks following spring applications; June 2 ratings were at wheat soft dough stage; July 20 ratings were made just prior to harvest.

Control of Russian-thistle with Spartan® Charge in spring wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Franz Farms near Lind, WA to evaluate the effect of Spartan Charge on Russian-thistle control in 'Dark Northern' spring wheat. Spartan Charge is a premixture of carfentrazone and sulfentrazone, with both active ingredients being protox inhibitors (Group 14).

The soil at this site is a Shano silt loam with 1.7% organic matter and a pH of 6.4. 'Dark Northern' spring wheat was seeded on April 6th using a double disk drill. Post plant pre-emergence treatments were applied on April 8th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 77°F, relative humidity of 29% and the wind out of the NW at 2 mph. Post-emergence treatments were applied on May 11th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 79°F, relative humidity of 19% and the wind out of the S at 7 mph. Wheat was at the one- to three-tiller stage and was 10 inches tall. Russian-thistle was 3 inches tall at the time of application.



No crop injury was observed in this study. On May 11th, when the post-emergence application was made, the Russian-thistle population across the entire trial was very low. It was decided to make the application at that time, because jointing was not that far off in the spring wheat. Visits were made to the site on June 1st and July 5th and at those times the Russian-thistle population was still very low. At some point in July the Russian-thistle population really increased and caused the grower to spray on August 5th (Roundup 22 fl oz/A + Class Act® 22 fl oz/A + InterLock® 4.0 fl oz/A) to desiccate the plants prior to their harvest on the 20th. All treatments except 2,4-D amine (Weedar® 64) reduced Russian-thistle densities compared to the nontreated check. Spartan Charge may help with Russian-thistle control in spring wheat.

Treatment	Rate	Application Date(s)	Russian-thistle		8/24	
			5/11	8/24	Yield	Test Weight
	fl oz/A		Ave. number of plants per plot		bu/A	lb/bu
Spartan Charge fb Brox [®] 2EC + Rhomene [®] MCPA ¹	5.1 fb 24 + 8	4/8 & 5/11	0 a ²	1 a	19 a	58 a
Spartan Charge fb Weedar 64 ¹	7.6 fb 24	4/8 & 5/11	0 a	5 ab	15 a	58 a
Spartan Charge	7.6	4/8	0 a	6 ab	16 a	61 a
Spartan Charge fb Weedar 64 ¹	5.1 fb 24	4/8 & 5/11	0 a	6 ab	17 a	60 a
Huskie [®]	13.5	5/11	1 a	7 ab	17 a	60 a
Brox 2EC + Rhomene MCPA ¹	24 + 8	5/11	1 a	7 ab	16 a	60 a
Spartan Charge fb Weedar 64 ¹	3.8 fb 24	4/8 & 5/11	1 a	8 b	17 a	60 a
Spartan Charge	3.8	4/8	0 a	9 b	18 a	59 a
Spartan Charge	5.1	4/8	0 a	9 b	16 a	61 a
Weedar 64 ¹	24	5/11	2 a	16 c	18 a	59 a
Nontreated Check	--	--	1 a	22 c	16 a	60 a

¹ Treatments were tank mixed with 0.25% v/v NIS

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Supremacy® tank mixes for the control of mayweed chamomile in spring wheat

Henry Wetzel and Drew Lyon

A field study was conducted at the WSU Cook Agronomy Farm near Pullman, WA to generate post-emergence broadleaf weed control data with Supremacy herbicide in tank mix combinations. Supremacy contains fluroxypyr a product in the synthetic auxin group (Group 4) and thifensulfuron and tribenuron products in the sulfonyleurea family within the acetolactate synthase (ALS) inhibitor group (Group 2).

The soil at this site is a Thatuna silt loam with 4.3% organic matter and a pH of 5.1. On April 19th, 'Diva' spring wheat was planted using a Horsch air drill with 12-inch row spacing. The initial post-emergence application took place on May 26th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 60°F, relative humidity of 44% and the wind out of the W at 5 mph. Wheat was at the second detectable tiller stage and was 12 inches tall. Mayweed chamomile was one-inch tall at the time of application and at a density of 15 plants per square foot. The second post-emergence application took place on June 7th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. Conditions were an air temperature of 83°F, relative humidity of 26% and there was no air movement. Wheat was at the two node stage and was 19 inches tall. Mayweed chamomile was four inches tall at the time of application and at a density of 13 plants per square foot.

No crop injury was observed among all treatments evaluated. At the June 30th rating, 35 and 22 days after the initial and second application, none of the treatments were providing commercially acceptable control. When the final rating was taken the wheat was approaching maturity and the mayweed chamomile was flowering. Even though mayweed chamomile plants could be seen within the plots, the lack of flowering was factored into the weed control rating. Supremacy at 6.0 oz/A and Starane® Flex at 13.5 fl oz/A provided 0.094 and 0.0878 lb ae fluroxypyr per acre, respectively. These two treatments did not provide commercially acceptable control of mayweed chamomile. The addition of Maestro® Advanced 12.8 fl oz/A to Supremacy at either 5 or 6 oz/A, at either application timing, significantly improved mayweed chamomile control. Maestro Advanced should be considered as a tank mix partner for Supremacy for mayweed chamomile control. Adding additional thifensulfuron and tribenuron from Audit® 1:1 to the various Supremacy tank mixtures did not improve mayweed chamomile control. Yield data was not collected within the trial area.

Treatment	Rate	Application Date	Mayweed chamomile control	
			6/30	7/14
	fl oz/A		-----%	
Nontreated Check	--	--	--	--
Supremacy + Maestro Advanced	6 oz + 12.8	6/7	66 a ¹	91 a
Supremacy + Maestro Advanced	6 oz + 16	6/7	64 ab	90 a
Supremacy + Maestro Advanced	6 oz + 12.8	5/26	62 ab	87 ab
Supremacy + Maestro Advanced	5 oz + 12.8	5/26	64 ab	86 a-c
Supremacy + Maestro Advanced + Audit 1:1	6 oz + 12.8 + 0.2 oz	6/7	50 a-c	85 a-c
Supremacy + Maestro Advanced + Audit 1:1	5 oz + 12.8 + 0.2 oz	6/7	60 a-c	82 a-c
ARY-0546-001 + Comet [®] + Maestro Advanced	0.3 oz + 8 + 12.8	6/7	50 a-c	82 a-c
Supremacy + Maestro Advanced + Audit 1:1	5 oz + 12.8 + 0.2 oz	5/26	47 a-c	74 a-c
Supremacy + Huskie [®]	6 oz + 11	6/7	42 bc	70 bc
Supremacy + Brox [®] 2EC	6 oz + 16	6/7	37 cd	70 bc
Supremacy + Rhonox [®] MCPA Ester	6 oz + 8.6	6/7	44 a-c	67 cd
Starane Flex	13.5	6/7	17 de	49 de
Supremacy + R-11 [®]	6 oz + 0.25% v/v	6/7	12 e	32 e

¹ Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Evaluation of Arysta experimental formulations for the control of common lambsquarters and mayweed chamomile in spring wheat

Henry Wetzel and Drew Lyon

A field study was conducted at the WSU Cook Agronomy Farm near Pullman, WA to generate post-emergence broadleaf weed control data with Arysta's experimental formulations including AL-X1581ad, AL-X1780aa and AL-X1795aa.

The soil at this site is a Palouse silt loam with 3.6% organic matter and a pH of 5.3. On April 19th, 'Diva' spring wheat was planted using a Horsch air drill with 12-inch row spacing. The post-emergence application took place on May 26th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 43 psi at 2.3 mph. Conditions were an air temperature of 64°F, relative humidity of 36% and the wind out of the W at 5 mph. Wheat was at the first detectable tiller stage and was 12 inches tall. Common lambsquarters was two inches tall at the time of application and at a density of 23 plants per square foot. Mayweed chamomile was 1.5 inches tall at the time of application and at a density of 5 plants per square foot.

No crop injury was observed among all treatments evaluated. In general, the experimental compounds had better activity on common lambsquarters than mayweed chamomile. AL-X1780aa tank mixed with either 2,4-D LV 6, Maestro[®] Advanced or Rhonox[®] MCPA, provided outstanding control of common lambsquarters when a rating was taken 32 DAT (June 27th). AL-X1581ad when tank mixed with Audit[®] 1:1 and WideMatch[®], provided outstanding control of common lambsquarters when a rating was taken 32 DAT (June 27th). AL-X1795aa was tested as a solo product at two rates and provided outstanding control of common lambsquarters when a rating was taken 32 DAT (June 27th). At the June 27th rating, 32 DAT, none of the treatments were providing commercially acceptable control of mayweed chamomile. When the final rating was taken, July 14th (49 DAT) the wheat was approaching maturity and the mayweed chamomile was flowering. Even though mayweed chamomile plants could be seen within the plots, the lack of flowering was factored into the weed control rating. At this time, only AL-X1581ad tank mixed with Audit 1:1 + WideMatch was providing excellent control of mayweed chamomile. PerfectMatch[™] and the tank mix of Everest[®] 2.0 plus Supremacy[®] also were providing excellent control of mayweed chamomile at the final rating evaluation. Yield data was not collected within the trial area.

Treatment	Rate fl oz/A	Common lambsquarters control		Mayweed chamomile control	
		6/10	6/27	6/27	7/14
		15 DAT	32 DAT	32 DAT	49 DAT
		-----%		-----%	
Nontreated Check	--	--	--	--	--
AL-X1780aa + 2,4-D LV 6 Ester ¹	16.8 + 8.7	87 a ²	99 a	34 a	75 ab
AL-X1780aa + Rhonox [®] MCPA Ester	16.8 + 13	87 a	97 a	22 a	72 a-c
AL-X1795aa	15.8	85 ab	97 a	25 a	64 a-c
AL-X1795aa	19	85 ab	96 a	45 a	61 bc
AL-X1581ad + Audit 1:1 + WideMatch	2 + 0.4 oz + 16	81 a-c	95 a	60 a	94 a
AL-X1780aa + Maestro Advanced	16.8 + 16	85 ab	89 ab	40 a	55 b-d
Everest 2.0 + Supremacy	1 + 5 oz	77 a-d	85 a-c	52 a	81 ab
PerfectMatch [™]	16	75 b-d	74 b-d	42 a	94 a
AL-X1581ad + ARY-0546-001 + Metsulfuron + Comet [®]	2 + 0.285 oz + 0.0357 oz + 8	79 a-d	74 b-d	27 a	27 d
AL-X1581ad + ARY-0546-001 + Comet	2 + 0.285 oz + 8	75 b-d	71 cd	27 a	49 cd
AL-X1780aa	14	71 c-e	69 cd	22 a	57 b-d
AL-X1780aa	16.8	70 de	67 de	25 a	56 b-d
GoldSky [®]	16	62 e	60 de	30 a	75 ab
Huskie [®] Complete	2.27	69 de	51 e	30 a	75 ab

¹ All treatments were tank mixed with NIS at 0.25% v/v and AMS at 1.0 lb/A.

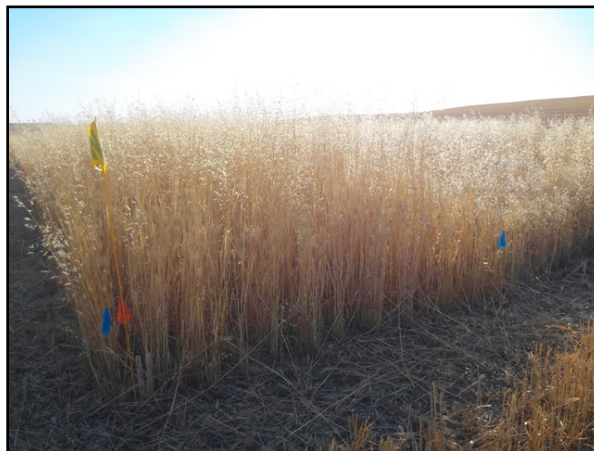
² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Evaluation of AL-X1581ad for the control of wild oats in spring wheat

Henry Wetzel, Derek Appel and Drew Lyon

A field study was conducted at Duane Oehlwein's Farm near Davenport, WA to generate wild oat control data with Arysta's experimental formulation AL-X1581ad.

The soil at this site is a silt loam with 3.1% organic matter and a pH of 6.7. The seedbed was conventionally prepared and received 75:8:10 lb/A of nitrogen:phosphorus:sulfur. On April 20th, 'Diva' spring wheat was planted (65 lb/A) to a depth of 1.5 in. using a disc drill with 7.5-inch row spacing. The post-emergence application took place on May 20th. with a CO₂-powered backpack sprayer set to deliver 10 gpa at 25 psi at 3 mph. Conditions were an air temperature of 59°F, relative humidity of 46% and the wind out of the NE at 5 mph. Wheat was at the third detectable tiller stage and was 6 inches tall. Wild oats were four inches tall at the time of application and at a density of 2 plants per square foot.



No crop injury was seen with any treatments in this trial. Within this trial, the wild oat distribution was so uniform and heavy, and in the absence of an herbicide treatment, yield was significantly reduced. There were no significant differences among herbicide treatments at any of the evaluation dates. The level of wild oat control with AL-X1581ad was comparable to the two commercial standards, Everest[®] 2.0 and Varro[®]. There was not a rate response for wild oat control with AL-X1581ad. The addition of Audit[®] 1:1 to AL-X1581ad did not significantly improve its efficacy.

Treatment	Rate	Wild oat control			Yield	Test weight
		6/16	6/29	7/16		
		27 DAT	40 DAT	57 DAT		
	fl oz/A	-----%-----			bu/A	lb/bu
Nontreated check		--	--	--	34 b	62 a
Everest 2.0 ¹	0.75	55 a ²	69 a	70 a	50 a	60 a
AL-X1581ad	1.5	72 a	74 a	75 a	50 a	60 a
AL-X1581ad + Audit 1:1	1.5 + 0.4 oz	55 a	75 a	79 a	53 a	60 a
AL-X1581ad	2	66 a	76 a	81 a	59 a	61 a
AL-X1581ad + Audit 1:1	2 + 0.4 oz	71 a	85 a	89 a	60 a	62 a
Varro	6.85	69 a	80 a	84 a	57 a	62 a

¹ All treatments were tank mixed with NIS at 0.25% v/v and AMS at 1.0 lb/A.

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Volunteer buckwheat control in irrigated spring wheat

Mark Thorne, Drew Lyon and Tim Waters

Buckwheat seed contamination in wheat is a concern for exports to Asia because it is considered an allergen risk in some countries, similar to the allergen risk of peanuts in the United States (NRCS bulletin, NB 190-16-8 ECS). Buckwheat is double-cropped or planted as a cover crop in the Columbia Basin irrigated agricultural region. It is normally planted in early summer following harvest of the



previous crop and then harvested later in autumn. Buckwheat seed lost at harvest or plowed under with the cover crop can persist in the soil seedbank and become a weed in spring wheat grown the following year contaminating the harvested grain. We conducted a field trial to evaluate postemergence herbicide applications at two different stages of spring wheat growth on the eventual number of volunteer buckwheat seed contaminating harvested spring wheat grain.

The field site was located in Pasco, WA on land being farmed by WSU Franklin County Extension for agricultural research. During November 2015, a 150-foot² area was broadcast seeded with commercial buckwheat seed to simulate buckwheat crop harvest seed rain. The area was then disk-harrowed, irrigated, and seeded to a wheat cover crop. The site was sprayed with glyphosate in early February 2016 to kill the cover crop. On February 25, 2016, a dry granular fertilizer was spread over the plot site and the site was disk-harrowed 4 inches deep to break up the sod and incorporate the fertilizer. Buckwheat seed was re-broadcasted over the plot site and the site was disk-harrowed a second time and packed with a roller pulled behind the harrow. The field was seeded to 'Expresso' hard-red spring wheat at 160 lb/A using a 42-inch wide double disk drill with 6 openers on 6-inch spacing. Soil temperature averaged 40° F in the top 6 inches. Each plot consisted of 3 drill passes wide by 25 feet long; however, only the center drill pass was used for evaluation. The field site was sprinkler irrigated starting in April and received one application of a pyrethroid insecticide in April to control a cereal leaf beetle infestation.

Early postemergence herbicide treatments were applied on April 11 when the majority of the spring wheat had 4-5 leaves and the canopy was 4-9 inches in height. Volunteer buckwheat plants had 3 leaves and were 2-6 inches tall. Buckwheat density was variable and averaged 1-6

plants m⁻². The early treatments were broadcast applied with a CO₂ pressurized backpack sprayer and 10-foot spray boom at 3 mph. Application rate was 15 gal/A at 30 psi. Late postemergence herbicide treatments were applied with a tractor-pulled applicator that simulated center-pivot chemigation. The treatments were applied on April 29 when the majority of spring wheat was in the boot stage with a flag leaf showing. Volunteer buckwheat in the cotyledon stage was present in all plots but flowering plants were present only in plots with no early herbicide application. Herbicides were metered into a stream of water on the applicator and into an 11.7-foot spray boom with HH Fulljet nozzles. Volume output was 2700 gal/A at 66 psi moving 1 mph to simulate a 0.1-inch irrigation rate.

Herbicide efficacy was evaluated visually on April 26, two weeks following early treatments, and included buckwheat control and crop herbicide injury and the number of flowering buckwheat plants per plot. These evaluations were repeated on May 11, two weeks following late treatments and four weeks following the early treatment, and repeated again on June 23, one week prior to harvest. Plots were harvested on June 30 with a Kincaid plot combine and the grain was bagged individually from each 3.5 by 25-foot center drill pass per plot. The grain samples were cleaned with a Clipper seed cleaner, evaluated for moisture content with a Foss grain analyzer, and then hand-screened to determine number of buckwheat seeds in each sample. Crop yield was converted to bu/A and reported on a 12% moisture basis.

Both Huskie[®] and GoldSky[®] applied as an early postemergence treatment controlled volunteer buckwheat plants that established early with the crop (Table 1). Densities were not different from zero and were less than non-treated plots; however, Huskie was visually more effective than GoldSky at the April 29 evaluation as GoldSky treated plants were slower to show injury with some green stems and leaves remaining. By May 11, two weeks following the chemigation treatments, control of buckwheat was not different from zero with all treatments except Huskie/Brox[®] 2EC (early/late), None/Brox 2EC, and None/None (Table 1). Furthermore, densities in plots only treated late with Maestro[®] Advanced or Starane[®] NXT had near to complete control.

Episodic periods of drought between watering up until the May 11 evaluation reduced buckwheat density in the non-treated check and likely affected density and germination in all plots. Irrigation following May 11 was more frequent and densities of flowering buckwheat plant increased in all plots by the June 23 pre-harvest evaluation (Table 2). The only exception was with None/Brox 2EC. The chemigation application of Brox 2EC initially controlled most of the pre-existing buckwheat but poorly controlled (15%) all other weeds present, including Russian thistle, common lambsquarters, kochia, and tumble mustard. Competition from these weeds likely kept the buckwheat density low (1.1 plants/plot) until harvest. GoldSky/None also gave poor control (31%) of the other weeds, but the early GoldSky application likely controlled some of the other weeds, which opened a window for buckwheat to re-establish by harvest.

At harvest, volunteer buckwheat densities were greatest in plots treated with Huskie/Brox 2EC, Huskie/None, GoldSky/Brox 2EC, GoldSky/None, and None/None (Table 2). The early postemergence treatments by themselves were not able to provide season-long control, and Brox 2EC was not effective in controlling later emerging buckwheat. Late postemergence treatments

by themselves did not completely control the other weeds present, but competition from these weeds may have helped to reduced buckwheat presence up until harvest. Disregarding these late-only treatments, combinations of early applied Huskie or GoldSky with late applications of Maestro Advanced or Starane NXT yielded the fewest flowering plants with Maestro Advanced providing more consistent control than Starane NXT. Fewer flowering buckwheat plants per plot also translated into fewer buckwheat seeds per harvest sample ($r=0.71$; $p\leq 0.0001$). Maestro Advanced was most consistent in preventing grain contamination, averaging less than one buckwheat seed per sample in each of the three treatments where it was applied (Table 2). Only the None/Maestro Advanced treatment yielded 0% contamination, but this may have been in part due to competition by the other weeds where no early weed control treatment was applied.

Wheat yields were variable across the plots with averages ranging between 49 and 71 bu/A (Table 2); however, differences between treatments were not significant at $p\leq 0.05$. Variability was likely due to periods of drought early in the crop growth cycle, as none of the herbicides caused any visually evident injury symptoms (data not shown).

Table 1. Density of flowering volunteer buckwheat plants, and visually-rated buckwheat control two weeks following early and late postemergence herbicide applications to irrigated spring wheat.¹

Trt	Herbicide applications per spring wheat stage		Buckwheat two weeks after early treatments ⁴		Buckwheat two weeks after late treatments ⁵	
	Early ² (spray)	Late ³ (Chemigation)	Flowering (plants/plot)	Control (%)	Flowering (plants/plot)	Control (%)
1	Huskie	Brox 2EC	0.3 b	98 a	1.0 c	96 a-c
2	Huskie	Maestro Advanced	0.0 b	98 a	0.0 d	100 a
3	Huskie	Starane NXT	1.0 b	96 a	0.5 d	96 a-c
4	Huskie	None	0.3 b	93 a	0.3 d	95 a-c
5	GoldSky	Brox 2EC	0.8 b	80 b	0.0 d	93 bc
6	GoldSky	Maestro Advanced	1.0 b	81 b	0.0 d	100 a
7	GoldSky	Starane NXT	0.0 b	80 b	0.0 d	96 a-c
8	GoldSky	None	0.0 b	81 b	0.0 d	87 c
9	None	Brox 2EC	12.7 a	0 -	1.5 b	85 c
10	None	Maestro Advanced	9.0 a	0 -	0.0 d	100 ab
11	None	Starane NXT	5.2 a	0 -	0.0 d	100 a
12	None	None	20.7 a	0 -	14.2 a	0 -

¹Means in each category followed by the same letter are not statistically significant at $p \leq 0.05$.

²Early herbicides were broadcast applied April 11 when spring wheat had 4-5 leaves. Huskie was applied at 13.5 oz/A with ammonium sulfate at 1 lb/A. GoldSky was applied at 16 oz/A with a non-ionic surfactant at 0.5% v/v.

³Late herbicides were applied through chemigation on April 29 when the spring wheat was at boot stage. Chemigation treatments were Brox 2EC at 32 oz/A, Maestro Advanced at 25.6 oz/A, and Starane NXT applied at 27.4 oz/A. Spray adjuvants were not added to the chemigation treatments.

⁴Early treatments were evaluated April 26, two weeks after applications and consisted of number of flowering buckwheat plants per plot and herbicide injury symptoms.

⁵Early and late treatments were evaluated on May 11, two weeks after chemigation and 4 weeks after early treatments.

Table 2. Harvest measurements of flowering buckwheat plant density, buckwheat seed in the harvest wheat sample, spring wheat yield, and control of weeds other than buckwheat.¹

Trt	Herbicide applications ² per spring wheat stage		Other Weed Control ³	Flowering Buckwheat Plants ⁴	Buckwheat Seeds ⁵	Wheat Yield ⁶
	Early	Late				
	(spray)	(Chemigation)	(%)	(plants/plot)	(seed/plot)	(bu/ac)
1	Huskie	Brox 2EC	93 ab	10.1 bc	51.4 ab	67 a
2	Huskie	Maestro Advanced	100 a	1.7 e-g	0.9 e	66 a
3	Huskie	Starane NXT	78 b	3.2 de	9.1 bc	53 a
4	Huskie	None	80 b	12.5 ab	7.2 b-d	71 a
5	GoldSky	Brox 2EC	77 b	6.2 b-d	6.4 cd	71 a
6	GoldSky	Maestro Advanced	91 ab	2.4 d-f	0.6 e	71 a
7	GoldSky	Starane NXT	91 ab	3.6 c-e	0.2 e	69 a
8	GoldSky	None	31 cd	12.2 b	19.9 a-c	65 a
9	None	Brox 2EC	15 d	1.1 e-g	0.5 e	49 a
10	None	Maestro Advanced	66 bc	0.7 fg	0.0 e	55 a
11	None	Starane NXT	67 bc	0.2 g	1.3 de	54 a
12	None	None	0 -	30.3 a	70.5 a	60 a

¹Means in each category followed by the same letter are not statistically significant at $p \leq 0.05$.

²See Table 1 for application rates.

³Herbicide efficacy in controlling weeds other than volunteer buckwheat was visually assessed June 23 and included Russian thistle, common lambsquarters, kochia, and tumble mustard.

⁴Flowering buckwheat plants were counted in each center drill pass per plot on June 23.

⁵Number of buckwheat seeds contaminating wheat harvested from each 3.5 by 25-ft plot. Means presented are estimated least squared means (LSMEANS) calculated by the GLIMMIX statistical procedure in SAS[®] statistical software.

⁶The center 3.5 by 25-foot drill pass of each plot was harvested for crop yield on June 30.

Evaluation of Palisade 2EC on Spring Wheat

ICB1016

Zuger, R.J. and I.C. Burke

Palisade 2EC (*trinexapac-ethyl*) is a plant growth regulator for grass species. Trinexapac-ethyl inhibits the formation of gibberellic acid preventing growth of the internodes of the plant leading to shorter plants and reduced risk of lodging (Nagelkrik 2012). Palisade 2EC is marketed by Syngenta.

Methods

The purpose of this study was to evaluate the effects a new formulation of Palisade 2EC at different application rates and timings on spring wheat. The study was established at the Spillman Agronomy Farm near Pullman, WA. Treatments were applied at two separate timings, Feekes 6 and Feekes 10, with one split application at both timings, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long.

Spring wheat stunting was visually rated 20, 36, and 56 (application A) days after treatment. Visual percent heading of spring wheat was rated 20 days after treatment of application timings A, Table 1. Plots were harvested using 5' header combine on August 30, 2016. Percent data were arcsine square-root transformed. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Spring wheat was significant stunting 20 days after application A compared to nontreated and both treatments of UAN (32 and 64 fl oz A⁻¹). Palisade 2EC applied at 0.114 lb ai A⁻¹ had the greatest percent stunting, 45%. Palisade applied at 0.081 lb ai A⁻¹ had significantly less stunting, 13%, than the higher rate of Palisade although similar stunting was observed with the split rate of Palisade 0.045 lb ai A⁻¹ (Table 2).

Percent spring wheat stunting 53 days after treatment for application A and 36 days after treatment for application B were similar for all treatments, less than 9%, except for Palisade 2 EC (0.114 lb ai A⁻¹) applied at Feekes 6 which had a significantly greater percent stunting, 35% (Table 2).

The percentage of spring wheat heading 17 days at treatment was significantly less for all applications including Palisade 2EC (0.045, 0.081, and 0.114 lb ai A⁻¹) at the Feekes 6 application timing. Palisade 2EC at a rate of 0.114 lb ai A⁻¹ (application A) had the least percent heading of 46%. Next was Palisade 2EC at a rate of 0.081 lb ai A⁻¹ (application A) with a percent heading of 82% and last was the split application of Palisade 2EC (0.045 lb ai A⁻¹, application A) with a percent heading of 91%. While all other treatments had percent headings of 100% 17 days after treatment.

Application timing and rate did not significantly effect on yield or test weight (Table 2).

Literature Cited

Nagelkrik M. 2012. The effect of Palisade 2EC plant growth regulator on the performance of soft winter wheat. Michigan State Extension, East Lansing, MI 4882

Table 1. Treatment application details

Study Application	A	B
Date	June 1, 2016	June 20, 2016
Application volume (GPA)	15	15
Crop Stage	Feekes 6	Feekes 10
Air temperature (°F)	66	76
Soil temperature (°F)	58	64
Wind velocity (mph, direction)	7, SW	7, SW
Cloud cover (%)	0	0

Table 2. Spring wheat percent heading, plant heights, and yield following applications of Palisade 2EC at different timings and rates. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		June 20, 2016	June 20, 2016	July 26, 2016	August 30, 2016	
		fl oz/A	lb ai/A	Stunting	Heading	Stunting	Yield	Test weight
				%	%	%	bu/A	lb/bu
Nontreated				-	-	-	59	60
Palisade 2 EC	A	5	0.081					
UAN	A	32		13 b	82 c	9 a	50	59
Palisade 2 EC	A	7	0.114					
UAN	A	64		45 a	46 d	35 b	48	59
UAN	A	32		0 c	100 a	3 a	54	60
UAN	A	64		0 c	100 a	0 a	56	59
Palisade 2 EC	B	5	0.081					
UAN	B	32		0 c	100 a	3 a	46	61
Palisade 2 EC	B	7	0.114					
UAN	B	64		0 c	100 a	0 a	51	60
Palisade 2 EC	A	2.75	0.045					
UAN	A	32		5 bc	91 b	6 a	46	60
Palisade 2 EC	B	2.75	0.045					

Management of Italian ryegrass in Spring Wheat with Pre-emergence Herbicides

ICB1116

Cook Agronomy Farm in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. The goal of this study was to evaluate the herbicide timing of pre-emergence herbicides at a later timing in spring wheat. The treatments of pre-emergence herbicides used were applied post emergence (POST) to 2 leaf spring wheat, detailed in Table 1. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Huskie (13.5 fl oz A⁻¹) and MCPA (8 fl oz A⁻¹) were applied for broadleaf weed control.

Crop injury was visually rated 15, 37 and 85 days after treatment (DAT) (Table 2). Italian ryegrass control was visually assessed 37 and 85 DAT (Table 2). Mayweed chamomile control was visually assessed 85 DAT (Table 2). Plots were harvested using a plot combine on August 30, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Crop injury 15 DAT was observed in all treatments compared to the nontreated control. Zidua at 2.68 oz/A had the least injury with 5% crop injury and Linex at 2.50 pt A⁻¹ had the greatest at 58% crop injury. At 37 DAT, significant crop injury was still present with most treatments. Fierce (1.50 oz A⁻¹), Zidua (2.68 oz A⁻¹), and Define at both rates (7.04 and 14.1 oz A⁻¹) were the only treatments with no significant crop injury compared to the nontreated control (Table 2). Crop injury lessened later into the growing season and by 85 DAT, significant crop injury was only observed for both rates of Linex (2.50 and 5.00 pt A⁻¹).

No significant differences in yield and test weight were observed between any of the treatments including the nontreated control.

All treatments had significant Italian ryegrass control 37 DAT with Zidua at 2.68 oz A⁻¹ provided the best control at 93% compared to the nontreated control of 0%. Linex at 2.50 pt A⁻¹ had the least Italian ryegrass control 37 DAT with 14% control. At 85 DAT all treatments, except Linex (2.50 pt A⁻¹), still provided significant control of the Italian ryegrass compared to the nontreated. Linex at 2.50 pt A⁻¹ had only 10% control and did not provided significant control compared to the nontreated (0%). Significant mayweed chamomile control was observed with all treatments except for both rates of Zidua and Define, compared to the nontreated control. V-10425 and Fierce had the greatest mayweed control at 91% and 88% control, respectively.

Table 1. Treatment application details

Study Application	A
Date	May 2, 2016
Application volume (GPA)	15
Crop Stage	2-leaf stage
Air temperature (°F)	76
Soil temperature (°F)	58
Wind velocity (mph, direction)	4, N
Next Rain Occurred On	May 15, 2016

Table 2. Percent crop injury and yield with pre-emergence herbicides applied to 2 leaf spring wheat. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		May 17, 2016	June 8, 2016	July 26, 2016	August 30, 2016	
				Crop Injury	Crop Injury	Crop Injury	Yield	Test weight
		lb ai/A		%	%	%	bu/A	lb/bu
Nontreated				0 a	0 a	0 a	47	62 a
Linex	A	2.50 pt/A	1.250	58 cd	44 cd	33 b	43	61 ab
Linex	A	5.00 pt/A	2.500	49 abcd	50 d	43 b	45	59 b
Valor SX	A	1.50 oz/A	0.048	13 abc	11 ab	4 a	49	61 ab
Valor SX	A	3.00 oz/A	0.096	29 abcd	21 abc	4 a	54	60 ab
Fierce	A	1.50 oz/A	0.071	13 abc	8 a	6 a	53	60 ab
V-10425	A	6.00 oz/A	0.071	53 bcd	25 abc	15 a	50	60 ab
Fierce	A	3.00 oz/A	0.143	33 abcd	34 bcd	8 a	52	60 ab
V-10425	A	12.0 oz/A	0.143	64 d	40 cd	16 a	47	58 b
Zidua	A	1.34 oz/A	0.071	22 abcd	15 ab	11 a	48	60 ab
Zidua	A	2.68 oz/A	0.142	5 ab	3 a	4 a	47	59 b
Define	A	7.04 oz/A	0.272	30 abcd	9 a	4 a	40	60 ab
Define	A	14.1 oz/A	0.544	20 abcd	4 a	8 a	50	59 ab

Table 3. Percent Italian ryegrass control and mayweed chamomile control with pre-emergence herbicides applied to 2 leaf spring wheat. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		June 6, 2016	July 26, 2016	July 26, 2016
				Italian ryegrass control	Italian ryegrass control	Mayweed chamomile control
		lb ai/A		%	%	%
Nontreated				0 a	0 a	0 a
Linex	A	2.50 pt/A	1.250	14 b	10 a	48 b
Linex	A	5.00 pt/A	2.500	68 c	61 b	76 c
Valor SX	A	1.50 oz/A	0.048	70 c	69 b	85 c
Valor SX	A	3.00 oz/A	0.096	71 c	64 b	83 c
Fierce	A	1.50 oz/A	0.071	71 c	63 b	78 c
V-10425	A	6.00 oz/A	0.071	79 cd	75 b	79 c
Fierce	A	3.00 oz/A	0.143	76 cd	68 b	88 c
V-10425	A	12.0 oz/A	0.143	87 cd	76 b	91 c
Zidua	A	1.34 oz/A	0.071	68 c	63 b	0 a
Zidua	A	2.68 oz/A	0.142	93 d	84 b	0 a
Define	A	7.04 oz/A	0.272	79 cd	65 b	0 a
Define	A	14.1 oz/A	0.544	84 cd	75 b	0 a

Comparison of BD1 and Roundup PowerMax® formulations of glyphosate for control of Russian-thistle

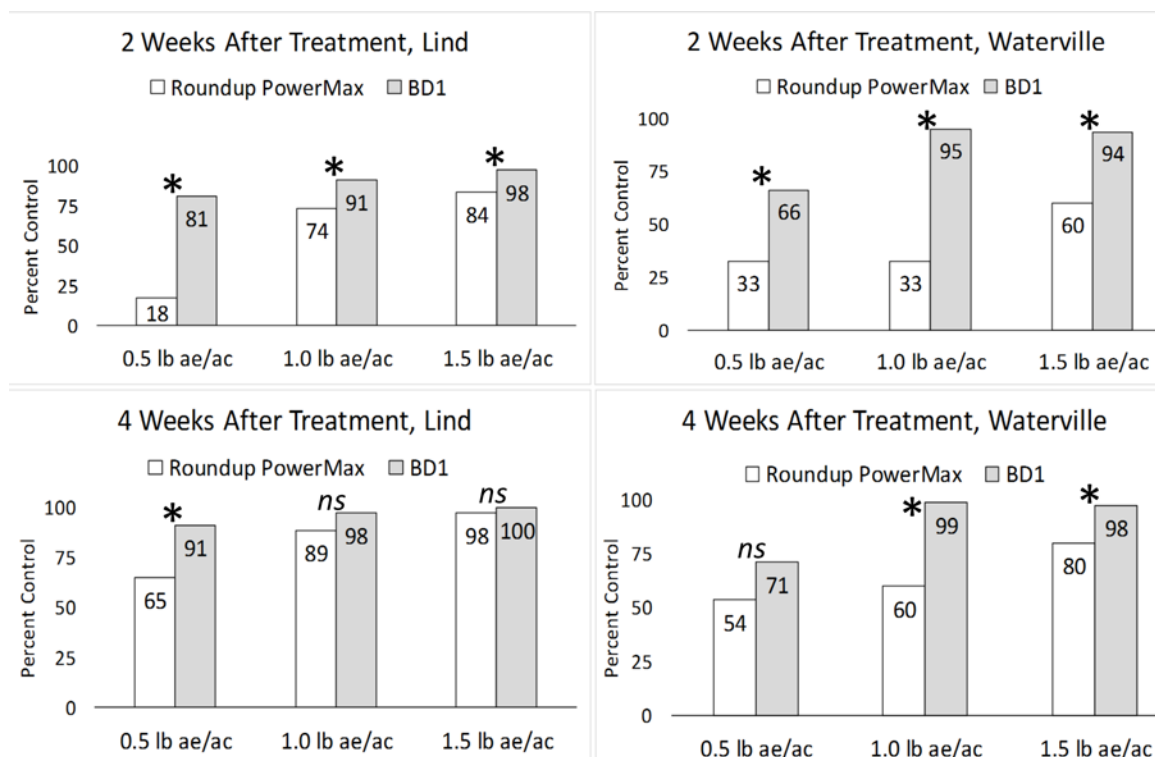
John Spring, Henry Wetzel and Drew Lyon

Field studies were conducted at the WSU Lind Dryland Research Station near Lind, WA, and near Waterville, WA to compare the performance of the experimental glyphosate formulation BD1 (Two Rivers Terminal, LLC) to equivalent rates of Roundup PowerMax (Monsanto Corp.) for control of Russian-thistle. Rates tested were 0.5, 1.0, and 1.5 lb acid equivalent per acre of each formulation.



The soil at the Lind site is a silt loam with 1.3% organic matter and a pH of 5.8. At the Lind site, applications were made to a heavy population of Russian-thistle in conventionally tilled fallow on June 1, 2016 using a CO₂-powered backpack sprayer calibrated to deliver 10 gpa at 44 psi through Teejet 11002XR flat fan nozzles at 2.3 mph. Plants were approximately 2-3 inches in height and 3-6 inches in diameter at this time. Applications were made from approximately 12:00 to 12:30 pm with an air temperature of 85 F, soil temperature of 64 F at 4 to 6 inches, relative humidity of 23%, and wind out of the SW at 4 to 6 mph. At the Waterville site, applications were made to a moderately dense population of Russian-thistle in chemical fallow on June 29, 2016 using a CO₂-powered backpack sprayer calibrated to deliver 10 gpa at 22psi through Teejet 11002 Turbo Teejet nozzles at 3.0 mph. Plants were 3-5 inches in both height and diameter at this time. Applications were made from 2:00 to 3:00 pm, with air temperature 94 F, soil 67 F at 4-6 inches, 20% relative humidity, and wind 2 to 6 mph.

At both sites, control was rated on a scale from 0% (no damage) to 100% (complete plant death) at 2 and 4 weeks after treatment. Plants treated with BD1 showed herbicide symptomology more quickly than those treated with Roundup PowerMax, with BD1 providing significantly higher control at 2 weeks after treatment at all rates at both sites. At 4 weeks after treatment, the difference between the level of control provided by the two formulations was less, but still present in many cases. At Lind, performance of BD1 was statistically indistinguishable from that of Roundup PowerMax for the higher rates. At the Waterville site, however, control from BD1 was significantly higher than that from Roundup PowerMax for the higher rates. Overall, BD1 performed at least as well as PowerMax for control of Russian-thistle at the rates tested, and often gave better control. Activity was much faster with BD1.



Rates/timings where the percent control from BD1 is statistically different from [higher], than that from Roundup PowerMax are marked with *. Rates/timings where differences are not statistically significant are marked *ns*. Significance testing performed using Welch's t-tests within each rate/site/timing combination with $\alpha=0.05$.

Confirmation of glyphosate resistant Russian-thistle in Washington State

John Spring and Drew Lyon

Field studies were conducted at the WSU Lind Dryland Research Station near Lind, WA, and at the WSU/ARS Palouse Conservation Field Station near Pullman, WA to quantify the magnitude of glyphosate resistance in a suspected resistant population of Russian-thistle collected in Columbia County, Washington.

Seeds of the suspected resistant population were collected from plants that had survived an application of glyphosate in a chemical fallow field in 2015. Seed from a population of Russian-thistle known to be susceptible to glyphosate were collected at a separate site in Washington in 2014. Seed of both types were started in a greenhouse in June 2016, and transplanted to field plots at 2 weeks after emergence. At 3 weeks after transplanting, glyphosate was applied at five rates (0, 16, 32, 64, and 128 fl oz /A of GlyStar® Original, plus 0.5% v/v NIS and 12 lb/100 gal AMS) using a CO₂ powered backpack sprayer calibrated to deliver 15 gpa at 20 psi through Teejet TurboTee 110015 nozzles. Plants were approximately 4" in height and diameter at the time of application. Applications were made at the Lind site on July 14th with an air temperature of 78 F, soil temperature of 70 F at 4 to 6 inches, and 28% relative humidity. Applications were made at the Pullman site on July 19th with an air temperature of 78 F, soil temperature of 68 F at 4 to 6 inches, and relative humidity of 35%. Percent control was estimated visually at 4 weeks after treatment on a scale of 0 (no control/injury) to 100 (complete plant death).

Resistance to glyphosate was confirmed in the suspected resistant population. Although resistance to typical field rates of glyphosate was present at both Lind and Pullman, the degree of resistance varied between sites. At Lind, hot, stressful conditions reduced the performance of glyphosate on the susceptible plants (with 32 fl oz/A providing only 72% control), however, the resistant plants survived 128 fl oz/A of glyphosate with only 60% control, clearly demonstrating a high level of resistance to glyphosate both relative to the susceptible check and in an absolute sense. At Pullman, susceptible thistle was completely controlled by all rates of glyphosate tested. The resistant population survived an application of 32 fl oz/A with only 50% control, but was well controlled by the time rates reached 64 fl oz/A. The resistant population was highly resistant to glyphosate relative to the susceptible check here as well, and survived a reasonable field use rate of glyphosate (0.75 lb ae/A). Overall, the resistant population exhibited approximately 4- to 8-fold resistance to glyphosate relative to the susceptible check, and would pose a major management challenge in a field setting.

The effect of temperature on the expression of glyphosate resistance (with higher temperatures resulting in much higher levels of resistance) that was seen in these trials has also been documented for several other weed species from around the world. This is important to keep in mind when managing potential glyphosate resistance in Russian-thistle. Under relatively cool conditions, the expression of resistance may be much lower, making detection and monitoring of resistant populations more complicated.

Percent control ratings at 4 weeks after application.

Rate (fl oz/A)	Lind		Pullman	
	Susceptible	Resistant	Susceptible	Resistant
0	0	0	0	0
16	34	0	100	20
32	72	4	100	50
64	100	21	100	94
128	100	61	100	100

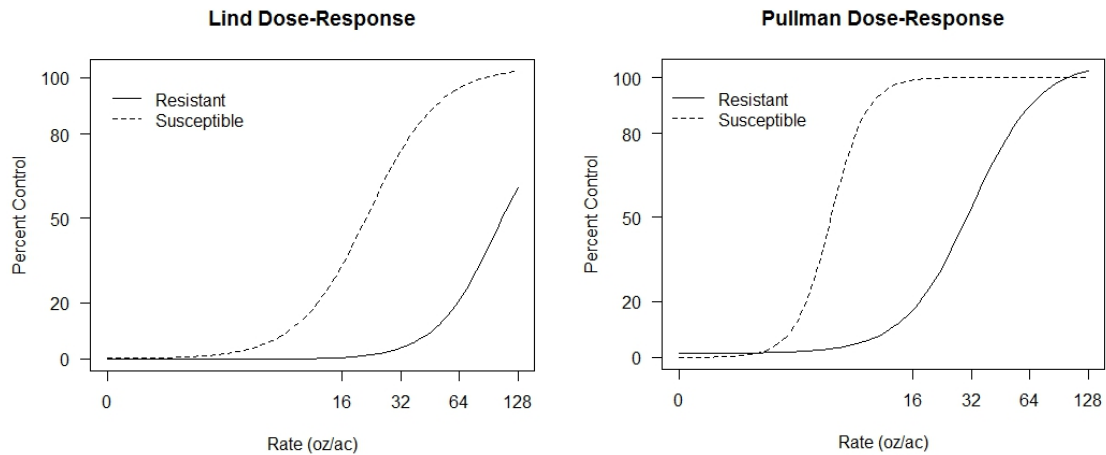
Resistant plants surviving 128 fl oz/A rate of glyphosate at Lind, 4 weeks after application.



Resistant plants surviving 32 fl oz/A rate of glyphosate at Pullman, 4 weeks after application.



Estimated dose-response curves for resistant and susceptible Russian-thistle populations at Lind and Pullman sites.



Smooth scouringrush control with fallow-applied herbicides in a winter wheat/spring wheat/fallow rotation

Mark Thorne, Derek Appel, Henry Wetzel and Drew Lyon

In 2015, we repeated a 2014 field trial evaluating herbicide control of smooth scouringrush in a no-till winter wheat/spring wheat/fallow cropping system. Smooth scouringrush is a deep-rooted native rhizomatous perennial that is becoming more prevalent in no-till/direct-seed cropping systems in eastern Washington. Current herbicide strategies for in-crop and fallow weed management have failed to reduce or control scouringrush, consequently, patches like the one pictured here near Pullman, WA are persisting.



Our study site was located in the intermediate rainfall zone of eastern Washington near Reardan, WA on land owned by the Spokane Hutterian Brethren. Plots were initially established July 24, 2014 in chemical fallow prior to winter wheat seeding. The trial consisted of two identical sets of plots. Plots on the right side of the trial had experimental herbicide applications only in 2014 and received a blanket chemical fallow treatment in 2015 similar to that used by the cooperating grower. Plots of the left side had experimental applications in both 2014 and 2015 (Table 1).

The field site was 300 feet upslope from a grass waterway with a gentle northwest slope. Soil type was an Athena silt loam with pH of 4.9 and 3.3% organic matter in the 0-6 inch depth. Herbicides were applied with a CO₂ backpack sprayer and eight-foot spray boom. All spray solutions were applied at 15 gal/A with 30 psi traveling 3.5 mph. The 2014 treatments were applied on July 25 with 70°F air temperature, 36% relative humidity, and a 6 mph wind out of the SW. In 2015, treatments were applied on August 10 with 84°F air temperature, 30% relative humidity and a 1-3 mph wind out of the N. Whetstone hard red winter wheat was seeded on September 10, 2014 at the rate of 60 lb/acre. The field was fertilized with 85-10-15 lb N-P-S per acre at the time of planting. On April 21, 'Glee' hard red spring wheat was seeded at a rate of 80 lb/A and fertilized with 100-40-30-0.8-0.6 lb N-P-S-B-Zn per acre. In both years wheat was seeded with a Bourgault 3710 disc drill on a 10-inch row spacing, and harvested with a Kincaid plot combine.

Winter wheat yield in 2015 averaged 72 bu/A, and spring wheat yield in 2016 averaged 55 bu/A; however, differences were not found between any of the treatments in either year (data not shown). This may have been due to the competitiveness of the winter wheat in 2015, and stand variability of the spring wheat in 2016; however, scouringrush density at this site may not have been sufficient to reduce wheat yield.

Herbicide efficacy was evaluated both visually and by measuring scouringrush stem density in each plot. Visual ratings were approximately 15 days (15 DAT) and 30 days (30 DAT) after herbicide applications and were based on the degree of herbicide injury to scouringrush stems as a percentage of the non-treated check plots. In 2014, ratings were on August 8 and 20; in 2015, plots were rated on August 28 and September 9. Scouringrush stem densities were counted in and between two 1-meter lengths of wheat rows in May and August of 2015 and 2016. Counts in 2015 evaluated the 2014 herbicide applications. Counts in 2016 evaluated the cumulative effect of the 2014 and 2015 applications to the left-side plots and evaluated the right-side plots two years following the 2014 applications.

Visual control ratings were generally higher for treatments that included MCPA ester; however, in 2014 MCPA ester with either clopyralid or chlorsulfuron showed the greatest control at both 15 DAT and 30 DAT (Table 2). Visually, MCPA ester was impressive as it turned the stems black soon after application (personal observation). In 2015, chlorsulfuron + MCPA ester at 30 DAT had the highest control but was not different from glyphosate + glufosinate or MCPA ester alone. Glyphosate + glufosinate was one of chemical fallow treatments used by the cooperating grower at this field site. Glyphosate by itself, a commonly applied chemical fallow herbicide, or with saflufenacil, showed very little control in either year. Furthermore, very little injury was observed from either 2,4-D LV6 or quinclorac (Table 2).

Herbicide efficacy based on scouringrush stem density differed considerably from the level of control observed with the visual ratings. Stem density was reduced substantially by chlorsulfuron + MCPA ester in relation to the non-treated plots following the 2014 application. Densities averaged 4.5 and 0.2 stems per 2 linear meters of row in the right and left sides, respectively (Table 3). In contrast, densities in the non-treated plots averaged 85.2 and 61.1 stems in the right and left sides, respectively. However, on the right-side where chlorsulfuron + MCPA ester was only applied in 2014, scouringrush density increased to 31.6 by August 2016. In contrast, scouringrush density on the left side remained low (1.2 stems/2 linear meters of row) through the August 2016 census. In this trial, no other herbicides consistently reduced stem density. Even after causing substantial visual injury, stem densities following MCPA ester applications were not different from the non-treated check at any census date on either the right or left side (Table 3). By the August 2016 census, only chlorsulfuron + MCPA ester had kept stem densities low.

This study found that herbicide control of smooth scouringrush was only achieved and maintained by application of chlorsulfuron + MCPA ester in both years. Given that MCPA ester by itself had no effect on stand density, it is highly probable that chlorsulfuron alone was effective. Standard chemical fallow treatments, including those with glyphosate, are not effective in controlling smooth scouringrush, even when they cause injury to the stems following application.

Table 1. Herbicides applied to chemical fallow in 2014 and 2015 for control of smooth scouringrush. Experimental treatments were applied to both sides in 2014 and only left-side plots in 2015. In 2015, right-side plots were treated with a blanket chemical fallow treatment.

Num	Treatment	Rate	Applications per side	
			2014	2015
1	non-treated	none	left and right	left only
2	2,4-D LV6	1.0 lb ae/A	left and right	left only
	non-ionic surfactant (NIS)	0.334 % v/v		
3	MCPA ester	1.0 lb ae/A	left and right	left only
	NIS	0.334 % v/v		
4	clopyralid	0.12 lb ae/A	left and right	left only
	MCPA ester	0.69 lb ae/A		
	NIS	0.334 % v/v		
5	chlorsulfuron	0.0234 lb ai/A	left and right	left only
	MCPA ester	1.0 lb ae/A		
	NIS	0.334 % v/v		
6	halosulfuron	0.0623 lb ai/A	left and right	left only
	MCPA ester	1.0 lb ae/A		
	NIS	0.334 % v/v		
7	glyphosate	1.13 lb ae/A	left and right	left only
	NIS	0.334 % v/v		
	ammonium sulfate (AMS)	3.13 lb/A		
8	glyphosate	1.13 lb ae/A	left and right	left only
	saflufenacil	0.089 lb ai/A		
	crop oil concentrate (COC)	1 % v/v		
	AMS	3.13 lb/A		
9	fluroxypyr	0.245 lb ae/A	left and right	left only
	NIS	0.334 % v/v		
10	quinclorac	0.248 lb ae/A	left and right	left only
	modified vegetable oil (MSO)	32 oz/A		
	AMS	3.13 lb/A		
11	glyphosate	0.75 lb ae/A	left and right	left only
	glufosinate	0.55 lb ai/A		
	NIS	0.334 % v/v		
	AMS	3.13 lb/A		
Blanket	glyphosate	2.0 lb ae/A		right only
	glufosinate	1.3 lb ai/A		
	AMS	1.0 lb/A		

Table 2. Scouringrush visual control following herbicide applications in chemical fallow in 2014 and 2015.

Treatment ¹	2014 ²		2015 ³	
	15 DAT	30 DAT	15 DAT	30 DAT
	-----injury as % of non-treated check) ⁴ -----			
non-treated	0 -	0 -	0 -	0 -
2,4-D LV6	35 de	39 ef	27 c	35 cd
MCPA ester	55 bc	55 cd	63 a	66 ab
clopyralid + MCPA ester	75 a	70 ab	42 bc	50 bc
chlorsulfuron + MCPA ester	77 a	79 a	42 bc	87 a
halosulfuron + MCPA ester	65 ab	67 bc	55 ab	60 bc
glyphosate	18 f	17 g	6 d	19 d
glyphosate + saflufenacil	15 f	10 g	7 d	34 cd
fluroxypyr	24 ef	29 f	31 c	32 cd
quinclorac	16 f	18 g	19 c	32 cd
glyphosate + glufosinate	42 cd	46 de	48 a-c	68 ab

¹See Table 1 for rates and adjuvants.

²Treatments applied July 25, 2014.

³Treatments applied August 10, 2015.

⁴Means in each column followed by the same letter are not different.

Table 3. Scouringrush stem counts in 2015 and 2016 following each previous year's applications.

Herbicide treatments ¹	Stem counts following ---- 2014 treatments ----		Stem counts following ---- 2015 treatments ----	
	May 2015	Aug 2015	May 2016	Aug 2016
--- (stem counts in and between 2 linear meters of row) ² ---				

Table 2a. Applications to right-side plots in 2014, then a blanket treatment in 2015

non-treated	85.2 a	73.5 a	52.6 a-d	93.3 a
2,4-D LV6	53.4 a-c	77.7 a	40.8 b-d	64.0 ab
MCPA ester	78.6 a-c	81.2 a	65.1 a-c	95.0 a
clopyralid + MCPA ester	80.5 ab	99.6 a	58.0 a-d	105.6 a
chlorsulfuron + MCPA ester	4.5 e	6.0 b	18.4 e	31.6 c
halosulfuron + MCPA ester	58.0 a-c	57.2 a	55.2 a-d	65.1 ab
glyphosate	43.0 cd	74.4 a	74.0 ab	85.1 ab
glyphosate + saflufenacil	43.9 b-d	70.5 a	32.6 de	64.3 ab
fluroxypyr	43.2 cd	72.3 a	57.0 a-d	65.6 ab
quinclorac	24.1 d	63.9 a	39.2 cd	48.1 bc
glyphosate + glufosinate	85.6 a	95.6 a	86.2 a	103.8 a

Table 2b. Applications to left-side plots in 2014 and repeated in 2015

non-treated	61.1 a	74.2 a	50.6 a	60.7 a
2,4-D LV6	32.5 a	46.2 a-d	22.8 cd	40.5 ab
MCPA ester	44.7 a	64.2 ab	30.1 a-d	44.1 ab
clopyralid + MCPA ester	38.0 a	65.5 ab	34.3 a-c	41.1 ab
chlorsulfuron + MCPA ester	0.2 c	0.7 e	0.2 e	1.2 c
halosulfuron + MCPA ester	35.1 a	52.5 a-c	28.1 b-d	42.4 ab
glyphosate	12.5 b	34.2 cd	23.5 cd	50.9 ab
glyphosate + saflufenacil	36.3 a	43.0 b-d	31.8 a-c	37.4 b
fluroxypyr	60.5 a	68.7 ab	31.5 a-c	44.8 ab
quinclorac	44.0 a	55.7 a-c	47.9 ab	50.0 ab
glyphosate + glufosinate	31.4 a	28.1 d	17.6 d	42.3 ab

¹See Table 1 for rates and adjuvants.

²Means in each column within each side followed by the same letter are not different.

Indaziflam for Downy Brome and Ventenata Management

ICB0116

Smoot Hill near Pullman, WA

Koby, L.E. & I.C. Burke

Methods

The study was established at Smoot Hill near Pullman, WA. The goal of the study was to evaluate indaziflam for control of annual grasses (downy brome, *Bromus tectorum* and *Ventenata dubia*) and annual broadleaves (mustards, *Brassica* spp. and prickly lettuce, *Lactuca serriola*) in the Palouse prairie. Treatments were applied in the winter prior to perennial grasses breaking dormancy (PRE) as a broadcast foliar application, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10 ft by 30 ft long.

Weed control was visually assessed 98, 137 and 253 days after treatment (DAT) (Table 2). All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Indaziflam applied at any application rate or formulation provided significantly greater annual grass and broadleaf weed control compared to the nontreated control. Significant differences between treated plots and the non-treated control became more defined over time from the initial treatment until the final assessment 253 DAT. Greater control of downy brome and ventenata as well as broadleaf species was observed in the later assessments conducted in August and November when compared to the assessment conducted in June. Tables 2, 3 and 4. The observed pattern was a reduction in the density of population downy brome and ventenata amongst native perennial grasses.

Table 1. Treatment application details

Study Application	A
Date	Feb 25, 2016
Application volume (GPA)	15
Air temperature (°F)	54
Soil temperature (°F)	40
Wind velocity (mph, direction)	5, E

Table 2. Percent weed control of various species following application of indaziflam at different application rates and formulations. Ratings taken June 2, 2016. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate	June 2, 2016			
			Ventenata Control	Brome Control	Mustard Control	P. Lettuce Control
		lb ai/A	%	%	%	%
Nontreated	-	-	0 a	0 a	0 a	0 a
Esplanade	A	5 fl oz/A				
Roundup WeatherMax	A	12 fl oz/A	73 b	85 b	45 ab	51 bc
Induce (NIS)	A	0.25% v/v				
Esplanade	A	7 fl oz/A				
Roundup WeatherMax	A	12 fl oz/A	96 c	98 b	91 b	83 b
Induce (NIS)	A	0.25% v/v				
Rezilon	A	3 oz/A				
Induce (NIS)	A	0.25% v/v	100 c	89 b	65 b	38 ab
Rezilon	A	4 oz/A				
Induce (NIS)	A	0.25% v/v	100 c	91 b	66 b	28 ab
Indaziflam+Rimsulfuron	A	4.5 oz/A				
Induce (NIS)	A	0.25% v/v	100 c	92 b	58 b	46 bc
Indaziflam+Rimsulfuron	A	6 oz/A				
Induce (NIS)	A	0.25% v/v	100 c	94 b	90 b	61 bc
Plateau 2L	A	7 fl oz/A				
Induce (NIS)	A	0.25% v/v	100 c	85 b	91 b	30 ab
Plateau 2L	A	12 fl oz/A				
Induce (NIS)	A	0.25% v/v	54 d	79 b	0 a	0 a

Table 3. Percent weed control of various species following application of indaziflam at different application rates and formulations. Ratings taken August 19, 2016. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate	Aug. 19, 2016				
			Ventenata Control	Brome Control	Mustard Control	P. Lettuce Control	Medusa Head Control
		lb ai/A	%	%	%	%	%
Nontreated	-	-	0 a	0 a	0 a	0 a	0 a
Esplanade	A	5 fl oz/A					
Roundup WeatherMax	A	12 fl oz/A	72 b	97 b	100 b	97 b	99 b
Induce	A	0.25% v/v					
Esplanade	A	7 fl oz/A					
Roundup-WeatherMax	A	12 fl oz/A	99 b	99 b	100 b	95 b	100 b
Induce (NIS)	A	0.25% v/v					
Rezilon	A	3 oz/A	99 b	99 b	100 b	93 b	100 b
Induce (NIS)	A	0.25% v/v					
Rezilon	A	4 oz/A	75 b	98 b	100 b	94 b	100 b
Induce (NIS)	A	0.25% v/v					
Indazaflam+Rimsulfuron	A	4.5 oz/A	96 b	100 b	100 b	94 b	95 b
Induce	A	0.25% v/v					
Indazaflam+Rimsulfuron	A	6 oz/A	96 b	100 b	100 b	88 b	100 b
Induce	A	0.25% v/v					
Plateau 2L	A	7 fl oz/A	97 b	100 b	100 b	85 b	100 b
Induce	A	0.25% v/v					
Plateau 2L	A	12 fl oz/A	97 b	100 b	100 b	92 b	100 b
Induce	A	0.25% v/v					

Table 4. Percent weed control of various species following application of indaziflam at different application rates and formulations. Ratings taken November 22, 2016. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		Nov. 22, 2016				
				Ventenata Control	Brome Control	Mustard Control	P. Lettuce Control	Medusa Head Control
			<i>lb ai/A</i>	%	%	%	%	%
Nontreated	-	-	-	0 a	0 a	0 a	0 a	0 a
Esplanade	A	5 fl oz/A	0.06					
Roundup WeatherMax	A	12 fl oz/A	5					
Induce	A	0.25% v/v	0.42	97 b	99 b	100 b	96 b	100 b
			0					
Esplanade	A	7 fl oz/A	0.09					
Roundup WeatherMax	A	12 fl oz/A	1					
Induce	A	0.25% v/v	0.42	100 b	100 b	100 b	87 b	100 b
			0					
Rezilon	A	3 oz/A	0.04					
Induce	A	0.25% v/v	7	100 b	100 b	100 b	92 b	100 b
Rezilon	A	4 oz/A	0.06					
Induce	A	0.25% v/v	25	98 b	100 b	100 b	90 b	100 b
Indazaflam+Rimsulfuron	A	4.5 oz/A	0.11					
Induce	A	0.25% v/v	8	100 b	100 b	100 b	96 b	98 b
Indazaflam+Rimsulfuron	A	6 oz/A	0.15					
Induce	A	0.25% v/v	7	100 b	100 b	100 b	94 b	100 b
Plateau 2L	A	7 fl oz/A	0.10					
Induce	A	0.25% v/v	9	100 b	100 b	100 b	87 b	100 b
Plateau 2L	A	12 fl oz/A	0.42					
Induce	A	0.25% v/v	0	96 b	99 b	100 b	98 b	100 b

Linuron (Linex) for Broadleaf Weed Control in Alfalfa

ICB0216

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Washington State University Research Farm near Othello, WA. Treatments were applied at three separate timings; pre-bud formation (application A), 5" tall crop stand before 1st cutting (application B), and split applications of Linex at 5" tall crop stand before 1st cutting and 6" tall crop stand after first cutting (application A & B), detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long.

Crop injury and crop stunting were visually rated for application A 33, 45, and 53 days after treatment (DAT). Crop injury was visually rated for application B 10 and 18 DAT. Plots were harvested using a sickle-bar mower on May 3, 2016, June 28, 2016, and August 9, 2016. Plant heights from two plants in each plot were recorded prior to harvest. Swaths of 2.5' by 30' were cut up the center of the plot, collected into totes and weighed in the field. Grab samples fresh weights were collected from each plot before being dried in an oven set at 60°C to determine percent moisture at harvest and hay dry matter yields were calculated.

Percent data were arcsine square-root transformed. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

No significant crop injury was observed 33 and 45 days after application code A (linuron applied pre-emergence). Significant crop injury was observed 10 days after application for all treatments applied at timing B, with the greatest percent injury of 60% for the highest rate of Linex (2.0 lb ai A⁻¹) + NIS (0.25 % v/v) (Table 2). Crop injury from the application B timing worsened 18 DAT (Table 2). Linex at 0.5, 1.0, and 2.0 lb ai A⁻¹ with NIS (0.25 % v/v) caused 25, 43 and 73% injury, respectively (18 DAT). Injury was also observed when linuron was applied after the first cutting, but only for the highest rate of linuron (2.0 lb ai A⁻¹). Significant crop stunting of 18% occurred 10 DAT for Linex at 2.0 lb ai A⁻¹ with NIS (0.25% v/v), while no other treatments had visual crop stunting. Eighteen days after application B, there was significant crop stunting for all applications made to 5" alfalfa prior to the first cutting (Table 1). Alfalfa in all treatments had recovered by the second cutting.

The effects of application B were also observed at the 1st cutting. The average plant heights and yields were significantly lower than that of applications A (Table 2). At 2nd cutting, minor difference in plant height were observed however no significant difference in yield were determined for any of treatment. By the 3rd cutting, crop previously injured by applications had grown out and there was no significant difference between plant heights or yield for any of the treatments.

Table 1. Treatment application details

Study Application	A	B	C
Date	February 26, 2016	April 1, 2016	May 27, 2016
Application volume (GPA)	15	15	15
Crop Stage	1" alfalfa	5" alfalfa	3-6" alfalfa after first cutting
Air temperature (°F)	44	60	56
Soil temperature (°F)	41	54	65
Wind velocity (mph, direction)	6, W	4, E	10, W

Table 2. Percent injury and crop stunting of alfalfa following applications of Linex at different rates with and without the addition of a surfactant, Induce (NIS). Othello, WA, 2015 -2016. Means followed by the same letter are not statistically different ($\alpha=0.05$).

Treatment	Application Code	Rate	lb ai/A	March 30, 2016	April 11, 2016		April 19, 2016		June 6, 2016	July 14, 2016
				Crop Injury	Crop Injury	Crop Stunting	Crop Injury	Crop Stunting	Crop Injury	Crop Injury
				%	%	%	%	%	%	%
Nontreated				0	0 a	0 a	0 a	0 a	0	0
Linex	A	1 pt/A	0.50	0	0 a	0 a	0 a	0 a	0	0
Linex	A	2 pt/A	1.00	0	0 a	0 a	0 a	0 a	0	0
Linex	A	4 pt/A	2.00	0	0 a	0 a	0 a	0 a	0	0
Linex Induce (NIS)	B	1 pt/A	0.50	0	23 b	0 a	25 b	9 ab	0	0
Linex Induce (NIS)	B	2 pt/A	1.00	0	41 c	0 a	43 c	13 b	0	0
Linex Induce (NIS)	B	4 pt/A	2.00	2	60 d	18 b	73 d	40 c	0	0
Linex Induce (NIS)	C	0.25 % v/v	0.50	0	0 a	0 a	0 a	0 a	5	0
Linex Induce (NIS)	C	0.25 % v/v	1.00	0	0 a	0 a	0 a	0 a	11	0
Linex Induce (NIS)	C	0.25 % v/v	2.00	0	0 a	0 a	0 a	0 a	25	0

Table 3. Alfalfa plant heights and yield for the 1st, 2nd, and 3rd cuttings applications of Linex at different rates with and without the addition of a surfactant, Induce (NIS). Othello, WA, 2015 - 2016. Means followed by the same letter are not statistically different ($\alpha=0.05$).

Treatment	Application Code	Rate	lb ai/A	June 7, 2016 1 st Cutting		June 28, 2016 2 nd Cutting		August 19, 2016 3 rd Cutting	
				Plant Ht	Yield	Plant Ht	Yield	Plant Ht	Yield
				cm	lb DM/A	cm	lb DM/A	cm	lb DM/A
Nontreated				68 ab	6090 a	74 a	5880	67	4230
Linex	A	1 pt/A	0.50	62 b	5900 a	75 a	4780	57	4410
Linex	A	2 pt/A	1.00	65 ab	6150 a	72 ab	5820	57	3810
Linex	A	4 pt/A	2.00	63 ab	5930 a	75 a	5160	62	4140
Linex Induce (NIS)	B B	1 pt/A 0.25 % v/v	0.50	53 c	3330 b	71 ab	5260	67	4920
Linex Induce (NIS)	B B	2 pt/A 0.25 % v/v	1.00	48 c	2710 bc	73 ab	6870	68	4500
Linex Induce (NIS)	B B	4 pt/A 0.25 % v/v	2.00	41 d	1700 c	70 ab	4970	78	4330
Linex	A	1 pt/A	0.50	71 a	6150 a	68 ab	5410	77	4320
Linex	C	1 pt/A	0.50						
Induce (NIS)	C	0.25 % v/v	0.50						
Linex	A	2 pt/A	1.00	66 ab	6060 a	68 ab	5390	69	4500
Linex	C	2 pt/A	1.00						
Induce (NIS)	C	0.25 % v/v	1.00						
Linex	A	4 pt/A	2.00	67 ab	5530 a	61 b	5530	71	4410
Linex	C	4 pt/A	2.00						
Induce (NIS)	C	0.25 % v/v	2.00						

Indazaflam (Alion) Efficacy and Crop Tolerance in Alfalfa

ICB1216

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Washington State University Research Farm near Othello, WA. Treatments were applied pre-bud formation, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 25' long.

Crop injury was visually rated for 33 and 53 days after treatment (DAT). Plots were harvested using a sickle-bar mower on May 3, 2016, June 28, 2016, and August 9, 2016. Plant heights from two plants in each plot were recorded prior to harvest. Swaths of 2.5' by 30' were cut up the center of the plot, collected into totes and weighed in the field. Grab samples fresh weights were collected from each plot before being dried in an oven set at 60°C to determine percent moisture at harvest and hay dry matter yields were calculated.

Percent data were arcsine square-root transformed. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

No significant crop injury was observed 33 and 53 days after treatment (DAT) (Table 2).

There was no significant effect of average plant height and yield observed for any treatment at the 1st, 2nd, or 3rd cutting.

Table 1. Treatment application details

Study Application	A
Date	February 26, 2016
Application volume (GPA)	15
Crop Stage	Pre-budbreak
Air temperature (°F)	44
Soil temperature (°F)	41
Wind velocity (mph, direction)	6, W

Table 2. Percent injury of alfalfa following applications of different herbicides. Othello, WA, 2015 -2016. Means followed by the same letter are not statistically different ($\alpha=0.05$).

Treatment	Application Code	Rate	March 30, 2016		April 19, 2016
			Crop Injury		Crop Injury
			lb ai/A	%	%
Nontreated				-	-
Alion	A	2.5 fl oz/A	0.033	0	0
Alion	A	4 fl oz/A	0.052	0	0
Chateau	A	4 oz/A	0.127	0	0
Raptor	A	6 fl oz/A	0.047	0	0

Table 3. Alfalfa plant heights and yield for the 1st, 2nd, and 3rd cuttings applications of different herbicides. Othello, WA, 2015 -2016. Means followed by the same letter are not statistically different ($\alpha=0.05$).

Treatment	Application Code	Rate	May 3, 2016 1 st Cutting		June 28, 2016 2 nd Cutting		August 9, 2016 3 rd Cutting	
			Yield		Plant Ht	Yield	Plant Ht	Yield
			lb ai/A	lb DM/A	cm	lb DM/A	cm	lb DM/A
Nontreated				5030	78	6360	52	4260
Alion	A	2.5 fl oz/A	0.033	4930	75	5490	63	3250
Alion	A	4 fl oz/A	0.052	4750	76	5560	58	4050
Chateau	A	4 oz/A	0.127	5510	72	5580	69	4040
Raptor	A	6 fl oz/A	0.047	4750	70	5270	70	3610

Herbicide application timings in chickpeas

Henry Wetzel and Drew Lyon

A field study was conducted on the WSU Cook Agronomy Farm near Pullman, WA to evaluate different herbicide application timings for the control of broadleaf weeds in chickpeas. Lack of rainfall to activate herbicides after application has been problematic in recent years. Early pre-plant applications might have more opportunity to be activated by rainfall than herbicides applied post-plant, pre-emerge. The soil at this site is a Naff silt loam with pH of 4.8 and organic matter content of 3.0%.



The pre-plant applications took place on April 7th and 28th using a CO₂ backpack sprayer set to deliver 10 gpa at 2.3 mph and 40 psi. Conditions on April 7th were an air temperature of 60°F, relative humidity of 40% and the wind was calm. Conditions on April 28th were an air temperature of 59°F, relative humidity of 48% and the wind out of the west at 4 mph. On May 13th, the entire trial area was sprayed with glyphosate to kill the common lambsquarters and Italian ryegrass that germinated following conventional ground preparation and rain that fell throughout April. On May 15th, the trial area received 0.57 in. of rainfall that most likely stimulated weed seed germination. On May 18th, ‘Frontier’ chickpeas were planted at a rate of 175 lb/acre at a depth of 1.5 inches using a Monosem vacuum planter with a 10-inch row spacing. The post-plant pre-emerge application took place on May 18th and the conditions were an air temperature of 71°F, relative humidity of 36% and the wind out of the west at 4 mph. The trial area was harvested with a Kincaid 8XP plot combine on September 15th.

Within two weeks of application, treatments applied on April 7th received a total of 0.36 inches of rain, treatments applied on April 28th received a total of 0.94 inch of rain, and treatments applied on May 18th received 0.15 inches of rain. Between May 20th and September 6th, the crop received a total of 2.21 inches of rain, with rainfall events being fairly spread out. Common lambsquarters was the only broadleaf weed uniformly distributed within the trial area. Crop injury was not noted with any treatments in this trial. Based on visual ratings, Spartan[®] and Sencor[®] generally provided the best control of common lambsquarters, Valor was intermediate and Lorox[®] provided very little control (Table 1). On the June 30th rating date, Sencor applied on May 18th was providing less control than on the two application dates in April.

Common lambsquarters density counts were taken on July 6th. Statistical analysis suggested that application date was not significant, so treatment means are averaged over the three dates (Table 2). Sencor, Spartan and Valor significantly reduced the density of common lambsquarters when compared to Lorox. Lorox’s activity on lambsquarters was between the other three herbicides and the nontreated check. Yield and 100-seed-weight were not affected by herbicide application date, thus treatment means were averaged over application date (Table 3). Spartan- and Valor[®]-treated plots yielded better than the nontreated check plots. Lorox- and Sencor-treated plots yielded similarly to the nontreated check plots. There were no differences noted among 100-seed-weight when compared among all herbicide treatments and the nontreated check.

Timely rains after the pre-plant herbicide applications provided good weed control from these early treatments. Even though we only received 0.15 inches of rainfall within the two weeks after the at-plant herbicide application, three days prior to planting we received 0.57 inches of rainfall, which may have helped to activate the post-plant pre-emerge treatments. Thus, in this study, all three herbicide application timings provided similar control of common lambsquarters.

Table 1. Herbicide, application date and their effects on common lambsquarters control in 'Frontier' chickpeas

Treatment	Rate	Application Date	Common lambsquarters control	
			6/17	6/30 ¹
	oz/A		-----%	
Lorox DF	20	4/7	26 d ²	17 d ²
Lorox DF	20	4/28	55 b-d	30 cd
Lorox DF	20	5/18	50 cd	22 cd
Sencor 75DF	8	4/7	91 a	81 a
Sencor 75DF	8	4/28	95 a	87 a
Sencor 75DF	8	5/18	75 a-c	52 bc
Spartan 4F	8 fl oz	4/7	96 a	85 a
Spartan 4F	8 fl oz	4/28	94 a	82 a
Spartan 4F	8 fl oz	5/18	95 a	79 ab
Valor SX	2	4/7	82 ab	66 ab
Valor SX	2	4/28	80 a-c	56 bc
Valor SX	2	5/18	52 b-d	52 bc

¹ Herbicide application date had a significant (Pr>F 0.0467) effect on common lambsquarters control

² Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by LSMEANS test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Table 2. Herbicide application and its effect on common lambsquarters abundance in ‘Frontier’ chickpeas

		Common lambsquarters
	Rate	7/6
Treatment	oz/A	plants per m ²
Spartan 4F	8 fl oz	3 ab ¹
Sencor 75DF	8	6 b
Valor SX	2	8 b
Lorox DF	20	23 c
Nontreated Check	--	40 d

¹ Means, based on twelve replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by LSMEANS test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Table 3. Herbicide application and its effect on yield and seed weight in ‘Frontier’ chickpeas, September 15, 2016.

Treatment	Rate	Yield	100-seed-weight
	oz/A	lb/A	g
Lorox DF	20	697 b ¹	36.3 a
Sencor 75DF	8	829 b	37.1 a
Spartan 4F	8 fl oz	1330 a	38.5 a
Valor SX	2	1330 a	37.6 a
Nontreated Check	--	675 b	37.0 a

¹ Means, based on twelve replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by LSMEANS test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Effects of tillage for herbicide incorporation on broadleaf weed control in ‘Frontier’ chickpeas

Henry Wetzel and Drew Lyon

A study was conducted at the Cook Agronomy Farm near Pullman, WA to evaluate herbicides for the control of broadleaf weeds. In addition, we evaluated if soil disturbance, after treatments were applied, affected product efficacy. The soil at this site is a Naff silt loam with pH of 4.8 and organic matter content of 3.0%. On May 13th, the entire trial area was sprayed with glyphosate to kill the common lambsquarters and Italian ryegrass that germinated following conventional ground



preparation and rain that fell throughout April. On May 15th, the trial area received 0.57 of an inch of rainfall that most likely stimulated weed seed germination. On May 18th, ‘Frontier’ chickpeas were planted at a rate of 175 lb/acre at a depth of 1.5 inches using a Monosem vacuum planter with a 10-inch row spacing. The post-plant, pre-emerge application took place on May 18th and the conditions were an air temperature of 75°F, relative humidity of 34% and the wind out of the west at 4 mph. On May 19th, half of the treated area, within each block, received a roller packer treatment by driving perpendicular to the treated area. The other half of the plot remained undisturbed. The trial area was harvested with a Kincaid 8XP plot combine on September 16th.

During the two weeks after application, only 0.15 of an inch of rainfall was received. This lack of rainfall after herbicide application likely contributed to the poor weed control observed in this trial. Poor herbicide activation by insufficient rainfall is often cited by growers as the reason for using light tillage to incorporate and activate herbicides. Between May 20th and September 6th, the crop received 2.21 inches of precipitation, with rainfall events being fairly spread out. Crop injury was not noted with any treatments in this trial. The initial visual weed control rating taken on June 17th did not suggest that rolling had an impact on common lambsquarters control with the herbicides tested (Table 1). Lorox[®] + Spartan[®] and Outlook[®] + Spartan were providing the best control of common lambsquarters. However, on the second evaluation (June 30th), none of the treatments were providing acceptable control of common lambsquarters. Rolling did have a significant effect and plots treated with Sharpen[®] + Sencor[®], Lorox + Spartan and Lorox + Valor[®], all exhibited reduced weed control when rolled. When it came to our final evaluation on July 6th, rolling did not have a significant effect on common lambsquarters density. Rolling did not have a significant effect on yield or 100-seed-weight, thus data were combined across rolling treatments and means are composed of eight replications (Table 2). All herbicide treatments increased yield when compared to the nontreated check.

Mechanical incorporation of herbicides did not improve weed control in this study despite a lack of sufficient rainfall for herbicide activation. In 2015, a year with sufficient rainfall for post-

plant, pre-emerge herbicide activation, rolling reduced weed control with some of the herbicide treatments compared to no mechanical herbicide incorporation. Growers should be sure to check herbicide labels before using tillage to incorporate herbicides.

Table 1. Evaluation of the combination of herbicides and soil surface disturbance and their effects on common lambsquarters control in 'Frontier' chickpeas.

Treatment	Rate	Mechanical	Common lambsquarters control		Common lambsquarters
		Treatment	6/17	6/30 ²	7/6
	oz/A		-----%-----		plants per m ²
Nontreated Check	--	Not-Rolled	--	--	89 e ¹
Nontreated Check	--	Rolled	--	--	97 e
Sharpen + Sencor 75DF	2 fl oz + 8	Not-Rolled	47 bc ¹	35 c ¹	47 b-d
Sharpen + Sencor 75DF	2 fl oz + 8	Rolled	40 cd	21 e	53 cd
Lorox DF + Spartan 4F	20 + 8 fl oz	Not-Rolled	85 a	59 a	27 ab
Lorox DF + Spartan 4F	20 + 8 fl oz	Rolled	80 a	47 b	32 a-c
Lorox DF + Valor SX	20 + 2	Not-Rolled	56 b	55 ab	25 ab
Lorox DF + Valor SX	20 + 2	Rolled	45 c	34 cd	33 a-d
Lorox DF + Pursuit [®]	20 + 2 fl oz	Not-Rolled	32 d	27 c-e	56 d
Lorox DF + Pursuit	20 + 2 fl oz	Rolled	35 cd	24 de	55 cd
Outlook + Spartan 4F	21 fl oz + 8 fl oz	Not-Rolled	85 a	55 ab	23 a
Outlook + Spartan 4F	21 fl oz + 8 fl oz	Rolled	81 a	50 ab	20 a

¹ Means, based on four replicates, within a column, followed by the same letter are not significantly different at P=0.05 as determined by the LSMEANS test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

² Mechanical treatment had a significant (Pr>F 0.0261) effect on common lambsquarters control.

Table 2. The effect of herbicides on yield and 100-seed-weight in 'Frontier' chickpeas, September 16, 2016.

Treatment	Rate	Yield	100 Seed weight
	oz/A	lb/A	g
Nontreated Check	--	878 b ¹	38.4 a
Sharpen + Sencor 75DF	2 fl oz + 8	1302 a	39.1 a
Lorox DF + Spartan 4F	20 + 8 fl oz	1322 a	38.6 a
Lorox DF + Valor SX	20 + 2	1167 a	38.5 a
Lorox DF + Pursuit	20 + 2 fl oz	1140 a	38.6 a
Outlook + Spartan 4F	21 fl oz + 8 fl oz	1320 a	37.8 a

¹ Means, based on eight replicates, within a column, followed by the same letter are not significantly different at P = 0.05 as determined by Fisher's protected LSD test, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Weed Control with Pyridate and Clethodim in Chickpea

ICB0416

Cook Agronomy Farm in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied post emergence (POST) at several different crop stages, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long.

Crop injury was visually rated 28 days after treatment (DAT) of application A (Table 2). Common lambsquarters control was visually assessed 114 DAT of application A (Table 3). Plots were harvested using a plot combine on September 20, 2016. All data was subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

There was no significant crop injury for any of the treatments 28 DAT of application A or 15 DAT of application C.

All treatments provided significant common lambsquarters control compared to the nontreated. Pyridate applied at the highest rate (48 fl oz A⁻¹) without and with NIS applied at 8 to 10" chickpeas provided the best common lambsquarters control at 95% and 94%, respectively.

Pyridate provided significantly higher yield for all treatments compared to the nontreated control except when pyridate and Select Max were applied together at the earliest application timing of 2 to 4" chickpeas (application A). Pyridate with Select Max and COC applied in the same tank mixture at application timing A did not result in yield significantly different from the nontreated control (Table 2).

Table 1. Treatment application details

Study Application	A	B	C
Date	May 24, 2016	June 3, 2016	June 6, 2016
Application volume (GPA)	15	15	15
Crop Stage	2-4"	6"	8-10"
Air temperature (°F)	57	67	80
Soil temperature (°F)	62	60	68
Wind velocity (mph, direction)	3, SE	4, S	4, E
Next rain occurred on	June 8, 2016	June 8, 2016	June 8, 2016

Table 2. Percent crop injury for chickpea, percent common lambsquarters control and yield following applications of pyridate and clethodim at different application timings. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Applicati on Code	Rate		June 21, 2016	Sep 15, 2016	Sep 26, 2016
			lb ai/A	Crop Injury %	Common lambsquarters control %	Yield lb/A
Nontreated	-	-	-	0	0 a	926 a
Pyridate (Tough)	A	24 fl oz/A	0.940	10	88 bc	1840 b
Select Max	B	16.5 fl oz/A	0.125			
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	A	48 fl oz/A	1.880	13	84 bc	1890 b
Select Max	B	16.5 fl oz/A	0.125			
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	A	24 fl oz/A	0.940	20	78 bc	1730 b
Induce (NIS)	A	0.25% v/v				
Select Max	B	16.5 fl oz/A	0.125			
Agridex (COC)	B	0.25% v/v		0	65 bc	1950 b
Pyridate (Tough)	A	48 fl oz/A	1.880			
Induce (NIS)	A	0.25% v/v				
Select Max	B	16.5 fl oz/A	0.125	3	85 bc	1500 ab
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	A	24 fl oz/A	0.940			
Select Max	A	16.5 fl oz/A	0.125	5	82 bc	1510 ab
Agridex (COC)	A	0.25% v/v				
Pyridate (Tough)	A	24 fl oz/A	1.880			
Select Max	A	16.5 fl oz/A	0.125	5	58 b	1810 b
Agridex (COC)	A	0.25% v/v				
Pyridate (Tough)	C	24 fl oz/A	0.940			
Select Max	B	16.5 fl oz/A	0.125	15	95 c	2020 b
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	C	48 fl oz/A	1.880			
Select Max	B	16.5 fl oz/A	0.125	18	87 bc	1800 b
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	C	24 fl oz/A	0.940			
Induce (NIS)	C	0.25% v/v		8	94 c	2140 b
Select Max	B	16.5 fl oz/A	0.125			
Agridex (COC)	B	0.25% v/v				
Pyridate (Tough)	C	48 fl oz/A	1.880	15	85 bc	1870 b
Select Max	C	16.5 fl oz/A	0.125			
Agridex (COC)	C	0.25% v/v				
Pyridate (Tough)	C	24 fl oz/A	1.880	20	84 bc	1810 b
Select Max	C	16.5 fl oz/A	0.125			
Agridex (COC)	C	0.25% v/v				

Weed Control with Pyridate and Clethodim in Chickpea

ICB0616

Palouse Conservation Field Station in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Palouse Conservation Field Station in Pullman, WA. Treatments were applied post emergence (POST) at several different crop stages, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Lorox (2.5 lb/A), Outlook (21 fl oz/A), and Valor (2 oz/A) were applied pre-emergence (PRE) at planting to establish a weed free trial. Glyphosate at 32 fl oz/A with ammonium sulfate at 3 lb/100 gal was applied 22 days before harvest as a burn down application.

Crop injury was visually rated 28 days after treatment (DAT) of application A (Table 2). Common lambsquarters control was visually assessed 28 DAT of application A (Table 2). Plots were harvested using a plot combine on September 21, 2016. Common lambsquarters percent data was arcsine square-root transformed. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

No significant crop injury was observed for any treatment 28 DAT compared to the nontreated control.

All treatments provided significantly greater percent common lambsquarters control compared to the nontreated. Pyridate at 48 fl oz A⁻¹ with NIS (0.25% v/v) applied to 8 to 10" chickpeas with Select Max being applied prior provided the greatest lambsquarters control at 98% control.

No significant difference in yield was observed for any treatment.

Table 1. *Treatment application details*

Study Application	A	B	C
Date	May 24, 2016	June 3, 2016	June 6, 2016
Application volume (GPA)	15	15	15
Crop Stage	2-4"	6"	8-10"
Air temperature (°F)	60	68	81
Soil temperature (°F)	54	60	68
Wind velocity (mph, direction)	2, E	6, W	4, E
Next rain occurred on	June 8, 2016	June 8, 2016	June 8, 2016

Table 2. Percent crop injury, common lambsquarters control and yield for chickpeas following applications of pyridate at different application timings. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate	June 21, 2016	June 21, 2016	September 21, 2016
			Crop injury	Common lambsquarters control	Yield
		lb ai/A	%	%	lb/A
Nontreated	-	-	0	0 a	1560
Pyridate (Tough)	A	24 fl oz/A	0.940		
Select Max	B	16.5 fl oz/A	0.125	4	83 bc
Agridex (COC)	B	0.25% v/v			1580
Pyridate (Tough)	A	48 fl oz/A	1.880		
Select Max	B	16.5 fl oz/A	0.125	13	82 bc
Agridex (COC)	B	0.25% v/v			1790
Pyridate (Tough)	A	24 fl oz/A	0.940		
Induce (NIS)	A	0.25% v/v			
Select Max	B	16.5 fl oz/A	0.125	0	86 bc
Agridex (COC)	B	0.25% v/v			1970
Pyridate (Tough)	A	48 fl oz/A	1.880		
Induce (NIS)	A	0.25% v/v			
Select Max	B	16.5 fl oz/A	0.125	23	58 c
Agridex (COC)	B	0.25% v/v			1680
Pyridate (Tough)	A	24 fl oz/A	0.940		
Select Max	A	16.5 fl oz/A	0.125	0	86 bc
Agridex (COC)	A	0.25% v/v			1900
Pyridate (Tough)	A	24 fl oz/A	1.880		
Select Max	A	16.5 fl oz/A	0.125	5	82 bc
Agridex (COC)	A	0.25% v/v			1560
Pyridate (Tough)	C	24 fl oz/A	0.940		
Select Max	B	16.5 fl oz/A	0.125	0	68 bc
Agridex (COC)	B	0.25% v/v			1660
Pyridate (Tough)	C	48 fl oz/A	1.880		
Select Max	B	16.5 fl oz/A	0.125	8	92 bc
Agridex (COC)	B	0.25% v/v			1620
Pyridate (Tough)	C	24 fl oz/A	0.940		
Induce (NIS)	C	0.25% v/v			
Select Max	B	16.5 fl oz/A	0.125	11	64 bc
Agridex (COC)	B	0.25% v/v			1530
Pyridate (Tough)	C	48 fl oz/A	1.880		
Induce (NIS)	C	0.25% v/v			
Select Max	B	16.5 fl oz/A	0.125	0	98 b
Agridex (COC)	B	0.25% v/v			1790
Pyridate (Tough)	C	24 fl oz/A	0.940		
Select Max	C	16.5 fl oz/A	0.125	3	66 bc
Agridex (COC)	C	0.25% v/v			1660
Pyridate (Tough)	C	24 fl oz/A	1.880		
Select Max	C	16.5 fl oz/A	0.125	6	88 bc
Agridex (COC)	C	0.25% v/v			1820

Crop Tolerance with Pyridate and Clethodim in Chickpea

ICB0716

Central Ferry Research Farm near Pomeroy, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Central Ferry Research Farm near Pomeroy, WA. Treatments were applied post emergence (POST) at several different crop stages, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long and were supplemented with irrigation. Lorox (2.5 lb A⁻¹) and Outlook (21 fl oz A⁻¹) were applied pre-emergence (PRE) at planting to establish a weed free trial. Trial was hand weeded July 5, 2016. Irrigation was shut-off three weeks before harvest. Glyphosate at 32 fl oz A⁻¹ with ammonium sulfate at 3 lb/100 gal was applied 14 days before harvest as a burn down application.

Canopy cover was visually rated 21 days after treatment (DAT) of application A (Table 2). Crop injury was visually rated 6 and 44 DAT of application A (Table 2). Percent pest pressure was visually rated 6 DAT of application A (Table 2). Plots were harvested using a 5' plot combine on September 26, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

There was no significant crop injury compared to the nontreated was observed at 6 or 44 DAT after application A.

No difference in pest pressure was observed 6 DAT after application A in any treatments.

Percent crop canopy cover was not significantly from the nontreated control.

There was no significant difference in yield observed for any of the treatments. Results confirm chickpeas have a tolerance for pyridate with and without a nonionic surfactant (NIS) when compared to a nontreated control in a weed free environment.

Table 1. Treatment application details

Study Application	A	B	C
Date	June 1, 2016	June 3, 2016	June 22, 2016
Application volume (GPA)	15	15	15
Crop Stage	2-4"	6"	8-10"
Air temperature (°F)	67	78	85
Soil temperature (°F)	64	66	70
Wind velocity (mph, direction)	9, S	4, NW	4, S
Next rain occurred on	June 10, 2016	June 10, 2016	July 8, 2016

Table 2. Percent crop injury, pest pressure, crop injury and yield in chickpeas following applications of pyridate and clethodim at different application timings. Central Ferry, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		June 7, 2016	June 7, 2016	June 22, 2016	July 14, 2016	September 26, 2016
				Crop Injury	Pest Pressure	Canopy Cover	Crop Injury	Yield
		lb ai/A		%	%	%	%	lb/A
Nontreated	-	-	-	0	0	100	0	1020
Pyridate (Tough)	A	24 fl oz/A	0.940					
Select Max	B	16.5 fl oz/A	0.125	0	2	76	8	1240
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	A	48 fl oz/A	1.880					
Select Max	B	16.5 fl oz/A	0.125	3	5	73	6	1350
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	A	24 fl oz/A	0.940					
Induce (NIS)	A	0.25% v/v						
Select Max	B	16.5 fl oz/A	0.125	3	5	75	3	1250
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	A	48 fl oz/A	1.880					
Induce (NIS)	A	0.25% v/v						
Select Max	B	16.5 fl oz/A	0.125	0	3	76	10	1330
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	A	24 fl oz/A	0.940					
Select Max	A	16.5 fl oz/A	0.125	0	1	78	11	1270
Agridex (COC)	A	0.25% v/v						
Pyridate (Tough)	A	24 fl oz/A	1.880					
Select Max	A	16.5 fl oz/A	0.125	0	0	79	3	1430
Agridex (COC)	A	0.25% v/v						
Pyridate (Tough)	C	24 fl oz/A	0.940					
Select Max	B	16.5 fl oz/A	0.125	1	1	75	1	1080
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	C	48 fl oz/A	1.880					
Select Max	B	16.5 fl oz/A	0.125	1	1	84	8	1250
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	C	24 fl oz/A	0.940					
Induce (NIS)	C	0.25% v/v						
Select Max	B	16.5 fl oz/A	0.125	0	4	69	19	1040
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	C	48 fl oz/A	1.880					
Induce (NIS)	C	0.25% v/v						
Select Max	B	16.5 fl oz/A	0.125	3	3	76	14	1200
Agridex (COC)	B	0.25% v/v						
Pyridate (Tough)	C	24 fl oz/A	0.940					
Select Max	C	16.5 fl oz/A	0.125	0	0	71	6	1120
Agridex (COC)	C	0.25% v/v						
Pyridate (Tough)	C	24 fl oz/A	1.880					
Select Max	C	16.5 fl oz/A	0.125	2	1	71	16	1240
Agridex (COC)	C	0.25% v/v						

Effect of Carrier Volume on Pyridate Efficacy

ICB2716

Palouse Conservation Field Station in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Palouse Conservation Field Station near Pullman, WA. The goal of the study was to evaluate pyridate for broadleaf weed control at different spray volumes. Treatments were applied post emergence (POST) to 3 to 4 leaf weeds, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Lorox (2.5 lb A⁻¹), Valor (2 oz A⁻¹) and Outlook (21 fl oz A⁻¹) were applied pre-emergence (PRE) at planting to begin with a weed free trial. Select Max (16 fl oz A⁻¹) with NIS (1 % v/v) was applied POST on June 3, 2016 for grass weed control.

Weed control was visually assessed 28 DAT of application A (Table 2). Plots were harvested using a plot combine on September 21, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Pyridate applied at any spray volume provided significantly greater broadleaf weed control compared to the nontreated control. Although no significant difference in weed control was found between any of the spray volume solutions, percent weed control decreased as spray volume increased.

No significant difference in yield was observed for any of the treatments.

Table 1. Treatment application details

Study Application	A
Date	May 24, 2016
Application volume (GPA)	15
Crop Stage	3-4 Leaf Weeds
Air temperature (°F)	58
Soil temperature (°F)	59
Wind velocity (mph, direction)	3, SW
Next rain occurred on	June 8, 2016

Table 2. Percent broadleaf weed control and yield following applications of pyridate at increasing spray volumes in chickpea. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	GPA	Application Code	Rate	June 21, 2016	September 21, 2016	
				Weed Suppression	Yield	
			lb ai/A	%	lb/A	
Nontreated			-	20 a	1580	
Pyridate (Tough)	15	A	14 fl oz/A	0.940	92 b	1770
Pyridate (Tough)	20	A	14 fl oz/A	0.940	99 b	1830
Pyridate (Tough)	25	A	14 fl oz/A	0.940	94 b	1660
Pyridate (Tough)	30	A	14 fl oz/A	0.940	72 b	1890
Pyridate (Tough)	35	A	14 fl oz/A	0.940	78 b	1760
Pyridate (Tough)	40	A	14 fl oz/A	0.940	71 b	1540

Tolerance of Chickpea Varieties to Pyridate

ICB4216

Cook Agronomy Farm in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the WSU Cook Agronomy Farm near Pullman, WA. Treatments were applied post emergence (POST) detailed in Table 1 and Table 2. The study was conducted in a randomized split plot design with 3 replications within variety. Plots were 8' by 16' long. Chickpea varieties used were Royal, Sierra, Billy bean, and Sawyer. The chickpea varieties were planted in 75' strips using a Monosem planter on an 8 inch row spacing. Trial area was treated with glyphosate before planting as a preplant burn down.

Crop injury and common lambsquarters control were visually rated 19 days after treatment (DAT) of application A (Table 2). Plots were harvested by hand using 3 quarter-meter² quadrats per plot on September 1, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

No significant difference in crop injury were observed compared to the nontreated control. The variety Sierra had the greatest amount of visual injury 19 DAT with 38% injury with pyridate at 24 fl oz/A and 35% injury with pyridate at 48 fl oz A⁻¹. Greater injury was observed at the higher rate of pyridate compared to the nontreated within each variety (Table 2).

The greater percent common lambsquarters control was observed at the highest rate of pyridate (48 fl oz/A) within each variety. Common lambsquarters control was significantly greater when pyridate was applied compared to the variety nontreated control.

Within variety, pyridate at 24 fl oz A⁻¹ applied to the Royal yielded 760 lb/A higher than the nontreated control at 610 lb A⁻¹. At 48 fl oz A⁻¹ of pyridate, Royal yielded 1450 lb A⁻¹ more than the nontreated control. Sierra yields were similar with 880 lb more per acre at 24 fl oz A⁻¹ of pyridate and 1800 lb more per acre at 48 fl oz A⁻¹ compared to the nontreated control with 430 lb A⁻¹ yield. Sawyer also had an increase in yield as the rate of pyridate increased. The nontreated control for Sawyer yielded 430 lb A⁻¹ well the pyridate at 24 fl oz A⁻¹ yielded 1500 lb A⁻¹ and 48 fl oz A⁻¹ of pyridate yielded significantly more at 2090 lb A⁻¹. Billy bean yielded the best out of the four varieties at both rates of pyridate with 2010 lb A⁻¹ (24 fl oz A⁻¹ pyridate) and 2600 lb A⁻¹ (48 fl oz A⁻¹ pyridate) significantly greater than the yield for the Billy bean nontreated treatment of 690 lb A⁻¹.

Table 1. Treatment application details

Study Application	A
Date	June 1, 2016
Application volume (GPA)	15
Crop Stage	4-6" weeds
Air temperature (°F)	75
Soil temperature (°F)	62
Wind velocity (mph, direction)	7, SW
Next rain occurred on	June 8, 2016

Table 2. Percent crop injury, percent common lambsquarters control, and yield following applications of paraquat with and without a nonionic surfactant at different application timings in chickpea. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Rate		June 20, 2016	June 20, 2016	September 1, 2016
			Crop Injury	Common lambsquarters control	Yield
	lb ai/A		%	%	lb/A
Variety: Royal					
Nontreated	-	-	0	0 a	610 a
Pyridate (Tough)	24 fl oz/A	0.94			
NIS (Induce)	0.25 % v/v		7	38 ab	1370 ab
Pyridate (Tough)	48 fl oz/A	1.88			
NIS (Induce)	0.25% v/v		27	87 c	2060 bc
Variety: Sierra					
Nontreated	-	-	0	0 a	430 a
Pyridate (Tough)	24 fl oz/A	0.94			
NIS (Induce)	0.25 % v/v		38	58 bc	1310 ab
Pyridate (Tough)	48 fl oz/A	1.88			
NIS (Induce)	0.25% v/v		35	90 c	2220 bc
Variety: Billy bean					
Nontreated	-	-	0	0 a	690 a
Pyridate (Tough)	24 fl oz/A	0.94			
NIS (Induce)	0.25 % v/v		7	53 bc	2010 bc
Pyridate (Tough)	48 fl oz/A	1.88			
NIS (Induce)	0.25% v/v		3	93 c	2610 c
Variety: Sawyer					
Nontreated	-	-	0	0 a	430 a
Pyridate (Tough)	24 fl oz/A	0.94			
NIS (Induce)	0.25% v/v		8	70 bc	1500 abc
Pyridate (Tough)	48 fl oz/A	1.88			
NIS (Induce)	0.25% v/v		15	93 c	2090 bc

Pyroxasulfone Crop Response and Weed Management in Chickpeas

ICB2216

Cook Agronomy Farm in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied pre-emergence (PRE), detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Billy bean chickpeas were planted May 4, 2016.

Common lambsquarters control was visually assessed 47 DAT of application A (Table 2). Plots were harvested using a plot combine on September 16, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Pyroxasulfone applied alone did not provide significant common lambsquarters control when compared to the nontreated control. Valor, Lorox, or Sharpen had to be in the treatment mixture for significant common lambsquarters control. The significantly greatest common lambsquarters control was observed for treatment 7 when Valor and Lorox were applied with the pyroxasulfone (Zidua), compared to the nontreated control. When pyroxasulfone was in the herbicide mixture, significant common lambsquarters control was observed for treatment 5 and 6 when either Valor or Sharpen were also in the mixture (Table 2).

When pyroxasulfone was applied alone (Treatment 2, 3 and 4) yields of 790, 790, and 820 lb A⁻¹, respectively, were not significantly different from the nontreated control yield of 750 lb A⁻¹. Treatment 5 (Zidua + Valor) provided the significantly greatest yield of 1290 lb A⁻¹ compared to the nontreated control. Treatment 8 (Outlook + Sharpen) also had a significant effect on yield compared to the nontreated control with 1230 lb A⁻¹ compared to 750 lb A⁻¹.

Table 1. Treatment application details

Study Application	A	B	C
Date	May 4, 2016	May 5, 2016	June 3, 2016
Application volume (GPA)	15	15	15
Crop Stage	PRE	PRE	POST
Air temperature (°F)	74	65	65
Soil temperature (°F)	60	59	59
Wind velocity (mph, direction)	4, S	5, S	6, SW
Next rain occurred on	May 5, 2016	May 5, 2016	June 8, 2016

Table 2. Percent common lambsquarters control and yield in chickpea following applications of pyroxasulfone in different herbicide combinations. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

#	Treatment	Application Code	Rate	lb ai/A	June 20, 2016	September 16, 2016
					Common lambsquarters control	Yield
1	Nontreated	-	-	-	% 0 a	lb/A 750 a
2	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	23 a	790 a
	Pyroxasulfone (Zidua)	B	1.20 oz/A	0.064		
3	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	3 a	790 a
	Pyroxasulfone (Zidua)	B	1.68 oz/A	0.089		
4	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	10 a	820 a
	Pyroxasulfone (Zidua)	B	2.03 oz/A	0.108		
5	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	60 ab	1290 c
	Pyroxasulfone (Zidua)	B	2.03 oz/A	0.108		
	Valor	B	2.00 oz/A	0.064		
6	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	61 ab	1040 abc
	Sharpen	A	2.0 fl oz/A	0.045		
	Pyroxasulfone (Zidua)	B	1.68 oz/A	0.089		
	Sharpen	B	2.0 fl oz/A	0.045		
	Select Max	C	16.5 fl oz/A	0.125		
7	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	83 b	910 ab
	Pyroxasulfone (Zidua)	B	1.68 fl oz/A	0.089		
	Valor	B	2.00 oz/A	0.064		
	Lorox	B	40.00 oz/A	1.250		
	Select Max	C	16.5 fl oz/A	0.125		
8	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	48 ab	1230 bc
	Sharpen	A	2.0 fl oz/A	0.045		
	Outlook	B	21 fl oz/A	0.980		
	Sharpen	B	2.0 fl oz/A	0.045		
	Select Max	C	16.5 fl oz/A	0.125		
9	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	15 a	990 abc
	Spartan	A	4 fl oz/A	0.125		
	Pyroxasulfone (Zidua)	B	1.68 oz/A	0.089		
	Select Max	C	16.5 fl oz/A	0.125		
10	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	3 a	970 abc
	Outlook	B	21 fl oz/A	0.980		
11	Glyphosate (RT3)	A	21.3 fl oz/A	0.750	36 ab	940 abc
	Sharpen	A	2 fl oz/A	0.045		
	Sharpen	B	2 fl oz/A	0.045		
12	Handweeded Check	-	-	-	53 ab	790 a

Tolerance of Chickpea to Paraquat Applied At-Cracking

ICB3616

Cook Agronomy Farm in Pullman, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied post emergence (POST) at several different crop stages, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Outlook at 21 fl oz A⁻¹ and Loroz at 1.5 lb A⁻¹ was applied pre emergence (PRE).

Crop injury was visually rated 9, 17, 36, and 41 days after treatment (DAT) of application A (Table 2). Common lambsquarters control was visually assessed 36 and 41 DAT of application A (Table 3). Plots were harvested using a plot combine on September 20, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

All treatments had significant control of common lambsquarters compared to the nontreated. There was no observed differences in lambsquarters control within the treatments based on application timing (Table 3).

Approximately 5 to 9 days prior to each paraquat application timing, significant crop injury was present. More severe injury was observed after the later paraquat application timings with greater than 68% injury 9 DAT for plants treated at 7 days after crop-cracking and greater than 59% injury 7 DAT for plants treated at 9 days after crop-cracking (Table 2). Crop injury was no longer present by August 26, 2016 with no significant difference in crop injury compared to the nontreated control. The earlier crop injury did not cause a lasting significant effect to yield. No significant difference in yield observed for any of the treatments (Table 2).

Table 1. Treatment application details

Study Application	A	B	C	D
Date	May 16, 2016	May 20, 2016	May 24, 2016	May 26, 2016
Application volume (GPA)	15	15	15	15
Crop Stage	At Cracking	4 DA Crack	7 DA Crack	10 DA Crack
Air temperature (°F)	58	56	54	60
Soil temperature (°F)	55	55	51	58
Wind velocity (mph, direction)	5, NW	12, NW	5, E	9, S
Next rain occurred on	May 17, 2016	May 20, 2016	June 8, 2016	June 8, 2016

Table 2. Percent common lambsquarters control in chickpea following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate	June 21, 2016		August 26, 2016	
			Common lambsquarters control		Common lambsquarters control	
		lb ai/A		%		%
Nontreated	-	-	-	0 a	-	0 a
Paraquat (Gramoxone)	A	8 fl oz/A	0.125	67 b		73 b
Paraquat (Gramoxone)	A	8 fl oz/A	0.125	95 b		71 b
NIS	A	0.25 % v/v				
Paraquat (Gramoxone)	B	8 fl oz/A	0.125	70 b		71 b
Paraquat (Gramoxone)	B	8 fl oz/A	0.125	64 b		58 b
NIS	B	0.25 % v/v				
Paraquat (Gramoxone)	C	8 fl oz/A	0.125	66 b		55 b
Paraquat (Gramoxone)	C	8 fl oz/A	0.125	67 b		55 b
NIS	C	0.25 % v/v				
Paraquat (Gramoxone)	D	8 fl oz/A	0.125	68 b		55 b
Paraquat (Gramoxone)	D	8 fl oz/A	0.125	85 b		76 b
NIS	D	0.25 % v/v				
Paraquat (Gramoxone)	A	16 fl oz/A	0.250	91 b		81 b
Paraquat (Gramoxone)	A	16 fl oz/A	0.250	86 b		65 b
NIS	A	0.25 % v/v				
Sharpen	A	2 fl oz/A	0.045	63 b		61 b
NIS	A	0.25 % v/v				

Table 3. Percent crop injury for chickpea and yield following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		May 25		Jun 2		Jun 21		Aug 26		Yield
				Crop Injury	DAT	Crop Injury	DAT	Crop Injury	DAT	Crop Injury	DAT	
		fl oz/A	lb ai/A	%		%		%		%		lb/A
Nontreated	-	-	-	0 a		0 a		0 a		0		1090
Paraquat	A	8.0	0.125	25 ab	9	8 ab	25	5 a	36	0	71	1380
Paraquat NIS	A	8.0 0.25% v/v	0.125	14 ab	9	0 a	25	0 a	36	0	71	1640
Paraquat	B	8.0	0.125	55 b	5	14 ab	13	8 ab	32	0	67	1440
Paraquat NIS	B	8.0 0.25% v/v	0.125	45 ab	5	31 b	13	4 a	32	0	67	1100
Paraquat	C	8.0	0.125	21 ab	1	71 c	9	35 ab	28	5	63	1400
Paraquat NIS	C	8.0 0.25% v/v	0.125	5 a	1	68 c	9	10 ab	28	0	63	1560
Paraquat	D	8.0	0.125	6 a		59 c	7	11 ab	26	0	61	1430
Paraquat NIS	D	8.0 0.25% v/v	0.125	15 ab		73 c	7	33 ab	26	13	61	1720
Paraquat	A	16.0	0.250	48 ab	9	14 ab	25	3 a	36	0	71	1510
Paraquat NIS	A	16.0 0.25% v/v	0.250	35 ab	9	3 a	25	3 a	36	0	71	1250
Sharpen NIS	A	2.0 0.25% v/v	0.045	91 c	9	56 c	25	38 a	36	0	71	1230

Tolerance of Chickpea to Paraquat Applied At-Cracking

ICB4016

Central Farm Research Farm in Pomeroy, WA

Zuger, R.J. & I.C. Burke

Methods

The study was established at the Central Ferry Research Farm near Pomeroy, WA. Treatments were applied post emergence (POST) at several different crop stages, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long and were supplemented with irrigation. Lorox (2.5 lb A⁻¹) and Outlook (21 fl oz A⁻¹) were applied pre-emergence (PRE) at planting to establish a weed free trial. Irrigation was shut-off two weeks before harvest. Trial was hand weeded July 5, 2016. Irrigation was shut-off three weeks before harvest. Glyphosate at 32 fl oz A⁻¹ with ammonium sulfate at 3 lb/100 gal was applied 14 days before harvest as a burn down application.

Crop injury was visually rated 2 and 51 days after treatment (DAT) of application A (Table 2). Common lambsquarters control was visually assessed 2 DAT of application A (Table 2). Plots were harvested using a plot combine on September 26, 2016. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

No herbicide was applied for application timing B.

On June 7, 2016, crop injury depended on application timing. Crop injury 4 days after treatment for paraquat (73%) and paraquat with the addition of NIS (54%) applied 10 days after crop-cracking (application D) were significantly greater than the nontreated and the other paraquat treatments made at earlier days (Table 2). At 6 and 14 days after treatment, significant crop injury was also present for treatments of paraquat (34%) and paraquat with NIS (36%) applied at 7 days after crop-cracking (application C) and paraquat (31%) applied at cracking (application A) (Table 2). Crop injury for all other treatments made at crop-cracking (application A) was not significantly different from the nontreated.

On July 14, 2016, no significant crop injury was present for any application timing.

There was no significant difference in pest pressure between treatments.

Yield was not significantly different between treatments indicating chickpeas can regenerate after injury caused by paraquat when compared to a nontreated control in a weed free environment.

Table 1. Treatment application details

Study Application	A	B	C	D
Date	May 24, 2016	Not Applied	June 1, 2016	June 3, 2016
Application volume (GPA)	15		15	15
Crop Stage	At Cracking	4 DA Crack	7 DA Crack	10 DA Crack
Air temperature (°F)	59		62	78
Soil temperature (°F)	57		64	70
Wind velocity (mph, direction)	7, S		9, S	4, NW
Next rain occurred on	June 10, 2016		June 10, 2016	June 10, 2016

Table 2. Percent crop injury, pest pressure, and yield for chickpeas following applications of paraquat with and without a nonionic surfactant at different application timings. Central Ferry, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Applicat ion Code	Rate		Jun 7		Jun 7	Jul 14	Sep 20
				Crop Injury		Pest Pressure	Crop Injury	Yield
				%	DAT	%	%	lb/A
Nontreated		fl oz/A	lb ai/A	0 a	-	0	0	1140
Paraquat (Gramoxone)	A	8.0	0.125	31 ab	14	2	10	1380
Paraquat NIS	A	8.0	0.125	14 a	14	2	15	1390
	A	0.25 % v/v						
Paraquat	B	8.0	0.125	0 a	-	2	3	1320
Paraquat NIS	B	8.0	0.125	1 c	-	1	10	1160
	B	0.25 % v/v						
Paraquat	C	8.0	0.125	34 ab	6	1	5	1110
Paraquat NIS	C	8.0	0.125	36 ab	6	2	9	1250
	C	0.25 % v/v						
Paraquat	D	8.0	0.125	73 c	4	4	3	1390
Paraquat NIS	D	8.0	0.125	54 bc	4	4	19	1090
	D	0.25 % v/v						
Paraquat	A	16.0	0.250	14 a	14	0	8	1390
Paraquat NIS	A	16.0	0.250	14 a	14	0	1	1440
	A	0.25 % v/v						
Sharpen	A	2.0	0.045	8 a	14	0	8	1330
NIS	A	0.25 % v/v						

Weed Management Systems in Peas

ICB2416

Zuger, R.J. & I.C. Burke

The purpose of this study was to compare different chemicals in combination for herbicide efficacy on common lambsquarters (*Chenopodium album* L.) and evaluation of crop response in spring field peas.

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied pre-emergence (PRE), detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long.

Crop injury was visually rated 30 days after treatment (DAT). Common lambsquarters control was visually assessed 30 DAT. Plots were harvested by hand using 2 meter² quadrats per plot on August 8, 2016. Percent data were arcsine square-root transformed. All data were subjected to an analysis of variance using the statistical package built into the Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

Results

Crop injury differ depending on treatment. BoradAxe and BroadAxe + Lorox caused 74 and 54% injury 30 DAT. Similar injury of 56, 34, 76, 84, and 56%, respectively, were observed for Dual Magnum + Prowl H2O + Tricor, Zidua + Spartan, Outlook + Spartan, Outlook + Spartan + Lorox, and Outlook + Prowl H2O + Tricor. Crop injury was observed in all treatments except Zidua + Pursuit which caused 0% injury 30 DAT.

Common lambsquarters control did not significantly differ among the treatments. Common lambsquarters control was greatest for Dual Magnum + Prowl H2O + Tricor and Zidua + Pursuit at 99 and 91% control. Outlook + Spartan + Lorox provided the lowest percent control of 61%.

Spring field pea yields, 111 DAT, did not statistically differ among treatments (Table 2) although crop response was present 30 DAT for multiple treatments.

Table 1. Treatment application details

Study Application	A
Date	April 19, 2016
Application volume (GPA)	15
Crop Stage	Pre-emergence
Air temperature (°F)	65
Soil temperature (°F)	53
Wind velocity (mph, direction)	11, E
Next rain occurred on	April 22, 2016

Table 2. Percent crop injury for field peas, percent Common lambsquarters control, and yield following applications of different chemical combinations. Pullman, WA, 2016. Means followed by the same letter are not statistically significantly different ($\alpha=0.05$).

Treatment	Application Code	Rate		May 19, 2016	May 19, 2016	August 8, 2016
				Crop Injury	Common lambsquarters Control	Yield
		lb ai/A	%	%	lb/A	
Nontreated	-	-	-	-	-	1300
BroadAxe	A	25.2 fl oz/A	1.380	74 ab	85	1460
BroadAxe	A	25.2 fl oz/A	1.380	54 abc	80	1510
Lorox	A	2.5 lb/A	1.250			
Dual Magnum	A	1.33 pt/A	1.270	56 abc	99	1390
Prowl H2O	A	2.4 pt/A	0.990			
Tricor	A	5.33 oz/A	0.250			
Zidua	A	1.68 oz/A	0.089	34 abc	83	1560
Spartan	A	4.54 fl oz/A	0.142			
Zidua	A	1.68 oz/A	0.089	26 bc	76	1810
Spartan	A	4.54 fl oz/A	0.142			
Lorox	A	2.5 lb/A	1.250			
Zidua	A	1.68 fl oz/A	0.089	18 c	71	1600
Prowl H2O	A	2.4 pt/A	0.990			
Tricor	A	5.33 oz/A	0.250			
Outlook	A	21 fl oz/A	0.980	76 ab	84	1330
Spartan	A	4.54 fl oz/A	0.142			
Outlook	A	21 fl oz/A	0.980	84 a	61	1550
Spartan	A	4.54 fl oz/A	0.142			
Lorox	A	2.5 lb/A	1.250			
Outlook	A	21 fl oz/A	0.980	56 abc	80	1360
Prowl H2O	A	2.4 pt/A	0.990			
Tricor	A	5.33 oz/A	0.250			
Outlook	A	21 fl oz/A	0.980	23 bc	66	1360
Command	A	1.3 pt/A	0.487			
Zidua	A	1.68 oz/A	0.089	0 c	91	1710
Pursuit	A	3 fl oz/A	0.047			

Precipitation data (September 1, 2015 to August 31, 2016) from AgWeatherNet station Pullman NE, Cook Agronomy Farm East

Precipitation		Precipitation		Precipitation		Precipitation	
Date	(in.)	Date	(in.)	Date	(in.)	Date	(in.)
9/5/15	0.39	10/3	0.02	11/1	0.02	12/2	0.07
9/17	0.29	10/7	0.20	11/5	0.12	12/3	0.06
Total	0.68	10/26	0.05	11/6	0.29	12/4	0.04
Normal ¹	0.77	10/27	0.01	11/8	0.27	12/6	0.41
Dep Norm	-0.09	10/28	0.04	11/9	0.64	12/7	1.41
		10/29	0.05	11/11	0.05	12/8	0.56
		10/30	0.10	11/13	0.08	12/9	0.21
		10/31	0.76	11/15	0.02	12/10	0.43
		Total	1.23	11/17	0.66	12/11	0.01
		Normal	1.58	11/19	0.01	12/12	0.48
		Dep Norm	-0.35	11/20	0.01	12/13	0.02
				11/24	0.17	12/18	0.36
				Total	2.34	12/19	0.01
				Normal	2.91	12/20	0.06
				Dep Norm	-0.57	12/21	0.45
						12/22	0.04
						12/24	0.04
						12/26	0.01
						12/29	0.04
						Total	4.71
						Normal	2.56
						Dep Norm	2.15

¹ Normal precipitation values are based on the 1980 to 2010 record period, kept by the National Weather Service.

Precipitation data (September 1, 2015 to August 31, 2016) from AgWeatherNet station Pullman NE, Cook Agronomy Farm East, Con't

Precipitation		Precipitation		Precipitation		Precipitation	
Date	(in.)	Date	(in.)	Date	(in.)	Date	(in.)
1/2/16	0.01	2/2	0.01	3/1	0.19	4/1	0.05
1/8	0.02	2/3	0.01	3/3	0.02	4/4	0.01
1/11	0.01	2/4	0.21	3/5	0.10	4/12	0.05
1/12	0.21	2/6	0.01	3/6	0.18	4/13	0.07
1/13	0.67	2/11	0.03	3/7	0.05	4/14	0.24
1/16	0.14	2/12	0.09	3/8	0.04	4/22	0.15
1/17	0.37	2/13	0.20	3/9	0.34	4/23	0.03
1/18	0.07	2/14	0.10	3/10	0.10	4/29	0.30
1/19	0.23	2/15	0.02	3/11	0.15	4/30	0.59
1/20	0.12	2/16	0.01	3/12	0.22	Total	1.49
1/21	0.12	2/18	0.62	3/13	0.25	Normal	1.75
1/22	0.11	2/19	0.02	3/14	0.03	Dep Norm	-0.26
1/23	0.25	2/27	0.20	3/17	0.07		
1/27	0.02	2/28	0.04	3/20	0.18		
1/28	0.53	Total	1.57	3/21	0.19		
1/29	0.21	Normal	1.81	3/22	0.94		
1/31	0.03	Dep Norm	-0.24	3/24	0.19		
Total	3.12			3/27	0.07		
Normal	2.55			3/28	0.04		
Dep Norm	0.57			Total	3.35		
				Normal	2.05		
				Dep Norm	1.30		

Precipitation data (September 1, 2015 to August 31, 2016) from AgWeatherNet station Pullman NE, Cook Agronomy Farm East, Con't

Precipitation		Precipitation		Precipitation		Precipitation	
Date	(in.)	Date	(in.)	Date	(in.)	Date	(in.)
5/5	0.05	6/8	0.28	7/6	0.07	8/8	0.02
5/14	0.01	6/10	0.13	7/8	0.29	8/9	0.36
5/15	0.57	6/14	0.01	7/9	0.22	8/10	0.01
5/17	0.01	6/16	0.01	7/10	0.04	Total	0.39
5/20	0.07	6/18	0.23	7/12	0.01	Normal	0.66
5/21	0.04	6/24	0.18	Total	0.63	Dep Norm	-0.27
5/22	0.04	Total	0.84	Normal	0.65		
Total	0.79	Normal	1.49	Dep Norm	-0.02		
Normal	1.77	Dep Norm	-0.65				
Dep Norm	-0.98						

Precipitation data (September 1, 2015 to August 31, 2016) from AgWeatherNet station
Davenport

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
9/5/15	0.94	10/7	0.04	11/1	0.10	12/3	0.29
9/6	0.01	10/10	0.02	11/5	0.06	12/5	0.11
9/14	0.01	10/18	0.11	11/7	0.13	12/6	0.42
Total	0.96	10/26	0.04	11/8	0.06	12/7	1.00
		10/27	0.01	11/9	0.24	12/8	0.46
		10/28	0.14	11/11	0.01	12/9	0.19
		10/29	0.02	11/14	0.08	12/10	0.19
		10/30	0.01	11/17	0.26	12/12	0.23
		10/31	0.37	11/24	0.12	12/16	0.07
		Total	0.76	Total	1.06	12/18	0.08
						12/19	0.06
						12/21	0.02
						Total	3.12

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
1/5/16	0.04	2/4	0.05	3/1	0.26	4/4	0.11
1/6	0.60	2/11	0.09	3/5	0.27	4/14	0.18
1/7	0.02	2/12	0.08	3/6	0.45	4/27	0.04
1/8	0.08	2/13	0.08	3/7	0.01	4/29	0.08
1/12	0.30	2/17	0.03	3/9	0.54	Total	0.41
1/13	0.15	2/18	0.17	3/10	0.09		
1/16	0.08	2/19	0.11	3/11	0.14		
1/17	0.41	2/27	0.02	3/12	0.28		
1/18	0.01	Total	0.63	3/13	0.20		
1/19	0.51			3/20	0.16		
1/20	0.01			3/21	0.13		
1/21	0.35			3/22	0.70		
1/22	0.10			3/23	0.05		
1/23	0.20			3/24	0.02		
1/25	0.01			3/27	0.11		
1/27	0.02			3/28	0.04		
1/28	0.35			Total	3.45		
1/29	0.09						
Total	3.33						

Precipitation data (September 1, 2015 to August 31, 2016) from AgWeatherNet station
Davenport, Con't

Precipitation		Precipitation		Precipitation		Precipitation	
Date	(in.)	Date	(in.)	Date	(in.)	Date	(in.)
5/4	0.14	6/8	0.02	7/5	0.01	8/7	0.07
5/5	0.01	6/10	0.28	7/6	0.02	8/9	0.09
5/9	0.01	6/18	0.14	7/7	0.02	8/10	0.01
5/15	0.08	6/24	0.56	7/8	0.06	Total	0.17
5/19	0.06	Total	1.00	7/9	0.33		
5/21	0.10			7/12	0.05		
5/22	0.13			7/17	0.07		
5/27	0.05			7/18	0.01		
Total	0.58			7/22	0.29		
				Total	0.86		