2017 WSU Weed Control Report

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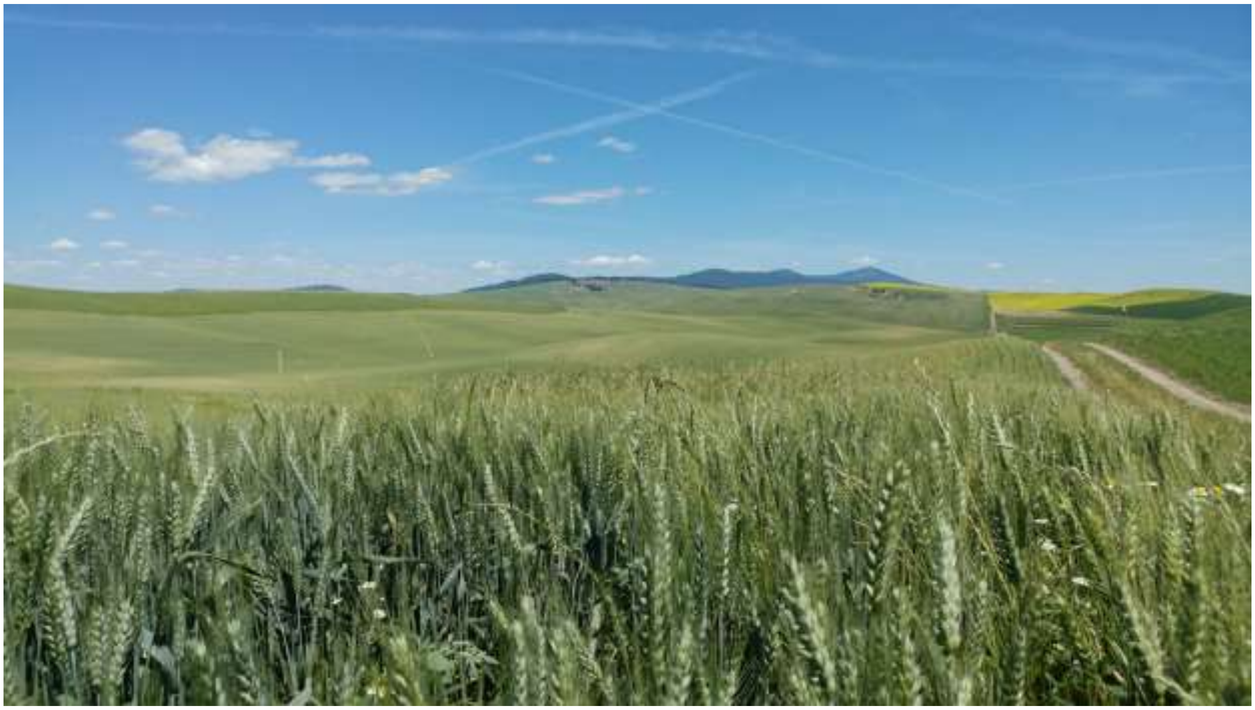

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Some of the pesticides discussed in this presentation were tested under an experimental use permit granted by WSDA. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator 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.

Evaluating Osprey® Xtra for downy brome and tumble mustard control in winter wheat

Derek Appel, Henry Wetzel and Drew Lyon

A field study was conducted at the Wilke Farm near Davenport, WA to evaluate spring applications of Osprey Xtra for the control of downy brome and tumble mustard in winter wheat. Osprey Xtra contains mesosulfuron, the active ingredient in Osprey, plus thiencarbazone. This herbicide is not yet registered for use in wheat. Both of these active ingredients are in Mechanism of Action Group 2, which are compounds that inhibit acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Osprey Xtra also contains mefenpyr-diethyl, which is used as a safener in combination with the active ingredients for selective weed control in wheat. Delayed preemergence applications of Anthem® Flex (carfentrazone + pyroxasulfone), Axiom® DF (metribuzin + flufenacent) and Zidua® (pyroxasulfone) were applied alone and in combination with spring postemergence applications of Osprey Xtra (thiencarbazone + mesosulfuron) and PowerFlex® HL (pyroxsulam) in winter wheat.

The soil for this site is a Broadax silt loam with 2.9% organic matter and a pH of 5.4. On September 20, 2016, 'Jasper' winter wheat was planted into chemical fallowed ground using a no-till drill with a 7.5-inch row spacing. Seeding rate was 65 lb/acre and seed was planted at a depth of 1.5-inch. Starter fertilizer was applied below the seed at planting at a rate of 100, 8 and 10 lb/acre of N:P:S. Delayed preemergence treatments were applied on September 25th using a CO_2 backpack sprayer set to deliver 10 gpa at 30 psi. Conditions were an air temperature of 60°F, relative humidity of 45% and the wind out of the southwest at 7 mph. Spring treatments were applied on May 3rd using a CO_2 backpack sprayer set to deliver 10 gpa at 30 psi. Downy brome was 4 inches tall and tumble mustard rosettes had an average diameter of 4 inches at the time of application. Conditions were an air temperature of 58°F, relative humidity of 50% and the wind out of the southwest at 7 mph. The plots were harvested on August 9 using a Kincaid 8XP plot combine.

No significant crop injury was observed in this study (data not shown). Fall applied Anthem Flex, Axiom or Zidua provided excellent control of downy brome. Spring applied sequential applications of Osprey Xtra or PowerFlex HL following fall treatments did not improve downy brome control, suggesting that the majority of the downy brome emerged in the fall. Spring applications of Osprey Xtra or PowerFlex HL alone provided fair control of downy brome and was similar to the fall application of Maverick. Spring applied sequential applications of Osprey Xtra or PowerFlex HL to the fall applications of Anthem Flex, Axiom and Zidua significantly improved tumble mustard control when compared to the fall application of Anthem Flex, Axiom or Zidua alone. Spring applied Osprey Xtra or PowerFlex HL alone provided fair to good control of tumble mustard. Overall yield and test weight means were 98 bu/A and 53.3 lb/bu, respectively. Reduced yield in the Axiom- and Maverick-treated plots may have been due to the lack of tumble mustard control. Reduced yield in the nontreated check plots was likely due to the lack of control of either of the weed species. Even though delayed preemergence applications of

Anthem Flex, Axiom DF and Zidua provided season long control of downy brome in this study, a planned spring application of a Group 2 herbicide is advisable for years when soil-applied herbicides may not work as well as in this study and as a wise herbicide resistance management strategy. The spring postemergence treatments were also needed for acceptable tumble mustard control.

			6/6/17		
			Downy brome	Tumble mustard	8/9/17
Treatment	Rate	Application date(s)	control	control	Yield
	(fl oz/A)		-------------------(0-100%)--------------------		(bu/A)
Nontreated Check	--		--	--	82 de
Axiom DF	10 oz	9/25/16	93 a[2]	3 g	69 e
Zidua	1.5 oz	9/25/16	86 ab	40 e	104 ab
Anthem Flex	3.5	9/25/16	92 a	60 d	95 b-d
Axiom DF fb Osprey Xtra[1]	10 oz fb 4.75 oz	9/25/16 fb 5/3/17	85 ab	88 ab	100 a-c
Zidua fb Osprey Xtra[1]	1.5 oz fb 4.75 oz	9/25/16 fb 5/3/17	90 a	89 ab	111 a
Anthem Flex fb Osprey Xtra[1]	3.5 fb 4.75 oz	9/25/16 fb 5/3/17	94 a	95 a	106 ab
Osprey Xtra[1]	4.75 oz	5/3/17	72 c	80 bc	101 ab
Axiom DF fb PowerFlex HL[1]	10 oz fb 2.0 oz	9/25/16 fb 5/3/17	91 a	83 b	106 ab
Zidua fb PowerFlex HL[1]	1.5 oz fb 2.0 oz	9/25/16 fb 5/3/17	94 a	89 ab	103 ab
Anthem Flex fb PowerFlex HL[1]	3.5 fb 2.0 oz	9/25/16 fb 5/3/17	95 a	89 ab	111 a
PowerFlex HL[1]	2.0 oz	5/3/17	75 bc	73 c	107 ab
Maverick	0.67 oz	9/25/16	78 bc	10 f	85 cd

[1] Spring applied treatments containing Osprey Xtra or PowerFlex HL were tank mixed with 0.5% NIS and 2.0 qt UAN/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 Osprey® Xtra for the control of downy brome in winter wheat

Derek Appel, Henry Wetzel and Drew Lyon

A field study was conducted at the Wilke Farm near Davenport, WA to evaluate Osprey Xtra for downy brome control in winter wheat. Osprey Xtra (thiencarbazone + mesosulfuron) active ingredients are both in the Mechanism of Action Group 2, which are compounds that inhibit acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Osprey Xtra also contains mefenpyr-diethyl, which is used as a safener in combination with the active ingredients for selective weed control in wheat. Osprey Xtra is not yet registered for use in wheat. Osprey Xtra was compared to the current formulation of Osprey, which only contains (mesosulfuron + mefenpyr-diethyl). The addition of one or two emulsifiable concentrate (EC) herbicide formulations have been shown to increase the activity of Osprey Xtra, and is why those treatments were included in this study.

The soil for this site is a Broadax silt loam with 2.9% organic matter and a pH of 5.4. On September 20, 2016, 'Jasper' winter wheat was planted into chemical fallowed ground using a no-till drill with 7.5-inch row spacing. Seeding rate was 65 lb/acre and seed was planted to a 1.5-inch depth. Starter fertilizer was applied below the seed at planting at a rate of 100 lb N, 8 lb P and 10 lb S per acre. Spring treatments were applied on May 3rd using a CO_2 backpack sprayer set to deliver 10 gpa at 30 psi. Downy brome was 4 inches tall at the time of the application. Conditions were an air temperature of 64°F, relative humidity of 48% and the wind out of the southwest at 7 mph. The plots were harvested on August 9 using a Kincaid 8XP plot combine.

There was not a significant difference between Osprey and Osprey Xtra in relation to control of downy brome. Both products provided fair control of downy brome. None of the broadleaf tank mixes enhanced Osprey or Osprey Xtra's control of downy brome. The mean yield was 64 bu/A. There were no significant differences among herbicide treatments and the nontreated check in relation to yield.

		6/6	8/9
		Downy brome	
Treatment	Rate	control	Yield
	fl oz/A	-----0-100%------	bu/A
Nontreated Check		--	59 a
Osprey[1]	4.75 oz	79 a	64 a
Osprey Xtra[1]	4.75 oz	73 a	63 a
Osprey + Huskie[2]	4.75 oz + 13.5	79 a	59 a
Osprey Xtra + Huskie[2]	4.75 oz + 13.5	75 a	68 a
Osprey + Huskie + Brox-M[2]	4.75 oz + 13.5 + 16	78 a	62 a
Osprey Xtra + Huskie + Brox-M[2]	4.75 oz + 13.5 + 16	83 a	73 a
Osprey + Huskie + WideMatch[2]	4.75 oz + 13.5 + 16	79 a	64 a
Osprey Xtra + Huskie + WideMatch[2]	4.75 oz + 13.5 + 16	73 a	63 a

[1] Treatments were tank mixed with 2.0 qt UAN + 0.5% v/v NIS

[2] Treatments were tank mixed with 2.0 qt UAN + 0.25% v/v NIS

[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.

Broadleaf and grass weed control with spring applications of Quelex™ plus PowerFlex® HL in winter wheat

Derek Appel, Henry Wetzel and Drew Lyon

A field study was conducted at the Wilke Farm near Davenport, WA to evaluate broadleaf and grass weed control with spring applications of Quelex plus PowerFlex HL in winter wheat. Quelex is a recently registered product of Dow/DuPont that contains halauxifen-methyl (Group 4) and florasulam (Group 2) herbicide active ingredients. PowerFlex HL contains pyroxsulam which is also a Group 2 herbicide. While florasulam and pyroxsulam have the same mode of action, florasulam only provides activity on broadleaf weeds whereas pyroxsulam is active on both broadleaf and grassy weeds.

The soil for this site is a Broadax silt loam with 2.9% organic matter and a pH of 5.4. On September 20, 2016, 'Jasper' winter wheat was planted into chemical fallowed ground using a no-till drill with 7.5-inch row spacing. Seeding rate was 65 lb/acre and seed was planted to a 1.5-inch depth. Starter fertilizer was applied below the seed at planting at a rate of 100 lb N, 8 lb P and 10 lb S per acre. Spring treatments were applied on May 3rd using a CO_2 backpack sprayer set to deliver 10 gpa at 30 psi. Downy brome was 4 inches tall and tumble mustard rosettes had an average diameter of 4 inches at the time of application. Conditions were an air temperature of 65°F, relative humidity of 52% and the wind out of the southwest at 8 mph. The plots were harvested on August 9th using a Kincaid 8XP plot combine.

No significant crop injury was observed in this study (data not shown). All treatments provided fair to good control of downy brome. The addition of Quelex did not improve the level of downy brome control that PowerFlex HL was providing on its own. PowerFlex HL alone provided good control of tumble mustard whereas all other treatments provided excellent control. Adding Quelex to PowerFlex HL resulted in improved tumble mustard control. Overall yield and test weight means were 98 bu/A and 55.6 lb/bu, respectively. There were no significant differences among treatments on yield and test weight.

		5/24	6/6
		Downy brome	Tumble mustard
Treatment	Rate	control	
	fl oz/A	---------------------0-100%---------------------	
Nontreated Check	--	--	--
PowerFlex HL[1]	2.0 oz	81 a[2]	83 c
PowerFlex HL + Quelex[1]	2.0 oz + 0.75 oz	80 a	91 b
PowerFlex HL + Quelex + WideMatch[1]	2.0 oz + 0.75 oz + 16	86 a	96 ab
PowerFlex HL + Quelex + 2,4-D Ester LV[1]	2.0 oz + 0.75 oz + 8	76 a	100 a
PowerFlex HL + Talinor + CoAct+ + NIS	2.0 oz + 13.7 + 2.75 + 0.5% v/v	75 a	100 a
PowerFlex HL + Huskie[1]	2.0 oz + 13.5	85 a	100 a
Olympus + 2,4-D Ester LV[1]	0.6 oz + 8	83 a	100 a
Osprey[1]	4.75 oz	74 a	91 b
Osprey + WideMatch[1]	4.75 oz + 16	68 a	100 a
PerfectMatch[1]	20	86 a	99 a
PowerFlex + WideMatch[1]	2.0 oz + 16	80 a	98 a

[1] Treatments were tank mixed with AMS 1.52 lb/A and NIS 0.5% v/v

[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.

Preemergence and Postemergence Herbicides for Downy Brome Control in Clearfield Winter Wheat

Zuger, R.J., A.L. Hauvermale, & I.C. Burke

Downy brome continues to be a problematic and widespread weed in inland PNW wheat-fallow rotations. Acetolactate synthase inhibitor resistance continues to spread, and there are very few herbicide options remaining. Our objective was to identify one or more herbicide treatments with different herbicide modes of action for management of downy brome.

The study was established in a Clearfield winter wheat field near Anatone, WA. Whole plot treatments were applied delayed preemergence (delayed-PRE) to 4 to 5-leaf wheat and 2-leaf downy brome on November 16, 2016, detailed in Table 1, Table 2 and Table 4. The whole plots were 10’ by 75’ long and then split into 10’ by 25’ long plots in the spring for postemergence (POST) applications. Split plot treatments were applied in the spring POST on April 5, 2017, detailed in Table 1, Table 3, and Table 5. The study was conducted in a randomized complete block with 4 replications.

Downy brome (*Bromus tectorum*) control and crop injury was assessed by visual estimation at 127, 154, 174, and 189 days after treatment (DAT) of application A the delayed-PRE (Table 2, 3, 4, & 5). Downy brome biomass was harvested by collecting two 1/10th meter quadrants from each split-plot on June 15, 2017 (Table 2 & 3). Plots were harvested using a Kincaid plot combine on July 31, 2017.

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) and R (R Development Core Team 2008). Significant differences between treatments were analyzed using Fisher’s protected LSD in R using the agricolae package.

The combination of both a fall applied delayed-PRE and a spring applied POST herbicide treatment did not impact the efficiency of downy brome control, crop injury, or yield. Downy brome control with Zidua plus TriCor DF and TriCor DF alone was greatest for the duration of the study with 53% and 50% (127 DAT), 76% and 68% (174 DAT), and 60% and 78% control (189 DAT), respectively (Table 2). Zidua alone had lower downy brome control with 28%, 12%, and 15% control at 127, 174, and 189 DAT, respectively, possibly due to the late timing of application with downy brome at the 2-leaf stage present (Table 2). Zidua inhibits long chain fatty acid synthesis (Group 15) preventing root and shoot formation of germinating seedlings and has little to no effect on already germinated weeds. Zidua with TriCor DF and TriCor DF alone both significantly reduced the amount of downy brome biomass compared to the nontreated control. Downy brome biomass in the nontreated control was 2035 lb A^{-1} compared to 291 lb A^{-1} downy brome biomass for Zidua with TriCor DF and 725 lb A^{-1} for TriCor DF.

POST applications of Powerflex and Beyond in the spring had no significant impact on the visual ratings of downy brome control or downy brome biomass compared to non-POST treatments (Table 3). Significant crop injury was present in March, 127 days after the delayed-PRE treatments, for both the Zidua with TriCor DF and TriCor DF alone compared to the nontreated with 78% and 53%, respectively. However, although not significantly different all delayed-PRE treatments caused some visual injury compared to the nontreated control at 127 DAT (Table 4). No crop injury was observed again till 189 DAT of the delayed-PRE. Zidua with TriCor DF (15%) and TriCor DF alone (18%) had greater crop injury compared to the nontreated (0%) at189 DAT. No crop injury was observed for either POST treatment at 14 DAT (Table 5).

There were no differences in crop yield observed for the delayed-PRE treatments. However, when POST treatments were applied a significant reduction in yield was observed possibly due to the low night time temperature of 45˚F. When no POST treatment was applied yield was 74 bu A^{-1} compared to 63 bu A^{-1} for Powerflex HL and 67 bu A^{-1} for Beyond.

Table 1. *Treatment application details*

Study Application	A	B
Date	November 16, 2016	April 5, 2017
Application Timing	Delayed-PRE	POST
Application volume (GPA)	15	15
Day air temperature (˚F)	35	50
Night air temperature (˚F)	27	45
Soil temperature (˚F)	48	39
Wind velocity (mph, direction)	8, SW	10, S
Next rain occurred on	November 20, 2017	April 7, 2017

Table 2. *Downy brome percent control and biomass following preemergence applications. Anatone, WA, 2016-2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	Application Timing	Rate		Downy Brome Control				Downy Brome Biomass
				3/23/17 127 DAT	4/19/17 154 DAT	5/9/17 174 DAT	5/24/17 189 DAT	6/15/17
		field rate	lb ai/A	%	%	%	%	LB/A
Nontreated	A	-	-	-	-	-	-	2035 a
Zidua	A	1.50 oz/A	0.080	28 abcd	35	12 bc	15 ab	1793 a
Zidua **Outrider** **NIS**	A A A	1.50 oz/A 0.66 oz/A 0.25 % v/v	0.080 0.031	23 abc	34	26 b	43 bc	1400 ab
Zidua **TriCor DF** **NIS**	A A A	1.50 oz/A 0.5 lb/A 0.25 % v.v	0.080 0.375	53 d	63	76 a	60 cd	291 c
Hoelon	A	2.66 pt/A	1.000	30 abcd	28	14 bc	8 ab	1311 ab
Hoelon **Outrider** **NIS**	A A A	2.66 pt/A 0.66 oz/A 0.25 % v/v	1.000 0.031	18 ab	30	20 bc	10 ab	1249 ab
Outrider **NIS**	A A	0.66 oz/A 0.25 % v/v	0.031	28 abcd	28	8 bc	13 ab	1852 a
Outrider **Olympus** **NIS**	A A A	0.66 oz/A 0.60 oz/A 0.25 % v/v	0.031 0.026	15 ab	31	0 c	10 ab	1913 a
TriCor DF **NIS**	A A	0.50 lb/A 0.25 % v/v	0.375	50 cd	58	68 a	78 d	725 bc
Prowl H2O	A	2.1 pt/A	1.000	10 ab	17	3 c	0 a	1917 a
Valor	A	2 oz/A	0.064	33 bcd	32	0 c	0 a	1359 ab
Outlook	A	16 fl oz/A	0.750	23 abc	26	5 bc	8 ab	1528 ab
Finesse **NIS**	A A	0.40 oz/A 0.25 % v/v	0.016	15 ab	21	0 c	20 ab	1677 a
			LSD	*19*	*NA*	*21*	*25*	*939*

Table 3. *Percent downy brome control and downy brome biomass following postemergence applications. Anatone, WA, 2016-2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

				Downy Brome Control				*Downy Brome Biomass*
Treatment	**Application Timing**	**Rate**		**3/23/17 127 DAT**	**4/19/17 154 DAT**	**5/9/17 174 DAT**	**5/24/17 189 DAT**	**6/15/17**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**LB/A**
No POST		-	-	-	27	21	-	1416
Powerflex HL **NIS** **UAN**	B B B	2 oz/A 0.25 % v/v 2.5 gal/100 gal	0.016	-	33	17	-	1554
Beyond **NIS** **UAN**	B B B	6 fl oz/A 0.25 % v/v 2.5 gal/100 gal	0.094	-	41	21	-	1425
			LSD	-	*NS*	*NS*	-	*NS*

Table 4. *Percent crop injury and yield following delayed preemergence applications. Anatone, WA, 2016-2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

				Crop Injury				*Yield*
Treatment	**Application Timing**	**Rate**		**3/23/17 127 DAT**	**4/19/17 154 DAT**	**5/9/17 174 DAT**	**5/24/17 189 DAT**	**7/31/2017**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**bu/A**
Nontreated	A	-	-	0 a	-	-	-	65
Zidua	A	1.50 oz/A	0.080	43 abc	8	0	0 a	71
Zidua **Outrider** **NIS**	A A A	1.50 oz/A 0.66 oz/A 0.25 % v/v	0.080 0.031	38 ab	21	0	15 b	73
Zidua **TriCor DF** **NIS**	A A A	1.50 oz/A 0.5 lb/A 0.25 % v.v	0.080 0.375	78 c	38	10	8 a	73
Hoelon	A	2.66 pt/A	1.000	43 abc	24	0	0 a	67
Hoelon **Outrider** **NIS**	A A A	2.66 pt/A 0.66 oz/A 0.25 % v/v	1.000 0.031	33 ab	28	0	3 a	68
Outrider **NIS**	A A	0.66 oz/A 0.25 % v/v	0.031	25 ab	19	0	0 a	66
Outrider **Olympus** **NIS**	A A A	0.66 oz/A 0.60 oz/A 0.25 % v/v	0.031 0.026	18 ab	21	0	0 a	66
TriCor DF **NIS**	A A	0.50 lb/A 0.25 % v/v	0.375	53 bc	36	10	18 b	74
Prowl H2O	A	2.1 pt/A	1.000	13 ab	19	0	0 a	61
Valor	A	2 oz/A	0.064	35 ab	23	8	0 a	67
Outlook	A	16 fl oz/A	0.750	30 ab	26	0	3 a	66
Finesse **NIS**	A A	0.40 oz/A 0.25 % v/v	0.016	13 ab	23	20	3 a	66
			LSD	*28*	*NS*	*NS*	*7*	*NS*

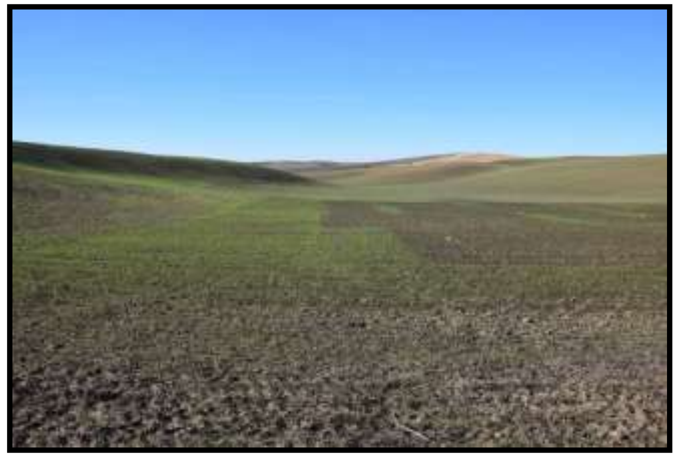
Table 5. *Percent crop injury and yield following postemergence applications. Anatone, WA, 2016-2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

				Crop Injury				*Yield*
Treatment	**Application Timing**	**Rate**		**3/23/17 127 DAT**	**4/19/17 154 DAT**	**5/9/17 174 DAT**	**5/24/17 189 DAT**	**7/31/2017**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**bu/A**
No POST		-	-	-	21	-	-	74 a
Powerflex HL **NIS** **UAN**	B B B	2 oz/A 0.25 % v/v 2.5 gal/100 gal	0.016	-	25	-	-	63 b
Beyond **NIS** **UAN**	B B B	6 fl oz/A 0.25 % v/v 2.5 gal/100 gal	0.094	-	26	-	-	67 b
			LSD	-	*NS*	-	-	*5*

Thank you to the grower and their family for the use of their land.

Evaluation of application timings with Zidua® for the control of Italian ryegrass in winter wheat

Henry Wetzel and Drew Lyon



A field study was conducted at the Cook Agronomy Farm near Pullman, WA to determine the application timing of Zidua that would provide optimum control of Italian ryegrass in winter wheat. We evaluated four herbicide application timings in relation to wheat growth stage: preemergence, delayed preemergence, spike leaf emerged and early tillering.

The soil at this site is a Naff silt loam with 3.6% organic matter and a pH of 5.0. The trial area was conventionally summer fallowed. On September 29, 2016, 'Puma' winter wheat was seeded at 90 lb seed per acre at a depth of 1.5 inches with a John Deere 9400 hoe drill on a 7-inch row spacing. The ground was fertilized with granular urea on November 10th with 100 lb N per acre. Preemergence treatments were applied on September 30th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 44 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 67°F and relative humidity of 19%. Delayed preemergence treatments were applied on October 4th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 45 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 56°F and relative humidity of 60%. Spike leaf treatments were applied on October 11th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 47 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 52°F and relative humidity of 46%. Early tillering treatments were applied on April 9, 2017 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 44 psi at 2.3 mph. The applications were made under winds out of the east at 4 mph with an air temperature of 43°F and relative humidity of 65%. The plots were harvested on August 10th using a Kincaid 8XP plot combine.

October was an extremely wet month with 22 days receiving rainfall and totaling 4.78 inches. Initial counts of Italian ryegrass plants in the nontreated check occurred on October 12th. A significant portion of Italian ryegrass germinated in the fall and survived the winter due to prolonged snow cover. In the spring, it was difficult to get back into the field from all the fall precipitation, snow melt and continued rains in late winter/early spring. On April 9th, when the early tillering application was made, wheat was at 1 to 2 tillers and 6 to 7 inches tall and the Italian ryegrass ranged from 2-leaf to fully tillered, with the majority of the plants 1- to 3-tiller, at a height of 3 to 5 inches. The density of Italian ryegrass in the nontreated checks was so high that it seemed unlikely that additional plants were going to emerge in the spring. The trial area was also non-uniformly infested with wireworms which had some level of impact on yield. The wireworm damage was most pronounced in the spring. However, we believe that yield was most influenced by the level of Italian ryegrass control. Zidua (2.5 oz/A) or Zidua + PowerFlex® HL (2.5 + 2.0 oz/A) applied at spike leaf or Zidua (1.5 oz/A) preemergence followed by Zidua (1.0 oz/A) spike leaf; Zidua (1.5 oz/A) preemeregence followed by Zidua + PowerFlex HL (1.0 + 2.0 oz/A) spike leaf provided the best control of Italian ryegrass. The addition of PowerFlex HL to the aforementioned treatments did not improve control compared to Zidua alone. The best Italian ryegrass control was achieved when a total of 2.5 oz/A of Zidua was applied in the fall. It did not matter if it was applied as sequential treatments or all at once at the spike leaf stage. The 2.5 oz/A rate cannot be applied to wheat prior to emergence, so if a grower wants to ensure some level of control prior to wheat emergence, they will need to apply Zidua at 1.0 to 1.75 oz/A (depending on soil type) preplant surface or preemergence and then follow with a sequential treatment of 0.75 to 1.5 oz/A (not to exceed a total of 2.5 oz/A). Zidua + PowerFlex HL applied at early tillering in the spring did not provide commercially acceptable control of Italian ryegrass. When Zidua applications were split between fall and spring, the fall applications were providing most of the control and the spring applications added very little.

				6/23	8/10
				Italian ryegrass	
Treatment #	Treatment	Rate	Application Timing[2]	control	Yield
		oz/A		-----0-100%------	bu/A
1	Nontreated Check	--	--	--	33 b
2	Zidua	1.5	preemergence	75 e[3]	103 a
3	Zidua	1.5	delayed preemergence	81 c-e	101 a
4	Zidua + Sencor	1.5 + 1.45	delayed preemergence	79 de	104 a
5	Zidua	2.5	spike leaf	90 a-c	102 a
6	Zidua + PowerFlex HL	2.5 + 2.0	spike leaf	89 a-c	83 a
7	Zidua	2.5	early tillering	30 f	40 b
8	Zidua + PowerFlex HL[1]	2.5 + 2.0	early tillering	27 f	44 b
9	Zidua	1.5	preemergence	95 a	96 a
9	Zidua	1.0	spike leaf		
10	Zidua	1.5	preemergence	91 ab	89 a
10	Zidua + PowerFlex HL	1.0 + 2.0	spike leaf		
11	Zidua	1.5	preemergence	79 de	94 a
11	Zidua	1.0	early tillering		
12	Zidua	1.5	preemergence	85 b-d	103 a
12	Zidua + PowerFlex HL[1]	1.0 + 2.0	early tillering		

[1] Treatment was tank mixed with 0.5% NIS and 2.0 qts UAN/a

[2] Dates of application, premergence (9/30/16), delayed preemergence (10/4/16), spike leaf (10/11/16) and early tillering (4/9/17)

[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.

Evaluate Axiom® DF and Osprey® Xtra for the control of Italian ryegrass in winter wheat
Henry Wetzel and Drew Lyon

A field study was conducted at the Cook Agronomy Farm near Pullman, WA to evaluate the control of Italian ryegrass in winter wheat with Axiom DF and Osprey Xtra. Osprey Xtra (thiencarbazone + mesosulfuron) active ingredients are both in the Mechanism of Action Group 2, which are compounds that inhibit acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Osprey Xtra also contains mefenpyr-diethyl, which is used as a safener in combination with the active ingredients for selective weed control in wheat. This herbicide is not yet registered for use in wheat. Osprey Xtra only has postemergence activity on Italian ryegrass. We evaluated two herbicide application timings in relation to wheat growth stage: delayed preemergence and early tillering.

The soil at this site is a Palouse silt loam with 3.9% organic matter and a pH of 5.2. The trial area was conventionally summer fallowed. On September 29, 2016, 'Puma' winter wheat was seeded at 90 lb seed per acre at a depth of 1.5 inches with a John Deere 9400 hoe drill on a 7-inch row spacing. The ground was fertilized with granular urea on November 10th with 100 lb N per acre. Delayed preemergence treatments were applied on October 4th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 45 psi at 2.3 mph. The applications were made under winds out of the east at 2 mph with an air temperature of 52°F and relative humidity of 64%. Early tillering treatments were applied on April 11, 2017 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 44 psi at 2.3 mph. The applications were made under winds out of the east at 7 mph with an air temperature of 56°F and relative humidity of 38%. The plots were harvested on August 7th using a Kincaid 8XP plot combine.

October was an extremely wet month with 22 days receiving rainfall and totaling 4.78 inches. Initial counts of Italian ryegrass plants in the nontreated check occurred on October 12th. A significant portion of Italian ryegrass germinated in the fall and survived the winter due to prolonged snow cover. In the spring, it was difficult to get back into the field from all the fall precipitation, snow melt and continued rains in late winter/early spring. On April 11th, when the postemergence application was made, wheat was at 3 tillers and 7 to 8 inches tall and the Italian ryegrass was fully tillered at a height of 2 to 3 inches. The density of Italian ryegrass in the nontreated checks was so high that it seemed unlikely that additional plants were going to emerge in the spring. Treatments that included a delayed preemergence application of Anthem Flex or Zidua provided good to excellent control of Italian ryegrass. Treatments that included a delayed preemergence application of Axiom DF provided fair control of Italian ryegrass. The addition of a spring application of either PowerFlex® HL or Osprey Xtra added to fall-applied treatments did not improve Italian ryegrass control when compared to the fall applications alone. Spring applications of either Osprey Xtra or PowerFlex HL alone did not provide commercially acceptable control of Italian ryegrass. The lack of efficacy from the spring applications might be partially explained by the lack of a spring germinating cohort of Italian ryegrass. The fall germinating cohort of Italian ryegrass may have been too large for effective control with spring herbicide applications. Another possible explanation is that the Italian ryegrass population in this field may have been resistant to Group 2 herbicides. Fall herbicide applications led to the best Italian ryegrass control, which in turn led to the highest yields, when compared to spring applied Osprey Xtra, PowerFlex HL or the nontreated check treatments.

				6/14/17	8/7/17
			Application	Italian ryegrass	
Treatment #	Treatment	Rate	Date	control	Yield
		(oz/A)		-----0-100%------	bu/A
1	Nontreated Check	--		--	58 e
2	Axiom DF	10	10/4/16	77 b[2]	92 cd
3	Zidua	1.5	10/4/16	89 a	111 ab
4	Anthem Flex	3.5 fl oz	10/4/16	92 a	103 a-c
5	Axiom DF	10	10/4/16	79 b	99 bc
5	Osprey Xtra[1]	4.75	4/11/17		
6	Zidua	1.5	10/4/16	91 a	107 a-c
6	Osprey Xtra[1]	4.75	4/11/17		
7	Anthem Flex	3.5 fl oz	10/4/16	95 a	116 ab
7	Osprey Xtra[1]	4.75	4/11/17		
8	Osprey Xtra[1]	4.75	4/11/17	15 d	66 e
9	Axiom DF	10	10/4/16	80 b	107 a-c
9	PowerFlex HL[1]	2	4/11/17		
10	Zidua	1.5	10/4/16	94 a	120 a
10	PowerFlex HL[1]	2	4/11/17		
11	Anthem Flex	3.5 fl oz	10/4/16	95 a	116 ab
11	PowerFlex HL[1]	2	4/11/17		
12	PowerFlex HL[1]	2	4/11/17	24 c	76 de

[1] Treatment was tank mixed with 0.5% NIS and 2.0 qts UAN/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.

Fall Application of Metribuzin for Italian Ryegrass Control After Preemergence Herbicide Failure

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

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied postemergence (POST) to 1 to 3-leaf Italian ryegrass in emerged 3 to 5-leaf winter wheat after failure of the delayed preemergent herbicide Zidua at 1.75 oz A^{-1} to control the Italian ryegrass, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 10' long. Winter wheat, variety Puma, was planted on October 8, 2016. The trial site was than treated with 1.75 oz A^{-1} of Zidua as a delayed preemergent on October 12, 2016 for Italian ryegrass and mayweed chamomile control. Treatments were applied November 7, 2016. In the spring, Huskie (15 fl oz A^{-1}), Rhomene (0.75 pt A^{-1}), nonionic surfactant (NIS; 0.25% v/v), and urea ammonium nitrate (UAN; 0.5 qt A^{-1}) was applied May 9, 2017 for broadleaf weed control. Paraquat (3 pt A^{-1}) was included as a negative control with the intention of killing all winter emerging Italian ryegrass present at time of application.

Italian ryegrass control was visually assessed 150 days after treatment (DAT). Crop stand reduction was also visually assessed 150 DAT (Table 2). Italian ryegrass biomass was collected 218 DAT by hand harvesting above ground biomass from two 1/10th meter quadrants in each plot and then air dried in oven for 72 hours before recording biomass. Plots were hand harvested by collecting 1 m^2 quadrats per plot on August 1, 2017. 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 difference in winter wheat stand reduction 150 DAT for any of the metribuzin treatments. There was a significant stand reduction for both the glufosinate (28% reduction) and paraquat (97% reduction) treatments (Table 2).

Visually Italian ryegrass control at 150 DAT increased as the rate of metribuzin increased with 30, 66, 51, 54 and 84% control at 0.047, 0.094, 0.140, 0.188, and 0.375 lb ai A^{-1} metribuzin, respectively. Metribuzin at 0.375 lb ai A^{-1} (84%) and the negative control of paraquat (90%) had the greatest control of the Italian ryegrass at 150 DAT. However, by 218 DAT, there was no longer a significant difference in Italian ryegrass control between treatments and the nontreated control with no difference in Italian ryegrass biomass (Table 2).

The metribuzin treatments had no significant effect on yield compared to the nontreated control.

Fig 1. Italian ryegrass control with metribuzin after preemergence herbicide failure. Left: nontreated control. Middle: Metribuzin at 0.047 lb ai A^{-1}. Right: Metribuzin at 1.040 lb ai A^{-1}.

Table 1. *Treatment application details*

Study Application	
Date	November 7, 2016
Application volume (GPA)	15
Crop Stage	4 leaves
Air temperature (˚F)	51
Soil temperature (˚F)	47
Wind velocity (mph, direction)	10, E
Cloud Cover	60 %
Next rain occurred on	November 13, 2016

Table 2. *Percent Italian ryegrass control, Italian ryegrass biomass, and winter wheat yield following applications of metribuzin. Pullman, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

			April 6, 2017 **150 DAT**		***June 20, 2017*** **218 DAT**	***August 1, 2017***
			Stand Reduction	**Italian ryegrass control**	**Italian ryegrass biomass**	**Yield**
	field rate	**lb ai/A**	**%**	**%**	**lb/A**	**bu/A**
Nontreated	-	-	-	-	2108	96 a
Metribuzin	1 oz/A	0.047	3 c	30 b	2275	87 a
Metribuzin	2 oz/A	0.094	1 c	66 ab	2184	87 a
Metribuzin	3 oz/A	0.140	5 c	51 ab	1622	96 a
Metribuzin	4 oz/A	0.188	0 c	54 ab	2548	92 a
Metribuzin	8 oz/A	0.375	11 c	84 a	2161	105 a
Glufosinate	22 fl oz/A	0.402	28 b	56 ab	3685	81 a
Paraquat	3 pt/A	1.040	97 a	90 a	3406	15 b
		LSD	*11*	*33*	*1922*	*18*

Evaluation of PRE/POST applications for the control of rattail fescue in direct-seeded soft white winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Wolf Farms near Uniontown, WA to evaluate herbicide application timing and its effect on rattail fescue control in direct-seeded winter wheat. We evaluated Anthem® Flex (carfentrazone + pyroxasulfone) and Axiom® DF (metribuzin + flufenacent) for preemergence control. Both of these products have active ingredients in the Mechanism of Action Group 15, which are compounds that inhibit the synthesis of very long-chain fatty acids. We evaluated Everest® 2.0 (flucarbazone) and Osprey® Xtra (thiencarbazone + mesosulfuron) for postemeregence control. Both of these products have active ingredients in the Mechanism of Action Group 2, which are compounds that inhibit acetolactate synthase, a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Osprey Xtra is not yet registered for use in wheat.

The soil at this site is an Athena silt loam with 3.3% organic matter and a pH of 5.0. The field was previously in field peas. On October 18, 2016, 'SYN107' soft white winter wheat was seeded at 1 x 10^6 seeds per acre with a Cross Slot® drill on a 10-inch row spacing. The ground was fertilized at the same time with 60 lb N: 30 lb P: 20 lb S per acre. An additional 40 lb N per acre was applied in the spring. From September 1 to the planting date, a weather station in Colton (approx. 6 miles north of the test site) recorded 22 days of rainfall totaling 2.94 inches, with the majority falling in October. Because of this, a significant amount of rattail fescue germinated prior to initiating the trial. We applied RT 3® (32 fl oz/A) + AMS (12 lb/100 gal) + Silwet® L-77 (0.25% v/v) in 20 GPA on October 24th over the entire trial area. Preemergence treatments were applied on October 25th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 46 psi at 2.3 mph. The applications were made under winds out of the southeast at 4 mph with an air temperature of 49°F and relative humidity of 72%. Fall postemergence treatments were applied on November 7th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 46 psi at 2.3 mph. The applications were made under winds out of the southeast at 8 mph with an air temperature of 59°F and relative humidity of 48%. Spring postemergence treatments were applied on April 28, 2017 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 41 psi at 2.3 mph. The applications were made under winds out of the west at 4 mph with an air temperature of 55°F and relative humidity of 40%. At the time of fall postemergence application, rattail fescue had one leaf emerged and ranged in height from 1.25 to 1.5 inches and the wheat had one leaf unfolded and was 1.5 to 2.5 inches in height. The density of rattail fescue increased as you moved from the first to the fourth rep of the trial. The plots were harvested on August 16 using a Kincaid 8XP plot combine.

With all of the fall precipitation, a significant amount of rattail germinated prior to wheat emergence. The application of RT 3 may have killed all of the emerged rattail fescue because the follow up applications of the preemeregence herbicides, Anthem Flex and Axiom DF, provided season long control, whereas the nontreated checks were recolonized with rattail fescue when rated in the spring. Fall or spring postemergence applications of either Everest 2.0 or Osprey Xtra did not control rattail fescue well. Fall applications may not have been effective because a significant portion of the rattail fescue was killed or weakened by the RT 3 application. Rattail fescue control was no better with the combination treatments of fall preemergence followed by spring postemergence than with only fall preemergence treatments, suggesting that the fall preemergence treatments were providing most of the control. This also suggests that the majority of rattail fescue germinated in the fall. Overall yield and test weight means were 84 bu/A and 55.4 lb/bu, respectively. There were no significant differences in yield or test weight among treatments when compared to the nontreated check. Even though preemergence applications of Anthem Flex and Axiom DF provided season long control of rattail fescue in this study, a planned spring application of a Group 2 herbicide is advisable for years when soil-applied herbicides may not work well as in this study and as a wise herbicide resistance management strategy.

				Rattail fescue control		8/16/17
Trt #	Treatment	Rate	Application Date	5/19/17	6/20/17	Yield
		fl oz/A		---------------------0-100%--------------------		bu/A
1	Nontreated Check			--	--	84 a
2	Anthem Flex	3.5	10/25/16	100 a[3]	100 a	85 a
3	Anthem Flex	3.5	10/25/16	100 a	100 a	87 a
3	Osprey Xtra[1]	4.75 oz	11/7/16			
4	Axiom DF	10 oz	10/25/16	99 a	96 a	85 a
5	Everest 2.0[2]	1.0	11/7/16	40 c	45 c	84 a
6	Osprey Xtra[1]	4.75 oz	11/7/16	52 bc	52 bc	82 a
7	Axiom DF	10 oz	10/25/16	100 a	100 a	85 a
7	Everest 2.0[2]	1.0	4/28/17			
8	Axiom DF	10 oz	10/25/16	100 a	100 a	84 a
8	Osprey Xtra[1]	4.75 oz	4/28/17			
9	Anthem Flex	3.5	10/25/16	100 a	100 a	83 a
9	Everest 2.0[2]	1.0	4/28/17			
10	Anthem Flex	3.5	10/25/16	100 a	100 a	91 a
10	Osprey Xtra[1]	4.75 oz	4/28/17			
11	Anthem Flex	2.5	10/25/16	100 a	100 a	89 a
11	Anthem Flex + Everest 2.0[2]	2.0 + 1.0	4/28/17			
12	Anthem Flex	2.5	10/25/16	100 a	100 a	87 a
12	Anthem Flex + Osprey Xtra[1]	2.0 + 4.75 oz	4/28/17			
13	Everest 2.0[2]	1.0	4/28/17	67 b	56 bc	78 a
14	Osprey Xtra[1]	4.75 oz	4/28/17	57 bc	70 b	79 a

[1] Treatments were tank mixed with 0.5% v/v NIS + 2.0 qt/A UAN

[2] Treatments were tank mixed with 0.5% v/v NIS

[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.

Evaluation of Osprey® Xtra for the postemergence control of rattail fescue in direct-seeded hard red winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Wolf Farms near Uniontown, WA to evaluate Osprey Xtra for its postemergence rattail fescue control in direct-seeded hard red winter wheat. Osprey Xtra (thiencarbazone + mesosulfuron) active ingredients are both in the Mechanism of Action Group 2, which are compounds that inhibit acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Osprey Xtra also contains mefenpyr-diethyl, which is used as a safener in combination with the active ingredients for selective weed control in wheat. Osprey Xtra was compared to the current formulation of Osprey, which only contains (mesosulfuron + mefenpyr-diethyl). Osprey Xtra is not yet registered for use in wheat. The addition of one or two broadleaf emulsifiable concentrate (EC) herbicide formulations have been shown to increase the activity of Osprey Xtra on rattail fescue, and is why those treatments were included in this study.

The soil at this site is an Athena silt loam with 3.4% organic matter and a pH of 4.7. The field was previously in field peas. On October 24, 2016, 'Rimrock/Keldin' hard red winter wheat blend was seeded at 1 x 10^6 seeds per acre with a Cross Slot® drill on a 10-inch row spacing. The ground was fertilized at the same time with 60 lb N: 30 lb P: 20 lb S per acre. The ground was fertilized with an additional 50 lb N per acre in the spring. From September 1 to the planting date, a weather station in Colton (approx. 6 miles north of the test site) recorded 25 days of rainfall totaling 3.33 inches, with the majority falling in October. Most likely, the majority of rattail fescue germinated in the fall. Postemergence treatments were applied on April 21, 2017 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 43 psi at 2.3 mph. The applications were made under winds out of the northeast at 3 mph with an air temperature of 58°F and relative humidity of 44%. At the time of application, the majority of rattail fescue had two detectible tillers and was 0.75 inch tall and the wheat had three detectable tillers with a height ranging from 6 to 8 inches. Rattail fescue was uniformly distributed across the trial area.

Osprey Xtra provided better control of rattail fescue than the current Osprey formulation. Rattail fescue control was not improved by tank mixing one or two EC concentrate herbicide formulations with Osprey Xtra. Osprey + Huskie + Brox-M provided comparable control to Osprey Xtra. Test weight was not influenced by any treatments and the mean was 59.2 lb/bu. Yield was negatively impacted by the presence of rattail fescue. Osprey Xtra-, Osprey Xtra + Huskie-, Osprey + Huskie + Brox-M- and Osprey Xtra + Huskie + WideMatch-treated plots exhibited an increase in yield compared to the nontreated check.

		Rattail fescue control				
		5/19	6/2	6/13		8/16
Treatment	Rate	28 DAT	42 DAT	53 DAT		Yield
	fl oz/A	---------------------------0-100%---------------------------				bu/A
Nontreated Check		--	--	--		71 c
Osprey[1]	4.75 oz	55 bc[3]	50 de	44 cd		76 bc
Osprey Xtra[1]	4.75 oz	72 a	69 a-c	72 ab		87 a
Osprey + Huskie[2]	4.75 oz + 13.5	57 bc	57 cd	57 bc		80 a-c
Osprey Xtra + Huskie[2]	4.75 oz + 13.5	75 a	71 ab	75 ab		85 ab
Osprey + Huskie + Brox-M[2]	4.75 oz + 13.5 + 16	67 ab	60 b-d	62 ab		84 ab
Osprey Xtra + Huskie + Brox-M[2]	4.75 oz + 13.5 + 16	76 a	75 a	80 a		80 a-c
Osprey + Huskie + WideMatch[2]	4.75 oz + 13.5 + 16	52 c	40 e	37 d		78 a-c
Osprey Xtra + Huskie + WideMatch[2]	4.75 oz + 13.5 + 16	67 ab	67 a-c	70 ab		83 ab

[1] Treatments were tank mixed with 2.0 qt UAN/A + 0.5% v/v NIS

[2] Treatments were tank mixed with 2.0 qt UAN/A + 0.25% v/v NIS

[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 on Mike Nelson's Farm near Albion, 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 that was recently registered for use in wheat and barley. 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 Palouse silt loam with 4.3% organic matter and a pH of 5.7. The field was previously in chickpeas. On September 8, 2016, the field was fertilized with 100 lb N:15 lb P:10 lb S per acre. On September 28th, 'ORCF-102' winter wheat was conventionally planted using a JD 455 disk drill with a 7.5-inch row spacing. At the time of planting, the field received 10 lb N:15 lb P:1qt Zn per acre. Postemergence treatments were applied on May 2nd with a CO_2-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 48°F and relative humidity of 75%. The majority of the wheat had just begun to joint and was 16 inches tall. Mayweed chamomile distribution was uniform across the trial area. Mayweed chamomile was 3.0 inches tall at the time of application and had a density of 34 plants per square foot in the nontreated check plot. Mayweed chamomile was continuing to germinate at the time of application.

Crop injury was not noted with any treatments in this study. Thirteen days after treatment (DAT) (May 15th), WideMatch-, WideMatch + Affinity TankMix- and WideMatch + Rhonox MCPA Ester-treated plots exhibited the best control of mayweed chamomile. By 42 DAT, all three rates of Talinor + CoAct+ were providing a similar level of control as the aforementioned treatments. The addition of Orion (florasulam + MCPA Ester) at 17 fl oz/A to Talinor + CoAct+ (13.7 + 2.75 fl oz/A) did not improve efficacy against mayweed chamomile when compared to Talinor + CoAct+ applied alone. Huskie did not provide the level of control that the Talinor- and WideMatch-based treatments did. Huskie is only labeled for partial control of mayweed chamomile in winter wheat. Affinity TankMix + Rhonox MCPA Ester provided a similar level of control as the Huskie treatments. Overall yield and test weight means were 136 bu/A and 60 lb/bu, respectively. There were no significant differences in yield or test weight among treatments when compared to the nontreated check. The wheat stand was very uniform and competitive with mayweed chamomile which allowed for most of the herbicide treatments to work well. Talinor is an effective herbicide for mayweed chamomile control in winter wheat.

		Mayweed chamomile control				
		5/15	6/13	7/28		8/3
Treatment	Rate	13 DAT	42 DAT	87 DAT		Yield
	fl oz/A	------------------0-100%------------------				bu/A
Nontreated Check		--	--	--		133 a
Talinor + CoAct+[1]	13.7 + 2.75	60 cd[4]	82 ab	99 a		137 a
Talinor + CoAct+[1]	16 + 3.2	67 bc	84 ab	97 a		135 a
Talinor + CoAct+[1]	18.2 + 3.6	65 bc	85 ab	99 a		143 a
Huskie[2]	11	50 de	71 bc	76 a-c		141 a
Huskie[3]	13.5	57 c-e	57 c	60 c		129 a
Huskie[3]	15	57 c-e	64 c	60 c		132 a
WideMatch	16	82 a	85 ab	94 ab		136 a
Affinity TankMix + WideMatch[2]	0.6 oz + 16	81 a	90 a	100 a		131 a
WideMatch + Rhonox MCPA Ester	16 + 12	82 a	91 a	99 a		143 a
Affinity TankMix + Rhonox MCPA Ester[2]	0.6 oz + 12	47 e	60 c	66 bc		132 a
Talinor + Orion + CoAct+[1]	13.7 + 17 + 2.75	72 ab	82 ab	95 ab		139 a

[1] Treatments were tank mixed with 1.0% v/v crop oil concentrate
[2] Treatments were tank mixed with 0.25% v/v NIS
[3] Treatments were tank mixed with 0.25% v/v NIS + 1.0 lb AMS/A
[4] 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 Huskie® and tankmix partners for the control of mayweed chamomile in winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted on Mike Nelson's Farm near Albion, WA to generate broadleaf weed control data with Bayer's Huskie herbicide in winter wheat. Huskie is a premixture of bromoxynil (Group 6) and pyrasulfotole (Group 27) herbicides. Huskie is only labeled for partial control of mayweed chamomile in winter wheat and is why the study was designed to look at tankmix partners. Talinor™ contains bicyclopyrone, which is also a Group 27 herbicide, and bromoxynil, and is why it is included as a comparison treatment against Huskie.

The soil at this site is a Palouse silt loam with 4.3% organic matter and a pH of 5.7. The field was previously in chickpeas. On September 8, 2016, the field was fertilized with 100 lb N:15 lb P:10 lb S per acre. On September 28th, 'ORCF-102' winter wheat was conventionally planted using a JD 455 disk drill with 7.5-inch row spacing. At the time of planting, the field received 10 lb N:15 lb P:1qt Zn per acre. Postemergence treatments were applied on May 2nd with a CO_2-powered backpack sprayer set to deliver 10 gpa at 42 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 50°F and relative humidity of 65%. The majority of the wheat had just begun to joint and was 16 inches tall. Mayweed chamomile distribution was uniform across the trial area. Mayweed chamomile was 3.0 inches tall at the time of application and had a density of 29 plants per square foot in the nontreated check plot. Mayweed chamomile was continuing to germinate at the time of application.

Crop injury was not noted with any treatments in this study. Thirteen days after treatment (DAT) (May 15th), WideMatch- (both rates applied), Huskie + Brox-M + WideMatch-, and Huskie + Brox-M-treated plots exhibited the best control of mayweed chamomile. There was not a significant difference in regards to mayweed chamomile control among the two rates of WideMatch evaluated throughout the study. By 42 DAT, most of the treatments were providing a similar, acceptable level of control with the exception of Huskie, Huskie + Starane Flex, and Huskie + Sentrallas. This carried through to the final rating on 7/28 (87 DAT), six days prior to harvest. Overall yield and test weight means were 129 bu/A and 60 lb/bu, respectively. Herbicide treatments did not have an effect on yield and test weight. WideMatch and WideMatch + Brox-M were the tank mix partners for Huskie that improved its control of mayweed chamomile.

		Mayweed chamomile control				
		5/15	6/13	7/28		8/3
Treatment	Rate	13 DAT	42 DAT	87 DAT		Yield
	fl oz/A	----------------------------0-100%----------------------------				bu/A
Nontreated Check		--	--	--		108 a
Huskie[1]	13.5	57 ef[3]	62 b	54 c		137 a
Huskie + Brox-M[1]	13.5 + 16	72 a-c	69 ab	69 a-c		133 a
Huskie + WideMatch[1]	13.5 + 16	62 d-f	79 a	82 ab		128 a
Huskie + Starane Flex[1]	13.5 + 13.5	57 ef	61 b	54 c		129 a
Huskie + Orion[1]	13.5 + 17	67 b-d	72 ab	80 a-c		115 a
Huskie + Sentrallas[1]	13.5 + 10	55 f	62 b	66 bc		141 a
Talinor + CoAct+[2]	13.7 + 2.75	65 c-e	79 a	96 a		143 a
Talinor + Orion + CoAct+[2]	13.7 + 17 + 2.75	60 d-f	76 a	94 a		139 a
WideMatch	16	80 a	80 a	91 ab		132 a
WideMatch	21.23	81 a	81 a	94 a		121 a
Huskie + Brox-M + WideMatch[1]	13.5 + 16 + 16	76 ab	79 a	93 ab		122 a

[1] Treatments were tank mixed with 1.0 qt/A UAN + 0.25% v/v NIS

[2] Treatments were tank mixed with 1.0% v/v crop oil concentrate

[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.

Postemergence Mayweed Chamomile Control in Winter Wheat without Clopyralid

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

The objective of the following study was to evaluate mayweed chamomile (*Anthemis cotula* L.) control in winter wheat without the active ingredient clopyralid, a synthetic auxin commonly used for mayweed chamomile control.

Methods

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied to mayweed chamomile at 3 inches or greater in diameter post emergence (POST) in winter wheat, detailed in Table 1 and Table 2. Widematch was included as an industry standard. The study was conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Winter wheat, variety Puma, was planted on October 8, 2016. The trial site had been treated with 1.75 oz A^{-1} of Zidua as a delayed preemergence (PRE) on October 12, 2016 for Italian ryegrass and mayweed chamomile control. Axial XL at a rate of 16.4 fl oz A^{-1} was applied POST on June 2, 2017 for Italian ryegrass control.

Mayweed chamomile control was visually assessed 16 and 42 days after treatment (DAT). Crop stunting and injury was visually assessed 16 DAT (Table 2). Plots were hand harvested by taking two meter-squared quadrats per plot on August 1, 2017. 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 16 DAT. All treatments provided mayweed chamomile compared to the nontreated 16 DAT. Huskie with MCPA ester (68%), Brox-M with Affinity Broadspec and MCPA ester (64%) and Widematch (83%) provided the greatest amount of mayweed chamomile control 16 DAT (Table 2). Mayweed chamomile control increased 42 DAT with all treatments providing mayweed chamomile control compared to the nontreated control. Mayweed chamomile control was greatest for Huskie with MCPA ester (76%), Peak with Brox-M and Starane Ultra (76%), and Widematch (99%) 42 DAT (Table 2). No significant differences in winter wheat yield were observed (Table 2).

Table 1. *Treatment application details*

Study Application	
Date	May 9, 2017
Application volume (GPA)	15
Crop Stage	8 tillers
Air temperature (˚F)	66
Soil temperature (˚F)	54
Wind velocity (mph, direction)	6, W
Cloud Cover	0%
Next rain occurred on	May 11, 2017

Table 2. *Percent mayweed chamomile control and winter wheat yield. Pullman, WA, 2017. Means followed by the same letter are not statistically significantly different (α=0.05).*

				May 25, 2017		*June 20, 2017*	*August 1, 2017*
Treatment	**Field Rate**	**Active Ingredients**	**lb ai/A**	**Crop Injury**	**Mayweed Control**	**Mayweed Control**	**Yield**
				%	**%**	**%**	**bu/A**
Nontreated			-	-	-	-	79
Huskie **MCPA ester** **NIS**	13.5 fl oz/A 1 pt/A 0.5% v/v	pyrasulfotole & bromoxynil MCPA ester	0.033 0.185 0.462	0	68	76	88
Talinor **CoAct+** **COC**	18.2 fl oz/A 3.6 fl oz/A 1% v/v	bicyclоprone & bromoxynil	0.044 0.208	0	35	50	82
Starane Flex **MCPA ester** **NIS**	14 fl oz/A 1 pt/A 0.5% v/v	florasulam & fluroxypyr MCPA ester	0.005 0.091 0.462	0	36	50	94
Starane Ultra **Affinity Broadspec** **MCPA ester** **NIS**	5.7 fl oz/A 1 oz/A 1 pt/A 0.5% v/v	fluroxypyr thifensulfuron & tribenuron MCPA ester	0.125 0.014 0.007 0.462	0	46	72	86
Starane Ultra **Harmony Extra XP** **MCPA ester** **NIS**	5.7 fl oz/A 0.45 oz/A 1 pt/A 0.5% v/v	fluroxypyr thifensulfuron & tribenuron MCPA ester	0.125 0.014 0.007 0.462	0	49	61	87
Orion **Starane Ultra** **NIS**	17 fl oz/A 5.7 fl oz/A 0.5% v/v	florasulam & MCPA ester fluroxypyr	0.004 0.310 0.125	0	38	41	97
Peak **Starane Ultra** **NIS**	0.5 oz/A 5.7 fl oz/A 0.5% v/v	prosulfuron fluroxypyr	0.018 0.125	0	35	65	91
Brox-M **Starane Flex** **NIS**	14 fl oz/A 14 fl oz/A 0.5% v/v	bromoxynil & MCPA ester florasulam & fluroxypyr	0.219 0.219 0.005 0.091	0	44	53	93
Brox-M **Harmony Extra XP** **NIS**	14 fl oz/A 0.45 oz/A 0.5% v/v	bromoxynil & MCPA ester thifensulfuron & tribenuron	0.219 0.219 0.014 0.007	0	34	61	91
Brox-M **Affinity Broadspec** **MCPA ester** **NIS**	14 fl oz/A 1 oz/A 1 pt/A 0.5% v/v	bromoxynil & MCPA ester thifensulfuron & tribenuron MCPA ester	0.219 0.219 0.016 0.016 0.462	0	64	70	95
Peak **Brox-M** **Starane Ultra** **NIS**	0.5 oz/A 14 fl oz/A 5.7 fl oz/A 0.5% v/v	prosulfuron bromoxynil MCPA ester fluroxypyr	0.018 0.219 0.219 0.125	0	48	76	86
Widematch **NIS**	1.33 pt/A 0.5% v/v	clopyralid & fluroxypyr	0.125 0.125	0	83	99	90
			LSD	*NS*	*NS*	*NS*	*NS*

Rush skeletonweed control in winter wheat.
Mark Thorne, John Spring, Henry Wetzel, Ian Burke and Drew Lyon

Rush skeletonweed (*Chondrilla juncea* L.) is a deep-rooted perennial plant that has persisted on farmland across eastern Washington since the land was taken out of the Conservation Reserve Program (CRP) and put back into winter wheat production. Wheat yield is reduced where dense stands of rush skeletonweed deplete seed zone moisture during the fallow phase of the winter wheat/fallow rotation resulting in failed emergence of fall-seeded winter wheat (Figure 1). During the crop phase, rush skeletonweed flourishes and proliferates in areas where the wheat stand is thin or absent. Herbicide control in the crop phase is one part of an overall strategy to reduce or eradicate skeletonweed from these production areas.

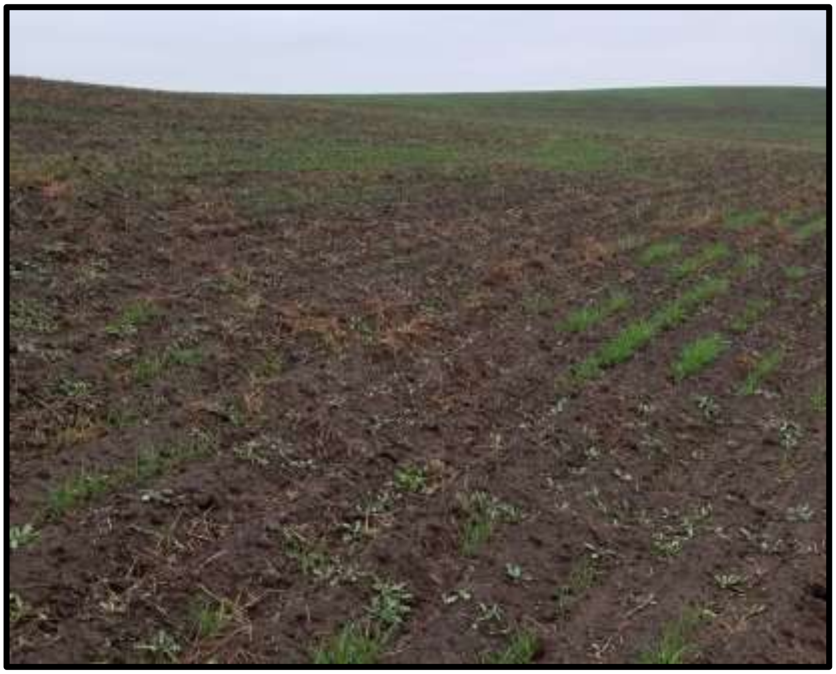


Figure 1. Failed emergence of winter wheat in areas where rush skeletonweed depleted seed zone moisture.

We repeated an herbicide trial initially conducted in 2015-16 on land near LaCrosse, WA evaluating five different synthetic auxin herbicides for control of rush skeletonweed in winter wheat. Milestone® contains the active ingredient aminopyralid, Stinger® contains the active ingredient clopyralid, DPX-MAT28-128 is an experimental product containing the herbicide aminocyclopyrachlor, Clarity® contains dicamba as the active ingredient, and 2,4-D LV6 is a low-volatile ester formulation of 2,4-D. Herbicides were applied on October 29, 2016 when the wheat was tillering, and on April 5, 2017 when the wheat was well tillered with nodes present 1 inch above the crown. Rush skeletonweed was in the rosette stage at both application times and ranged from 1 to 9 inches in diameter in October, and 2-8 inches in diameter in April. The land had been in CRP until October 2013 and the first post-CRP crop was harvested in 2014. In 2016, the field was in summer fallow and was seeded to ‘ORCF-102’ winter wheat at 60 lb/A on September 2 with a John Deere HZ616® grain drill. The field had been fertilized prior to seeding with 85 lb nitrogen, 10 lb phosphorus, 10 lb sulfur, and 10 lb chloride per acre. At both treatment dates, herbicides were applied with a CO_2 pressurized backpack sprayer and 10-foot spray boom delivering 15 gpa spray volume. Boom pressure was 25 psi and ground speed was 3 mph. For maintenance of the plot area, a blanket treatment of 1.0 oz/A of Affinity® BroadSpec was applied on April 11, 2017 to control a dense population of tumble mustard. On May 8, 2017, the plot area was sprayed with 4.0 oz/A of Propi-Star® fungicide to control stripe rust. Experimental design was a randomized complete block with four replicated blocks and a factorial arrangement of herbicides and timing. Plot dimension was 10 by 30 feet.

Figure 2. Rush skeletonweed in winter wheat

Rush skeletonweed density was somewhat variable across the plot site where dense patches coincided with thin wheat stands (Figure 2). For consistency with the 2015/16 trial, two one-meter quadrats per plot were flagged on October 19, 2016 and all rush skeletonweed plants in each quadrat were counted to establish baseline initial densities in which to monitor until harvest. Rush skeletonweed densities were recounted in all quadrats on April 4, just prior to the spring herbicide applications, on April 20, two weeks following spring applications, June 12, when the wheat was in the soft-dough stage and again on July 19, prior to crop harvest. Additionally, herbicide control was evaluated visually on a whole-plot basis as percent of the non-treated check plots. Visual ratings on April 4, 2016 evaluated fall-applied herbicides and were prior to the spring-applied treatments. April 20 ratings evaluated control two weeks following spring applications as well as a second evaluation of the fall applications. Follow-up ratings were also made on June 12 and July 19. The plots were harvested on July 26 with a Kincaid® plot combine and grain samples were bagged from each plot and sub-sampled for grain moisture and test weight. In about 50% of the plots, blank or thin patches of wheat existed where fall emergence was poor. Visual estimations of the percent area affected in each plot were made prior to harvest (data not shown) and were used to standardize wheat yield to reduce variability from initial stand density. Standardized wheat yield was converted to bu/A and reported on a 12% moisture basis.

Rush skeletonweed densities prior to fall applications were similar across plots and averaged between 7 to 13 plants/m^2 (Table 1). By the April 4 census, fall-applied Milestone and Stinger had reduced rush skeletonweed density to less than 1 plant/m^2, but no reduction was seen with the other herbicides tested. At this census, the spring treatments had not yet been applied. At the June 12 census, fall-applied Stinger was most effective in controlling rush skeletonweed with only 0.4 plants/m^2 remaining. Spring-applied Stinger and Milestone were equally effective with densities of 1.3 and 1.4 plants/m^2. Results were mixed for DPX-MAT28-128, Clarity, and 2,4-D LV6. Fall-applied DPX-MAT28-128 resulted in 2.8 plants/m^2 and was not different from Milestone; however, spring-applied DPX-MAT28-128 was less effective than Milestone and not different than the non-treated check (Table 1). Clarity, and 2,4-D LV6 were the least effective fall-applied treatments, but spring-applied Clarity was better than the non-treated check. By the July 19 pre-harvest census, no differences in density was found between any of the treatments

(Table 1). By harvest, the dense wheat canopy was up to 52 inches tall and had shaded out many of the rush skeletonweed plants. This reduced the number of plants in denser colonized plots, including the non-treated checks, and diminished differences between all treatments.

Table 1. Rush skeletonweed density in winter wheat in response to herbicide applications.

		Rush skeletonweed census dates[2]			
Treatments[1]	Rate	19 Oct	4 Apr	12 Jun	19 Jul
	(oz/A)	-------------------------(plants/m^2)----------------------			
Fall-applied herbicides					
Non-treated	-	9.1 a	14.2 a	12.2 a	1.6 a
Milestone	0.6	11.3 a	0.8 b	2.4 d	1.3 a
Stinger	8.0	7.4 a	0.6 b	0.4 e	0.3 a
DPX-MAT28-128	1.7	9.4 a	9.4 a	2.8 cd	0.7 a
Clarity	4.0	7.6 a	8.3 a	5.5 bc	2.1 a
2,4-D LV6	8.7	11.1 a	12.2 a	6.0 b	1.3 a
Spring-applied herbicides					
Non-treated	-	12.8 a	15.5 a	17.3 a	2.5 a
Milestone	0.6	9.0 a	12.7 a	1.4 c	0.5 a
Stinger	8.0	9.5 a	12.5 a	1.3 c	0.8 a
DPX-MAT28-128	1.7	9.1 a	9.5 a	7.9 ab	0.8 a
Clarity	4.0	10.3 a	11.0 a	4.4 b	0.6 a
2,4-D LV6	8.7	8.1 a	10.0 a	9.0 ab	1.0 a

[1]All herbicide applications included a non-ionic surfactant (R-11®) at 0.25% v/v rate. Fall treatments were applied on October 29, 2016; spring treatments were applied on April 5, 2017. DPX-MAT28-128 is an experimental product containing the synthetic auxin aminocyclopyrachlor as the active ingredient.

[2] Means in each column, within each application time, followed by the same letter are not different at $p \leq 0.05$. The October 19, 2016 census established baseline densities and was prior to herbicide applications.

Visual control ratings were made over the whole plot area and gave similar results to the density measurements. Fall-applied Milestone and Stinger resulted in the greatest control, between 90 and 100%, at the April 4 and April 20 ratings (Table 2). By the June 12 rating, control with Milestone had declined to 80% compared with 97% control with Stinger. At this time, Milestone control was not different than DPX-MAT28-128, but control was greater than with Clarity or 2,4-D LV6. The decline in control from Milestone was due to plants bolting that had previously appeared dead. Injury or control from the spring-applied herbicides was only slightly evident two weeks after application on April 20 as only minor curling or burning could be seen on the rush skeletonweed leaves (Table 2). By June 12, within the spring-applied treatments, Milestone and Stinger had resulted in the greatest injury. For plants treated with DPX-MAT28-128, Clarity, or 2,4-D LV6, only slight suppression of bolting plants was the most common injury. At the July 19 pre-harvest rating, nearly all remaining plants had bolted and were nearing flowering, and heavy competition by the wheat crop made these ratings more variable than earlier ratings. No difference in control was found between fall-applied Milestone, Stinger, or DPX-MAT28-128; however, control with Stinger was still greater than 90%. Clarity and 2,4-D LV6 gave the least amount of control at 48 and 55%, respectively. No difference was found between any of the spring-applied treatments.

Table 2. Rush skeletonweed visual control ratings in winter wheat.

		Visual control ratings[2]			
Treatments[1]	Rate	04 Apr	20 Apr	12 Jun	19 Jul
	(oz/A)	----------------------------(%)----------------------------			
Fall-applied herbicides					
Non-treated	-	0 -	0 -	0 -	0 -
Milestone	0.6	95 a	96 ab	80 b	82 abc
Stinger	8.0	97 a	100 a	97 a	96 a
DPX-MAT28-128	1.7	72 b	63 c	67 bc	85 ab
Clarity	4.0	79 b	81 bc	35 d	48 c
2,4-D LV6	8.7	81 b	80 bc	55 cd	55 bc
Spring-applied herbicides					
Non-treated	-	0 -	0 -	0 -	0 -
Milestone	0.6	0 -	4 a	88 a	91 a
Stinger	8.0	0 -	6 a	85 a	90 a
DPX-MAT28-128	1.7	0 -	4 a	40 b	81 a
Clarity	4.0	0 -	7 a	57 b	80 a
2,4-D LV6	8.7	0 -	6 a	40 b	68 a

[1] See Table 1 for application details.

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

The wheat stand was exceptionally heavy across most of the plot area with the highest yields averaging 40 bu/A more than the long-term average for this area. Fall-applied herbicides had no effect on test weight; however, spring-applied DPX-MAT28-128 reduced test weight nearly 1.5 lb/bu compared with all other treatments (Table 3). Both fall and spring applications of DPX-MAT28-128 reduced crop yield with the spring application causing a substantial amount of kernel abortion that reduced yield up to 75%. Wheat yield was also reduced by 2,4-D LV6 applied in the fall, but not in the spring (Table 3). Stinger applied in the spring had lower yield than the highest yielding treatments, but was not different than Milestone or the non-treated check. Clarity had no apparent effect on yield applied in either fall or spring.

Overall, Milestone or Stinger applied in fall or spring were superior in controlling rush skeletonweed in winter wheat compared with DPX-MAT28-128, 2,4-D LV6, or Clarity. Stinger is currently labeled for winter wheat at 5.3 oz/A; however, 8 oz/A is consistent with rates for control of perennial weeds. Milestone is not yet labeled in the U.S. The experimental herbicide DPX-MAT28-128 can injure wheat and reduce yield, especially when applied in the spring. These results are similar to results from the 2015-16 trial.

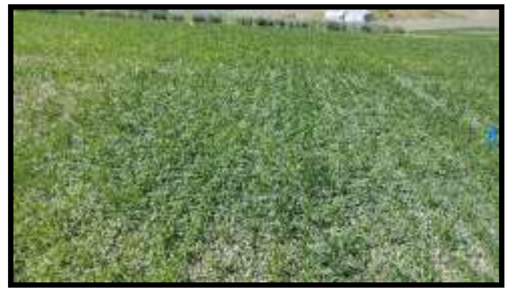
Table 3. Winter wheat test weight and yield following fall- and spring-applied herbicides applications to control rush skeletonweed.

Treatments[1]	Rate	Test weight	Crop yield
	(oz/A)	lb/bu	bu/A
Fall-applied herbicides			
Non-treated	-	62.9 a	106 a
Milestone	0.6	62.9 a	93 ab
Stinger	8.0	62.8 a	105 a
DPX-MAT28-128	1.7	62.8 a	77 b
Clarity	4.0	62.8 a	101 a
2,4-D LV6	8.7	63.0 a	79 b
Spring-applied herbicides			
Non-treated	-	62.8 a	91 bc
Milestone	0.6	62.8 a	91 bc
Stinger	8.0	62.8 a	88 c
DPX-MAT28-128	1.7	61.3 b	28 d
Clarity	4.0	62.6 a	104 ab
2,4-D LV6	8.7	62.7 a	109 a

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

Evaluation of Quelex™ for the control of common lambsquarters in spring wheat

Henry Wetzel and Drew Lyon



A field study was conducted at the Spillman Farm near Pullman, WA to evaluate Quelex for the control of common lambsquarters in spring wheat. Quelex is a new herbicide premixture that is offered by Dow/DuPont for the control of annual broadleaf weeds in wheat (including durum), barley and triticale. Quelex contains florasulam and the Arylex™ active (halauxifen-methyl), which are in the Mechanism of Action Groups 2 and 4, respectively. Florasulam is a compound that inhibits acetolactate synthase (ALS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine and valine. Halauxifen-methyl is a synthetic auxin and its primary action appears to affect cell wall plasticity and nucleic acid metabolism.

The soil at this site is a Palouse silt loam with 3.2% organic matter and a pH of 5.2. The trial area was seeded to 'JD' soft white spring club wheat with a John Deere disk drill on a 7-inch row spacing. Postemergence treatments were applied on June 8th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 45 psi at 2.3 mph. The applications were made under winds out of the northwest at 5 mph with an air temperature of 64°F and relative humidity of 53%. The wheat was primarily at 2 tiller and a height of 9 inches. The common lambsquarters were 1.5 inches tall and at an average density of 1,700 plants per square yard.

No significant crop injury was observed with any of the herbicide treatments. Bromoxynil-based treatments including Huskie, Quelex + Huskie and Quelex + Bromac were the first to show excellent control of common lambsquarters, 13 days after treatment. Lambsquarters in these treatments exhibited pronounced leaf tip burning. Plants in the other treatments exhibited more twisting, but leaves remained green and healthy. We were unable to evaluate all of the products individually and in combination with Quelex to see what the new premixture added control-wise to the products on the market. We chose to look at Huskie and WideMatch as they are very commonly used in the high rainfall zone for annual broadleaf weed control. Quelex as a stand-alone product was very slow acting and on the final rating date was not providing commercially acceptable control. The addition of Quelex to Huskie did not increase its performance. The addition of Quelex to WideMatch did increase its performance on common lambsquarters. WideMatch is not labelled for the control of common lambsquarters, which is supported by our observations in this study.

		Common lambsquarters control		
		6/21	7/3	7/25
Treatment[1]	Rate	13 DAT	25 DAT	47 DAT
	fl oz/A	---------------------------0-100%----------------------------		
Nontreated Check		--	--	--
Quelex	0.75 oz	27 de[2]	58 e	71 c
Quelex + WideMatch	0.75 oz + 16	37 cd	76 cd	93 ab
Quelex + WideMatch	0.75 oz + 21.3	42 bc	78 b-d	94 ab
Quelex + 2,4-D LV Ester	0.75 oz + 8	42 bc	83 a-d	100 a
Quelex + MCPA LV Ester	0.75 oz + 12	45 bc	89 a-d	100 a
Quelex + Curtail M	0.75 oz + 32	52 b	86 a-d	100 a
Quelex + PerfectMatch	0.75 oz + 16	40 b-d	73 d	85 b
Quelex + Huskie	0.75 oz + 13.5	90 a	90 ab	98 a
Quelex + Bromac	0.75 oz + 12.8	86 a	93 a	100 a
WideMatch	16	20 e	38 f	49 d
Huskie	13.5	89 a	85 a-d	96 ab

[1] All herbicide treatments, except WideMatch 16 fl oz/A, were tank mixed with NIS (0.25% v/v) + AMS (1.52 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.

Postemergence Mayweed Chamomile Control in Spring Wheat without Clopyralid

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

The objective of the following study was to evaluate mayweed chamomile (*Anthemis cotula* L.) control in spring wheat without the active ingredient clopyralid, a synthetic auxin commonly used for mayweed chamomile control.

The study was established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied to mayweed chamomile at 4 inches or greater in diameter postemergence (POST) in spring wheat, detailed in Table 1 and Table 2. Widematch (clopyralid and fluroxypyr) was included as an industry standard. The study was conducted in a randomized complete block with 4 replications with10' by 30' long plots. Spring wheat 'Seahawk' was planted on April 22, 2017. Axial XL at 16.4 fl oz A^{-1} was applied on June 7, 2017 for Italian ryegrass control.

Mayweed chamomile control was visually assessed 48 days after treatment (DAT) (Table 2). Plots were harvested using a 5' plot combine on August 18, 2017. 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).

Huskie with MCPA ester, Talinor, Brox-M with Harmony Extra SP, Peak with Starane Ultra, Brox-M with Affinity Broadspec, and Peak with Brox-M and Starane Ultra provided the greatest mayweed chamomile control at 48 DAT with 83, 99, 89, 95, 99, and 99% control, respectively (Table 2). Active ingredients bromoxynil, an photosystem II inhibitor, or prosulfuron, an acetolactate synthase inhibitor, were present in all treatments with the greatest percent control of mayweed chamomile.

At harvest, no significant differences in percent moisture, test weight, and yield between any of the treatments and the nontreated control.

Table 1. *Treatment application details*

Study Application	
Date	June 2, 2017
Application volume (GPA)	15
Crop Stage	5 tillers
Air temperature (˚F)	67
Soil temperature (˚F)	68
Wind velocity (mph, direction)	3.9, NW
Cloud Cover	5%
Next rain occurred on	June 4, 2017

Table 2. *Percent mayweed chamomile control and spring wheat yield. Pullman, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

				July 20, 2017 48 DAT	*August 18, 2017*		
Treatment	**Field Rate**	**Active Ingredients**	**lb ai/A**	**Mayweed Control**	**Moistu re**	**Test Weight**	**Yield**
				%	**%**	**lb/bu**	**bu/A**
Nontreated	-	-	-	-	15	62	32
Huskie **MCPA ester** **NIS**	13.5 fl oz/A 1 pt/A 0.5% v/v	pyrasulfotole & bromoxynil MCPA ester	0.033 0.185 0.462	83 a	15	62	49
Talinor **CoAct+** **COC**	18.2 fl oz/A 3.6 fl oz/A 1% v/v	bicyclopyrone & bromoxynil	0.044 0.208	99 a	14	63	48
Starane Flex **MCPA ester** **NIS**	14 fl oz/A 1 pt/A 0.5% v/v	florasulam & fluroxypyr MCPA ester	0.005 0.091 0.462	50 ab	15	61	59
Starane Ultra **Affinity Broadspec** **MCPA ester** **NIS**	5.7 fl oz/A 1 oz/A 1 pt/A 0.5% v/v	fluroxypyr thifensulfuron & tribenuron MCPA ester	0.125 0.014 0.007 0.462	54 ab	14	62	41
Starane Ultra **Harmony Extra XP** **MCPA ester** **NIS**	5.7 fl oz/A 0.45 oz/A 1 pt/A 0.5% v/v	fluroxypyr thifensulfuron & tribenuron MCPA ester	0.125 0.014 0.007 0.462	63 ab	13	62	65
Orion **Starane Ultra** **NIS**	17 fl oz/A 5.7 fl oz/A 0.5% v/v	florasulam & MCPA ester fluroxypyr	0.004 0.310 0.125	69 ab	13	62	44
Peak **Starane Ultra** **NIS**	0.5 oz/A 5.7 fl oz/A 0.5% v/v	prosulfuron fluroxypyr	0.018 0.125	89 a	12	58	53
Brox-M **Starane Flex** **NIS**	14 fl oz/A 14 fl oz/A 0.5% v/v	bromoxynil & MCPA ester florasulam & fluroxypyr	0.219 0.219 0.005 0.091	60 ab	13	62	42
Brox-M **Harmony Extra XP** **NIS**	14 fl oz/A 0.45 oz/A 0.5% v/v	bromoxynil & MCPA ester thifensulfuron & tribenuron	0.219 0.219 0.014 0.007	95 a	15	61	57
Brox-M **Affinity Broadspec** **MCPA ester** **NIS**	14 fl oz/A 1 oz/A 1 pt/A 0.5% v/v	bromoxynil & MCPA ester thifensulfuron & tribenuron MCPA ester	0.219 0.219 0.016 0.016 0.462	99 a	14	62	55
Peak **Brox-M** **Starane Ultra** **NIS**	0.5 oz/A 14 fl oz/A 5.7 fl oz/A 0.5% v/v	prosulfuron bromoxynil & MCPA ester fluroxypyr	0.018 0.219 0.219 0.125	99 a	10	46	55
Widematch **NIS**	1.33 pt/A 0.5% v/v	clopyralid & fluroxypyr	0.125 0.125	19 b	14	62	41
			LSD	*34*	*NS*	*NS*	*NS*

Volunteer buckwheat control in irrigated spring wheat – year two.

Mark Thorne, Henry Wetzel, Drew Lyon, Tim Waters

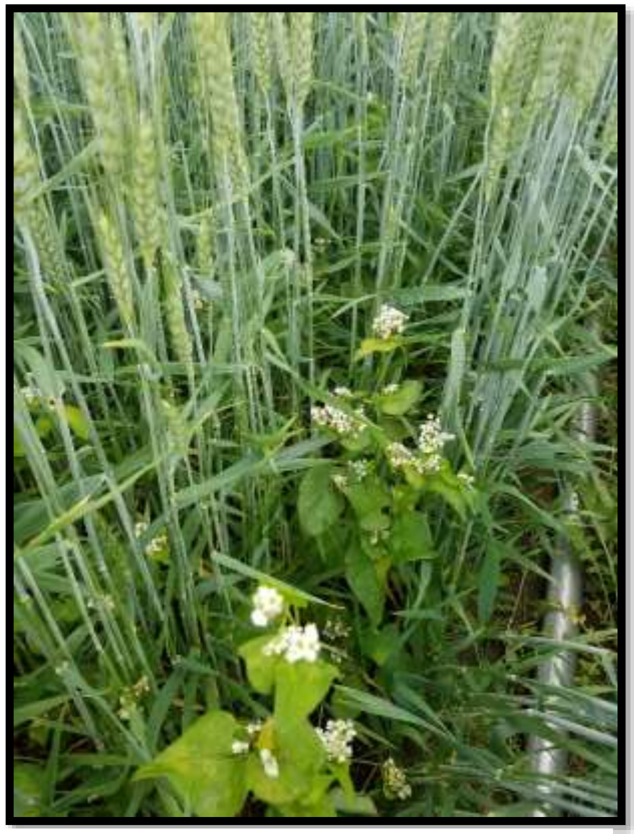


Figure 1. Volunteer buckwheat plants flowering in a crop of irrigated spring wheat.

A study initiated in 2016 was repeated in 2017 to evaluate postemergence herbicide control of volunteer buckwheat (*Fagopyrum esculentum* Moench) in irrigated spring wheat. 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 (Figure 1).

The field site, located in Pasco, WA, was on land being farmed by WSU Franklin County Extension for agricultural research. The plot area had been in potatoes during 2016, therefore buckwheat was not present in the seedbank for the 2017 trial. On March 6, 2017, 48 lb of 'Mancan' buckwheat seed was spread over an 80- by 300-ft area, which resulted in 32 seeds/foot^2. The seed was then incorporated into the top 5 inches of soil with a disk-harrow and then spring-tooth harrowed and rolled with a packer. The field was then seeded on March 6 to 'Expresso' hard-red spring wheat at 184 lb/A using a 42-inch wide double disk drill with 6 openers on 6-inch spacing. Soil temperature averaged 42° F in the top 6 inches. The experimental design was a randomized complete block with four replications per treatment. Each plot consisted of 3 drill passes, each 30 feet long; however, only the center drill pass was used for evaluation. Fertilizer was applied with irrigation and the field site was sprinkler irrigated up until two weeks prior to harvest.

Early postemergence herbicide treatments were applied on April 19 when the majority of the spring wheat had 4 to 5 leaves. Volunteer buckwheat plants ranged from cotyledon to two-leaf stage and averaged 24 plants/m^2. The early treatments were broadcast applied with a CO_2 pressurized backpack sprayer and 10-foot spray boom at 3 mph. Application rate was 15 gpa at 30 psi. Late postemergence herbicide treatments were applied with a tractor-pulled applicator that simulated center-pivot chemigation. The treatments were applied on May 18 when the majority of spring wheat was in the boot stage with some heads emerging. Volunteer buckwheat seedlings were present in most plots, but flowering plants were abundant only in non-treated check plots. 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 gpa at 66 psi moving 1 mph to simulate a 0.1-inch irrigation rate. See Table 1 for herbicides and rates of application. Throughout the trial, non-treated check plots were hand-weeded to control all other weeds except volunteer buckwheat.

Table 1. Applications of early and late postemergence (POST) herbicides for control of volunteer buckwheat in irrigated spring wheat.

Trt	Herbicide	Rate (fl oz/a)	Timing[1]	Application method
1	Huskie	13.5	Early POST	Broadcast
	Brox 2EC	32	Late POST	Chemigation
2	Huskie	13.5	Early POST	Broadcast
	Maestro Advanced	25.6	Late POST	Chemigation
3	Huskie	13.5	Early POST	Broadcast
	Starane NXT	27.4	Late POST	Chemigation
4	Huskie	13.5	Early POST	Broadcast
	None	-	-	-
5	GoldSky	16	Early POST	Broadcast
	Brox 2EC	32	Late POST	Chemigation
6	GoldSky	16	Early POST	Broadcast
	Maestro Advanced	25.6	Late POST	Chemigation
7	GoldSky	16	Early POST	Broadcast
	Starane NXT	27.4	Late POST	Chemigation
8	GoldSky	16	Early POST	Broadcast
	None	-	-	-
9	Non-treated check	-	-	-

[1] Early POST herbicides were broadcast applied April 19 when the spring wheat had 4 to 5 leaves. Huskie was applied with ammonium sulfate at 1 lb/A. GoldSky was applied with a non-ionic surfactant at 0.5% v/v. Treatments were applied with a hand-held 10-ft spray boom. Volunteer buckwheat ranged from cotyledon to 2 leaves and averaged 12 plants/m^2. Late POST herbicides were applied through chemigation on May 18 when the majority of spring wheat was at boot stage, but some were beginning to head. Spray adjuvants were not added to the chemigation treatments. Volunteer plants ranged from cotyledon to older injured plants from early the POST treatments. Density was light and varied by efficacy of early POST treatments.

Herbicide efficacy was rated visually as percent control compared with the non-treated plots. Early postemergence (POST) treatments were rated 2 and 4 weeks after treatment (WAT) on May 3 and 18, respectively. Late POST chemigation treatments were rated 2 WAT on June 1. In addition, flowering buckwheat plants were counted at 2 and 4 WAT for both the early and late

POST applications, with the last census occurring at harvest on July 13. Plots were harvested with a Wintersteiger® plot combine and the grain from each center 3.5- by 30-foot drill pass was bagged, weighed, and then hand-screened to determine number of buckwheat seeds per kg of wheat. Sub-samples were oven dried at 60°F for 72 hours to determine grain moisture content. Crop yield was converted to bu/A and reported on a 12% moisture basis.

Early POST applications of Huskie® were more effective than GoldSky® in controlling early establishing volunteer buckwheat plants (Table 2). Huskie control was near 100% at 2 and 4 WAT, whereas, GoldSky control was only near 70% at 2 WAT but increased to 85% at 4 WAT. Buckwheat plants treated with Huskie displayed significant burn-down injury by 2 WAT, but Goldsky treated plants were only curled and yellowed at 4 WAT. Late POST chemigation treatments were at or near 100% effective in maintaining control 2 WAT (Table 2). Plots only treated with early POST applications of Huskie and GoldSky had slightly lower control by the final rating.

Table 2. Visual control ratings of volunteer buckwheat plants following early and late postemergence (POST) herbicide applications in irrigated spring wheat.

			Buckwheat Control[3]		
Trt	Early[1]	Late[2]	Early POST 2 WAT	Early POST 4 WAT	Late POST 2 WAT
	(spray)	(chemigation)	(%)		
1	Huskie	Brox 2EC	100 a	100 a	100 a
2	Huskie	Maestro Advanced	99 a	100 a	100 a
3	Huskie	Starane NXT	99 a	100 a	100 a
4	Huskie	None	100 a	100 a	96 b
5	GoldSky	Brox 2EC	69 b	85 b	99 ab
6	GoldSky	Maestro Advanced	69 b	85 b	100 a
7	GoldSky	Starane NXT	68 b	85 b	100 a
8	GoldSky	None	70 b	85 b	90 c
9	None	None	0 -	0 -	0 -

[1] Early treatments were evaluated May 3 and May 18, 2 and 4 weeks (WAT) after broadcast applications, respectively. See Table 1 for application rates.

[2] Late treatments were evaluated on June 1, 2 weeks after chemigation treatments (WAT). See Table 1 for application rates.

[3] Injury symptoms ranged from slight epinasty and curling on leaves to complete death. Means in each category followed by the same letter are statistically identical at $p \leq 0.05$. The non-treated check (Trt=9) is not included in the statistical comparison.

Buckwheat plants emerged with crop and were flowering in the non-treated check plots at each census. Flowering plant density at the 2 WAT early POST census averaged 14.3 plants/m^2 (Table 3). Early POST Huskie applications were more effective at inhibiting flower production than GoldSky. At 2 WAT, Huskie treated plants were dead and incapable of flowering. In contrast, GoldSky treated plots had up to 1.0 flowering plants/m^2 (Table 3). By the early POST 4 WAT, no flowering plants were found in any of the treated plots. Flowering was controlled until harvest in all plots receiving both an early and a late application. Plots with only an early POST treatment had a few flowering plants by the last census (Table 3); however, differences were not found between any of the treatments except when compared with the non-treated check.

Table 3. Density of flowering volunteer buckwheat plants following early and late postemergence (POST) herbicide applications to irrigated spring wheat.

			Flowering Buckwheat Plants[3]			
Trt	Early[1]	Late[2]	Early POST 2 WAT	Early POST 4 WAT	Late POST 2 WAT	Late POST 4 WAT
	(spray)	(chemigation)	------------- (flowering plants/m²) -------------			
1	Huskie	Brox 2EC	0 c	0 b	0 b	0 b
2	Huskie	Maestro Advanced	0 c	0 b	0 b	0 b
3	Huskie	Starane NXT	0 c	0 b	0 b	0 b
4	Huskie	None	0 c	0 b	0.07 b	0.13 b
5	GoldSky	Brox 2EC	0.8 b	0 b	0 b	0 b
6	GoldSky	Maestro Advanced	0.9 b	0 b	0 b	0 b
7	GoldSky	Starane NXT	1 b	0 b	0 b	0 b
8	GoldSky	None	0.7 b	0 b	0.03 b	0.06 b
9	None	None	14.3 a	29.2 b	26.5 a	12.5 a

[1] Early POST treatments were evaluated May 3 and May 18, 2 and 4 weeks after broadcast treatments (WAT), respectively. See Table 1 for application rates.

[2] Late POST treatments were evaluated on June 1 and June 13, 2 and 4 weeks after treatments (WAT), respectively. See Table 1 for application rates.

[3] Means in each category followed by the same letter are statistically identical at p≤0.05.

Low numbers of buckwheat plants in treated plots resulted in low numbers of buckwheat seeds per harvest sample. The non-treated plots average 142 seeds/kg of wheat but all treated plots had buckwheat seed densities less than 0.1 seeds/kg and were not different from zero (Table 4). Wheat yields were variable across the plots with averages ranging between 71 and 91 bu/A; however, yield differences between treatments were not significant at p≤0.05.

In this trial, good control of volunteer buckwheat was seen with all treatments; however, some evidence suggested that both early and late POST applications were needed to keep buckwheat from flowering and producing seed later on in the trial as the wheat crop ripened. Applications of Huskie were very effective in quickly controlling early emerging buckwheat plants while GoldSky was slower acting. There were no differences in efficacy between the chemigation treatments, which may have been partly due to low buckwheat presence following the initial early emergence. Very few seedlings were observed after the initial flushes (data not shown). Buckwheat contamination was only abundant in wheat harvested from the non-treated plots (Figure 2.) This study will be repeated in 2018 to verify results from 2016 and 2017.

Table 4. Volunteer buckwheat seed contamination in irrigated spring wheat following early and late postemergence (POST) herbicide applications.

Trt[1]	Early POST	Late POST	Buckwheat Contamination in Spring Wheat[2]
	(spray)	(chemigation)	(buckwheat seeds/kg wheat)
1	Huskie	Brox 2EC	0 b
2	Huskie	Maestro Advanced	0 b
3	Huskie	Starane NXT	0 b
4	Huskie	None	<0.1 b
5	GoldSky	Brox 2EC	<0.1 b
6	GoldSky	Maestro Advanced	<0.1 b
7	GoldSky	Starane NXT	0 b
8	GoldSky	None	0 b
9	None	None	142 a

[1] See Table 1 for application rates.
[2] Means in each category followed by the same letter are statistically identical at $p \leq 0.05$.

Figure 2. Volunteer buckwheat seed contamination in spring wheat.

Evaluation of glyphosate plus adjuvants at two timings for the control of rattail fescue in fallow, 2017

Henry Wetzel and Drew Lyon

A field study was conducted at Wolf Farms near Uniontown, WA to evaluate the efficacy of glyphosate plus adjuvants for the control of rattail fescue in fallow ground. A second objective was to determine if the size of the plants had an effect on the efficacy of the herbicide/adjuvant combinations.

The soil at this site is an Athena silt loam with 4.8% organic matter and a pH of 4.4. The ground was previously in winter wheat. Spring wheat was planted around our trial area on April 21st. The initial treatments were applied on May 8th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 36 psi at 2 mph. We chose to use TeeJet Turbo TwinJet® 11002 nozzles as they are best suited for broadcast spraying where superior leaf coverage and canopy penetration is important. The applications were made under winds out of the north at 1 mph with an air temperature of 52°F and relative humidity of 57%. At the time of application, the majority of rattail fescue was fully tillered and was 3 inches tall. A second set of treatments were applied on June 2nd with a CO_2-powered backpack sprayer set to deliver 10 gpa at 45 psi at 2.3 mph. The applications were made under winds out of the northwest at 3 mph with an air temperature of 66°F and relative humidity of 56%. At the time of application, the majority of rattail fescue was 12 inches tall. Some plants showed seedheads in the boot stage. A third set of treatments involved two applications that were applied on May 8th and June 2nd. Rattail fescue was uniformly distributed across the trial area.

Gly Star® Original was the glyphosate formulation chosen for this study as it does not contain an adjuvant package. The results of this study show the importance of adding adjuvants to glyphosate to control rattail fescue. However, all of the adjuvants provided a similar level of improved rattail fescue control when compared to glyphosate alone. Treatments that were applied on May 8th provided good control of rattail fescue when Gly Star Original was tank mixed with either of the three adjuvants. Treatments that were applied on June 2nd provided excellent control of rattail fescue when Gly Star Original was tank mixed with either of the three adjuvants. In treatments that were sequentially applied on May 8th and June 2nd, the second application appeared to control escaped plants from the initial treatment and hence provided quicker control, when compared to the treatments that were just applied on June 2nd. In the end, the sequential treatments and the June 2nd treatments provided the best and similar level of control of rattail fescue. It seemed that the size of the plant was important in improving the efficacy of glyphosate on rattail fescue control. The larger plants (12 inches in height) at the June 2nd application date provided more surface area for the herbicide to come in contact with.

			5/19	6/1	6/20	7/5
Treatment	Rate	Application date	Rattail fescue control			
	fl oz/A	2017	-------------------------------------0-100%--------------------------------------			
Nontreated Check	--	--	--	--	--	--
Gly Star Original[1]	24	5/8	38 c[2]	55 c	50 e	47 c
Gly Star Original + MVO	24 + 1% v/v	5/8	60 a	75 ab	70 d	57 bc
Gly Star Original + Wetcit	24 + 0.5% v/v	5/8	57 a	80 ab	72 cd	60 bc
Gly Star Original + Silwet L-77	24 + 0.5% v/v	5/8	60 a	75 ab	71 d	65 b
Gly Star Original	24	6/2	--	--	57 e	91 a
Gly Star Original + MVO	24 + 1% v/v	6/2	--	--	79 b-d	99 a
Gly Star Original + Wetcit	24 + 0.5% v/v	6/2	--	--	88 ab	100 a
Gly Star Original + Silwet L-77	24 + 0.5% v/v	6/2	--	--	75 cd	99 a
Gly Star Original	24	5/8 + 6/2	45 bc	58 c	81 bc	90 a
Gly Star Original + MVO	24 + 1% v/v	5/8 + 6/2	52 ab	79 ab	94 a	98 a
Gly Star Original + Wetcit	24 + 0.5% v/v	5/8 + 6/2	55 ab	83 a	96 a	99 a
Gly Star Original + Silwet L-77	24 + 0.5% v/v	5/8 + 6/2	58 a	70 b	93 a	95 a

[1] All treatments were tank mixed with ammonium sulfate at 8.5 lbs per 100 gallons of finished spray solution.
[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.

Kochiavore™ in combination with adjuvants for the control of Russian-thistle in chemical fallow

Lynn Sosnoskie, Henry Wetzel and Drew Lyon

A field study was conducted in Douglas County, WA in wheat stubble to evaluate the control of Russian-thistle with Kochiavore in combination with adjuvants. Kochiavore contains the active ingredients 2,4-D, bromoxynil and fluroxypyr in the Mechanism of Action Groups 4, 5 and 4, respectively.

Postemergence treatments were applied on July 24th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 2.5 mph. The applications were made under winds out of the north at 10 mph with an air temperature of 68°F and relative humidity of 32%. Russian-thistle plants were 3 to 6 inches in height and diameter and the average portion of the plot area covered with Russian-thistle was between 20 and 35%.

The initial rating was taken on August 7th, which was 14 days after application. Russian-thistle plants treated with Kochiavore + AG17018 (24 + 16 fl oz/A), Kochiavore + AG16017 (24 + 12 fl oz/A) and (24 + 16 fl oz/A) exhibited significantly more injury than those treated with Kochiavore (24 fl oz/A). At the next rating time, August 17th, Russian-thistle injury from Kochiavore + AG16017 (24 + 12 fl oz/A) dropped off, but the other two treatment were still exhibiting greater Russian-thistle injury than just Kochiavore applied alone at 24 fl oz/A. Proper adjuvant selection can improve the control of Russian-thistle in summer fallow with Kochiavore herbicide.

		8/7	8/17	8/7	8/17
		Mean number of Russian-thistle plants/yd^2			
Treatment	Rate			Russian-thistle injury	
	fl oz/A			----------------0-100%-----------------	
Nontreated Check		10 c[1]	13 e	--	--
Kochiavore	24	3 ab	4 a-c	81 bc	68 b-d
Kochiavore + AG16017	24 + 8	6 b	8 d	75 c	59 d
Kochiavore + AG16017	24 + 12	3 ab	4 a-c	88 ab	71 bc
Kochiavore + AG16017	24 + 16	2 a	3 ab	91 ab	79 ab
Kochiavore + AG17018	24 + 16	2 a	2 a	95 a	86 a
Kochiavore + AG17017	24 + 12	4 ab	6 b-d	81 bc	66 cd
Kochiavore + AG14039	24 + 8	2 a	7 cd	81 bc	35 e
Kochiavore + AG14039	24 + 12	3 ab	6 b-d	86 a-c	74 bc

[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.

Sharpen® plus Rugged® with adjuvants for the control of Russian-thistle in chemical fallow
Lynn Sosnoskie, Henry Wetzel and Drew Lyon

A field study was conducted in Douglas County, WA in wheat stubble to evaluate the control of Russian-thistle with Sharpen + Rugged in combination with adjuvants. Sharpen contains the active ingredient saflufenacil in the Mechanism of Action Group 14. Rugged is Winfield/United proprietary formulation of 2,4-D amine, which is in the Mechanism of Action Group 4. Cornerstone® 5 Plus contains the active ingredient glyphosate, which is in the Mechanism of Action Group 9, and was included as a standard.

Postemergence treatments were applied on July 24th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 2.5 mph. The applications were made under winds out of the north at 10 mph with an air temperature of 68°F and relative humidity of 32%. Russian-thistle plants were 3 to 6 inches in height and diameter and mean plot coverage was between 20 and 35%.

The initial rating was taken on August 7th, which was 14 days after application. At that time, Russian-thistle plants treated with Sharpen + Rugged, with or without the adjuvants StrikeLock™ or Exuro®, exhibited the most injury. Sharpen + StrickLock, while better than Sharpen alone, did not provide an acceptable level of control. Sharpen + Exuro provided fair control of Russian-thistle. Cornerstone 5 Plus and Sharpen without an adjuvant provided very little activity on Russian-thistle in this study. The second rating was taken 24 days after application on August 21st. Visual control of Russian-thistle had declined compared to the previous rating date for all treatments. From July 24 to August 12, the average low, average high and average temperature were 63 F, 89 F and 76 F, respectively. These conditions were very conducive for Russian-thistle growth and development and may have been why some plants grew out of the initial injury or new plants emerged. In addition, the size of the plants at the time of application were larger than ideal. At the August 17th rating, the addition of Exuro to Sharpen + Rugged, improved Russian-thistle control compared to Sharpen + Rugged alone. Proper adjuvant selection can improve the control of Russian-thistle with Sharpen + Rugged herbicide tank mix.

		8/7	8/17	8/7	8/17
		Mean number of			
Treatment	Rate	Russian-thistle plants/yd^2		Russian-thistle injury	
	fl oz/A			---------------0-100%--------------	
Nontreated Check		14 e[1]	16 c	--	--
Cornerstone 5 Plus	24	10 d	12 bc	25 d	14 ef
Rugged	16	7 a-d	8 ab	64 b	44 b-d
Sharpen	1	9 cd	11 ab	18 d	4 f
Sharpen + StrikeLock	1 + 8	9 cd	11 ab	41 c	30 de
Sharpen + StrikeLock	1 + 12	9 cd	10 ab	46 c	31 de
Sharpen + Exuro	1 + 12	8 b-d	9 ab	69 b	51 a-c
Sharpen + Exuro	1 + 16	10 d	11 ab	69 b	35 cd
Sharpen + Rugged	1 + 16	3 a	8 ab	86 a	45 b-d
Sharpen + Rugged + StrikeLock	1 + 16 + 8	5 ab	7 a	85 a	56 ab
Sharpen + Rugged + StrikeLock	1 + 16 + 12	6 a-c	8 ab	89 a	63 ab
Sharpen + Rugged + Exuro	1 + 16 + 12	4 ab	8 ab	89 a	65 a
Sharpen + Rugged + Exuro	1 + 16 + 16	3 a	7 a	91 a	68 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 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 with fall applications in winter wheat stubble

Mark Thorne, John Spring, Henry Wetzel, Ian Burke, and Drew Lyon

Rush skeletonweed (*Chondrilla juncea* L.) is a deep tap-rooted perennial invasive plant species that spreads by rhizomes and seeds. Rush skeletonweed is in the Asteraceae (sunflower) family and competes aggressively for soil moisture and nitrogen, particularly during spring and summer months. In eastern Washington, rush skeletonweed became established on thousands of acres of rangeland in Whitman and Lincoln counties, and then spread into adjacent farmland when the land was enrolled in the Conservation Reserve Program (CRP). Recently, CRP contracts have expired and much of the CRP land is now back in wheat production. Consequently, stands of rush skeletonweed on CRP land have persisted into winter wheat production.

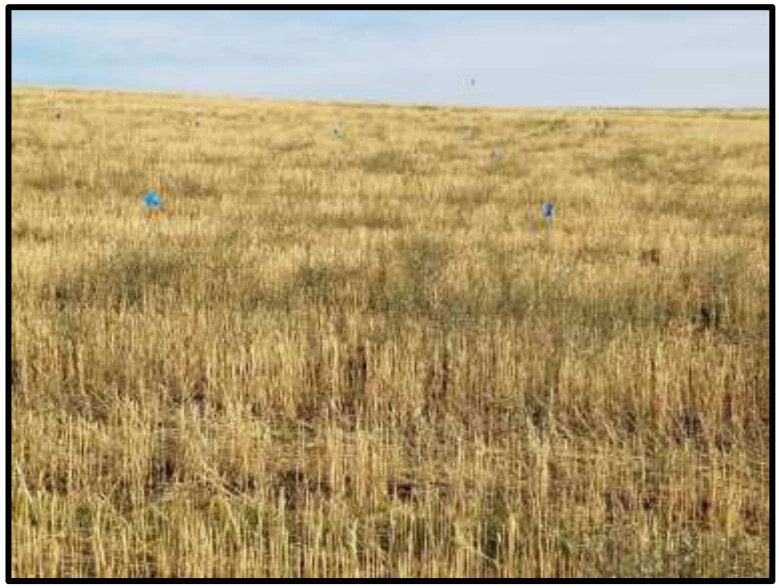


Figure 1. Rush skeletonweed in wheat stubble following harvest.

The winter wheat/fallow rotation is predominant in this area with tillage as the primary tool used through the fallow year to control weeds, conserve moisture, and prepare the seedbed for fall planting. Standard weed management strategies do not control or prevent rush skeletonweed from flourishing during the fallow phase of the rotation. Rush skeletonweed resprouts following early-spring aid-to-tillage glyphosate applications and subsequent tillage operations, including rod weeding. Furthermore, tillage can spread the infestation by fragmenting and spreading rhizomes that will resprout and start new plants.

Infestations of rush skeletonweed in fallow reduce wheat yield potential by depleting soil moisture. Germination of wheat seeded into moisture-depleted soil is delayed until fall rains replenish the seed zone, or fails to emerge if fall rains crust the soil surface. Reseeding can fill in areas of poor emergence, but yield potential of late-emerging wheat is low. Effective herbicide control of rush skeletonweed during the fallow phase would increase yields by preserving soil moisture, and would reduce the number of rod weeding operations currently required to keep dense stands from further depleting soil moisture.

A preliminary trial was established October 2016 near LaCrosse, WA to compare herbicides applied following winter wheat harvest for rush skeletonweed control during the following fallow year. The site had been taken out of CRP in fall of 2013 and seeded to winter wheat. The field was fallowed in 2014-15 and in winter wheat 2015-16. A relatively uniform stand of rush skeletonweed was present while in CRP and persisted into wheat production. Winter wheat was harvested July 2016 and the remaining wheat stubble was left standing through the fall and winter.

Herbicide treatments were applied October 19, 2016 using a CO_2 pressurized 10-ft hand-held spray boom. The spray output was 15 gpa at 24 psi travelling 3 mph. At the time of application, the sky was clear and air temperature was 67 °F with 43% relative humidity. The soil temperature was 48 °F at 3 inches and the surface was moist. Design of the trial was a randomized complete block with four replications per treatment. Individual plots measured 10 by 30 feet.

At the time of herbicide application, the majority of rush skeletonweed plants were bolted with actively growing leaves, likely benefiting from early occurring above average October rains. Bolted plants were up to 29 inches tall and contained buds with flowers or seeds, but a few plants were still in the rosette stage. The density of plants was variable across the trial site and range from 1 to 12 plants/m^2.

The field that contained the study site was originally planned to be in fallow through 2017, but the volume of wheat stubble was too great for fallow tillage operations. Consequently, the stubble was burned in the spring of 2017 and the field was seeded to spring wheat. Rush skeletonweed re-emerged following the burn and was present in the spring wheat crop. Herbicide efficacy was evaluated on June 21, 2017 by counting all plants in a 6- by 28-foot area in the center of each plot. Even though the field contained spring wheat instead of fallow, it was determined these measurements would be useful for evaluating efficacy of the fall-applied herbicides.

Results of June 21 evaluations were straightforward and encouraging. Applications of Milestone®, Stinger®, or Arsenal® reduced the presence of rush skeletonweed (Table). High rates of Stinger and Arsenal completely controlled the population in three out of the four plots (25% presence), while the high rate of Milestone controlled the population in two of the four plots treated (50% presence).

Rush skeletonweed density was reduced to near zero with both rates of Stinger and the high rates of both Milestone and Arsenal (Table). The low rates of Milestone and Arsenal also resulted in good control with densities averaging 0.6 plants/m^2 for each treatment (Table). The high rates of aminocyclopyrachlor or Ally XP® resulted in only intermediate control with densities of 1.3 and 2.1 plants/m^2 but were more effective than their corresponding low rates, which were not different from the non-treated check. The RT 3® + 2,4-D LV6 treatment also resulted in intermediate control with 2.7 plants/m^2 remaining.

Results of this trial suggest that control of rush skeletonweed during the fallow year may be possible with Stinger, Milestone, or Arsenal; however, Milestone and Arsenal are not label for fallow applications in winter wheat production. Both high and low rates of Stinger were equally effective and resulted in good control. For the other herbicides tested, the high rate was more effective than the low rate. The more common application of glyphosate + 2,4-D does not appear to be effective and only slightly better than applying nothing.

Effect of fall-applied herbicides on rush skeletonweed in winter wheat stubble. Rush skeletonweed presence and density were assessed June 2017 of the following year.

Treatment	Rate	Unit	Presence [1]	Density
			(%)	(plants/m^2)
Nontreated	-	-	100	3.7 ab
Milestone (aminopyralid)	0.594	fl oz/a	100	0.6 ef
Milestone (aminopyralid)	1.19	fl oz/a	50	<0.1 g
Stinger (clopyralid)	0.5	pt/a	75	0.2 fg
Stinger (clopyralid)	1	pt/a	25	<0.1 g
Aminocyclopyrachlor	1.71	fl oz/a	100	4.1 ab
Aminocyclopyrachlor	3.43	fl oz/a	100	1.3 de
Arsenal (imazapyr)	1.5	pt/a	75	0.6 f
Arsenal (imazapyr)	3	pt/a	25	<0.1 g
Ally XP (metsulfuron)	0.1	oz/a	100	5.6 a
Ally XP (metsulfuron)	0.2	oz/a	100	2.1 cd
RT 3 (glyphosate) + 2,4-D LV6 (2,4-D ester)	32 + 8.6	fl oz/a	100	2.7 bc

[1] Presence defined as the percentage of plots with the same treatment having at least one rush skeletonweed plant.

Preemergence Herbicides for Downy Brome Management

Zuger, R.J., A.L. Hauvermale & I.C. Burke

Downy brome continues to be a problematic and widespread weed in inland PNW wheat-fallow rotations. Acetolactate synthase inhibitor resistance continues to spread, and there are very few herbicide options remaining. Our objective was to identify one or more herbicide treatments with different herbicide modes of action for management of downy brome.

The study was established in a fallow field near Anatone, WA. Treatments were applied preemergence (PRE) on November 10, 2016, detailed in Table 1 and Table 3. Glyphosate (RT3) and ammonium sulfate (AMS Max) was also applied on November 10, 2016 as a burn-down. The study was conducted in a randomized complete block with 4 replications. Plots were 5’ by 10’ long.

Downy brome (*Bromus tectorum*) control was assessed by visual estimation at 133, 180, 195, 200, and 202 days after treatment (DAT) of application (Table 2). Downy brome biomass was harvested by collecting two $1/10^{th}$ meter quadrants from each plot on June 15, 2017. 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).

Zidua with Hoelon and Outlook at 133 DAT both provided significant downy brome control compared to the nontreated control with 73% control for both herbicide treatments and 0% control for the nontreated. Downy brome control with Zidua, Zidua with Hoelon, and Hoelon with Outrider at 180 DAT was greater compared to the nontreated control at 93%, 98%, 78% control, respectively (Table 3). Finesse and Prowl H2O did not provide significant downy brome control at 180 DAT. Similar results were observed at 195 DAT and 200 DAT. By May 31, 2017 (202 DAT), the only treatments to still maintain significant downy brome control compared to the nontreated control (0%) were Zidua (80%), Zidua with Outrider (63%), and Zidua with Hoelon (98%). Zidua, Zidua with Outrider, Zidua with Hoelon, and Hoelon with Outrider significantly reduced the amount of downy brome biomass compared to the nontreated control. Downy brome biomass in the nontreated control was 638 lb A^{-1} compared to 139 lb A^{-1} downy brome biomass for Zidua, 242 lb A^{-1} for Zidua with Outrider, 117 lb A^{-1} Zidua with Hoelon, and 385 lb A^{-1} for Hoelon with Outrider.

Table 1. *Treatment application details*

Study Application	
Date	November 10, 2016
Application volume (GPA)	15
Air temperature (˚F)	54
Soil temperature (˚F)	48
Wind velocity (mph, direction)	8, S
Next rain occurred on	November 15, 2016

Table 2. *Blanket application details. Applied on November 10, 2016.*

Treatment	**Rate**	
	Field Rate	**lb ai/A**
Glyphosate (RT3)	32 fl oz/A	1.375
AMS Max	8 lb/100 gal	

Table 3. *Percent downy brome control and downy brome biomass following preemergent applications. Anatone, WA, 2016-2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05).*

			Downy Brome Control					***Downy Brome Biomass***
Treatment	**Rate**		**3/23/17** ***133 DAT***	**5/9/17** ***180 DAT***	**5/24/17** ***195 DAT***	**5/29/17** ***200 DAT***	**5/31/17** ***202 DAT***	**6/15/17**
		lb ai/A	**%**	**%**	**%**	**%**	**%**	**LB/A**
Nontreated	-	-	0 a	0 a	0 a	0 a	0 a	638 ab
Zidua	1.50 oz/A	0.080	40 ab	93 bc	88 d	86 bc	80 cd	139 de
Zidua Outrider	1.50 oz/A 0.66 oz/A	0.080 0.031	48 ab	73 bc	75 cd	79 bc	63 bcd	242 cde
Zidua Hoelon	1.50 oz/A 2.66 pt/A	0.080 1.000	73 b	98 c	90 d	98 c	98 d	117 e
Hoelon	2.66 pt/A	1.000	48 ab	70 bc	63 bcd	71 bc	40 abc	475 abcd
Hoelon Outrider	2.66 pt/A 0.66 oz/A	1.000 0.031	43 ab	78 bc	75 cd	75 bc	50 abc	385 bcde
Outrider	0.66 oz/A	0.031	53 ab	70 bc	43 bc	48 abc	10 ab	642 ab
Outrider Olympus	0.66 oz/A 0.60 oz/A	0.031 0.026	28 ab	45 b	23 ab	28 ab	25 ab	568 abc
TriCor DF	0.50 lb/A	0.375	9 ab	56 bc	45 bc	60 bc	18 ab	558 abc
Prowl H_2O	2.1 pt/A	1.000	25 ab	0 a	38 abc	33 ab	8 a	796 a
Outlook	16 fl oz/A	0.750	73 b	63 bc	50 bcd	61 bc	33 ab	460 abcd
Valor	2 oz/A	0.064	34 ab	43 b	32 abc	53 bc	18 ab	706 ab
Finesse	0.40 oz/A	0.016	28 ab	0 a	25 ab	28 ab	5 a	808 a
		LSD	*40*	*32*	*27*	*35*	*33*	*239*

Thank you to the grower and their family for the use of land.

Annual Invasive Grass Weed Control with Indaziflam & Propoxycarbazone

Zuger, R.J., L.E. Koby, & I.C. Burke

The study was established on a conservation reserve program (CRP) site near Albion, WA. The objective of the study was to evaluate Esplanade (indaziflam), Lambient (propoxycarbazone), Rezilon (rimsulfuron), Plateau 2XL (imazapic), and Accord XRT II (glyphosate) for control of annual grasses (ventenata, *Ventenata dubia* (Leers) Coss. and downy brome, *Bromus tectorum* L.) in Palouse prairie. Treatments were applied in the fall of 2016 when perennial grasses were dormant as a broadcast foliar application, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications with 10' by 30' long plots. Climate for 2016 through 2017 was much wetter than normal, with normal temperatures (Figure 1, pg. 92).

Weed cover and perennial grass (crop) stand was visually assessed 205 and 233 days after treatment (DAT) (Table 2, 3 & 4). 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).

Ventenata (VETDU) cover was reduced 205 days after treatment (DAT) for all treatments with less than 6% VETDU cover compared to the nontreated which had 13% VETDU cover (Table 2). At 233 DAT, all treatments, except Plateau 2XL (39%) and Accord XRT II (63%), reduced the percent cover for VETDU (less than 8%) compared to the nontreated control (51%) (Table 3). Esplanade in combination with either Lambient, Rezilon, Plateau, or Accord XRT had the greatest reduction in VETDU cover. Treatments had no effect on weed cover of downy brome (BROTE), medusa-head rye (ELYCM), prickly lettuce (LACSE) and field bindweed (CONAR) compared to the nontreated control; however, low and uneven populations throughout the trial created non-assessable populations of those weeds (Table 2 & 3).

Perennial grass, smooth brome, had greater percent stand coverage for Esplanade in combination with either Lambient (73%), Rezilon (68%), Plateau (76%), or Accor XRT (84%) compared to any of the herbicides alone (less than 46%) and the nontreated control (8%) (Table 4). Plateau 2XL (16%) and Accord XRT II (12%) alone had no differences in smooth brome stand cover when compared to the nontreated control (8%) (Table 4). Results indicate that as ventenata is managed, the perennial grass spp. stand begins to recover, but that there is considerable injury in certain treatments – cover was less than the nontreated check.

Table 1. *Treatment application details.*

Study Application	**A**
Date	November 9, 2016
Application volume (GPA)	15
Air temperature (˚F)	54
Soil temperature (˚F)	49
Wind velocity (mph, direction)	7, E
Cloud cover	35%
Next rain occurred on	November 13, 2016

Table 2. *Percent cover of ventenata (VETDU), downy brome (BROTE), medusa-head rye (ELYCM), prickly lettuce (LACSE), and field bindweed (CONAR) following application of indaziflam with different tank partners. Albion, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population.*

Trt	**Rate**		***June 2, 2017* 205 DAT**				
			VETDU Cover	**BROTE Cover**	**ELYCM Cover**	**LACSE Cover**	**CONAR Cover**
	field rate	*lb ai/A*	*%*	*%*	*%*	*%*	*%*
Nontreated	-	-	13 a	8	17	5	3
Esplanade NIS	7 fl oz/A 0.25% v/v	0.091	1 b	1	3	9	3
Lambient NIS	1.2 oz/A 0.25% v/v	0.053	6 ab	-	15	3	9
Rezilon NIS	4 oz/A 0.25% v/v	0.063	1 b	-	2	26	-
Plateau 2L NIS	7 fl oz/A 0.25% v/v	0.109	1 b	100	13	3	10
Accord XRT II NIS	12 fl oz/A 0.25% v/v	0.475	4 b	3	1	-	13
Esplanade Lambient NIS	7 fl oz/A 1.2 oz/A 0.25% v/v	0.091 0.053	0 b	-	0	3	3
Esplanade Rezilon NIS	7 fl oz/A 4 oz/A 0.25% v/v	0.091 0.063	0 b	3	0	3	5
Esplanade Plateau 2L NIS	7 fl oz/A 7 fl oz/A 0.25% v/v	0.091 0.109	0 b	-	7	3	3
Esplanade Accord XRT II NIS	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	0 b	-	3	-	4
		LSD	*7*	*NS*	*NS*	*NS*	*NS*

Table 3. *Percent cover of ventenata (VETDU), downy brome (BROTE), medusa-head rye (ELYCM), prickly lettuce (LACSE), and field bindweed (CONAR) following application of indaziflam with different tank partners. Albion, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population.*

Trt	**Rate**		***June 30, 2017*** **233 DAT**				
			VETDU Cover	**BROTE Cover**	**ELYCM Cover**	**LACSE Cover**	**CONAR Cover**
	field rate	***lb ai/A***	*%*	*%*	*%*	*%*	*%*
Nontreated	-	-	51 a	5	27	3	6
Esplanade NIS	7 fl oz/A 0.25% v/v	0.091	5 b	-	22	10	5
Lambient NIS	1.2 oz/A 0.25% v/v	0.053	8 b	3	29	14	3
Rezilon NIS	4 oz/A 0.25% v/v	0.063	1 b	-	13	20	10
Plateau 2L NIS	7 fl oz/A 0.25% v/v	0.109	39 a	3	19	5	2
Accord XRT II NIS	12 fl oz/A 0.25% v/v	0.475	63 a	5	0	-	8
Esplanade Lambient NIS	7 fl oz/A 1.2 oz/A 0.25% v/v	0.091 0.053	0 b	-	0	-	3
Esplanade Rezilon NIS	7 fl oz/A 4 oz/A 0.25% v/v	0.091 0.063	0 b	-	0	10	-
Esplanade Plateau 2L NIS	7 fl oz/A 7 fl oz/A 0.25% v/v	0.091 0.109	0 b	-	0	5	5
Esplanade Accord XRT II NIS	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	0 b	-	0	-	18
		LSD	*24*	*NS*	*NS*	*NS*	*NS*

Table 4. *Percent cover of perennial grasses, bluebunch wheatgrass (Agropyron spicatum) and smooth brome (Bromus inermis), following application of indaziflam with different tank partners. Albion, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population.*

Trt	Rate		***June 2, 2017*** **205 DAT**		***June 30, 2017*** **233 DAT**	
			Bluebunch wheatgrass Cover	**Smooth brome Cover**	**Bluebunch wheatgrass Cover**	**Smooth brome Cover**
	field rate	***lb ai/A***	***%***	***%***	***%***	***%***
Nontreated	-	-	13	34	-	8 c
Esplanade NIS	7 fl oz/A 0.25% v/v	0.091	50	31	3	36 bc
Lambient NIS	1.2 oz/A 0.25% v/v	0.053	33	28	-	25 c
Rezilon NIS	4 oz/A 0.25% v/v	0.063	34	29	25	46 abc
Plateau 2L NIS	7 fl oz/A 0.25% v/v	0.109	22	43	25	16 c
Accord XRT II NIS	12 fl oz/A 0.25% v/v	0.475	3	48	14	12 c
Esplanade Lambient NIS	7 fl oz/A 1.2 oz/A 0.25% v/v	0.091 0.053	29	57	23	73 a
Esplanade Rezilon NIS	7 fl oz/A 4 oz/A 0.25% v/v	0.091 0.063	50	63	63	68 ab
Esplanade Plateau 2L NIS	7 fl oz/A 7 fl oz/A 0.25% v/v	0.091 0.109	38	51	25	76 a
Esplanade Accord XRT II NIS	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	-	47	-	84 a
		LSD	*NS*	*NS*	*NS*	*27*

Invasive Annual Grass Control with Esplanade and Method 240SL

Zuger, R.J., L.E. Koby, & I.C. Burke

The study was established on a conservation reserve program (CRP) site near Albion, WA. The objective of the study was to evaluate Esplanade (indaziflam) and Method 240SL (aminocyclopyrachlor) for control of annual grasses (ventenata (VETDU), downy brome (BROTE), and medusa-head rye (ELYCM) in Palouse prairie. Treatments were applied in the fall and spring when perennial grasses were dormant as a broadcast foliar application, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications with 10' by 30' long plots. Climate was much wetter than normal, with normal temperatures (Figure 1, pg. 92).

Weed cover and perennial grass (crop) stand was visually assessed 205 and 233 days after the first treatment timing (DAT) or 42 and 70 days after the second treatment timing (DAT) (Table 2 & 3). 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

Ventenata (VETDU) cover at 205 DAAT and 42 DABT was the least for the fall applications of Esplanade with Method at 2 fl oz A^{-1} and Esplanade with Accord XRT II and the spring applications of esplanade with Methods at either 4 or 8 fl oz A^{-1} (Table 2). By 233 DAAT and 70 DABT, all combinations of esplanade with methods at either timing (fall or spring) reduced the percent ventenata cover (less than 16%) compared to other treatments (greater than 36% VETDU cover). Treatments had no effect on weed cover of downy brome (BROTE) and prickly lettuce (LACSE); however, low and uneven populations throughout the trial created non-assessable populations of those weeds. Percent medusa-head rye (ELYCM) cover was reduced by all treatments 233 DAAT and 70 DABT compared to the nontreated control (Table 2).

There was no difference in perennial grass coverage for any treatment 205 DAAT and 42 DABT (Table 3). However, towards the end on June, 233 DAAT and 70 DABT, more smooth brome (BROIN) was present for treatments of Esplanade with Method 240SL at other timing as while as esplanade with Accord XRT II applied in the fall (A) and Method alone at 8 fl oz A^{-1} applied in the spring (B) compared to the nontreated control (Table 3). Bluebunch wheatgrass (AGRSP) and intermediate wheatgrass (AGRIT) had low and uneven populations throughout the trial and were not assessable.

Table 1. *Treatment application details.*

Study Application	A	B
Date	November 9, 2016	April 21, 2017
Application volume (GPA)	15	15
Application timing	Fall	Spring
Air temperature (˚F)	54	48
Soil temperature (˚F)	49	50
Wind velocity (mph, direction)	7, E	4, SW
Cloud cover	35%	50%
Next rain occurred on	November 13, 2016	April 23, 2017

Table 2. *Percent cover of ventenata (VETDU), downy brome (BROTE), medusa-head rye (ELYCM), and prickly lettuce (LACSE) following application of Esplanade and Method 240SL at different application timings and combinations. Albion, WA, 2017. DAAT = days after treatment A & DABT = days after treatment B. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population.*

				VETDU Cover	**BROTE Cover**	**ELYCM Cover**	**LACSE Cover**	**VETDU Cover**	**BROTE Cover**	**ELYCM Cover**	**LACSE Cover**
		field rate	***lb ai/A***	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Nontreated	-	-	-	19 ab	3	12	13	40 abc	3	80 a	41
Esplanade **NIS**	A A	7 fl oz/A 0.25% v/v	0.091	11 ab	35	1	12	18 bc	35	1 b	18
Method 240SL **NIS**	A A	2 fl oz/A 0.25% v/v	0.031	22 ab	-	10	6	38 abc	-	3 b	12
Method 240SL **NIS**	A A	4 fl oz/A 0.25% v/v	0.063	34 ab	3	0	1	57 ab	-	0 b	1
Method 240SL **NIS**	A A	8 fl oz/A 0.25% v/v	0.125	50 a	53	0	1	67 a	3	18 b	5
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 2 fl oz/A 0.25% v/v	0.091 0.031	1 b	1	0	5	2 c	-	0 b	-
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 4 fl oz/A 0.25% v/v	0.091 0.063	18 ab	23	3	0	0 c	-	-	-
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 8 fl oz/A 0.25% v/v	0.091 0.125	13 ab	50	5	0	0 c	-	0 b	-
Esplanade **Accord XRT II** **NIS**	A A A	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	3 b	9	15	2	0 c	3	0 b	20
Esplanade **NIS**	B B	7 fl oz/A 0.25% v/v	0.091	18 ab	10	13	1	23 bc	13	28 b	3
Method 240SL **NIS**	B B	2 fl oz/A 0.25% v/v	0.031	18 ab	1	8	4	36 abc	15	23 b	38
Method 240SL **NIS**	B B	4 fl oz/A 0.25% v/v	0.063	34 ab	14	10	5	57 ab	13	24 b	16
Method 240SL **NIS**	B B	8 fl oz/A 0.25% v/v	0.125	14 ab	4	0	0	20 bc	0	0 b	-
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 2 fl oz/A 0.25% v/v	0.091 0.031	13 ab	3	0	4	16 c	13	13 b	11
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 4 fl oz/A 0.25% v/v	0.091 0.063	8 b	1	7	0	8 c	49	34 b	0
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 8 fl oz/A 0.25% v/v	0.091 0.125	5 b	3	3	0	12 c	-	18 b	-
Esplanade **Accord XRT II** **NIS**	B B B	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	19 ab	8	1	0	14 c	-	2 b	8
			LSD	*24*	*NS*	*NS*	*NS*	*25*	*-*	*23*	*NS*

Table 3. *Percent cover of perennial grasess, bluebunch wheatgrass (AGRSP), intermediate wheatgrass (AGRIT) and smooth brome (BROIN) following application of Esplanade and Method 240SL at different application timings and combinations. Albion, WA, 2017. DAAT = days after treatment A & DABT = days after treatment B. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population*

				AGRSP Cover	**AGRIT Cover**	**BROIN Cover**	**AGRSP Cover**	**AGRIT Cover**	**BROIN Cover**
		field rate	*lb ai/A*	*%*	*%*	*%*	*%*	*%*	*%*
Nontreated	-	-	-	-	18	11	-	3	28 abc
Esplanade **NIS**	A A	7 fl oz/A 0.25% v/v	0.091	-	11	19	50	45	28 abc
Method 240SL **NIS**	A A	2 fl oz/A 0.25% v/v	0.031	-	14	14	-	-	43 abc
Method 240SL **NIS**	A A	4 fl oz/A 0.25% v/v	0.063	-	34	1	-	25	34 abc
Method 240SL **NIS**	A A	8 fl oz/A 0.25% v/v	0.125	-	17	3	5	-	23 bc
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 2 fl oz/A 0.25% v/v	0.091 0.031	-	21	43	38	-	59 abc
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 4 fl oz/A 0.25% v/v	0.091 0.063	-	26	15	25	-	79 a
Esplanade **Method 240SL** **NIS**	A A A	7 fl oz/A 8 fl oz/A 0.25% v/v	0.091 0.125	1	24	16	38	-	74 ab
Esplanade **Accord XRT II** **NIS**	A A A	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	-	11	6	-	-	74 ab
Esplanade **NIS**	B B	7 fl oz/A 0.25% v/v	0.091	13	22	4	13	-	25 abc
Method 240SL **NIS**	B B	2 fl oz/A 0.25% v/v	0.031	25	7	29	-	-	28 abc
Method 240SL **NIS**	B B	4 fl oz/A 0.25% v/v	0.063	13	6	6	-	-	14 c
Method 240SL **NIS**	B B	8 fl oz/A 0.25% v/v	0.125	43	18	25	25	-	76 ab
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 2 fl oz/A 0.25% v/v	0.091 0.031	-	23	28	-	-	66 ab
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 4 fl oz/A 0.25% v/v	0.091 0.063	25	29	16	-	45	49 abc
Esplanade **Method 240SL** **NIS**	B B B	7 fl oz/A 8 fl oz/A 0.25% v/v	0.091 0.125	-	18	23	-	-	71 ab
Esplanade **Accord XRT II** **NIS**	B B B	7 fl oz/A 12 fl oz/A 0.25% v/v	0.091 0.475	-	30	12	-	-	64 abc
			LSD	*NS*	*NS*	*NS*	-	-	*31*

Invasive Annual Grass Control with Laramie and Glyphosate 5.4 + Laramie

Zuger, R.J., L.E. Koby, & I.C. Burke

The study was established a conservation reserve program (CRP) site near Albion, WA. The objective of the study was to evaluate Laramie 25DF (rimsulfuron) and Laramie 25DF with Glyphosate 5.4 for control of annual grasses (ventenata, *Ventenata dubia* (Leers) Coss. and downy brome, *Bromus tectorum* L.) in Palouse prairie. Treatments were applied mid- and late-winter when perennial grasses were dormant as a broadcast foliar application, detailed in Table 1 and Table 2. The study was conducted in a randomized complete block with 4 replications with 8' by 20' long plots. Climate was much wetter than normal, with normal temperatures (Figure 1, pg. 92). Snow was present on the site until just before Application A.

Weed cover and perennial grass (crop) stand was visually assessed 71 days after the first treatment timing (DAAT) or 45 days after the second treatment timing (DABT) (Table 2 & 3). 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

Ventenata (VETDU) cover was reduced 71 days after the first application timing (DAAT) and 45 days after the second application timing (DABT) compared to the nontreated control. Treatments in timing C had not been applied as of June 2, 2017 (Table 2). Treatments had no effect on weed cover of downy brome (BROTE), medusa-head rye (ELYCM), western salsify (TRODM), and rush skeletonweed (CHOJU) compared to the nontreated control; however, low and uneven populations throughout the trial created non-assessable populations of those weeds. Rimsulfuron (Laramie 25 DF) applied at the higher rate of 0.063 lb ai A^{-1} had higher prickly lettuce (LACSE) cover (15%) 71 DAAT compared to the nontreated control (7%) and other application A treatments (<7%) and the later timing of application B (<5%). The higher coverage of prickly lettuce could likely be due to less competition from native species and other weed species as well as herbicide resistance. Field bindweed (CONAR) cover was not affected by treatment compared to the nontreated.

Imazapic (Panoramic 2SL) applied at 0.125 lb ai A^{-1} at the second application timing (B) had a significantly greater percent bluegrass spp. stand (79%) compared to the nontreated control (30%) 45 DABT. Percent bluegrass spp. cover for all other treatments at the second application timing (B) were similar to the higher rate of imazapic applied at timing B 45 DABT, as well as both rates of rimsulfuron (Laramie 25DF) and both rates of imazapic (Panoramic 2 SL) applied at timing A 71 DAAT (Table 3). Results indicate that as ventenata is managed, the bluegrass spp. stand begins to recover, but that there is considerable injury in certain treatments – cover was less than the nontreated check.

Table 1. *Treatment application details.*

Study Application	A	B	C
Date	March 23, 2017	April 18, 2017	October 16, 2017
Application volume (GPA)	15	15	15
Application timing*	326 GDD	664 GDD	-
Air temperature (˚F)	41	46	58
Soil temperature (˚F)	50	50	48
Wind velocity (mph, direction)	6, S	4, SW	5, E
Cloud cover	50%	100%	0%
Next rain occurred on	March 24, 2017	April 20, 2017	October 19, 2017

* Growing degree days (GDD) were from January 1, 2017 till spray date at 32 degrees

Table 2. *Percent cover of ventenata (VETDU), downy brome (BROTE), medusa-head rye (ELYCM), prickly lettuce (LACSE), western salsify (TRODM), rush skeletonweed (CHOJU), and field bindweed (CONAR) following application of rimsulfuron at different application rates and formulations. Albion, WA, 2017. DAAT = days after treatment A and DABT = days after treatment B. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population.*

				VETDU Cover	BROTE Cover	ELYCM Cover	LACSE Cover	TRODM Cover	CHOJU Cover	CONAR Cover
		field rate	*lb ai/A*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Nontreated	-	-	-	36 a	9	19	1 b	2	-	9 b
Laramie 25DF **MSO**	A A	3 oz/A 1% v/v	0.047	0 b	-	-	7 b	5	3	5 b
Laramie 25DF **MSO**	A A	4 oz/A 1% v/v	0.063	0 b	3	-	15 a	6	-	18 b
Glyphosate 5.4 **Laramie 25DF** **MSO**	A A A	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	0 b	-	-	7 b	8	9	5 b
Panoramic **MSO**	A A	6 fl oz/A 1% v/v	0.094	8 b	11	5	3 b	6	-	3 b
Panoramic **MSO**	A A	8 fl oz/A 1% v/v	0.125	5 b	25	-	2 b	5	-	3 b
Laramie 25DF **MSO**	B B	3 oz/A 1% v/v	0.047	7 b	5	25	3 b	3	13	8 b
Laramie 25DF **MSO**	B B	4 oz/A 1% v/v	0.063	1 b	3	-	5 b	1	-	8 b
Glyphosate 5.4 **Laramie 25DF** **MSO**	B B B	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	6 b	11	-	5 b	3	-	3 b
Panoramic **MSO**	B B	6 fl oz/A 1% v/v	0.094	0 b	5	-	3 b	8	-	5 b
Panoramic **MSO**	B B	8 fl oz/A 1% v/v	0.125	0 b	-	-	4 b	3	5	3 b
Laramie 25DF **MSO**	C C	3 oz/A 1% v/v	0.047	46 a	18	3	3 b	4	-	18 b
Laramie 25DF **MSO**	C C	4 oz/A 1% v/v	0.063	33 a	15	3	10 ab	3	13	30 a
Glyphosate 5.4 **Laramie 25DF** **MSO**	C C C	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	44 a	-	25	1 b	3	1	14 b
Panoramic **MSO**	C C	6 fl oz/A 1% v/v	0.094	38 a	5	18	-	3	-	13 b
Panoramic **MSO**	C C	8 fl oz/A 1% v/v	0.125	35 a	35	18	-	6	8	8 b
			LSD	*20*	*NS*	-	*5*	*NS*	-	*10*

Table 3. *Percent cover of perennial grasess, panicled willowweed (Epilobium brachycarpum* C. Presl*) and bluegrass spp., following application of rimsulfuron at different application rates and formulations. Albion, WA, 2017. DAAT = days after treatment A and DABT = days after treatment B. Means followed by the same letter are not statistically significantly different (α=0.05). A (-) indicates a non-assessable population*

				Panicle Willowweed Cover	Bluegrass spp. Cover
		field rate	*lb ai/A*	*%*	*%*
Nontreated	-	-	-	3	30 bc
Laramie 25DF **MSO**	A A	3 oz/A 1% v/v	0.047	3	68 ab
Laramie 25DF **MSO**	A A	4 oz/A 1% v/v	0.063	1	36 abc
Glyphosate 5.4 **Laramie 25DF** **MSO**	A A A	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	3	18 bc
Panoramic **MSO**	A A	6 fl oz/A 1% v/v	0.094	-	38 abc
Panoramic **MSO**	A A	8 fl oz/A 1% v/v	0.125	-	64 abc
Laramie 25DF **MSO**	B B	3 oz/A 1% v/v	0.047	-	49 abc
Laramie 25DF **MSO**	B B	4 oz/A 1% v/v	0.063	2	66 ab
Glyphosate 5.4 **Laramie 25DF** **MSO**	B B B	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	-	46 abc
Panoramic **MSO**	B B	6 fl oz/A 1% v/v	0.094	3	68 ab
Panoramic **MSO**	B B	8 fl oz/A 1% v/v	0.125	3	79 a
Laramie 25DF **MSO**	C C	3 oz/A 1% v/v	0.047	5	27 bc
Laramie 25DF **MSO**	C C	4 oz/A 1% v/v	0.063	-	21 bc
Glyphosate 5.4 **Laramie 25DF** **MSO**	C C C	6 fl oz/A 3 oz/A 1% v/v	0.253 0.047	-	23 bc
Panoramic **MSO**	C C	6 fl oz/A 1% v/v	0.094	-	16 c
Panoramic **MSO**	C C	8 fl oz/A 1% v/v	0.125	-	29 bc
			LSD	*NS*	*29*

Weed Management in Potatoes with Outlook, Eptam, and Matrix

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

The objective was to evaluate weed control with Outlook, Eptam, and Matrix to find alternative options for Sencor (metribuzin) due to the increasing concern for metribuzin resistance. The study was conducted twice, once in 2016 at the WSU Othello Research Farm near Othello, WA and again in 2017 at the WSU Tri-Cities Irrigated Research Farm in Pasco, WA. Treatments were applied preemergence (PRE), detailed in Table 1, 2 and 3. The study was conducted in a randomized complete block with 3 replications. Plots were 6' by 18' long and were supplemented with irrigation at both sites. Potato variety Alturas was planted on May 3rd, 2016 in Othello and May 11th, 2017 in Pasco. The 2016 study was applied with Select Max (32 fl oz A^{-1}; clethodim) and COC (1% v/v) for grass weed control due to heavy barnyardgrass pressure.

Broadleaf weed control was visually rated 45, 86, and 111 days after treatment (DAT) for the 2017 study and crop injury was visually assessed 16 DAT. No visual ratings were taken for the 2016 study. Both studies had were harvested by hand, collecting potatoes from a single row over a length of 5' from each plot in September. Potatoes were sorted before being weighed by size. 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).

Ratings for the 2017 study observed no visual crop injury 16 days after treatment (DAT). All treatments in 2017 visually control redroot pigweed (AMARE) and common lambsquarters (CHEAL) compared to the nontreated control at 45, 86, and 111 DAT (Table 2).

The 2016 study, treatments significantly increased market yield, US 1 & 2s greater than 6 ounces Tons A^{-1}, and percent number of US 1s greater 4 ounces and US 1 & 2s greater than 6 ounces compared to the nontreated control (Table 3). Market yield for the nontreated control was 10 tons A^{-1} and greater than 23 tons A^{-1} for all treatments applied. There was also an increased in percent number of culls for the nontreated control (62%) compared to all treatments (less than 30%). There were no differences between treatments and the nontreated control for the percent number of US 2s greater than 4 ounces (Table 3).

The repeated study in 2017, found in differences between any treatment and the nontreated control for market yield, US 1 & 2s greater than 6 ounces tons A^{-1}, and percent counts for US 1s and US 2s greater than 4 ounces, US 1 & 2s greater than 6 ounces, and culls (Table 4).

There was no difference in control and yields observed for any treatment with and without of Sencor (metribuzin) included in the treatment. Outlook, Eptam, and Matrix all provided the comparable broadleaf weed control and yield to Sencor (Table 2, 3, & 4).

Table 1. *Treatment application details*

Study Application	**2016 Study**	**2017 Study**
Date	May 9, 2017	May 23, 2017
Application volume (GPA)	15	15
Crop Stage	PRE	PRE
Air temperature (˚F)	59	80
Soil temperature (˚F)	61	74
Wind velocity (mph, direction)	8.8, NW	1.3, SE
Cloud cover (%)	0	0

Table 2. *Percent crop injury, broadleaf weed control for redroot pigweed (AMARE) and common lambsquarters (CHEAL) for 2017 potato study in Pasco, WA using either Outlook, Eptam, and Matrix in combination with other herbicides. Pasco, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α=0.05)*

			June 8, 2017 16 DAT	*July 7, 2017* 45 DAT		*August 17, 2017* 86 DAT	*September 11, 2017* 111 DAT	
Treatment	**Rate**		**Injury**	**AMARE Control**	**CHEAL Control**	**Weed Control**	**AMARE Control**	**CHEAL Control**
	field rate	***lb ai/A***	*%*	*%*	*%*	*%*	*%*	*%*
Nontreated			-	-	-	-	-	-
Outlook Sencor	18 fl oz/A 10.7 oz/A	0.840 0.500	0	99	99	98	99	99
Outlook Prowl H2O	18 fl oz/A 2.1 pt/A	0.840 1.000	0	99	99	98	99	96
Outlook Linex	18 fl oz/A 24 fl oz/A	0.840 0.750	0	99	99	99	99	99
Eptam Sencor	6 pt/A 10.7 oz/A	5.250 0.500	0	99	99	99	99	99
Eptam Prowl H2O	6 pt/A 2.1 pt/A	5.250 1.000	0	99	99	99	99	96
Eptam Linex	6 pt/A 24 fl oz/A	5.250 0.750	0	99	99	99	99	99
Matrix Sencor	1.47 oz/A 10.7 oz/A	0.023 0.500	0	99	99	99	99	98
Matrix Prowl H2O	1.47 oz/A 2.1 pt/A	0.023 1.000	0	99	99	96	99	99
Matrix Linex	1.47 oz/A 24 fl oz/A	0.023 0.750	0	99	99	98	99	99
Sencor Linex	10.7 oz/A 24 fl oz/A	0.500 0.750	0	99	99	99	69	99
Prowl H2O Linex	2.1 pt/A 24 fl oz/A	1.000 0.750	0	99	99	93	99	99
		LSD	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Table 3. *Average potato counts by grade size and yield at harvest for 2016 potato study in Othello, WA using either Outlook, Eptam, and Matrix in combination with other herbicides. Othello, WA, 2016. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α = 0.05).*

Treatment	**Rate**		**Counts** *September, 2016* **US 1s > 4 oz**	**US 2s > 4 oz**	**US 1 & 2s > 6 oz**	**Culls & < 4 oz**	**Yield** *September, 2016* **US 1 & 2 > 6 oz**	**Market**
	field rate	*lb ai/A*	*%*	*%*	*%*	*%*	*Tons/A*	*Tons/A*
Nontreated			35 b	3	12 b	62 a	1 b	10 b
Outlook **Sencor**	18 fl oz/A 10.7 oz/A	0.840 0.500	71 a	6	50 a	23 b	15 a	30 a
Outlook **Prowl H2O**	18 fl oz/A 2.1 pt/A	0.840 1.000	71 a	4	50 a	24 b	15 a	29 a
Outlook **Linex**	18 fl oz/A 24 fl oz/A	0.840 0.750	69 a	6	49 a	25 b	14 a	28 a
Eptam **Sencor**	6 pt/A 10.7 oz/A	5.250 0.500	73 a	4	48 a	23 b	14 a	29 a
Eptam **Prowl H2O**	6 pt/A 2.1 pt/A	5.250 1.000	71 a	6	52 a	23 b	16 a	31 a
Eptam **Linex**	6 pt/A 24 fl oz/A	5.250 0.750	72 a	8	58 a	20 b	16 a	27 a
Matrix **Sencor**	1.47 oz/A 10.7 oz/A	0.023 0.500	75 a	2	50 a	23 b	14 a	28 a
Matrix **Prowl H2O**	1.47 oz/A 2.1 pt/A	0.023 1.000	71 a	9	55 a	20 b	12 a	23 a
Matrix **Linex**	1.47 oz/A 24 fl oz/A	0.023 0.750	69 a	10	48 a	21 b	14 a	29 a
Sencor **Linex**	10.7 oz/A 24 fl oz/A	0.500 0.750	76 a	2	49 a	22 b	16 a	30 a
Prowl H2O **Linex**	2.1 pt/A 24 fl oz/A	1.000 0.750	69 a	1	36 a	30 b	9 a	25 a
		LSD	*12*	*NS*	*17*	*12*	*7*	*7*

Table 4. *Average potato counts by grade size and yield at harvest for 2017 potato study in Pasco, WA using either Outlook, Eptam, and Matrix in combination with other herbicides. Pasco, WA, 2017. DAT = days after treatment. Means followed by the same letter are not statistically significantly different (α = 0.05).*

Treatment	**Rate**		**Counts** *September 22, 2017* **US 1s > 4 oz**	**US 2s > 4 oz**	**US 1 & 2s > 6 oz**	**Culls & < 4 oz**	**Yield** *September 22, 2017* **US 1 & 2 > 6 oz**	**Market**
	field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**Tons/A**	**Tons/A**
Nontreated			17	0	61	21	15	24
Outlook **Sencor**	18 fl oz/A 10.7 oz/A	0.840 0.500	28	0	54	18	15	28
Outlook **Prowl H2O**	18 fl oz/A 2.1 pt/A	0.840 1.000	30	1	45	24	12	24
Outlook **Linex**	18 fl oz/A 24 fl oz/A	0.840 0.750	46	0	43	23	10	23
Eptam **Sencor**	6 pt/A 10.7 oz/A	5.250 0.500	20	2	60	17	18	29
Eptam **Prowl H2O**	6 pt/A 2.1 pt/A	5.250 1.000	19	1	61	18	20	33
Eptam **Linex**	6 pt/A 24 fl oz/A	5.250 0.750	27	2	46	24	16	30
Matrix **Sencor**	1.47 oz/A 10.7 oz/A	0.023 0.500	26	2	43	28	10	22
Matrix **Prowl H2O**	1.47 oz/A 2.1 pt/A	0.023 1.000	41	1	42	15	13	27
Matrix **Linex**	1.47 oz/A 24 fl oz/A	0.023 0.750	47	1	35	17	10	24
Sencor **Linex**	10.7 oz/A 24 fl oz/A	0.500 0.750	28	1	51	19	17	33
Prowl H2O **Linex**	2.1 pt/A 24 fl oz/A	1.000 0.750	19	1	50	28	15	27
		LSD	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Herbicide application timings for the control of broadleaf weeds 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. It would also be extremely beneficial for growers to have a product to apply postemergence to control broadleaf weeds that may have escaped a preemergence application. This was the first year that we evaluated pyridate (proposed tradename Tough) for postemergence broadleaf weed control in crop. Pyridate is in the Mechanism of Action Group 6, which is an inhibitor of photosynthesis at photosystem II site B. Tough is not yet registered for use in chickpeas.

The soil at this site is a Palouse silt loam with pH of 5.0 and organic matter content of 2.9%. The ground was conventionally prepared by cross cultivating on April 19th. The pre-plant application took place on April 25th using a CO_2 backpack sprayer set to deliver 10 gpa at 2.3 mph and 41 psi. Conditions on April 25th were an air temperature of 53°F, relative humidity of 47% and the wind out of the west at 8 mph. On May 11th, '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 11th and the conditions were an air temperature of 73°F, relative humidity of 46% and the wind out of the west at 3 mph. The postemergence application took place on June 30th and the conditions were an air temperature of 78°F, relative humidity of 32% and the wind out of the south at 4 mph. Common lambsquarters and mayweed chamomile plants ranged in height from 2.5 to 7 and 3.5 to 6 inches, respectively. The trial area was harvested with a Kincaid 8XP plot combine on September 11th.

With the abundant fall, winter and early spring precipitation, we expected significant broadleaf weed competition in our chickpea planting. This was not the case. Weed competition was low to moderate in this study. This was the main reason why the postemergence treatment Tough was applied so late (June 30th) as we anticipated weeds to continue to emerge after planting. On April 25 and 26 and from May 11 through 17, the trial area received 0.69 and 0.98 inches of rainfall, respectively. This was sufficient rainfall for the preemergence and the post-plant pre-emerge herbicide treatments to be activated. There was no crop injury observed for any herbicide treatments in this trial. All herbicide treatments provided good to excellent control of common lambsquarters on the July 21st rating date except for Spartan + Lorox and Valor + Lorox applied post-plant pre-emerge, which provided fair and poor control, respectively. In previous trials, Lorox has not provided good control of common lambsquarters. All herbicide treatments provided excellent control of mayweed chamomile on the July 21st rating date except for Spartan + Outlook and Valor + Lorox applied post-plant pre-emerge, which both provided good control. The addition of Tough to some of the soil applied treatments did not significantly improve weed control in this study. This was likely due to timely rains that resulted in good activation of soil applied herbicides and the lack of late emerging weeds. All herbicide treatments increased chickpea yield when compared to the nontreated check.

				-------------------7/21-------------------		
				Common	Mayweed	
			Application	lambsquarters	chamomile	9/11
Treatment #	Treatment	Rate	Timing[1]	control	control	Yield
		fl oz/A		-----------------0-100%-----------------		lb/A
1	Nontreated Check	--		--	--	280 d
2	Spartan	8	preemergence	94 a[2]	98 ab	780 a-c
2	Sencor + Sharpen	8 oz + 2	post-plant pre-emerge			
3	Spartan	8	preemergence	99 a	100 a	840 a
3	Sencor + Sharpen	8 oz + 2	post-plant pre-emerge			
3	Tough + NIS	48 + 0.25% v/v	postemergence			
4	Spartan	8	preemergence	99 a	98 ab	620 bc
4	Tough + NIS	48 + 0.25% v/v	postemergence			
5	Sencor + Sharpen	8 oz + 2	post-plant pre-emerge	84 ab	88 b	620 bc
6	Sencor + Sharpen + Lorox	8 oz + 2 + 20 oz	post-plant pre-emerge	81 ab	99 ab	690 bc
7	Valor + Lorox	2 oz + 20 oz	post-plant pre-emerge	22 c	74 c	650 a-c
8	Valor + Outlook	2 oz + 21	post-plant pre-emerge	85 ab	90 ab	580 c
9	Spartan	8	preemergence	86 ab	94 ab	660 a-c
9	Lorox	20 oz	post-plant pre-emerge			
10	Spartan + Lorox	8 + 20 oz	post-plant pre-emerge	64 b	90 ab	710 a-c
11	Spartan	8	preemergence	100 a	96 ab	590 c
11	Outlook	21	post-plant pre-emerge			
12	Spartan + Outlook	8 + 21	post-plant pre-emerge	81 ab	75 c	730 a-c
13	Sencor + Sharpen	8 oz + 2	post-plant pre-emerge	94 a	91 ab	820 ab
13	Tough + NIS	48 + 0.25% v/v	postemergence			

[1]Dates of application: preemergence (4/25), post-plant pre-emerge (5/11), postemergence (6/30)
[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.

Update on Weed Control with Pyridate and Clethodim in Chickpea

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

Postemergence (POST) broadleaf weed control is currently not an option for chickpea (*Cicer arietinum*) growers in the Pacific Northwest – there are no registered products. Preemergence (PRE) options exist but require spring precipitation for activation. As a consequence, broadleaf weed control in chickpea is difficult and often unacceptable.

Pyridate, previously labeled as Tough 5EC in peanuts and corn, is a photosystem II inhibitor. Chickpeas are tolerant due to metabolic detoxification of the herbicide, making pyridate a possible fit as a POST broadleaf herbicide in chickpeas (Gimenez-Espinosa and De Prado, 1997). The objective of the study was to evaluate pyridate effectiveness for broadleaf weed control in a field setting.

Both studies were established at the Cook Agronomy Farm near Pullman, WA, over two years with one being conducted in 2016 and the repeated study in 2017. Treatments were applied post emergence (POST) at several different crop stages with and without the addition of a surfactant and clethodim (Select Max) detailed in table 1, 2 and 3. Both studies were conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long. Studies were planted with chickpea variety Billy bean by the farm crew on May 4, 2016 and May 10, 2017, with both studies emerging 12 days later. No preemergent herbicides were applied to either study. In 2016, common lambsquarters (CHEAL) presented high weed pressure while in 2017 mayweed chamomile (ANTCO) was the dominant weed present with CHEAL also present.

Crop injury was visually rated 28 days after treatment(DAT16) of application A for the 2016 study (DAT16). CHEAL control was visually assessed 114 DAT16. The 2017 study was visually rated for crop injury 2 and 21 days after treatment of application A (DAT17), and CHEAL, ANTCO, and Italian ryegrass (LOLMU) control were visually assessed 23 days after the last application, or 43 DAT17 after the first application. Plots were harvested using a 5' plot combine on September 20, 2016 and September 11, 2017. 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).

When the study was conducted in 2016, there was no significant crop injury for any of the treatments 28 DAT of application A or 15 DAT16 of application C. All treatments provided common lambsquarters (CHEAL) 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 (Table 3). 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 is yield significantly different from the nontreated control (Table 3).

The study, repeated in 2017, also observed no significant crop injury was observed for any treatment 21 and 43 DAT17 after the first application (A). All timings and pyridate rates provided excellent common lambsquarters control compared to the nontreated. Pyridate applied at the first application timing (A) at 2 to 4" chickpeas provided greater control of mayweed chamomile (ANTCO) with 99% control overall (23 DAT17) compared to the later application timing (C) at 8 to 10" chickpeas which provided 78% to 90% control (Table 4). The earlier application likely had greater activity due to the ANTCO being smaller in size. At application A the ANTCO was ½" in diameter compared to 3" in diameter at the later timing of application C (Table 2). A consistent Italian ryegrass (LOLMU) population allowed grass weed control to be rated in 2017. Clethodim (Select Max) as a tank mix partner or applied alone was included in these studies to determine compatibility and crop safety. There was no significant difference between applying clethodim with pyridate or in a separate tank mix at a later timing (Table 4) for LOLMU control. However, waiting until the chickpeas are at 8 to 10” or 15 days after chickpea emergence does significantly reduce LOLMU control because of the larger grass size. At application A and B, the LOLMU was 2” or less in height compared to application C where the LOLMU had doubled in size (Table 2).

Fig 1 .*2016 Pyridate Weed Control Study CHEAL Control. Left: Nontreated control. Right: Pyridate (48 fl oz A^{-1}) with NIS applied to 8 to 10” chickpeas.*

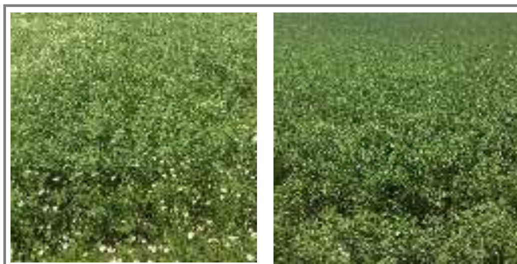


Fig 2. *2017 Pyridate Weed Control Study ANTCO Control. Left: Nontreated control. Right: Pyridate (48 fl oz A^{-1}) with NIS applied to 2 to 4” chickpeas.*

Table 1. *2016 study 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. *2017 study treatment application details*

Study Application	A	B	C
Date	May 30, 2017	June 2, 2017	June 19, 2017
Application volume (GPA)	15	15	15
Crop size	3.5”	6”	8”
CHEAL height	1”	-	3”
ANTCO diameter	0.5”	-	3”
LOLMU height	1.5”	2”	4”
Air temperature (˚F)	86	73	80
Soil temperature (˚F)	66	64	68
Wind velocity (mph, direction)	10, E	4, NW	8.2, E
Cloud Cover	15%	10%	1%
Next rain occurred on	June 1, 2017	June 4, 2017	June 26, 2017

Table 3. *Percent crop injury for chickpea, percent common lambsquarters control and yield following applications of pyridate and clethodim at different application timings. Pullman, WA, 2016. DAT = days after treatment for the 2016 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	Application Code	Rate		*June 21, 2016* 28 DAT	*September 15, 2016* 114 DAT	*September 26, 2016*
				Crop Injury	CHEAL control	Yield
		field rate	lb ai/A	%	%	lb/A
Nontreated	-	-	-	-	-	926 a
Pyridate	A	24 fl oz/A	0.940			
Clethodim	B	16.5 fl oz/A	0.125	10	88 ab	1840 b
COC	B	0.25% v/v				
Pyridate	A	48 fl oz/A	1.880			
Clethodim	B	16.5 fl oz/A	0.125	13	84 ab	1890 b
COC	B	0.25% v/v				
Pyridate	A	24 fl oz/A	0.940			
NIS	A	0.25% v/v		20	78 ab	1730 b
Clethodim	B	16.5 fl oz/A	0.125			
COC	B	0.25% v/v				
Pyridate	A	48 fl oz/A	1.880			
NIS	A	0.25% v/v		0	65 ab	1950 b
Clethodim	B	16.5 fl oz/A	0.125			
COC	B	0.25% v/v				
Pyridate	A	24 fl oz/A	0.940			
Clethodim	A	16.5 fl oz/A	0.125	3	85 ab	1500 ab
COC	A	0.25% v/v				
Pyridate	A	24 fl oz/A	1.880			
Clethodim	A	16.5 fl oz/A	0.125	5	82 ab	1510 ab
COC	A	0.25% v/v				
Pyridate	C	24 fl oz/A	0.940			
Clethodim	B	16.5 fl oz/A	0.125	5	58 b	1810 b
COC	B	0.25% v/v				
Pyridate	C	48 fl oz/A	1.880			
Clethodim	B	16.5 fl oz/A	0.125	15	95 a	2020 b
COC	B	0.25% v/v				
Pyridate	C	24 fl oz/A	0.940			
NIS	C	0.25% v/v		18	87 ab	1800 b
Select Max	B	16.5 fl oz/A	0.125			
COC	B	0.25% v/v				
Pyridate	C	48 fl oz/A	1.880			
NIS	C	0.25% v/v		8	94 a	2140 b
Clethodim	B	16.5 fl oz/A	0.125			
COC	B	0.25% v/v				
Pyridate	C	24 fl oz/A	0.940			
Clethodim	C	16.5 fl oz/A	0.125	15	85 ab	1870 b
COC	C	0.25% v/v				
Pyridate	C	24 fl oz/A	1.880			
Clethodim	C	16.5 fl oz/A	0.125	20	84 ab	1810 b
COC	C	0.25% v/v				
			LSD	*NS*	*22*	*557*

Table 4. *Percent chickpea crop injury, percent common lambsquarters (CHEAL), mayweed chamomile (ANTCO), and Italian ryegrass (LOLMU) control and yield following applications of pyridate and clethodim at different application timings. Pullman, WA, 2017. DAT = days after treatment for the 2017 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 1, 2017 **2 DAT**	***June 20, 2017*** **21 DAT**		***July 12, 2017*** **43 DAT**		***September 11, 2017***
Treatment	**Application Code**	**Rate**		**Crop Injury**	**Crop Injury**	**CHEAL Control**	**ANTCO Control**	**LOLMU Control**	**Yield**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**%**	**lb/A**
Nontreated	-	-	-	-	-	-	-	-	1489
Pyridate **Clethodim** **COC**	A B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	99 a	36 ab	1793
Pyridate **Clethodim** **COC**	A B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	99	99 a	56 ab	2091
Pyridate **NIS** **Clethodim** **COC**	A A B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	99 a	49 ab	1753
Pyridate **NIS** **Clethodim** **COC**	A A B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	99	99 a	45 ab	2088
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	99 a	25 ab	1991
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	99	99 a	76 a	2106
Pyridate **Clethodim** **COC**	C B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	88 ab	34 ab	1965
Pyridate **Clethodim** **COC**	C B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	98	90 ab	49 ab	1871
Pyridate **NIS** **Select Max** **COC**	C C B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	78 b	28 ab	1624
Pyridate **NIS** **Clethodim** **COC**	C C B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	99	86 ab	51 ab	1855
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	99	84 ab	6 b	1722
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	99	84 ab	5 b	1489
			LSD	*NS*	*NS*	*NS*	*10*	*34*	*498*

Update on Crop Tolerance with Pyridate and Clethodim in Chickpea

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

Postemergence (POST) broadleaf weed control is currently not an option for chickpea (*Cicer arietinum*) growers in the Pacific Northwest – there are no registered products. Preemergence (PRE) options exist but require spring precipitation for activation. As a consequence, broadleaf weed control in chickpea is difficult and often unacceptable.

Pyridate, previously labeled as Tough 5EC in peanuts and corn, is a photosystem II inhibitor. Chickpeas are tolerant due to metabolic detoxification of the herbicide, making pyridate a possible fit as a POST broadleaf herbicide in chickpeas (Gimenez-Espinosa and De Prado, 1997). The objective of the study was to evaluate chickpea crop tolerance to pyridate in a field setting with and without the addition of either nonionic surfactant (NIS) or clethodim and crop oil concentrate (COC) as tank mix partners.

The 2016 study and repeated study of 2017 were both established at the Central Ferry Research Farm near Pomeroy, WA. Treatments were applied post emergence (POST) at several different crop stages with and without the addition of a surfactant and clethodim (Select Max), detailed in Table 1, 2 and 3. Both studies were conducted in a randomized complete block with 4 replications. Plots were 10' by 30' long and were supplemented with irrigation. Studies were planted with chickpea variety Billy bean using a Monosem planter on 10" row spacing at a depth of 1.5" on May 11, 2016 and May 1, 2017. PRE herbicides, Lorox (2.5 lb A^{-1}) and Outlook (21 fl oz A^{-1}), were applied pre-emergence (PRE) immediately after each planting to establish weed free trials. The 2016 study 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 burn down applications.

Fig 1. *2016 Paraquat Efficiency Study. Top: Nontreated Control. Middle: Paraquat (8 fl oz A^{-1}) applied 4 days after crop emergence. Bottom: Paraquat (8 fl oz A-1) applied 10 days after cracking.*

For the 2016 trial, canopy cover was visually rated 21 days after treatment (DAT16) of application A. Crop injury was visually rated 6 and 44 DAT16 if application A. Crop canopy cover was also rated in 2016 at 21 DAT16 of application A. Percent pest pressure was visually rated 6 DAT16 of application A (Table 2). The repeated study in 2017 had visually crop injury ratings taken 8 and 21 days after treatment (DAT17) of application A. Crop stunting was visually assessed 46 DAT17 of application A. Plots were harvested using a 5' plot combine on September 26, 2016 and August 24, 2017. 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).

The 2016 study observed no significant crop injury compared to the nontreated at either 6 or 44 DAT after application A. Although not significant, minimal leaf burning was observed after each pyridate application (Table 3). No differences in pest pressure were observed 6 DAT16 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.

The repeated study in 2017 had similar results with no significant crop injury compared the nontreated at 8 and 21 DAT17, no significant crop stunting compared to the nontreated 46 DAT17, and no significant differences in yield 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. The addition of clethodim (Select Max) and COC with pyridate also did not effect the chickpea tolerance to pyridate.

Table 1. *2016 study 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. *2017 study treatment application details*

Study Application	**A**	**B**	**C**
Date	May 22, 2017	May 25, 2017	May 30, 2017
Application volume (GPA)	15	15	15
Crop stage	3.5”	6”	8”
Air temperature (˚F)	85	58	85
Soil temperature (˚F)	72	68	75
Wind velocity (mph, direction)	3, NW	2, N	6, N
Cloud Cover	2%	100%	0%

Table 3. *Percent crop injury, pest pressure, crop canopy cover, and yield in chickpeas following applications of pyridate and clethodim at different application timings. Central Ferry, WA, 2016. DAT = days after treatment for the 2016 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 7, 2016 **6 DAT**	***June 7, 2016*** **6 DAT**	***June 22, 2016*** **21 DAT**	***July 14, 2016*** **44 DAT**	***September 26, 2016***
Treatment	**Application Code**	**Rate**		**Crop Injury**	**Pest Pressure**	**Canopy Cover**	**Crop Injury**	**Yield**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**lb/A**
Nontreated	-	-	-	-	-	100	-	1020
Pyridate **Clethodim** **COC**	A B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	2	76	8	1240
Pyridate **Clethodim** **COC**	A B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	3	5	73	6	1350
Pyridate **NIS** **Clethodim** **COC**	A A B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	3	5	75	3	1250
Pyridate **NIS** **Clethodim** **COC**	A A B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	3	76	10	1330
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	1	78	11	1270
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	79	3	1430
Pyridate **Clethodim** **COC**	C B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	1	1	75	1	1080
Pyridate **Clethodim** **COC**	C B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	1	1	84	8	1250
Pyridate **NIS** **Clethodim** **COC**	C C B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	4	69	19	1040
Pyridate **NIS** **Clethodim** **COC**	C C B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	3	3	76	14	1200
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	71	6	1120
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	2	1	71	16	1240
			LSD	*NS*	*NS*	*NS*	*NS*	*NS*

Table 4. *Percent crop injury, stunting, and yield in chickpeas following applications of pyridate and clethodim at different application timings. Central Ferry, WA, 2017. DAT = days after treatment for the 2017 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	Application Code	Rate		*May 30, 2017* 8 DAT	*June 12, 2017* 21 DAT	*July 7, 2017* 46 DAT	*August 24, 2017*
				Crop Injury	Crop Injury	Crop Stunting	Yield
		field rate	lb ai/A	%	%	%	lb/A
Nontreated	-	-	-	-	-	-	1746
Pyridate **Clethodim** **COC**	A B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	0	1518
Pyridate **Clethodim** **COC**	A B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	1	0	18	1495
Pyridate **NIS** **Clethodim** **COC**	A A B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	1	0	5	1960
Pyridate **NIS** **Clethodim** **COC**	A A B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	4	0	10	1554
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	3	0	0	1970
Pyridate **Clethodim** **COC**	A A A	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	10	1911
Pyridate **Clethodim** **COC**	C B B	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	0	5	1782
Pyridate **Clethodim** **COC**	C B B	48 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	1	0	10	1428
Pyridate **NIS** **Clethodim** **COC**	C C B B	24 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	0.940 0.125	1	0	0	1774
Pyridate **NIS** **Clethodim** **COC**	C C B B	48 fl oz/A 0.25% v/v 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	0	1613
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	0.940 0.125	0	1	0	1595
Pyridate **Clethodim** **COC**	C C C	24 fl oz/A 16.5 fl oz/A 0.25% v/v	1.880 0.125	0	0	0	1507
			LSD	*NS*	*NS*	*NS*	*NS*

Update on Weed Control and Crop Tolerance to Paraquat Applied At-Cracking to Chickpeas

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

The objective of these studies was to evaluate chickpea crop tolerance to paraquat in a field setting with the addition of a nonionic surfactant and weed efficacy by paraquat.

The 2016 study and repeated study of 2017 were both established at the Cook Agronomy Farm near Pullman, WA. Treatments were applied post emergence (POST) at several different timings starting at chickpea cracking, detailed in Table 1, 2, 3 & 4. Each study was conducted in a randomized complete block with 4 replications with 10' by 30' long plots. In 2016, glyphosate was applied as a pre-plant burndown, two weeks prior to planting while in 2017 the pre-plant burndown application of glyphosate was applied on May 8, 2017 just 2 days prior to planting. Studies were planted with chickpea variety 'Billy Bean' on May 4, 2016 and May 10, 2017. Outlook at 21 fl oz A^{-1} and Lorox at 1.5 lb A^{-1} was applied preemergence (PRE) at planting. Due to heavy Italian ryegrass pressure in 2017, Clethodim 2 EC at 16 fl oz A^{-1} with Hellfire at 0.25 % v/v was applied POST on June 19, 2017.

Crop injury was visually rated 9, 17, 36, and 102 days after treatment (DAT16) of application A for the 2016 study (Table 4). Common lambsquarters control was visually assessed 36 and 102 DAT16 of application A (Table 3). For the repeated 2017 study, crop injury was visually rated 9 and 28 DAT17 of application A (Table 5). Crop heights were recorded 28 DAT17 after application A by measuring 3 chickpea plants per plot. Italian ryegrass control was visually assessed 9, 28 and 50 DAT17 of application A (Table 3). Common lambsquarters and mayweed chamomile control was also visually assessed 50 DAT17 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).

Plots were harvested using a plot combine on September 7, 2017. 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).

In 2016, all treatments had significant control of common lambsquarters compared to the nontreated. There were no observed differences in lambsquarters control within the treatments based on application timing (Table 3). Approximately 5 to 9 days after each paraquat application timing, significant crop injury was present. More serve injury was observed after the later paraquat application timings with greater than 68% injury 9 DAT16 for plants treated at 7 days after crop-cracking and greater than 59% injury 7 DAT16 for plants treated at 9 days after crop-cracking (Table 4). 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 effect to yield. No differences in yield observed for any of the treatments (Table 4).

The repeated study in 2017, significant crop injury was observed 2 days after treatment C, while there was no significant crop injury 9 DAT17 of application A and 6 DAT17 of application B on the same rating date (Table 6). No significant stand reduction was observed for any treatment or application timing 28 DAT17 of application A (Table 6). The addition of a nonionic surfactant had no effect on injury.

On June 1, 2016, significant Italian ryegrass control was present for all paraquat treatments applied (application D not applied at this time) compared to the nontreated control. Paraquat applied at a rate of 8 fl oz A^{-1} 4 and 8 days after cracking and applied at a higher rate (16 fl oz A^{-1}) at cracking provided significantly greater percent control of Italian ryegrass compared to Sharpen applied at chickpea cracking (Table 5). Paraquat applied at cracking provided 59 to 60% at (8 fl oz A^{-1} & 8 fl oz A^{-1} with NIS) and 76 to 83% (16 fl oz A^{-1} & 16 fl oz A^{-1} with NIS) control of Italian ryegrass. Paraquat applied 4 days after cracking had 86 to 83% (8 fl oz A^{-1} & 8 fl oz A^{-1} with NIS) control and applied at 7 days after cracking paraquat control 92 to 93% (8 fl oz A^{-1} & 8 fl oz A^{-1} with NIS) of Italian ryegrass (Table 5). Later observations of Italian ryegrass indicated diminished control as the season progressed. On June 20, 2017, there is a significant reduction in Italian ryegrass control for application A compared to applications C and D. Application A had less than 25% control for any treatment compared to greater than 53% for application C & D (Table 5). By July 12, 2017, Italian ryegrass control had reduced to less than 40% for all treatments, except for paraquat applied at 8 fl oz A^{-1} 7 days after cracking which had 66% control of Italian ryegrass. Due to the diminishment of Italian ryegrass control, the entire site was treated with clethodim and crop oil concentrate on July 19, 2017.

The earliest application timing, at chickpea cracking (A), provided significantly greater common lambsquarters control compared to the nontreated and later application timings for both paraquat and sharpen 50 DAT17 with greater than 46% control (Table 5). Although paraquat applied with NIS applied 11 days after cracking also provided significant common lambsquarters control (46%) (Table 5). The addition of a nonionic surfactant did not significantly impact the percent control of Italian ryegrass and common lambsquarters control for any application timing.

Overall, all treatments provided significant control of mayweed chamomile compared to the nontreated control (Table 5). The greatest percent controls were for paraquat applied 8 days after cracking with and without NIS provided 96 and 98% control of mayweed chamomile, respectively. Paraquat applied 11 days after cracking with NIS also provided 97% control as well as the at cracking treatment of Sharpen which provided 93% control 50 DAT17 (Table 5). No significant difference in yield were observed in the repeated 2017 study for any treatment (Table 6).

Even though no significant effect on yield was observed in either study, all treatments of paraquat with and without NIS and the Sharpen treatment provided greater yields compared to the nontreated control for both studies.

In conclusion, when paraquat is applied early in chickpea establishment weed control in chickpeas can be significantly increased and although significant crop injury occurred, injury does not translate into yield loss, possibly due to the reduction in weed competition early in the season.

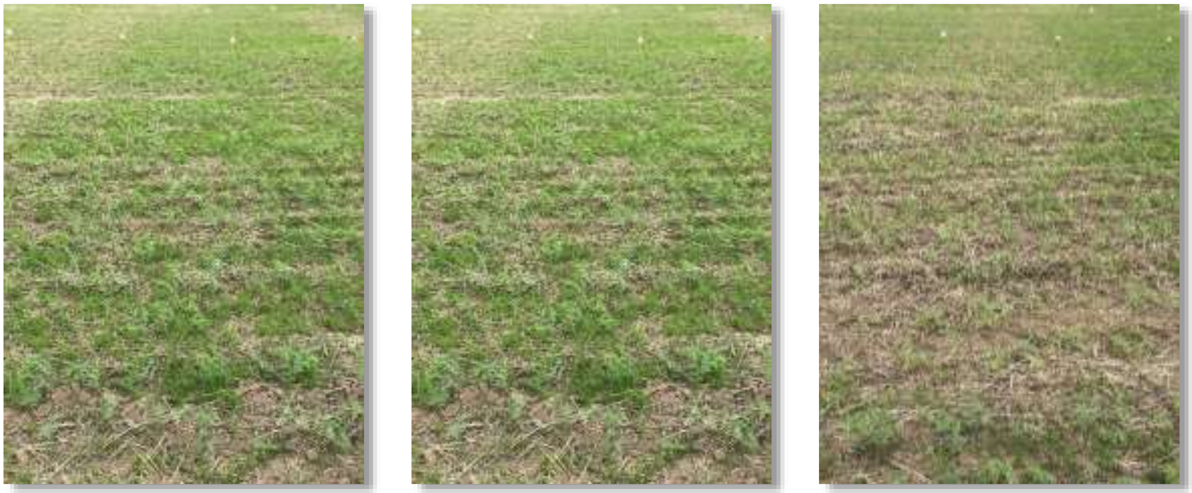


Fig 1. *2017 Study. Italian ryegrass control with paraquat in chickpeas. Left: Nontreated control 22 days after chickpea emergence. Center: 14 days after application of paraquat at 8 fl oz A^{-1} applied 8 days after chickpea emergence. Right: 11 days after application of paraquat at 8 fl oz A^{-1} applied 11 days after chickpea emergence.*

Table 1. *2016 study 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. *2017 study treatment application details*

Study Application	**A**	**B**	**C**	**D**
Date	May 23, 2017	May 26, 2017	May 30, 2017	June 2, 2017
Application volume (GPA)	15	15	15	15
Crop stage	At Cracking	4 DA Crack	8 DA Crack	11 DA Crack
Crop size	Emerging	0.5 to 1”	3 to 4”	4 to 7”
Air temperature (˚F)	84	63	86	73
Soil temperature (˚F)	68	57	66	64
Wind velocity (mph, direction)	7, W	1.1, W	10.2, E	4.1. NW
Cloud Cover	0%	0%	15%	10%
Next rain occurred on	May 31, 2017	May 31, 2017	May 31, 2017	June 4, 2017

Table 3. *Percent common lambsquarters control in chickpea following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2016. DAT = days after treatment for the 2016 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	Application Code	Rate		June 21, 2016 36 DAT Common lambsquarters control	August 26, 2016 102 DAT Common lambsquarters control
		field rate	lb ai/A	%	%
Nontreated	-	-	-	-	-
Paraquat	A	8 fl oz/A	0.125	67	73
Paraquat NIS	A A	8 fl oz/A 0.25 % v/v	0.125	95	71
Paraquat	B	8 fl oz/A	0.125	70	71
Paraquat NIS	B B	8 fl oz/A 0.25 % v/v	0.125	64	58
Paraquat	C	8 fl oz/A	0.125	66	55
Paraquat NIS	C C	8 fl oz/A 0.25 % v/v	0.125	67	55
Paraquat	D	8 fl oz/A	0.125	68	55
Paraquat NIS	D D	8 fl oz/A 0.25 % v/v	0.125	85	76
Paraquat	A	16 fl oz/A	0.250	91	81
Paraquat NIS	A A	16 fl oz/A 0.25 % v/v	0.250	86	65
Sharpen NIS	A A	2 fl oz/A 0.25 % v/v	0.045	63	61
			LSD	*NS*	*NS*

Table 4. *Percent crop injury for chickpea and yield following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2016. DAT = days after treatment for the 2016 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	Application Code	Rate		May 25, 2016 Crop Injury	*DAT*	June 2, 2016 Crop Injury	*DAT*	June 21, 2016 Crop Injury	*DAT*	August 26, 2016 Crop Injury	*DAT*	September 20, 2016 Yield
		field rate	lb ai/A	%		%		%		%		lb/A
Nontreated	-	-	-	-	-	-	-	-	-	-	-	1090
Paraquat	A	8 fl oz/A	0.125	25 ab	*9*	8 ab	*17*	5 a	*36*	0	*102*	1380
Paraquat NIS	A A	8 fl oz/A 0.25 % v/v	0.125	14 ab	*9*	0 a	*17*	0 a	*36*	0	*102*	1640
Paraquat	B	8 fl oz/A	0.125	55 b	*5*	14 ab	*13*	8 ab	*32*	0	*98*	1440
Paraquat NIS	B B	8 fl oz/A 0.25 % v/v	0.125	45 ab	*5*	31 b	*13*	4 a	*32*	0	*98*	1100
Paraquat	C	8 fl oz/A	0.125	21 ab	*1*	71 c	*9*	35 ab	*28*	5	*96*	1400
Paraquat NIS	C C	8 fl oz/A 0.25 % v/v	0.125	5 a	*1*	68 c	*9*	10 ab	*28*	0	*96*	1560
Paraquat	D	8 fl oz/A	0.125	6 a	-	59 c	*7*	11 ab	*26*	0	*94*	1430
Paraquat NIS	D D	8 fl oz/A 0.25 % v/v	0.125	15 ab	-	73 c	*7*	33 ab	*26*	13	*94*	1720
Paraquat	A	16 fl oz/A	0.250	48 ab	*9*	14 ab	*17*	3 a	*36*	0	*102*	1510
Paraquat NIS	A A	16 fl oz/A 0.25 % v/v	0.250	35 ab	*9*	3 a	*17*	3 a	*36*	0	*102*	1250
Sharpen NIS	A A	2 fl oz/A 0.25 % v/v	0.045	91 c	*9*	56 c	*17*	38 a	*36*	0	*102*	1230
			LSD	*30*		*19*		*21*		*NS*		*NS*

Table 5. *Percent common lambsquarters control in chickpea following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2017. DAT = days after treatment for the 2017 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

				***June 1, 2016* 9 DAT**	***June 20, 2017* 28 DAT**		***July 12, 2017* 50 DAT**	
Treatment	**Application Code**	**Rate**		**Italian ryegrass control**	**Italian ryegrass control**	**Italian ryegrass control**	**Common lambsquarters control**	**Mayweed chamomile control**
		field rate	**lb ai/A**	**%**	**%**	**%**	**%**	**%**
Nontreated	-	-	-	-	-	-	-	-
Paraquat	A	8 fl oz/A	0.125	59 ab	25 b	21 ab	55 abcd	89 abc
Paraquat **NIS**	A A	8 fl oz/A 0.25 % v/v	0.125	60 ab	10 b	13 ab	46 abcd	78 c
Paraquat	B	8 fl oz/A	0.125	86 a	41 ab	15 ab	33 bcd	91 ab
Paraquat **NIS**	B B	8 fl oz/A 0.25 % v/v	0.125	83 a	15 b	28 ab	15 cd	79 c
Paraquat	C	8 fl oz/A	0.125	92 a	81 a	66 a	8 d	98 a
Paraquat **NIS**	C C	8 fl oz/A 0.25 % v/v	0.125	93 a	79 a	36 ab	13 cd	96 a
Paraquat	D	8 fl oz/A	0.125	0 c	53 ab	13 ab	16 cd	80 bc
Paraquat **NIS**	D D	8 fl oz/A 0.25 % v/v	0.125	0 c	66 ab	40 ab	46 abcd	97 a
Paraquat	A	16 fl oz/A	0.250	76 a	15 b	0 b	71 ab	89 abc
Paraquat **NIS**	A A	16 fl oz/A 0.25 % v/v	0.250	83 a	25 b	23 ab	66 abc	86 abc
Sharpen **NIS**	A A	2 fl oz/A 0.25 % v/v	0.045	43 b	10 b	0 b	95 a	93 a
			LSD	*25*	*36*	*35*	*35*	*8*

Table 6. *Percent crop injury for chickpea and yield following applications of paraquat with and without a nonionic surfactant at different application timings. Pullman, WA, 2017. DAT = days after treatment for the 2017 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 1, 2017		***June 20, 2017***		***June 20, 2017***		***September 7, 2017***
Treatment	**Application Code**	**Rate**		**Crop Injury**	***DAT***	**Stand Reduction**	***DAT***	**Plant Ht.**	***DAT***	**Yield**
		field rate	**lb ai/A**	**%**		**%**		**cm**		**lb/A**
Nontreated	-	-	-	-	-	-	-	27 ab	-	1945
Paraquat	A	8 fl oz/A	0.125	0 a	*9*	0	*28*	26 ab	*28*	2695
Paraquat **NIS**	A A	8 fl oz/A 0.25 % v/v	0.125	0 a	*9*	0	*28*	28 a	*28*	2203
Paraquat	B	8 fl oz/A	0.125	0 a	*6*	0	*25*	26 ab	*25*	2486
Paraquat **NIS**	B B	8 fl oz/A 0.25 % v/v	0.125	1 a	*6*	0	*25*	26 ab	*25*	2695
Paraquat	C	8 fl oz/A	0.125	20 b	*2*	6	*21*	23 b	*21*	2357
Paraquat **NIS**	C C	8 fl oz/A 0.25 % v/v	0.125	20 b	*2*	8	*21*	24 ab	*21*	2499
Paraquat	D	8 fl oz/A	0.125	0 a	-	6	*18*	22 b	*18*	2079
Paraquat **NIS**	D D	8 fl oz/A 0.25 % v/v	0.125	0 a	-	9	*18*	24 ab	*18*	2061
Paraquat	A	16 fl oz/A	0.250	0 a	*9*	3	*28*	23 ab	*28*	2076
Paraquat **NIS**	A A	16 fl oz/A 0.25 % v/v	0.250	0 a	*9*	5	*28*	25 ab	*28*	2600
Sharpen **NIS**	A A	2 fl oz/A 0.25 % v/v	0.045	0 a	*9*	9	*28*	25 ab	*28*	2098
			LSD	*1*		*NS*		*3*		*NS*

Update on Tolerance of Chickpea to Paraquat Applied At-Cracking

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

The objective of these studies was to evaluate chickpea crop tolerance to paraquat in a field setting and crop tolerance with the addition of a nonionic surfactant.

Both the 2016 and the repeated 2017 study were 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 with 10' by 30' long plots. Studies were planted with chickpea variety Billy bean using a Monosem planter on 10" row spacing at a depth of 1.5" on May 11, 2016 and May 1, 2017. Trial sites were supplemented with irrigation throughout the growing season. Lorox (2.5 lb A^{-1}) and Outlook (21 fl oz A^{-1}) were applied pre-emergence (PRE) to establish a weed free trial both years. The 2016 study was hand weeded July 5, 2016 due to heavy wild oat pressure. The 2017 study was not hand weeded. Irrigation was ended 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.

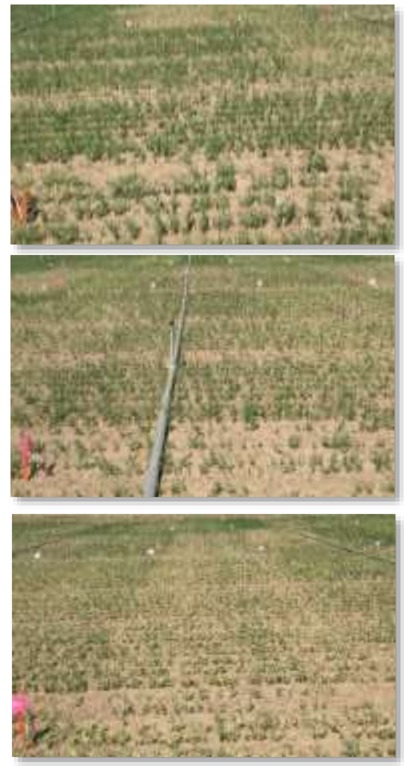


Fig 1. *Tolerance of chickpeas to paraquat. Top: Nontreated. Middle: Paraquat (8 fl oz A^{-1}) with NIS (0.25% v/v) applied at-cracking. Bottom: Paraquat (8 fl oz A^{-1}) with NIS (0.25% v/v) applied 4 days after cracking.*

Crop injury for the 2016 study was visually rated 2 and 51 days after treatment (DAT16) of application A (Table 2). Common lambsquarters (CHEAL) control was visually assessed 2 DAT16 of application A (Table 2). In 2017, crop injury was visually rated 12 and 25 days after treatment (DAT17) of application A (Table 2). Crop stand reduction was visually assessed 12 DAT17 of application A. Plant heights were also taken 25 DAT17. Plots were harvested using a Kincaid plot combine with a 5'-header on September 26, 2016 and August 24, 2017. 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).

In the 2016 study year, crop injury early on depended on application timing (Table 3). Crop injury 4 DAT16 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 DAT16, 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). Crop injury for all other treatments made at crop-cracking (application A) was not significantly different from the nontreated. By July 14, 2016, no crop injury was present for any application timing. There was no significant difference in common lambsquarters (CHEAL) control between treatments. Yield was similar between all treatments indicating chickpeas can regenerate after injury caused by paraquat when compared to a nontreated control in a weed-free environment (Table 3).

The repeated study in 2017, also observed that crop injury depended on application timing. Crop injury was greatest on May 30, 3017 for paraquat (8 fl oz A^{-1}) and paraquat (8 fl oz A^{-1}) with NIS applied 4 days after cracking with 21 and 30% crop injury, respectively. The same treatments applied 7 days after cracking as so had crop injury present on May 30, 2017 with 9% injury for paraquat at 8 fl oz A^{-1} and

14% injury for paraquat at 8 fl oz A^{-1} with NIS (Table 4). Stand reduction on May 20, 2017 was only observed in the 16 fl oz A^{-1} paraquat treatments at-cracking which had greater than 11% stand reduction compared to less than 1% reduction for all other treatments. On June 12, 2017 crop necrosis was lower for the later application timing of paraquat (8 fl oz A^{-1}) with and without NIS at 7 and 11 days after cracking compared to the other treatments. The treatments of 16 fl oz A^{-1} rate of paraquat at-cracking also had greater crop injury (greater than 48%) present on June 12, 2017. Plant heights were shorter for all treatments, except paraquat applied 11 days after cracking, on June 12, 2017 compared to the nontreated control. Yields were similar between all treatments and the nontreated control (Table 4).

Table 1. *2016 study 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		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. *2017 study treatment application details*

Study Application	**A**	**B**	**C**	**D**
Date	May 18, 2017	May 22, 2017	May 25, 2017	May 30, 2017
Application volume (GPA)	15	15	15	15
Crop stage	At Cracking	4 DA Crack	7 DA Crack	11 DA Crack
Crop size	Emerging	3.5”	6”	8”
Air temperature (˚F)	73	85	74	85
Soil temperature (˚F)	57	72	61	75
Wind velocity (mph, direction)	2, N	3, NW	5, E	6, N
Cloud Cover	5%	2%	60%	0%
Next rain occurred on	May 20, 2017	May 31, 2017	May 31, 2017	May 31, 2017

Table 3. *2016 study 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. DAT = days after treatment for the 2016 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	**Application Code**	**Rate**		***June 7, 2016*** **CHEAL Control**	**Crop Injury**		***July 14, 2016 51 DAT*** **Crop Injury**	***September 20, 2016*** **Yield**
		field rate	**lb ai/A**	**%**	**%**	**DAT**	**%**	**lb/A**
Nontreated		-	-	0	0 a	-	0	1140
Paraquat	A	8 fl oz/A	0.125	2	31 ab	14	10	1380
Paraquat **NIS**	A A	8 fl oz/A 0.25 % v/v	0.125	2	14 a	14	15	1390
Paraquat	B	8 fl oz/A	0.125	2	0 a	-	3	1320
Paraquat **NIS**	B B	8 fl oz/A 0.25 % v/v	0.125	1	1 c	-	10	1160
Paraquat	C	8 fl oz/A	0.125	1	34 ab	6	5	1110
Paraquat **NIS**	C C	8 fl oz/A 0.25 % v/v	0.125	2	36 ab	6	9	1250
Paraquat	D	8 fl oz/A	0.125	4	73 c	4	3	1390
Paraquat **NIS**	D D	8 fl oz/A 0.25 % v/v	0.125	4	54 bc	4	19	1090
Paraquat	A	16 fl oz/A	0.250	0	14 a	14	8	1390
Paraquat **NIS**	A A	16 fl oz/A 0.25 % v/v	0.250	0	14 a	14	1	1440
Sharpen **NIS**	A A	2 fl oz/A 0.25 % v/v	0.045	0	8 a	14	8	1330
			LSD	*NS*	*23.55*		*NS*	*NS*

Table 4. *2017 study percent crop injury, stand reduction, plant heights, and yield for chickpeas following applications of paraquat with and without a nonionic surfactant at different application timings. Central Ferry, WA, 2017. DAT = days after treatment for the 2017 study. Means followed by the same letter are not statistically significantly different (α=0.05).*

Treatment	**Application Code**	**Rate**		***May 30, 2017*** **Crop Injury**	**Stand Reduction**	**DAT**	***June 12, 2017*** **Crop Necrosis**	**DAT**	***June 12, 2017 25 DAT*** **Plant Ht.**	***August 24, 2017*** **Yield**
		field rate	**lb ai/A**	**%**	**%**	**-**	**%**	**-**	**cm**	**lb/A**
Nontreated		-	-	-	-	-	-	-	35 a	1993
Paraquat	A	8 fl oz/A	0.125	8 b	1 a	12	28 abcde	25	30 bcd	2251
Paraquat **NIS**	A A	8 fl oz/A 0.25 % v/v	0.125	5 ab	0 a	12	28 abcde	25	31 bcd	2136
Paraquat	B	8 fl oz/A	0.125	21 d	1 a	8	38 bcdef	21	28 cd	2060
Paraquat **NIS**	B B	8 fl oz/A 0.25 % v/v	0.125	30 e	0 a	8	55 ef	21	28 d	1889
Paraquat	C	8 fl oz/A	0.125	9 bc	0 a	5	10 ab	18	30 bcd	2165
Paraquat **NIS**	C C	8 fl oz/A 0.25 % v/v	0.125	14 c	0 a	5	23 abcd	18	30 bcd	2174
Paraquat	D	8 fl oz/A	0.125	0 a	0 a	-	18 abc	13	33 ab	2154
Paraquat **NIS**	D D	8 fl oz/A 0.25 % v/v	0.125	0 a	0 a	-	13 ab	13	32 abc	1973
Paraquat	A	16 fl oz/A	0.250	10 bc	13 b	12	50 def	25	27 d	2158
Paraquat **NIS**	A A	16 fl oz/A 0.25 % v/v	0.250	5 ab	11 ab	12	48 cdef	25	27 d	2129
Sharpen **NIS**	A A	2 fl oz/A 0.25 % v/v	0.045	5 ab	24 c	12	60 f	25	24 e	2193
			LSD	*5*	*7*		*21*		*3*	*NS*

Spring Canola Seeding Rates

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

Increased spring canola seed rates could increase crop stand establishment canopy development and ultimately, weed competitiveness and productivity by maximizing yield potential. In 2017, four separate studies were established in different rainfall zones and cropping systems scenarios, after no reduction in yield was observed as seeding rates increased from 2 lb A^{-1} to 12 lb A^{-1} during an initial study in 2016 conducted in Pullman, WA. These studies were established to evaluate canola seeding rates effects on crop yield and vegetative productivity across several different cropping scenarios.

Methods

All studies were planted with spring canola variety Hyclass 930 using an eight row Monosem planter on 10" row spacing calibrated to deliver seeding rate treatments. Seeding rates in 2016 were as follows; 3 (hilldrop), 4, 5, 6, 7, 8, 10, and 12 lb A^{-1}, and seeding rates in 2017 were; 4, 5, 6, 7, 8, 10, 11, and 12 lb A^{-1}. All studies were conducted in a randomized complete block design with 3 replications. The 2016 study was harvested using a Kincaid plot combine with a 5-foot header and the 2017 studies were all harvested using a 5-foot header Wintersteiger plot combine.

Pullman, WA

In 2016, the initial Pullman study was planted on April 20th, 2016 at the Cook Agronomy Farm near Pullman, WA, in a high rainfall zone with annual precipitation of greater than 17 inches (Schillinger et al. 2006). Plots were 10' by 75' long. The site was in a no-till system. The entire trial was fertilized with 80 lb of nitrogen and 20 lb of sulfur A^{-1}. Roundup PowerMax (glyphosate) was spilt applied at 11 fl oz A^{-1}, with 0.33 pt A^{-1} of Stinger (clopyralid) added at the later application timing, detailed in Table 1.

Table 1. *Blanket application details for the 2016 Pullman, WA study.*

Date	Treatment	Field Rate	lb ai/A
May 5, 2016	Roundup PowerMax	11 fl oz/A	0.387
	AMS	3 lb/100 gal	
May 26, 2016	Roundup PowerMax	11 fl oz/A	0.387
	Stinger	0.33 pt/A	0.124
	AMS	3 lb/100 gal	

Crop stand counts were taken 62 days after planting (DAP) by taking two subsamples of a meter per row within each plot. The study was harvested on September 20, 2016.

Pullman, WA

In 2017, the repeated Pullman study was planted a no-till system on May 9, 2017 at the Palouse Conservation Field Station near Pullman, WA, also in a high rainfall zone. Plots were 8' by 75' long. Canola crop emerged on May 22, 2017. Trial site was fertilized with 80 lb nitrogen and 20 lb sulfur A^{-1}on June 19, 2017. Trial was treated with Roundup Powermax (glyphosate) at 11 fl oz A^{-1} for broadleaf weed control on May 26, 2017, detailed in Table 2.

Fig 1. *Harvesting the 2017 Pullman, WA canola site*

__Table 2.__ Blanket application details for 2017 Pullman, WA study.

Date	Treatment	Field Rate	lb ai/A
May 26, 2016	Roundup PowerMax	11 fl oz/A	0.387
	NIS	0.25% v/v	
	AMS	3 lb/100 gal	

Leaf area index (LAI) was taken 44 [744 growing degree days (GDD)] and 72 (1462 GDD) DAP by taking two readings per plot [leaf area index (LAI) is the surface area of leaves per unit ground surface area and is used to characterize plant canopies]. The LAI for bare ground would equal 0 (Campbell and Norman 1998).Stand counts were taken 72 DAP by counting two meter lengths over two rows within each plot. Canola was harvested on September 6, 2017. The field site had an accumulative precipitation of 20.86" total for 1 year prior to harvest date of the trial (AgWeatherNet 2015).

Walla Walla, WA

The Walla Walla study was planted on April 21, 2017 in a grower's field north of Walla Walla, WA, also in a high rainfall zone. Site was in a conventional tillage system and had been fertilized prior to planting by grower. Plots were 10' by 75' long. Canola emerged on May 5, 2017.

Leaf area index (LAI) was taken 69 (1463 GDD) DAP by taking two readings per plot. Stand counts were taken 69 DAP by counting two meter lengths over two rows within each plot. Branching per plant was taken for four plants per plot 69 DAP. The study was harvested on August 14, 2017. The field site had an accumulative precipitation of 20.87" total for 1 year prior to harvest date of the trial (AgWeatherNet 2015).

Fig 2. *Walla Walla, WA, canola study 48 days after planting*

Davenport, WA

The Davenport study was planted on May 18, 2017 into a conventional system at the Wilke Research and Extension Farm near Davenport, WA. Davenport, WA, is in a medium rainfall zone with annual precipitation of 12 to 17 inches (Schillinger et al. 2006). Site had been fertilized (60 lb nitrogen and 15 lb sulfur A^{-1}) prior to planting. Plots were 10' by 75' long. Canola emerged on May 29, 2017.

Leaf area index (LAI) was taken 33 (635 GDD), 40 (809 GDD), and 61 (1403 GDD) DAP by taking two readings per plot. Stand counts were taken 40 DAP by counting two meter lengths over two rows within each plot. The study was harvested on August 22, 2017. The field site had an accumulative precipitation of 17.19" total for 1 year prior to harvest date of the trial (AgWeatherNet 2015).

Statistical Analysis

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

Pullman, WA

In 2016, spring canola stand counts increased as the seeding rate increased, with 10 plants m^{-1} for the 4 lb A^{-1} treatment and 31 plants m^{-1} for the 12 lb A^{-1} seeding rate (Table 3). As seeding rates increased, yields also increased. Yield for the seeding rate of 12 lb A^{-1} was higher than the lowest seeding rate of 4 lb A^{-1}, with 1362 lb A^{-1} compared to 824 lb A^{-1}. No reduction in yield was observed as seeding rate increased (Table 3).

Table 3. *Stand counts and yield for 2016 Pullman, WA, spring canola seeding rate study (Hyclass 930). Pullman, WA, 2016. DAP = days after planting. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 21, 2016 62 DAP	*August 18, 2016*
Trt	**Seeding Rate**			**Stand Counts**	**Yield**
	seed/m	**seed/ft**	**lb/A**	**plants/meter**	**lb/A**
1	26	8	4	10 a	824 a
2	32	10	5	15 ab	985 ab
3	39	12	6	16 ab	1012 ab
4	46	14	7	18 abc	970 ab
5	52	16	8	23 bc	1006 ab
6	66	20	10	25 cd	1222 ab
7	79	24	12	31 d	1362 b
Hill drop	20	6	3	12 a	1139 ab
			LSD	*6*	*304*

In the repeated 2017 study, there was no difference in canola stand counts, however, as seeding rate increased so did the number of plants m^{-1}, with 13 plants m^{-1} for the 4 lb A^{-1} treatment and 28 plants m^{-1} for the 12 lb A^{-1} seeding rate (Table 4). There were no observed differences in leaf area index (LAI) at 744 growing degree days (GDD) and 1462 GDD, although there was an increasing trend as seeding rate increased. As seeding rates increased, yields also increased. Yield for the seeding rate of 12 lb A^{-1} was greater than the lowest seeding rate of 4 lb A^{-1}, with 1825 lb A^{-1} compared to 1487 lb A^{-1} (Table 4).

Table 4. *Leaf area index (LAI), stand counts and yield for the 2017 Pullman, WA, spring canola seeding rate study (Hyclass 930). Pullman, WA, 2017. DAP = days after planting. GDD = growing degree days. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 22, 2017 44 DAP	*July 20, 2017* 72 DAP		*September 6, 2017*
Trt	**Seeding Rate**			**LAI**	**LAI**	**Stand Counts**	**Yield**
	seed/m	**seed/ft**	**lb/A**	***744 GDD***	***1462 GDD***	***plants/meter***	***lb/A***
1	26	8	4	1.23	2.87	13	1487 ab
2	32	10	5	1.21	2.79	17	1534 ab
3	39	12	6	1.28	2.56	16	1297 a
4	46	14	7	1.65	2.37	17	1623 ab
5	52	16	8	1.22	3.00	18	1471 ab
6	66	20	10	1.66	3.21	25	1742 b
7	73	22	11	1.43	2.65	23	1696 b
8	79	24	12	2.02	3.27	28	1825 b
			LSD	*NS*	*NS*	*NS*	*241*

Walla Walla, WA

The Walla Walla study had no difference in leaf area index (LAI) at 1463 GDD (Table 5). Stand counts increased as the seeding rate increased, with 7 plants m^{-1} at the 4 lb A^{-1} treatment and 25 plants m^{-1} for the 12 lb A^{-1} seeding rate. As seeding rate and stand counts increased, branching per plant decreased from 3.3 branches per plant to 1.4 branches per plant. There were no differences in yield for any seeding rate (Table 5). The lowest seeding rate of 4 lb A^{-1} produced 1928 lb A^{-1} yield and the highest seeding rate produced 1764 lb A^{-1} yield.

Table 5. *Leaf area index (LAI), stand counts, branch counts, and yield for the 2017 Walla Walla, WA, spring canola seeding rate study (Hyclass 930). Walla Walla, WA, 2017. DAP = days after planting. GDD = growing degree days. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 29, 2017 69 DAP			*August 14, 2017*
Trt	**Seeding Rate**			**LAI**	**Stand Counts**	**Branch Counts**	**Yield**
	seed/m	**seed/ft**	**lb/A**	***1463 GDD***	***plants/meter***	***branches/plant***	***lb/A***
1	26	8	4	3.62	7 a	3.3 a	1928
2	32	10	5	3.49	11 ab	2.5 abc	1855
3	39	12	6	3.21	10 ab	3.0 ab	1804
4	46	14	7	3.39	12 ab	2.6 abc	1791
5	52	16	8	3.05	14 bc	2.2 abc	1828
6	66	20	10	3.25	18 cd	1.6 bc	1812
7	73	22	11	3.18	21 de	1.5 bc	1854
8	79	24	12	3.68	25 e	1.4 c	1764
			LSD	*NS*	*4*	*1*	*NS*

<u>Davenport, WA</u>

The spring canola seeding rate study in Davenport, WA also had no difference in leaf area index (LAI) between any treatment at 635 GDD, 809 GDD, and 1403 GDD (Table 6). Stand counts, or plants per meter, increased at the planting rate increased with 12 plants m^{-1} for 4 lb A^{-1} and 38 plants m^{-1} for the 12 lb A^{-1} rate. No differences in yield were observed for any seeding rate (Table 6). The lowest seeding rate of 4 lb A^{-1} produced 819 lb A^{-1} yield and the highest seeding rate, 12 lb A^{-1}, produced 841 lb A^{-1} yield.

Table 6. *Leaf area index (LAI), stand counts and yield for spring canola seeding rate study (Hyclass 930). Davenport, WA, 2017. DAP = days after planting. GDD = growing degree days. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 20, 2017 33 DAP	*June 27, 2017* *40 DAP*		*July 18, 2017 61 DPP*	*August 22, 2017*
Trt	**Seeding Rate**			**LAI**	**LAI**	**Stand Counts**	**LAI**	**Yield**
	seed/m	**seed/ft**	**lb/A**	***635 GDD***	***804 GDD***	***plants/ m***	***1403 GDD***	***lb/A***
1	26	8	4	1.21	1.31	12 a	1.12	819
2	32	10	5	1.02	1.65	13 a	1.46	919
3	39	12	6	1.37	1.88	15 ab	1.66	908
4	46	14	7	1.43	1.55	19 bc	1.21	890
5	52	16	8	1.54	2.03	23 cd	1.33	925
6	66	20	10	1.55	1.87	26 d	2.09	932
7	73	22	11	1.35	2.14	32 e	1.18	794
8	79	24	12	1.74	1.76	38 f	1.42	841
			LSD	*NS*	*NS*	*4*	*NS*	*NS*

Fig 3. *Planting the Davenport, WA, canola study on May 18, 2017.*

Crop establishment and drill type should be taken into consideration when choosing a seeding rate to utilize maximum yield and economic returns. Fertilizer requirements, cultivar type and seed cost should also be taken into consideration when choosing a seeding rate.

Thank you to the Washington Oilseed Cropping Systems for support, the growers who made these studies possible, the USDA-ARS and Larry McGrew for the use of their Wintersteiger plot combine and to Winfield Solutions and Nate Clemans for providing the canola seed.

Additional Tables

Table 7. *Rainfall Totals (1 year based on Harvest Date (AgWeatherNet 2015)*

Trial Location	Harvest Date	Accum Precip (in)
Pullman, WA	September 6, 2017	20.86
Walla Walla, WA	August 14, 2017	20.87
Davenport, WA	August 22, 2017	17.19
Almira, WA	August 31, 2017	16.96

Table 8. *Composite soil analysis by location at planting*

Trial Location	NO3-N (lbs/A)	NH4-N (lbs/A)	S (ppm)	P (ppm)	K (ppm)	Boron (ppm)	Zinc (ppm)	% OM	pH	CEC	Soil Type
Pullman	69	17	3	47	628	0.46	0.89	3.52	5.3	15.4	Silt Loam
Walla Walla	156	16	4	38	752	0.39	1.05	2.14	5.3	13.8	Silt Loam
Davenport	63	12	2	23	463	0.37	0.83	2.76	5.1	13.5	Silt Loam
Almira	10	16	3	29	437	0.44	1.11	2.22	5.8	14.7	Silt Loam

Appendix

Almira, WA

A canola seeding rate study was also established in a grower's field near Almira, WA; a low rainfall zone with annual precipitation of less than 12 inches (Schillinger et al. 2006). The study was planted on May 18, 2017 using a monosom drill on 10' spacing calibrated to deliver seeding rate treatments detailed in Table 9. The field site was in a no-till management system. Plots were 10' by 80' long. Canola emerged on May 31, 2017. The site had heavy plant residue compared to the other study sites. However, due to unanticipated circumstances the Almira study did not receive fertilizer prior to or post planting. There was also no POST weed control applied to the Almira site.

Fig 4. *Planting the Almira, WA, canola study on May 18, 2017.*

Leaf area index (LAI) was recorded 33 (604 GDD), 40 (784 GDD), and 61 (1401 GDD) DAP by recording two measurements per plot. Stand counts were taken 40 DAP by counting two meter lengths over two rows within each plot. Canola was harvested on August 31, 2017. The field site had an accumulative precipitation of 16.96" total for 1 year prior to harvest date of the trial (AgWeatherNet 2015).

The spring canola seeding rate study in Almira, WA had no difference in leaf area index (LAI) between treatments at 604 GDD, 784 GDD, and 1401 GDD (Table 9). Stand counts, or plants per meter, increased at the planting rate increased with 10 plants m^{-1} for 4 lb A^{-1} and 33 plants m^{-1} for the 12 lb A^{-1} rate. There were no differences in yield observed for any seeding rates. However, canola yields decreased at seeding rates increased. The lowest seeding rate of 4 lb A^{-1} produced 447 lb A^{-1} yield and the highest seeding rate of 12 lb A^{-1} produced 223 lb A^{-1} yield (Table 9). The serve reduction in yield compared to the Davenport site could be due to the lack of available nutrients present at the Almira site since fertilizers were not applied. The soil sample indicated there was only 26 lb of nitrogen A^{-1} at Almira compared to 75 lb of nitrogen A^{-1} at Davenport (Table 8).

Table 9. *Leaf area index (LAI), stand counts and yield for spring canola seeding rate study (Hyclass 930). Almira, WA, 2017. DAP = days after planting. GDD = growing degree days. Means followed by the same letter are not statistically significantly different (α=0.05).*

				June 20, 2017 33 DAP	*June 27, 2017* 40 DAP		*July 18, 2017* 61 DAP	*August 31, 2017*
Trt	**Seeding Rate**			**LAI**	**LAI**	**Stand Counts**	**LAI**	**Yield**
	seed/m	**seed/ft**	**lb/A**	***604 GDD***	***784 GDD***	***plants/m***	***1401 GDD***	***lb/A***
1	26	8	4	0.50	0.78	10 a	0.94	447
2	32	10	5	0.31	0.56	11 a	0.76	396
3	39	12	6	0.27	0.72	14 a	0.71	382
4	46	14	7	0.24	0.72	17 a	0.69	380
5	52	16	8	0.12	0.54	17 a	0.88	325
6	66	20	10	0.17	0.44	24 b	0.75	282
7	73	22	11	0.14	0.58	25 b	0.61	267
8	79	24	12	0.19	0.38	33 c	0.58	223
			LSD	*NS*	*NS*	*8*	*NS*	*NS*

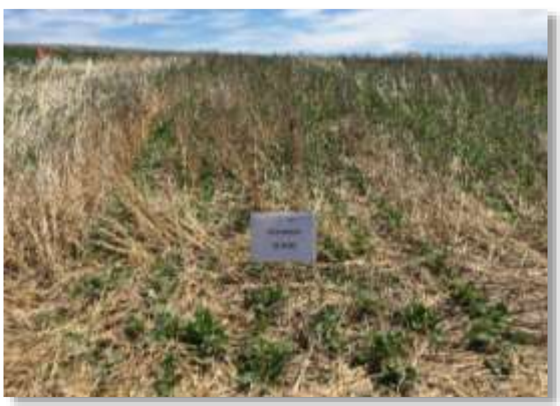


Fig 5. *Almira, WA, canola study 40 days after planting (DAP). Top Left: 5 lb A^{-1} seeding rate. Top Right: 7 lb A^{-1} seeding rate. Bottom Left: 11 lb A^{-1} seeding rate.*

References

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Schillinger W.F., R.I. Papendick, S.O. Guy, P.E. Rasmussen, and C.V. Kessel. 2006. Dryland Cropping in the Western United States. Pp. 365-393 in Peterson GA, ed. Dryland Agriculture, 2nd ed. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

Precipitation data (September 1, 2016 to August 31, 2017) from AgWeatherNet station Pullman NE, Cook Agronomy Farm East

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
9/2/16	0.07	10/4	0.19	11/6	0.07	12/4	0.16
9/6	0.13	10/7	0.16	11/13	0.07	12/11	0.23
9/17	0.05	10/9	0.64	11/14	0.27	12/20	0.19
9/29	0.05	10/10	0.25	11/15	0.27	12/25	0.1
Total	0.32	10/13	0.56	11/19	0.15	12/27	0.13
Normal[1]	0.77	10/14	0.17	11/20	0.29	12/30	0.1
Dep Norm	-0.45	10/15	0.32	11/23	0.18	Total	0.94
		10/16	0.08	11/28	0.28	Normal	2.56
		10/17	0.23	11/30	0.14	Dep Norm	-1.62
		10/20	0.28	Total	1.81		
		10/21	0.48	Normal	2.91		
		10/24	0.06	Dep Norm	-1.1		
		10/25	0.25				
		10/26	0.07				
		10/27	0.15				
		10/29	0.14				
		10/30	0.61				
		10/31	0.05				
		Total	4.78				
		Normal	1.58				
		Dep Norm	3.2				

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

Precipitation data (September 1, 2016 to August 31, 2017) from AgWeatherNet station Pullman NE, Cook Agronomy Farm East, Con’t

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
1/8/17	0.46	2/1	0.09	3/4	0.11	4/7	0.15
1/9	0.13	2/4	0.17	3/5	0.09	4/8	0.07
1/10	0.05	2/5	0.1	3/7	0.36	4/10	0.1
1/18	0.38	2/8	0.31	3/8	0.18	4/12	0.05
1/22	0.13	2/9	0.2	3/9	1.02	4/13	0.19
Total	1.24	2/15	0.37	3/11	0.12	4/17	0.12
Normal	2.55	2/16	0.5	3/13	0.31	4/20	0.08
Dep Norm	-1.31	2/17	0.05	3/14	0.31	4/25	0.23
		2/18	0.21	3/15	0.44	4/26	0.46
		2/19	0.12	3/17	0.15	Total	1.57
		2/20	0.25	3/18	0.53	Normal	1.75
		2/21	0.42	3/21	0.19	Dep Norm	-0.18
		2/22	0.05	3/24	0.16		
		2/26	0.14	3/26	0.12		
		Total	3.05	3/27	0.1		
		Normal	1.81	3/28	0.07		
		Dep Norm	1.24	3/29	0.5		
				Total	4.89		
				Normal	2.05		
				Dep Norm	2.84		

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
5/1	0.05	6/4	0.21	July	0.0	8/13	0.05
5/5	0.22	6/8	0.21	Total	0.0	Total	0.05
5/6	0.16	6/15	0.32	Normal	0.65	Normal	0.66
5/11	0.08	Total	0.83	Dep Norm	-0.65	Dep Norm	-0.61
5/12	0.18	Normal	1.49				
5/16	0.57	Dep Norm	-0.66				
5/17	0.14						
Total	1.44						
Normal	1.77						
Dep Norm	-0.33						

Precipitation data (September 1, 2016 to August 31, 2017) from AgWeatherNet station Davenport

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
9/2/16	0.12	10/7	0.31	11/6	0.14	12/20	0.27
9/17	0.07	10/8	0.08	11/14	0.1	Total	0.37
9/30	0.05	10/9	0.36	11/15	0.26		
Total	0.25	10/10	0.29	11/19	0.1		
		10/13	1.1	11/20	0.16		
		10/14	0.07	11/23	0.29		
		10/15	0.17	11/24	0.06		
		10/16	0.14	11/28	0.17		
		10/17	0.05	Total	1.42		
		10/20	0.44				
		10/24	0.15				
		10/26	0.43				
		10/27	0.36				
		10/30	0.33				
		10/31	0.29				
		Total	4.7				

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
1/18/17	0.82	2/4	0.13	3/3	0.08	4/5	0.07
1/21	0.07	2/6	0.07	3/7	0.07	4/7	0.24
1/22	0.05	2/9	0.21	3/8	0.27	4/10	0.1
1/23	0.12	2/15	0.93	3/9	0.23	4/12	0.57
Total	1.17	2/16	0.31	3/11	0.07	4/13	0.2
		2/18	0.11	3/13	0.32	4/17	0.39
		2/19	0.09	3/14	0.29	4/18	0.14
		2/20	0.19	3/17	0.11	4/20	0.05
		2/21	0.05	3/18	0.25	Total	1.84
		Total	2.15	3/21	0.23		
				3/22	0.09		
				3/24	0.68		
				3/29	0.37		
				Total	3.33		

Precipitation data (September 1, 2016 to August 31, 2017) from AgWeatherNet station Davenport, Con't

Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)	Date	Precipitation (in.)
5/1	0.12	6/15	0.25	July	0.0	August	0.0
5/11	0.18	6/26	0.06	Total	0.0	Total	0.0
5/14	0.12	6/28	0.05				
5/16	0.36	Total	0.38				
5/17	0.28						
5/20	0.45						
Total	1.58						

Figure 1. *Climate for nearest weather station located ~4 miles east of trial site.*