2020 WSU Weed Control Report

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Chaff-Lining to Control the Seed Bank of Italian Ryegrass

Lyman, K.C., R. Sloot, M. Thorne, D. Lyon, & I.C. Burke

Italian ryegrass is becoming more widespread and problematic in eastern Washington wheat production areas. The reliance on postemergence herbicides coupled with outcrossing pollination has resulted in widespread Group 1 and Group 2 herbicide resistance. Alternative approaches to management other than the typical chemical and mechanical methods are needed and must be adopted to manage Italian ryegrass.

Once such alternative management method could be chaff lining. Australians have been battling the same problem for many years and have introduced the idea of Harvest Weed Seed Control (HWSC). HWSC is a group of nonchemical approaches that take advantage of the target seed retention of the plant at the maturity stage (Lyon, 2020). Chaff lining is the cheapest option in terms of capital and overall cost, compared to other options, such as hammer-mill based seed destructors. Normally, when growers harvest their wheat crop that may be infested with Italian ryegrass, the Italian ryegrass seed that is contained in the chaff is spread back into the field. That can result in the seeding of hundreds of thousands of Italian ryegrass plants per acre. Chaff lining involves a simple chute that diverts the wheat chaff that contains Italian ryegrass seed into a narrow windrow and that does not disrupt the spreading of the straw. The chaff windrow is left for the grower to decide how to dispose of the seed/chaff. Farmers have devised several methods of managing seed in the chaff row, including burning the chaff row to singe the seed, bailing of the chaff row to send the seed to an off-farm site, managing the chaff row to decompose on the spot, or ideally, implementing controlled traffic and placing the chaff row in an area of repeated traffic passes. Concentrating the chaff into narrow windrows within the field can create a hostile environment for the Italian ryegrass germination and emergence (Lyon, 2020). This can result in reduced seed production/seed bank due to the competition among the Italian ryegrass plants.

Figure 1: Successful chaff lining windrow in a winter wheat crop using a modified Case 2388 hillside combine.

Chaff lining has not been implemented by growers in eastern Washington. The most significant hurdle is mounting a chute on the back of a hillside combine, without damaging the chaff chute or combine. Additionally, there is heavy skepticism by growers that the idea to divert the target seed to the desired windrow would be successful. The chaff lining method does have some specific drawbacks. The main problem is that approximately 50% of Italian ryegrass seeds shatter from the plant head, before the header reel even touches the plant (Mark Thorne, Unpublished Data). With a significant portion of the Italian ryegrass seed already on the ground, the impact of the management tactic may be incremental.

Figure 2: Rear view of spreader system and chute platform.

Figure 3: Side view of how the chute platform is mounted to the combine.

In the summer of 2020, a hillside combine (a Case Axial-Flow 2388 series) was modified to chaff line. The main modifications to the Case 2388 combine consisted of the addition of another straw spreader/shaft system, a baffle diverter and the chute platform.

Figure 4: Modified components in the spreader/shaft-system. The drive shaft mounts were reversed, necessitating a longer drive belt for the system.

The straw spreader/shaft system consisted of many common Case parts purchased from a local dealer. The straw spreader/shaft system was the most expensive part of the project, mainly because all the shaft parts and hardware were new. A secondary straw spreader/shaft system was necessary to not jeopardize the regular straw spreader/shaft system, in case the normal function of the combine was needed. The parts consisted of a horizontal shaft that was the width of the combine, 10-inch pulley, longer v- drive belt, shaft supports/bearings/spider gears and hardware (nuts/bolts/washers). Other parts were purchased and incorporated but may be unnecessary, such as new straw spreader cones, straw spreader fins and down shafts. The need of the secondary straw spreader/shaft system on the combine was to move the straw spreader cones back and up, so the chute platform could fit under the straw spreader/shaft system. The new straw spreader/shaft system sat 12 inches back and 4 inches up from the regular straw spreader/shaft system.

The straw baffle system consisted of one ¼-inch thick metal sheet that is mounted across the inside width of the combine and located behind the straw chopper. The baffle separates the chaff from the straw material. Coming from the straw chopper, the straw is traveling at a high velocity that goes over the top of the baffle and is flung to the back pan of the combine and then pushed out from the combine fan. The baffle then directs the chaff to the bottom pan of the combine and then to the chute. The baffle had to be bent at a certain pitch to facilitate the separation of chaff and the straw material.

Modifying the chute platform was the final and the most challenging step. The chute had to be mounted to both sides of the combine and not to the rear axle of the combine, which seemed like the most logical anchor point. The rear axle was independent of the combine, due to the leveling system. Therefore, the chute would become damaged if attached to the rear axle. Attaching the chute to the side of the combine was the best option due to the durability and stability the chute needed. Two 3' by 4' sheets were cut out from 1/8th inch sheet metal and manufactured to sit at the rear of the combine. The rectangular sheets were then bolted to independent frames that were bolted to the side of the combine. The chute mirrored the same angle of the combine when the leveling system was engaged.

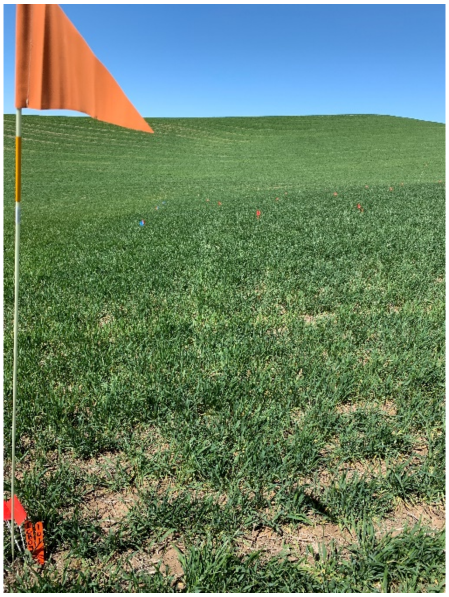
Figure 5: Internal baffle that separates chaff and straw material.

Success of the Italian ryegrass seed placement from the chute is yet to be determined. The chute was modified on the combine during the summer of 2020 and tested within a spring wheat field heavily infested with Italian ryegrass. Italian ryegrass seed densities will be assessed and identified in the spring of 2021, when germination occurs. It is unknown how many Italian ryegrass seeds are contained within the chaff lining windrow. Fine tuning the efficiency of the chaff lining project is needed to characterize the success of the modifications and the chaff lining project.

RyzUp SmartGrass® in Wheat to Stimulate Italian ryegrass Germination

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

Italian ryegrass is a problematic widespread weed in the inland pacific northwest high rainfall zones. Italian ryegrass management is increasingly more difficult due to widespread Acetyl CoA Carboxylase (ACCase) and acetolactate synthase (ALS) inhibitor resistance. The objective of this study was to evaluate the use of gibberellic acid (GA_3) (RyzUp Smartgrass) along with preemergence applications of Zidua, Fierce, and Fierce MTZ in a winter wheat system. Gibberellic acid is known to stimulate Italian ryegrass germination in laboratory and greenhouse settings, and could facilitate improved performance of preemergence herbicides. Additionally, the products Fierce and Fierce MTZ, each containing the active ingredient pyroxasulfone also found in Zidua, were evaluated for crop safety and efficacy on Italian ryegrass.



The study was established in a winter wheat plot near Pullman, WA, at the WSU Cook Agronomy Farm. Treatments were applied preemergence (PRE) on October 7, 2019 and postemergence (POST) on May 7, 2020 (Table 1). The study was conducted as a randomized complete block with four replications. Plots were 10’ by 30’ long. Preemergence treatments were assessed by visual estimation 28 days after treatment for winter wheat injury and Italian ryegrass control. Treatments were assessed for percent control 14, 27, 35, and 50 days after postemergence treatment (Table 2, only the 50 day after treatment assessment is presented). Italian ryegrass density and biomass was assessed by harvesting two m^2 quadrants from each plot 69 days after postemergence treatment. 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).

No injury was observed in winter wheat at 28 days after preemergence treatment (data not shown). Italian ryegrass control at 28 days after preemergence treatment were similar among treatments (Table 2). Percent control was less for Axial XL applied postemergence compared to treatments that included preemergence herbicides (Table 3). Italian ryegrass density and biomass were variable and similar among treatments (Table 4), but were numerically highest in the nontreated and Axial XL postemergence treatment.

Gibberellic acid (GA) has short-lived activity in the environment. Application of GA in the fall under cooler temperature conditions just prior to rainfall events may facilitate increased activity (ie, seed germination). This trial was conducted in winter wheat planted with a Horsch drill, a very high disturbance drill. The high level of soil disturbance likely incorporated the Italian ryegrass seed sufficiently to mitigate the GA activity. Future research will focus on applications in no-till environments where the seed bank is stratified at the soil surface.

Both Fierce and Fierce MTZ are effective herbicides for Italian ryegrass control. The use of flumioxazin and metribuzin in addition to the pyroxasulfone facilitates integrated herbicide management – the use of two or more modes of action active on the same weed species. Additional trials will address use in different tillage and residue systems.

Table 1. *Preemergent treatment application details.*

Study Application		
Date	October 7, 2019	May 7, 2020
Application volume (GPA)	15	15
Air temperature (˚F)	45.7	45.2
Soil temperature (˚F)	48.2	48.3
Wind velocity (mph, direction)	7, E	5.2, SE
Next rain occurred on	October 8, 2019	May 12, 2020

Table 3. *Percent injury for winter wheat and percent control for Italian ryegrass following preemergence applications of Zidua, RyzUp Smartgrass, Fierce, and Fierce MTZ, near Pullman, WA, 2019.*

		Italian Ryegrass Control[1]
Treatment	Rate	11/4/19 *28 DAT*[2]
	oz/A	— % Control —
Zidua	1.50	58 a
Zidua RyzUp	1.50 1.00	80 a
Fierce	3.00	85 a
Fierce MTZ	16.69	66 a
Fierce RyzUp	3.00 1.00	70 a
Fierce MTZ RyzUp	16.69 1.00	88 a

[1] *Means followed by the same letter are not statistically different (a=0.05).*
[2] *DAT = days after treatment.*

Table 4. *Italian ryegrass control for preemergence applications of Zidua, RyzUp Smartgrass, Fierce, and Fierce MTZ following postemergence applications of Axial XL, near Pullman, WA, 2020.*

			Italian ryegrass control[2]	
Treatment	Rate	Timing[1]	*5/21/2020 14 DAT*[3]	6/26/2020 *50 DAT*
	oz/A		——— % ———	
Axial XL	17.1	POST	64 b	62 b
Zidua Axial XL	1.50 17.1	PRE POST	81 a	90 a
Zidua RyzUp Axial XL	1.50 1.00 17.1	PRE PRE POST	83 a	85 a
Fierce Axial XL	3.00 17.1	PRE POST	79 a	86 a
Fierce MTZ Axial XL	16.7 17.1	PRE POST	80 a	84 a
Fierce RyzUp Axial XL	3.00 1.00 17.1	PRE PRE POST	86 a	92 a
Fierce MTZ RyzUp Axial XL	16.7 1.00 17.1	PRE PRE POST	75 a	81 a

[1] *PRE, preemergence; POST, postemergence.*
[2] *Means followed by the same letter are not statistically different (a=0.05).*
[3] *DAT = days after treatment.*

Table 5. *Italian ryegrass density and biomass for preemergence applications of Zidua, RyzUp Smartgrass, Fierce, and Fierce MTZ following postemergence applications of Axial XL, 69 days after treatment, for a study near Pullman, WA, 2020.*

Treatment	Rate	Timing[1]	Italian Ryegrass Density	Italian Ryegrass Biomass
	oz/A		plants m^{-2}	g m^{-2}
Nontreated	-	-	7 a	25 a
Axial XL	17.1	POST	6 a	14 a
Zidua Axial XL	1.50 17.1	PRE POST	0 a	0 a
Zidua RyzUp Axial XL	1.50 1.00 17.1	PRE PRE POST	2 a	6 a
Fierce Axial XL	3.00 17.1	PRE POST	5 a	10 a
Fierce MTZ Axial XL	16.7 17.1	PRE POST	1 a	8 a
Fierce RyzUp Axial XL	3.00 1.00 17.1	PRE PRE POST	1 a	3 a
Fierce MTZ RyzUp Axial XL	16.7 1.00 17.1	PRE PRE POST	3 a	19 a

[1] *PRE, preemergence; POST, postemergence.*

[2] *Means followed by the same letter are not statistically different (a=0.05).*

Downy Brome control with Fierce® and RyzUp SmartGrass® in Winter Wheat

Beaudoin, M.R., D. Appel, & I.C. Burke

The study objective was to evaluate Fierce (pyroxasulfone with flumioxazin) and Fierce MTZ (Pyroxasulfone, flumioxazin, and metribuzin) in systems with Powerflex HL (pyroxsulam) and RyzUp Smartgrass (GA_3) for downy brome control in winter wheat. RyzUp Smartgrass (GA_3) is a plant growth regulator that stimulates seed germination and alleviates seed dormancy in laboratory and greenhouse conditions. The combination of Fierce and RyzUp Smartgrass has potential to reduce downy brome seedbanks in winter wheat cropping systems.

Figure 1. Nontreated plot 12 days after

The study site was at the WSU Wilke Farm near Davenport, WA. Downy brome populations were present at the time of study establishment. Preemergence applications of Roundup Powermax, Zidua, Fierce, Fierce MTZ, and RyzUp Smartgrass were applied to winter wheat in the fall of 2019 (Table 1). Postemergence treatment of Powerflex HL was applied in the early spring of 2020, detailed in Table 2. Treatments were applied with a CO_2 powered backpack sprayer and a 5-foot boom with 4 Teejet 11002VS nozzles. The sprayer was calibrated to 15 gallons per acre (GPA). This study was conducted in a randomized complete block design with 4 replications. Plots were 10 ft by 30 ft long.

Figure 2. Treated plot 12 days after postemergence application of Powerflex HL.

Preemergence treatments were assessed by visual estimation 21, 189, and 217 days after treatment for winter wheat injury, percent control, and plant densities per m^2. Downy brome control was assessed 25 days after postemergence treatment with Powerflex. Density of downy brome was assessed, and biomass was harvested by collecting two m^2 quadrants 39 days after postemergence treatment from each plot. All data was subjected to an analysis of variance using the statistical package included in Agricultural Research Manager software system (ARM 8.5.0, Gylling Data Management).

At 21 days after preemergence treatment chlorosis and curling had occurred on winter wheat. Treatments that included Fierce MTZ at 15.37 oz/A caused injury, and when RyzUp at 1.0 oz/A applied in mixture with Fierce MTZ injury was greater than other treatments (Table 3). Assessment of downy brome control 189 and 217 days after preemergence treatment were similar (Table 3). Downy brome densities at 217 days after preemergence treatment were also similar among treatments, but were very variable, and herbicide treatments resulted in numerically lower densities (Table 3).

At 25 days after postemergence treatment percent control of downy brome was similar across treatments (Table 4). Downy brome densities at 39 days after postemergence treatment were similar across treatments (Table 4), but densities were numerically lower in treatments that included a preemergence herbicide system. A similar trend was observed with downy brome biomass harvested 39 days after postemergence treatment (Table 4).

Fierce MTZ caused injury, but that injury as not apparent after the winter. Downy brome density and biomass was variable, but always numerically lower where preemergence Fierce, Fierce MTZ, or Zidua was applied. Fierce and Fierce MTZ appear to be effective preemergence treatments for downy brome control in winter wheat.

Table 1. *Preemergent treatment application details*

Study Application	
Date	September 12, 2019
Application volume (GPA)	15
Air temperature (˚F)	60
Soil temperature (˚F)	55.2
Wind velocity (mph, direction)	2, E
Next rain occurred on	September 19, 2019
Accumulative Moisture for September 10 – 18 (IN)	0

Table 2. *Postemergent treatment application details*

Study Application	
Date	April 16, 2020
Application volume (GPA)	15
Air temperature (˚F)	50
Soil temperature (˚F)	42.8
Wind velocity (mph, direction)	5.7, E
Next rain occurred on	April 22, 2020
Accumulative Moisture for April 14 - 22 (IN)	0.14

Table 3. *Winter wheat injury, downy brome percent control, and downy brome density (plants/m²) in response to preemergence applications of Roundup Powermax, Zidua, Fierce, Fierce MTZ, and RyzUp Smartgrass. Davenport, WA, 2019/2020. DAT = days after treatment. Means followed by the same letter are not statistically different (a=0.05).*

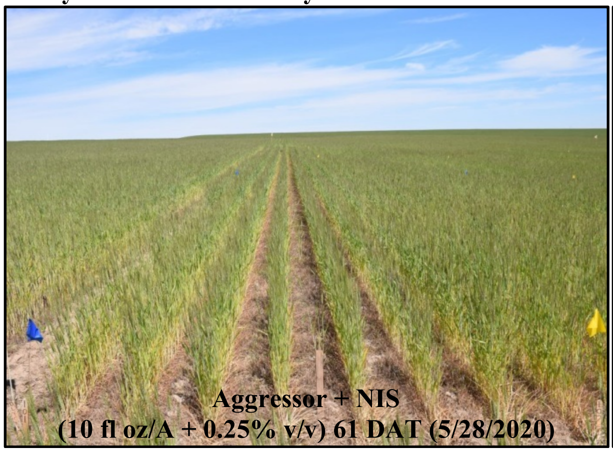
			Preemergence				
			Winter Wheat Injury	***Downy Brome Control***	***Downy Brome Control***	***Downy Brome Control***	***Downy Brome Density***
Treatment	Rate		**10/3/2019** ***21 DAT***	**10/3/2019** ***21 DAT***	**3/19/2020** ***189 DAT***	**4/16/2020** **217 DAT**	**4/16/2020** **217 DAT**
	oz/A	**Type**	**%**	**%**	**%**	**%**	**# m^{-2}**
Nontreated	-	-	0 b	0 a	0 b	94 a	18 a
Roundup Powermax	30.74	PRE	0 b	28 a	53 a	93 a	25 a
Zidua **Roundup Powermax**	1.50 30.74	PRE PRE	1 b	30 a	63 a	96 a	15 a
Fierce **Roundup Powermax**	3.00 30.74	PRE PRE	1 b	53 a	50 a	98 a	13 a
Fierce MTZ **Roundup Powermax**	15.37 30.74	PRE PRE	15 b	40 a	50 a	94 a	23 a
Fierce **RyzUp** **Roundup Powermax**	3.00 1.00 30.74	PRE PRE PRE	3 b	31 a	68 a	95 a	20 a
Fierce MTZ **RyzUp** **Roundup Powermax**	15.37 1.00 30.74	PRE PRE PRE	25 a	63 a	88 a	99 a	13 a

Table 4. *Percent control, densities of plants per m^2, and biomass in grams per m^2 following postemergence applications of Powerflex HL. Davenport, WA, 2020. DAT = days after treatment. Means followed by the same letter are not statistically different (a=0.05).*

			Postemergence		
			Downy Brome Control	***Downy Brome Density***	***Downy Brome Biomass***
Treatment	**Rate**		**5/11/2020** ***25 DAT***	**5/25/2020** ***39 DAT***	**5/25/2020** ***39 DAT***
	oz/A	**Type**	**%**	**# m^{-2}**	**G m^{-2}**
Nontreated	-	-	56 b	365 a	258 a
Roundup Powermax **Powerflex HL**	30.74 2.00	PRE POST	72 a	288 a	246 a
Zidua **Roundup Powermax** **Powerflex HL**	1.50 30.74 2.00	PRE PRE POST	88 a	85 a	91 a
Fierce **Roundup Powermax** **Powerflex HL**	3.00 30.74 2.00	PRE PRE POST	86 a	83 a	38 a
Fierce MTZ **Roundup Powermax** **Powerflex HL**	15.37 30.74 2.00	PRE PRE POST	82 a	108 a	106 a
Fierce **RyzUp** **Roundup Powermax** **Powerflex HL**	3.00 1.00 30.74 2.00	PRE PRE PRE POST	83 a	128 a	74 a
Fierce MTZ **RyzUp** **Roundup Powermax** **Powerflex HL**	15.37 1.00 30.74 2.00	PRE PRE PRE POST	84 a	118 a	33 a

Evaluation of Aggressor™ herbicide for the control of downy brome in the CoAXium™ wheat production system

Henry Wetzel and Drew Lyon



Aggressor + NIS
(10 fl oz/A + 0.25% v/v) 61 DAT (5/28/2020)

Nontreated Check
(5/28/2020)

The CoAXium™ wheat production system was recently developed by the Colorado Wheat Research Foundation, Inc., Limagrain Cereal Seeds, LLC and Albaugh, LLC. AXigen™ is the non-GMO trait in wheat that confers tolerance to the ACCase inhibitor (Group 1) herbicide Aggressor™ (quizalofop-P-ethyl). The AXigen trait is available to both private and public breeders, which is one of the reasons we were interested in evaluating the system. Aggressor is labelled to control annual grassy weeds such as downy brome, jointed goatgrass and feral rye that are problematic in the low to intermediate rainfall zones of eastern WA.

'LCS Fusion AX' winter wheat was conventionally seeded using a deep furrow hoe drill at Dennis Kenbel's Farm near Ritzville, WA on September 10, 2019. The soil at this site is a Ritzville silt loam. Postemergence treatments were applied on April 4th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 46 psi at 1.5 mph. The air temperature was 44°F, relative humidity was 37% and the wind was out of the east at 4 mph. The wheat was just beginning to joint and was 10 inches tall. Downy brome pressure was so high that it was difficult to take a plant count. At the time of application, downy brome plants on the furrow ridges were purple, whereas those plants in the furrow were green. While the snow came off in late February, cold starts to the days continued into the middle of April.

There was jointed goatgrass throughout the trial area. Since the downy brome density was so high, we could not easily distinguish between it and jointed goatgrass in the nontreated check plots. Thus, we were unable to take a jointed goatgrass control rating. Our observations included the following: OpenSky® and Osprey® Xtra provided poor downy brome control; and Aggressor-treated plots exhibited excellent downy brome control. There was no crop injury noted with any of the treatments in this trial. The level of downy brome control between the three rates of Aggressor evaluated was not significantly different. Downy brome control with Aggressor was not influenced by the addition of NIS, MVO or UAN. On the May 14th rating date, 40 days after application, all Aggressor treatments were providing greater than 91% control of downy brome (Table). On the same rating date, OpenSky and Osprey Xtra were providing 38 and 20% control, respectively, which is not commercially acceptable. It is likely that downy brome resistance to Group 2 herbicides was present in the trial area. In general, Aggressor-treated plots had a greater yield and test weight than the nontreated check plots (Table). OpenSky-treated plots had a greater yield than the nontreated check plots, but test weights were similarly low in both treatments. We noted that downy brome maturity was delayed in the OpenSky-treated plots, but not the Osprey Xtra-treated plots. OpenSky may have held back the downy brome enough during wheat grain fill, to improve yield. Had the treatments in this trial been applied in the fall, we may have seen more significant effects on wheat yield. This trial demonstrated the effectiveness of the CoAXium Wheat Production System for the control of downy brome. However, overuse of this new technology is likely to quickly result in selection of downy brome biotypes resistant to the active ingredient, quizalofop-P.

Treatment	Rate	5/14 40 DAT Downy brome control	7/22 109 DAT Yield	7/22 109 DAT Test Weight
	fl oz/A	--------%--------	(bu/A)	(lb/bu)
Aggressor™ + NIS	10 + 0.25% v/v	91 a[1]	37 a[2]	58.0 ab[1]
Aggressor + NIS	12 + 0.25% v/v	91 a	35 ab	59.9 a
Aggressor + MVO	10 + 1.0% v/v	95 a	35 ab	59.9 a
Aggressor + MVO	12 + 1.0% v/v	95 a	34 a-c	60.4 a
Aggressor + MVO	14 + 1.0% v/v	95 a	34 a-c	58.2 ab
OpenSky® + NIS + UAN	1.25 pt/a + 0.25% v/v + 3.0 gal/a	38 b	35 ab	53.5 c
Osprey® Xtra + NIS + UAN	4.75 oz/a + 0.5% v/v + 15% v/v	20 c	29 bc	55.4 bc
Aggressor + NIS + UAN	10 + 0.25% v/v + 3 gal/a	94 a	38 a	58.3 ab
Aggressor + MVO + UAN	10 + 1.0% v/v + 3 gal/a	95 a	34 a-c	59.8 a
Nontreated Check	--	--	28 c	53.1 c

[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.

[2] Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.01 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 Avadex® Microactiv™ herbicide for the control of downy brome and Italian ryegrass

Henry Wetzel and Drew Lyon

Triallate is an inhibitor of lipid biosynthesis; not ACCase inhibition (Group 8). Triallate is primarily absorbed by the emerging grass coleoptile, not as much through the roots. Triallate is sold in three products: Avadex MicroActiv, Avadex MinTill and Far-GO®. All three products are labeled for the control of wild oats and suppression of *Bromus* species in winter wheat. The Avadex granular formulations are not labeled for the control or suppression of Italian ryegrass, but the Far-GO formulation is labeled for the control of annual ryegrass in Oregon. The objectives of this study were twofold: 1) Determine the level of control that Avadex MicroActiv provides against downy brome and Italian ryegrass in a direct seed winter wheat production system, and 2) Acertain if the combination of Avadex MicroActiv with either Zidua® (Group 15), Zidua + Sencor® (Group 5), Beyond® (Group 2) or PowerFlex® HL (Group 2) provides better grass weed control than the products applied individually.

This study was conducted on land owned and farmed by the late Mark James near Dixie, WA. The soil at this site is an Athena silt loam with 2.9% organic matter and a pH of 5.2. Winter wheat was the previous crop. Crop residue remaining after harvest was burnt just prior to planting. The field was sprayed with glyphosate on October 6, 2019 and Avadex MicroActiv was applied with a 50 ft Valmar applicator on October 7th at 15 lb/A to half of the trial area by CHS Primeland. Two, 50 ft by 200 ft strips received Avadex MicroActiv and two strips did not. Herbicide treatments were randomized and replicated four times within the respective strips. On October 8th, the trial area received 0.47 inch of rainfall that aided in the activation and incorporation of the Avadex MicroActiv. Mechanical incorporation of the Avadex MicroActiv occurred at planting on October 10th with a Horsch high disturbance direct-seed drill with paired rows on a 15-inch row spacing. The cultivar 'UI Magic CL+' was seeded at a depth of 1.5 inches and a rate of 110 lb seed/acre. Zidua and Zidua + Sencor preemergence treatments were applied on October 11th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 52 psi at 2.3 mph. The air temperature was 59°F, relative humidity was 29% and the wind was out of the west at 4 mph. Beyond and PowerFlex HL were applied postemergence in the fall, November 18th, and in the late winter, February 28, 2020. On November 18, 2019 the air temperature was 61°F, relative humidity was 85% and the wind was out of the southwest at 6 mph. On February 28, 2020 the air temperature was 65°F, relative humidity was 32% and the wind was out of the southwest at 4 mph. Annual grass identification was difficult when the postemergence applications were made. On November 18, 2019 there was an average of 24 annual grass plants per square foot in the four, nontreated check plots. In general, annual grass weeds were 1- to 2-leaf and 2 to 3 inches in height and 3-leaf to 5-tiller and 2 to 3.25 inches in height at the fall and late winter application timings, respectively. Wheat was 2-leaf and 2- to 4-tillers at the fall and late winter application timings, respectively.

In the early spring, it became easier to distinguish that there was a good density of both downy brome and Italian ryegrass plants in the trial area. None of the herbicides applied caused any crop injury. Avadex MicroActiv and Zidua each provided some control of downy brome and Italian ryegrass. Avadex MicroActiv provided slightly better downy brome control, whereas Zidua provided slightly better Italian ryegrass control. Neither product provided commercially acceptable control of either annual grass weed when applied alone. The combination of Avadex MicroActiv plus Zidua provided the best control of downy brome and Italian rygrass and increased yield by 18 bu/A when compared to the nontreated check. The addition of Sencor to Zidua did not increase the control of either annual grass weed when compared to Zidua alone or in combination with Avadex MicroActiv. The group 2 herbicides (Beyond and PowerFlex HL) provided very little control of either downy brome or Italian ryegrass when applied on their own. However, when combining Beyond or PowerFlex HL with Avadex MicroActiv, downy brome control was better than Italian ryegrass control. This study demonstrated that as resistance to the postemergence Group 2 herbicides increases in both downy brome and Italian ryegrass, it will be important to use preplant and preemergence herbicides with at least two different sites of action to control these two troublesome annual grass weeds in wheat.

		----------------6/5/20----------------		7/18/20
		Downy brome	Italian ryegrass	
Treatment and Application Timing	Rate	control	control	Yield
		%	%	bu/a
Avadex® MicroActiv™[1]	15 lb/a	60 bc[5]	48 b	113 ab
Avadex MicroActiv[1] fb Zidua®[2]	15 lb/a fb 1.5 oz/a	90 a	88 a	117 a
Avadex MicroActiv[1] fb Zidua + Sencor®[2]	15 lb/a fb 1.5 oz/a + 2.0 oz/a	83 ab	83 a	113 ab
Avadex MicroActiv[1] fb Beyond®[3]	15 lb/a fb 5.0 fl oz/a	85 a	54 b	115 ab
Avadex MicroActiv[1] fb PowerFlex® HL[3]	15 lb/a fb 2.0 oz/a	78 ab	53 b	110 a-d
Avadex MicroActiv[1] fb Beyond[4]	15 lb/a fb 5.0 fl oz/a	74 ab	55 b	112 a-c
Avadex MicroActiv[1] fb PowerFlex HL[4]	15 lb/a fb 2.0 oz/a	61 bc	48 b	108 b-d
Zidua[2]	1.5 oz/a	44 cd	60 b	108 b-d
Zidua + Sencor[2]	1.5 oz/a + 2.0 oz/a	46 cd	61 b	110 a-d
Beyond[3]	5.0 fl oz/a	33 de	15 c	104 de
PowerFlex HL[3]	2.0 oz/a	15 ef	24 c	105 c-e
Beyond[4]	5.0 fl oz/a	26 d-f	15 c	105 c-e
PowerFlex HL[4]	2.0 oz/a	5 f	13 c	100 e
Nontreated Check	--	--	--	99 e

[1] preplant (October 7, 2019), [2] preemergence (October 11, 2019), [3] postemergence fall (November 8, 2019) and [4] postemergence late winter (February 28, 2020)

[5] 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 and Italian ryegrass in winter wheat

Henry Wetzel and Drew Lyon

The trial had three objectives: 1) Determine the postemergence activity of Osprey Xtra for the control of downy brome and Italian ryegrass, 2) Determine if adding one or two broadleaf herbicides that are formulated as emulsifiable concentrates (EC) will improve the performance of Osprey Xtra, and 3) Ascertain if a fall post-plant preemergence application of Zidua® followed by a spring postemergence application of Osprey Xtra provides better annual grass control than either product applied alone.

This study was conducted on land owned and farmed by the late Mark James near Dixie, WA. The soil at this site is an Athena silt loam with 2.9% organic matter and a pH of 5.2. Winter wheat was the previous crop. Crop residue remaining after harvest was burned just prior to planting. The field was sprayed with glyphosate on October 6, 2019. The field was planted on October 10th with a Horsch high disturbance direct-seed drill with paired rows on a 15-inch row spacing. The cultivar 'UI Magic CL+' was seeded at a depth of 1.5 inches and a rate of 110 lb seed/acre. Zidua preemergence treatments were applied on October 11th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 52 psi at 2.3 mph. The air temperature was 59°F, relative humidity was 29% and the wind was out of the west at 4 mph. Postemergence treatments, including Osprey Xtra and broadleaf herbicides, were applied on February 28, 2020 when the air temperature was 65°F, relative humidity was 32% and the wind was out of the southwest at 4 mph. Annual grass identification was difficult in the fall and when the postemergence applications were made in the late winter. On November 18, 2019 and February 28, 2020, there was an average of 12 and 18 annual grass plants per square foot, respectively in the four, nontreated check plots. In general, annual grass weeds were 3-leaf to 5-tiller and 2 to 3.25 inches in height at the postemergence application timing. Wheat was 2- to 4-tillers at the postemergence application timing.

Osprey Xtra provided little control of downy brome or Italian ryegrass in this study (Table). There is widespread resistance to the ALS-inhibiting herbicides (group 2) in downy brome biotypes found in Walla Walla County, which likely explains this result. The addition of Huskie® or Huskie + Brox®-M to Osprey Xtra did not significantly improve annual grass control when compared to Osprey Xtra applied alone. Downy brome and Italian ryegrass control was better in treatments containing Zidua, but following Zidua with Osprey Xtra and/or Huskie did not improve control compared to Zidua by itself. None of the treatments evaluated provided commercially acceptable control of downy brome or Italian ryegrass.

		-------------6/5------------	
		Downy brome	Italian ryegrass
Treatment[1]	Rate	control	control
	fl oz/A	-------------%-------------	
Nontreated check	--	--	--
Osprey® Xtra[2]	4.75 oz	10 d[4]	13 b
Osprey Xtra + Huskie®[3]	4.75 oz + 13.5	13 cd	20 b
Osprey Xtra + Huskie + Brox®-M[3]	4.75 oz + 13.5 + 16.0	23 b-d	23 b
Zidua®	1.5 oz	38 a-c	50 a
Zidua fb Osprey Xtra[2]	1.5 oz fb 4.75 oz	45 ab	64 a
Zidua fb Osprey Xtra + Huskie[3]	1.5 oz fb 4.75 oz + 13.5	54 a	58 a

[1] Zidua was applied on October 11, 2019 and Osprey Xtra + broadleaf herbicides were applied on February 28, 2020.

[2] Treatment included 0.5% v/v NIS + 2.0 qt/a UAN

[3] Treatment included 0.25% v/v NIS + 2.0 qt/a UAN

[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.

Herbicide timings for the control of Italian ryegrass in winter wheat

Henry Wetzel and Drew Lyon

A study was conducted to determine the optimal timing(s) for the use of group 15 herbicides including Zidua® SC (pyroxosulfone) and Axiom® DF [flufenacet plus metribuzin (group 5)]. Sencor® 75DF (metribuzin) was also evaluated at the wheat spike leaf and early tillering timing as a supplement to Zidua SC and Axiom DF. We evaluated three herbicide timings: (1) post-plant preemergence, (2) wheat spike leaf emergence and (3) early wheat tillering, which is typically late winter/early spring in Pullman.

The soil at this site is a Naff silt loam with 3.6% organic matter and a pH of 5.0. On October 1, 2019, the field was sprayed with RT 3® (glyphosate) + Aim® (carfentrazone) + Conform DP + Downrigger™ (32 + 1.0 + 3.0 + 6.9 fl oz/A) to burndown the field in preparation for planting. The trial area followed spring canola. On October 2nd, 'Norwest Tandem' winter wheat was planted with a Horsch direct-seed air drill with row openers on a 12-inch spacing. Post-plant preemergence treatments were applied on October 4th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 52 psi at 2.3 mph. The applications were made under moderate, 8 mph winds out of the southwest with an air temperature of 50°F and relative humidity of 56%. Wheat spike leaf emergence treatments were applied on October 24th. The applications were made under moderate, 6 mph winds out of the east with an air temperature of 54°F and relative humidity of 44%. The early tillering treatments were applied on February 27, 2020. The applications were made under calm conditions with an air temperature of 54°F and relative humidity of 40%. The majority of the wheat was four-leaf with the fifth emerging, thus in the early stages of tillering. On June 23rd, the trial area was sprayed with Priaxor® + Tilt® + NIS (6.0 + 4.0 fl oz/A + 0.125% v/v) to control stripe rust. The trial area was harvested with a Kincaid 8XP plot combine on August 26th.

Precipitation was extremely variable throughout the growing season, with much below average precipitation in some months and above average precipitation in other months. Temperatures did not fluctuate as much and in general they were below average in the spring and summer months. Italian ryegrass counts were taken on October 24, 2019 and February 27, 2020 in the nontreated check plots and they were 1 and 1.5 plants per square foot, respectively. The winter wheat and the Italian ryegrass finally started to grow after 2.21 inches of rain fell from May 17th to the 21st. Despite the low levels of Italian ryegrass at the herbicide application timings, by the time July came around there was a moderately heavy population throughout the trial area. None of the treatments evaluated in this trial caused any crop injury. All treatments containing Zidua SC provided ≥83% control of Italian ryegrass except Zidua SC (3.25 fl oz/A) at the post-plant preemergence timing, which provided only 69% control (Table). Treatments that contained Axiom DF provided anywhere from 54 to 59% control of Italian ryegrass, which is not commercially acceptable. Sencor 75DF, either added to Zidua SC or Axiom DF at the wheat spike leaf or early tillering application timings, did not improve control compared to Zidua SC or Axiom DF applied alone. Unlike previous studies, where early application of Zidua provided the best control of Italian rygrass, we were unable to determine an optimum application timing for Zidua SC or Axiom DF in this study. That was likely due to the late emergence of much of the Italian ryegrass in this study. The average yield and test weight among all treatments, including the nontreated check, was 125 bu/A and 59.2 lb/bu. Yield and test weight data were not presented since there were no significant differences among treatments.

Treatment	Rate	Application date[1]	7/22 Italian ryegrass control
	fl oz/A		%
Nontreated check	--	--	--
Zidua® SC	4.0	10/4/19	84 ab[2]
Zidua SC	3.25	10/4/19	69 a-d
Zidua SC	3.25	10/4/19	89 a
Zidua SC	0.75	10/24/19	
Zidua SC	3.25	10/4/19	83 a-c
Zidua SC	0.75	10/24/19	
Sencor® 75DF	3.0 oz	10/24/19	
Zidua SC	3.25	10/4/19	83 a-c
Zidua SC	0.75	2/27/20	
Zidua SC	3.25	10/4/19	84 ab
Zidua SC	0.75	2/27/20	
Sencor 75DF	3.0 oz	2/27/20	
Axiom® DF	10.0 oz	10/4/19	56 d
Axiom DF	8.0 oz	10/4/19	59 b-d
Axiom DF	8.0 oz	10/4/19	58 cd
Sencor 75DF	3.0 oz	10/24/19	
Axiom DF	8.0 oz	10/4/19	54 d
Sencor 75DF	3.0 oz	2/27/20	

[1] (10/4/2019) post plant preemergence; (10/24/2019) wheat spike leaf emergence; (2/27/2020) early wheat tillering

[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.

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 crop safety and mayweed chamomile control data with Corteva's broadleaf herbicides. The trial emphasis was on Arylex™ Active (halauxifen-methyl), clopyralid and fluroxypyr. All three active ingredients are synthetic auxins (group 4). Quelex® contains halauxifen-methyl and florasulam (group 2). Pixxaro™ EC contains fluroxypyr and halauxifen-methyl. WideMatch® contains clopyralid and fluroxypyr. WideARmatch™ contains clopyralid, fluroxypyr and halauxifen-methyl and was registered for use in 2020.

The soil at this site is a Palouse silt loam with 3.8% organic matter and a pH of 5.3. The field was previously in chickpeas. On September 23, 2019, the field was fertilized with 100 lb N:15 lb P:15 lb S per acre and incorporated with a cultivator. On September 24th, 'M-Press' winter wheat was conventionally planted using a JD 455 disk drill with a 7.5-inch row spacing at the rate of 105 lb seed per acre. At the time of planting, the field received M-Struct (8-24-0) starter fertilizer through the drill. Postemergence treatments were applied on April 8th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 46 psi at 2.3 mph. The applications were made with an air temperature of 65°F, relative humidity of 19% and winds were 2 to 4 mph out of the northwest. The majority of the wheat had just begun to joint and plants were 10 inches tall. Mayweed chamomile was uniformly distributed, and its population was moderate across the trial area. Mayweed chamomile was 1.0-inch-tall and 1.5-inch-wide at the time of application. The density was 2 plants per square foot in the nontreated check plots. Mayweed chamomile was continuing to germinate at the time of application. On April 15th, the trial area was treated to control eyespot and stripe rust with Tilt® + Priaxor® + McGregor's M-90 (4 fl oz/a + 6 fl oz/a + 0.125% v/v), and again on May 16th to control stripe rust with Trivapro® + McGregor's M-90 (13.7 fl oz/a + 0.125% v/v).

On April 29th, 21 days after treatment (DAT), Talinor™, WideMatch and WideARmatch + 2,4-D Ester LV6, were exhibiting the best control of mayweed chamomile. On May 13th, 35 DAT, all treatments were providing good to excellent control except Pixarro, Pixarro + Harmony® SG + Express® and Talinor (Table). On June 22nd, 75 DAT, 50 days prior to the field being harvested, all treatments provided complete mayweed chamomile control except Pixarro and Pixarro + Harmony SG + Express (Table). These results suggest that Corteva has several effective products for the control of mayweed chamomile in winter wheat. One should evaluate the product labels to see which of these products or tank mixtures would provide the best control for the weed spectrum on your farm. At the same time, evaluate potential crop rotation limitations.

Treatment	Rate	4/29	5/13	6/22
		Mayweed chamomile control		
	fl oz/A	----------------%----------------		
Nontreated Check	--	--	--	--
Pixxaro™ EC[1]	6.0	30 d[2]	23 e	45 b
Pixxaro EC + 2,4-D Ester LV6	6.0 + 8.0	43 c	78 b	100 a
Pixxaro EC + Harmony® SG + Express®[1]	6.0 + 0.2 oz + 0.2 oz	23 d	43 d	58 b
WideARmatch™[1]	14.0	53 bc	86 ab	100 a
WideARmatch + 2,4-D Ester LV6	14.0 + 8.0	60 ab	93 a	100 a
WideARmatch + Harmony SG + Express[1]	14.0 + 0.2 oz + 0.2 oz	53 bc	85 ab	100 a
Widematch® + Quelex®[1]	16.0 + 0.75 oz	53 bc	88 ab	100 a
Widematch[1]	16.0	58 ab	89 ab	100 a
CoAct+ + Talinor™[1]	3.2 + 16.0	68 a	63 c	100 a

[1] This treatment also included Activator 90 (0.25% 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.

Control of mayweed chamomile in winter wheat

Henry Wetzel and Drew Lyon

A study was established at Mark Hall's farm near Steptoe, WA to evaluate crop tolerance and mayweed chamomile control with herbicides in winter wheat. The objective of the study was to determine how FMC's Affinity® BroadSpec [thifensulfuron + tribenuron (group 2)] and Aim® EC [carfentrazone (group 14)] would influence the performance of Talinor™ [bicyclopyrone (group 27) + bromoxynil (group 6)] and WideMatch® [clopyralid + fluroxypyr (group 4)] for the control of mayweed chamomile in winter wheat. Moxy® 2E plus Affinity BroadSpec were considered tank mix partners for the control of mayweed chamomile in this study. Cadet™ [fluthiacet (group 14)] was also evaluated in combination with WideMatch. Cadet is not labeled for use in wheat.

The soil at this site is a Caldwell silt loam with 3.4% organic matter and a pH of 7.2. On October 12, 2019, PNW Trident II winter wheat, which is a blend of 'SY Assure' & 'Northwest Tandem', was conventionally planted using a disk drill with a 7.5-inch row spacing at the rate of 100 lb seed per acre. Postemergence treatments were applied on May 4, 2020 with a CO_2-powered backpack sprayer set to deliver 10 gpa at 49 psi at 2.3 mph. The applications were made under light, 2 mph winds out of the southwest with an air temperature of 64°F and relative humidity of 28%. The majority of the wheat had just begun to joint and plants were 16 inches tall. Mayweed chamomile was uniformly distributed, and its population was high across the trial area. Mayweed chamomile was 1.0-inch-tall at the time of application and had a density of 20 plants per square foot in the nontreated check plots. Mayweed chamomile was continuing to germinate at the time of application, as this area of the field was sub-irrigated. The trial area was harvest with a Wintersteiger plot combine on August 10th and 11th.

Crop injury was evident in Aim EC- and Cadet-treated plots 3 days after treatment (DAT) and peaked on May 11th, 7 DAT (Table). Small circular lesions were initially yellowish-brown with a dark brown border that over time appeared bleached in color. This was most likely a plant reaction from where the spray droplets landed on the leaf. These symptoms were only seen on the leaves that were actively growing at the time of application. There was no evidence of systemic movement of the compounds into newly emerged leaves after application. From a distance, symptoms appeared as a leaf tip necrosis or bronzing. Symptoms were present in the Aim EC- and Cadet-treated plots for the duration of the trial. As the wheat canopy expanded, these symptoms were low in the canopy and not very noticeable over time. In general, crop injury symptoms from Aim EC and Cadet were more evident when leaves were closely inspected than from a distance. Carfentrazone and fluthiacet are fast acting, contact herbicides. We hypothesized that the addition of Aim EC to Talinor, Moxy 2E + Affinity BroadSpec and WideMatch, as well as the addition of Cadet to WideMatch, would accelerate and improve control of mayweed chamomile, particularly when added to WideMatch, which often requires three to four weeks to kill mayweed chamomile plants. This was not the case when the initial rating was taken 14 DAT (May 18th) (Table). On June 16th, 43 DAT, all treatments containing Talinor and WideMatch were providing $\geq$87% control of mayweed chamomile (Table). Treatments containing Moxy 2E + Affinity BroadSpec provided fair control of mayweed chamomile. The addition of Affinity BroadSpec, Aim EC or Cadet to Talinor or WideMatch did not provide better mayweed chamomile control when compared to Talinor or WideMatch applied alone. The average yield among all treatments, including the nontreated check, was 84 bu/A. Yield data were not presented since there were no significant differences among treatments.

Treatment[1]	Rate	5/7	5/11	5/18	5/18	6/1	6/16
		Crop injury			Mayweed chamomile control		
	fl oz/A	-----------------%-----------------			-----------------%-----------------		
Nontreated check	--	--	--	--	--	--	--
CoAct +	2.75	0 a[2]	0 a[2]	0 a[2]	63 a[2]	85 ab[2]	88 ab[3]
Talinor™	13.7						
CoAct +	2.75	0 a	0 a	0 a	73 a	95 a	93 a
Talinor	13.7						
Affinity® BroadSpec	1.0 oz						
CoAct +	2.75	5 c	13 d	10 d	73 a	92 ab	90 ab
Talinor	13.7						
Aim® EC	0.5						
Affinity BroadSpec	1.0 oz						
Moxy® 2E	24	5 c	10 c	7 c	67 a	63 d	70 c
Aim EC	0.5						
Affinity BroadSpec	1.0 oz						
Moxy 2E	24	0 a	0 a	0 a	67 a	63 d	75 bc
Affinity BroadSpec	1.0 oz						
WideMatch®	16	4 bc	10 c	10 d	67 a	73 cd	90 ab
Aim EC	0.5						
WideMatch	16	0 a	0 a	0 a	70 a	90 ab	100 a
Affinity BroadSpec	1.0 oz						
WideMatch	16	1 a	5 b	3 b	70 a	88 ab	95 a
Affinity BroadSpec	1.0 oz						
Aim EC	0.5						
WideMatch	16	3 b	8 c	6 c	70 a	90 ab	95 a
Cadet™	0.75						
WideMatch	16	0 a	0 a	0 a	60 a	82 bc	87 a-c

[1] All treatments, excluding the nontreated check, were tank mixed with NIS at 0.25% v/v. Treatments were applied 5/4/20.

[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.

[3] Means, based on four replicates, within a column, followed by the same letter are not significantly different at P = 0.10 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 winter wheat tolerance to Talinor™ in combination with tank mix partners
Henry Wetzel and Drew Lyon

A field study was conducted on Mike Nelson's Farm near Albion, WA to generate crop safety data for Syngenta's Talinor broadleaf herbicide applied in combination with McGregor's Liquid Urea (20-0-0). Additional herbicide and/or fungicide products were tank mixed with Talinor and Liquid Urea to evaluate crop safety in a spring postemergence herbicide timing spray mixture. The combination of Talinor plus UAN was included because crop injury has been documented in the past. The treatment of Liquid Urea + Osprey® Xtra + Tilt® + NIS was included to evaluate crop response in the absence of Talinor.

The soil at this site is a Palouse silt loam with 3.8% organic matter and a pH of 5.3. The field was previously in chickpeas. On September 23, 2019, the field was fertilized with 100 lb N:15 lb P:15 lb S per acre and incorporated with a cultivator. On September 24th, 'M-Press' winter wheat was conventionally planted using a JD 455 disk drill with a 7.5-inch row spacing at the rate of 105 lb seed per acre. At the time of planting, the field received M-Struct (8-24-0) starter fertilizer through the drill. Postemergence treatments were applied on April 8th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 48 psi at 2.3 mph. The applications were made under calm conditions with an air temperature of 60°F and relative humidity of 30%. The majority of the wheat had just begun to joint and plants were 10 inches tall. Mayweed chamomile was not uniformly distributed, and its population was low to moderate across the trial area. Mayweed chamomile was 1.0-inch-tall at the time of application and had a density of less than one plant per square foot in the nontreated check plots. Mayweed chamomile was continuing to germinate at the time of application. On April 15th, the trial area was treated to control eyespot and stripe rust with Tilt + Talaris™ 4.5F + McGregor's M-90 (4 fl oz/a + 10 fl oz/a + 0.125% v/v), and again on May 16th to control stripe rust with Trivapro® + McGregor's M-90 (13.7 fl oz/a + 0.125% v/v).

Although the crop injury observed in the UAN 32 + CoAct + + Talinor + Osprey Xtra + Tilt + NIS treatment was greater than observed in other treatments, it was relatively minor. Symptoms were only bronzing and leaf spotting to the upper surface. In previous trials, UAN 32 was tested at 15 to 25% volume of the finished spray solution in combination with Talinor. Significant crop injury was observed in these studies which resulted in bleached streaks on uppermost leaves in the canopy and the injury symptoms did not move systemically. In this test, UAN 32 was tested at 5% volume of the finished spray solution. The majority of the injury observed in this test, looking out over the entire plot, was from the Osprey Xtra and it was transient. Compared to the nontreated check plots, plots treated with Osprey Xtra were stunted and not as vibrant green. The addition of Talinor to Osprey Xtra, did not influence the injury observed from Osprey Xtra. McGregor's Liquid Urea (20-0-0) appeared to be a safe alternative to UAN 32 to be used at the spring postemergence herbicide application timing with the various pesticides evaluated in this trial. With the low level of mayweed chamomile present, all treatments containing Talinor provided complete control. The treatment that only contained Osprey Xtra did not provide commercially acceptable control of mayweed chamomile. None of the treatments in this study influenced yield in that they were all comparable to the nontreated check.

		4/15	4/21	8/10
Treatment	Rate	Crop Injury		Yield
	fl oz/a	--------------%--------------		bu/a
Nontreated Check	--	--	--	162 a
UAN 32[1]	2 qt	11 b[4]	6 b	153 a
Liquid Urea 20-0-0[2]	3 gal	5 a	3 a	169 a
Tilt®[3]	4.0	5 a	3 a	161 a
Quilt Xcel®[3]	7.0	5 a	3 a	157 a
Trivapro®[3]	7.0	5 a	3 a	153 a
Peak® + Tilt[3]	0.5 oz + 4.0	5 a	3 a	160 a
Peak + Trivapro[3]	0.5 oz + 7.0	5 a	3 a	154 a
Orion®+ Tilt[3]	17 + 4.0	5 a	3 a	156 a
Orion + Trivapro + Tilt[3]	17 + 7.0 + 4.0	5 a	3 a	161 a

[1] Treatment included CoAct+ + Talinor + Osprey Xtra + Tilt + NIS [3.2 fl oz/a + 16 fl oz/a + 4.75 oz/a + 4.0 fl oz/a + 0.25% v/v].
[2] Treatment included Osprey Xtra + Tilt + NIS [4.75 oz/a + 4.0 fl oz/a + 0.25% v/v].
[3] Treatment included Liquid Urea (20-0-0) + CoAct + + Talinor + Osprey Xtra + NIS (M-90) [3.0 gal/a + 3.2 fl oz/a + 16 fl oz/a + 4.75 oz/a + 0.25% v/v].
[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.

Smooth Scouringrush control with Finesse® in winter wheat/spring wheat/no-till fallow rotations

Mark Thorne and Drew Lyon.

Smooth scouringrush has become a problem in no-till wheat/fallow rotations in the intermediate to low rainfall areas of eastern Washington (Figure 1). We are evaluating control following applications of Finesse (chlorsulfuron + metsulfuron) or Rhonox® (MCPA LV ester) during the no-till fallow phase, and Amber® (triasulfuron) or Rhonox during the crop phase. We have demonstrated that chlorsulfuron, one of the active ingredients in Finesse, is effective for controlling smooth scouringrush for at least two years after application. However, the question remains: is a second application in a subsequent fallow phase needed for long-term control? Furthermore, this study evaluates the application of Amber during the crop phase. Amber is molecularly similar to chlorsulfuron and may be a bridge application between the two fallow Finesse applications. Rhonox is a control treatment for broadleaf weeds in both the fallow and crop phases when either Finesse or Amber are not applied. It initially burns down smooth scouringrush stems, turning them black but does not appear to reduce smooth scouringrush stem density in the year following application.

Figure 1. Smooth scouringrush stems between rows of winter wheat.

Two trials were initiated in 2019, one near Edwall, WA on the Camp farm and a second near Steptoe, WA on the Hall farm. Each site is in a no-till winter wheat/spring wheat/no-till fallow rotation. The Edwall site is in the bottom of a gentle-sloping northwest-facing draw with good moisture and well-drained soil, which is classified as a Broadax silt loam. Soil organic matter and pH measured 2.9% and 5.0, respectively. The Steptoe site is on a low-lying flat with inundated soil during winter and early spring. Soil at Steptoe is classified as Caldwell silt loam. Soil organic matter and pH measured 3.4% and 7.2, respectively. Both sites average around 16 inches of precipitation per year.

At each site, plots measure 10 by 30 ft and are arranged in a randomized complete block design with four replications per treatment. All herbicide treatments are applied with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. Spray output was 15 gpa at 25 psi. Treatment sequences and herbicide rates are presented in Table 1.

Table 1. Herbicide sequences for long-term study for control of smooth scouringrush in wheat/fallow cropping systems in eastern Washington.

Edwall and Steptoe herbicide sequences*

Trt	Fallow 2019	WW 2020	SW 2021	Fallow 2022	WW 2023	SW 2024	Fallow 2025
1	Finesse	Amber	Amber	Finesse	Amber	Amber	Final evaluations
2	Finesse	Amber	Rhonox	Finesse	Amber	Rhonox	
3	Finesse	Amber	Amber	Rhonox	Amber	Amber	
4	Finesse	Rhonox	Rhonox	Rhonox	Rhonox	Rhonox	
5	Finesse	Rhonox	Rhonox	Finesse	Rhonox	Rhonox	
6	Rhonox	Rhonox	Rhonox	Rhonox	Rhonox	Rhonox	

*Trt=treatment; WW=winter wheat; SW=spring wheat
Finesse (chlorsulfuron/metsulfuron) is applied at 0.5 oz/A.
Amber (triasulfuron) is applied at 0.56 oz/A.
Rhonox (MCPA) is applied at 34.6 oz/A in fallow and 24 oz/A in crop.
All treatments include NIS surfactant at 0.33% volume/volume concentration.

At each evaluation, stem density is measured in each plot and presented as number of stems/yd^2. Identical treatments at the time of evaluation are grouped together for each analysis. All applications in 2020 were applied in the winter wheat phase of each rotation. At both Edwall and Steptoe, Finesse applied in the previous fallow year resulted in densities less than 1 stem/yd^2, and at each site, which were statistically different than the Rhonox only sequence (Table 2). No statistical difference was seen between Finesse followed by Amber and Finesse followed by Rhonox. Stem density in the Rhonox only treatment at Steptoe was considerably lower than the initial density in 2019 (818 vs 25 stems/yd^2). This site was inundated with water through the winter which appeared to substantially reduce stem emergence in the 2020 winter wheat crop.

Harvest yields at Steptoe were not different between treatments and averaged 67 bu/A. At Edwall, the Rhonox only sequence yielded 82 bu/A and was statistically lower than either Finesse followed by Amber or Finesse followed by Rhonox, which yielded 96 and 97 bu/A, respectively. Greater smooth scouringrush stem density at Edwall likely reduced wheat yield in the Rhonox only sequence.

This research continues to show that Finesse results in good control of smooth scouringrush (Figure 2). The three-year rotation will stretch the time between Finesse applications, which may be a good test for long-term control. In the spring wheat phase, smooth scouringrush may be emerged by the time Amber is applied, thus providing a better opportunity to test the efficacy of this herbicide.

Table 2. Control of smooth scouringrush in winter wheat/spring wheat/no-till fallow rotations with Finesse – Edwall and Steptoe, WA.

Time	Sequence*	Smooth scouringrush density**
		--------------stems per square yard------------
Fallow 2019 – Edwall		
	Initial	85
Fallow 2019 – Steptoe		
	Initial	818
WW Harvest 2020 - Edwall		
	Finesse/Amber	0.2 b
	Finesse/Rhonox	0.3 b
	Rhonox/Rhonox	185 a
WW Harvest 2020 - Steptoe		
	Finesse/Amber	0 b
	Finesse/Rhonox	0 b
	Rhonox/Rhonox	25 a

*See Table 1 for application rates.
** Means are based on four replicates per treatment. Means within a column for each location followed by the same letter are not significantly different at the 95% probability level, 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.

Figure 2. Smooth scouringrush in winter wheat near Steptoe, WA. The area highlighted in red was treated with Finesse the previous year while in no-till fallow.

Smooth Scouringrush control with Finesse® in a no-till winter wheat/fallow rotation

Mark Thorne, Dale Whaley, and Drew Lyon.

Smooth scouringrush has become a problem in no-till wheat/fallow rotations in the intermediate to low rainfall areas of eastern Washington (Figure 1). We are evaluating control following applications of Finesse (chlorsulfuron + metsulfuron) or Rhonox® (MCPA LV ester) during the no-till fallow phase, and Amber® (triasulfuron) or Rhonox during the crop phase. We have demonstrated that chlorsulfuron, one of the active ingredients in Finesse, is effective for controlling smooth scouringrush for at least two years after application. However, the question remains: is a second application in a subsequent fallow phase needed for long-term control? Furthermore, this study evaluates the application of Amber during the crop phase. Amber is molecularly similar to chlorsulfuron and may be a bridge application between the two fallow Finesse applications. Rhonox is a control treatment for broadleaf weeds in both the fallow and crop phases when either Finesse or Amber are not applied. It initially burns down smooth scouringrush stems, turning them black but does not appear to reduce smooth scouringrush density in the following year.

Figure 1. Effect of Finesse during the fallow year on smooth scouringrush density in the following winter wheat crop.

The study site was initiated near Omak, WA in 2017 on the Townsend farm in a no-till winter wheat/fallow rotation. The soil is classified as a Ferrell fine sandy loam. Soil organic matter ranges between 1.0 to 1.1% and pH between 5.7 to 6.3. The area has an annual rainfall average of 13 inches per year. Plots measure 10 by 30 ft and are arranged in a randomized complete block design with four replications per treatment. All herbicide treatments were applied with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack traveling 3 mph. Spray output was 15 gpa at 25 psi. Treatment sequences and herbicide rates are presented in Table 1.

Table 1. Herbicide sequences for long-term study for control of smooth scouringrush in a no-till winter wheat/fallow cropping system near Omak, WA.

Herbicide sequence*

Trt	Fallow 2017	WW 2018	Fallow 2019	WW 2020	Fallow 2021
1	Finesse	Amber	Finesse	Amber	Final evaluations
2	Finesse	Amber	Finesse	Rhonox	
3	Finesse	Amber	Rhonox	Rhonox	
4	Finesse	Rhonox	Rhonox	Rhonox	
5	Finesse	Rhonox	Finesse	Rhonox	
6	Rhonox	Rhonox	Rhonox	Rhonox	

*Trt=treatment; WW=winter wheat; SW=spring wheat.
Finesse (chlorsulfuron/metsulfuron) is applied at 0.5 oz/A.
Amber (triasulfuron) is applied at 0.56 oz/A.
Rhonox (MCPA) is applied at 34.6 oz/A in fallow and 24 oz/A in crop.
All treatments include NIS surfactant at 0.33% volume/volume concentration.

At each evaluation, stem density is measured in each plot and presented as number of stems/yd^2. Identical treatments at the time of evaluation are grouped together for each analysis. Applications in 2020 were applied in the winter wheat phase of the rotation. The herbicide sequence that included only Rhonox resulted in the highest density of 61 stems/yd^2 (Table 2). Finesse applied in the two previous fallow years resulted in the best control with densities ranging between 3 and 5 stems/yd^2. A single application of Finesse followed by a single application of Amber (Trt 3) resulted in 9 stems/yd^2 and was not statistically different than Finesse followed by only Rhonox (Trt 5), which averaged 14 stems/yd^2. Harvest yields were not different between treatments and averaged 62 bu/A. The final evaluation will occur in 2021 in the no-till fallow phase.

This research continues to show that Finesse results in good control of smooth scouringrush for at least two years after application, and a second application in the subsequent fallow year extends control. The efficacy of Amber is not yet evident; however, smooth scouringrush stems had not emerged at the time of application. In addition, the quick burn-down from Rhonox results in very little, if any, long-term control.

Table 2. Control of smooth scouringrush with Finesse in no-till winter wheat/no-till fallow.

Time	Sequence*	Smooth scouringrush density**
		--------------stems per square yard------------
Fallow 2017		
	Initial	186
WW Harvest 2018		
	Finesse/Amber	0 b
	Finesse/Rhonox	0 b
	Rhonox/Rhonox	139 a
Fallow 2019		
	Finesse/Amber	2 c
	Finesse/Rhonox	3 b
	Rhonox/Rhonox	45 a
WW Harvest 2020		
	Finesse/Amber/Finesse/Amber	3 d
	Finesse/Amber/Finesse/Rhonox	4 d
	Finesse/Amber/Rhonox/Rhonox	9 bc
	Finesse/Rhonox/Rhonox/Rhonox	14 b
	Finesse/Rhonox/Finesse/Rhonox	5 cd
	Rhonox/Rhonox/Rhonox/Rhonox	61 a

*See Table 1 for application rates.

**Means are based on four replicates per treatment. Means within a column followed by the same letter are not significantly different at the 95% probability level, 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.

Control of smooth scouringrush with sulfonylurea herbicides and non-ionic surfactants

Mark Thorne and Drew Lyon.

The sulfonylurea herbicide, chlorsulfuron, is effective for controlling smooth scouringrush (*Equisetum laevigatum*), and its long soil persistence is a likely factor. However, its persistence limits its use in areas where pulse or other susceptible crops are grown due to damage that can occur if the crops are planted within the plantback restriction period (see product labels for crop plantback restrictions). Other sulfonylureas have shorter plantback intervals, but their efficacy on smooth scouringrush may be lower. Recently, we have shown that the organosilicone non-ionic surfactant Silwet® L77 increases efficacy of glyphosate on smooth scouringrush. This trial compares Silwet L77 with M-90®, a commonly used non-ionic surfactant, each added to three different sulfonylurea herbicides. We compared Finesse® (chlorsulfuron + metsulfuron) with Amber® (triasulfuron) and Affinity® BroadSpec (thifensulfuron + tribenuron), both of which have relatively short plantback intervals. All herbicides were applied in 2019 during the no-till fallow phase of the rotation. In 2020, we evaluted treatments based on stem density in the winter wheat crop just prior to harvest.

Figure 1. Smooth scouringrush in no-till fallow.

The study site is located on the Hall farm near Steptoe, WA. The field is in a three-year rotation of no-till fallow/winter wheat/spring wheat. Soil pH and organic matter was 5.0 and 2.2%, respectively. Initial smooth scouringrush density averaged 468 stems/yd^2. Plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment and a factorial arrangement with three herbicides and two surfactants. All herbicide treatments were applied on June 12, 2019 with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. Spray output is 15 gpa at 25 psi.

A thick stand of smooth scouringrush in the nontreated check treatment averaged 239 stems/yd^2 but was not statistically different from any of the Amber or Affinity BroadSpec treatments (Table 1). Both Finesse treatments reduced density substantially compared with all other treatments. Finesse with Silwet L77 averaged 1 stem/yd^2 and was less dense than the Finesse + M-90 treatment, which averaged 5 stems/yd^2. Both Amber and Affinity BroadSpec may not have the soil persistence needed to give long-term control of smooth scouringrush. Furthermore, Silwet L77 improves efficacy of Finesse and appears to aid uptake through the stem.

Table 1. Herbicide and surfactant effect on smooth scouringrush in winter wheat following application in the previous fallow year.

Herbicide	Rate	Scouringrush density*
	oz /A + % v/v	stems/yd^2
Nontreated check		239 a
Finesse + M-90	0.5 + 0.25	5 b
Finesse + Silwet L77	0.5 + 0.25	1 c
Amber + M-90	0.56 + 0.25	265 a
Amber + Silwet L77	0.56 + 0.25	211 a
Affinity BroadSpec + M-90	1.5 + 0.25	216 a
Affinity BroadSpec + Silwet L77	1.5 + 0.25	186 a

*Means are based on four replicates per treatment. Means within a column followed by the same letter are not significantly different at the 95% probability level, 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® FX for the control of common lambsquarters and mayweed chamomile in spring wheat

Henry Wetzel and Drew Lyon

A study was established at the Cook Agronomy Farm near Pullman, WA to evaluate crop tolerance, common lambsquarters and mayweed chamomile control with herbicides in spring wheat. The objective of the study was to determine how Huskie [pyrasulfotole (group 27) + bromoxynil (group 6)] compares, efficacy- and crop safety-wise, to a new formulation, Huskie FX, which includes fluroxypyr (group 4).

The soil at this site is a Palouse silt loam with 2.5% organic matter and a pH of 5.3. On March 26th, 'Ryan' spring wheat was planted with a Horsch direct-seed air drill with row openers on a 12-inch spacing. Postemergence treatments were applied on May 16th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 50 psi at 2.3 mph. The applications were made under 6 mph winds out of the east with an air temperature of 60°F and relative humidity of 47%. From when the field was seeded until trial initiation (51 days), conditions were dry and the field only received 2.21 inches of rainfall. Wheat growth stage was variable. From two-leaf to two-three tillers, with height ranging from 8 to 12 inches. Some of the plants that were tillering had the first joint 0.5 to 0.75 of an inch above the crown of the plant. Common lambsquarters were uniformly distributed, and its population was high across the trial area. Common lambsquarters were 2.5-inch-tall and 2.5-inch-wide at the time of application and had a density of 21 plants per square foot in the nontreated check plots. Mayweed chamomile was uniformly distributed, and its population was high across the trial area. Mayweed chamomile was 1.5-inch-tall and 1.5-inch-wide at the time of application and had a density of 8 plants per square foot in the nontreated check plots. Common lambsquarters and mayweed chamomile was continuing to germinate at the time of application. The trial area was harvested with a Kincaid 8XP plot combine on August 26th.

The next five days following application, the trial area received 2.21 inches of rainfall and another 1.89 inches of rainfall up until weed control ratings concluded on June 16th. The mean maximum and minimum air temperatures were 67 and 46°F, respectively over this 32-day period. The environmental conditions, well above average soil moisture and moderate air temperatures, suggest that the broadleaf weeds had some ability to resist the herbicide treatments. The wheat stand was thin and did not add significant crop competition to the study. There was no crop injury observed among any of the treatments in this study. Huskie and Huskie FX provided a similar level of control of common lambsquarters and mayweed chamomile (Table). Huskie and Huskie FX provided better control of common lambsquarters than mayweed chamomile. Talinor™ provided similar control of common lambsquarters to Huskie and Huskie FX, but better control of mayweed chamomile. Brox® 2EC + Rhonox® MCPA LV Ester + Affinity® BroadSpec provided the best common lambsquarters control and comparable mayweed chamomile control to Talinor. Starane® NXT provided poor control of common lambsquarters and a similar level of control of mayweed chamomile to Huskie and Huskie FX. Yield data are not presented due to a significant infestation of Italian ryegrass.

		6/4	6/16	6/4	6/16
		19 DAT	31 DAT	19 DAT	31 DAT
		Common lambsquarters		Mayweed chamomile	
Treatment	Rate	control		control	
	fl oz/a	-------------%-------------		-------------%-------------	
Nontreated check	--	--	--	--	--
Huskie® FX	16.5	78 b[1]	76 b	50 b	46 b
AMS	0.5 lb				
Huskie	13.5	84 b	76 b	52 b	53 b
AMS	0.5 lb				
CoAct +	2.75	63 c	73 b	64 a	79 a
Talinor™	13.7				
COC	1.0% v/v				
Brox® 2EC	32	94 a	89 a	63 a	78 a
Rhonox® MCPA LV Ester	16				
Affinity® BroadSpec	1.0 oz				
NIS	0.25% v/v				
Starane® NXT	27.4	50 c	45 c	53 b	48 b
NIS	0.25% v/v				

[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.

Control of mayweed chamomile in spring wheat

Henry Wetzel, Derek Appel and Drew Lyon

A study was established at Duane Oehlwein's farm near Davenport, WA to evaluate crop tolerance and mayweed chamomile control with herbicides in spring wheat. The objective of the study was to determine how FMC's Affinity® BroadSpec [thifensulfuron + tribenuron (group 2)] and Aim® EC [carfentrazone (group 14)] would influence the performance of Huskie® [pyrasulfotole (group 27) + bromoxynil (group 6)] and Talinor™ [bicyclopyrone (group 27) + bromoxynil] for the control of mayweed chamomile in winter wheat. Moxy® 2E plus Affinity BroadSpec were considered tank mix partners for the control of mayweed chamomile in this study. Cadet™ [fluthiacet (group 14)] was also evaluated in combination with Huskie. Cadet is not labeled for use in wheat.

The soil at this site is a Broadax silt loam with 3.8% organic matter and a pH of 7.6. On April 12th, 'Louise' spring wheat was planted with a Morris no-till drill with Anderson openers on a 12-inch row spacing to a depth of 1.5 inch at a rate of 70 lb seed per acre. Postemergence treatments were applied on May 27th with a CO_2-powered backpack sprayer set to deliver 10 gpa at 48 psi at 2.3 mph. The applications were made under 4 mph winds out of the southwest with an air temperature of 72°F and relative humidity of 22%. The majority of the wheat had 1 to 2 tillers and plants were 6 inches tall. Mayweed chamomile was uniformly distributed, and its population was high across the trial area. Mayweed chamomile was 1.5-inch-tall and 1.5-inch-wide at the time of application and had a density of 17 plants per square foot in the nontreated check plots. Mayweed chamomile was continuing to germinate at the time of application as this area of the field was sub-irrigated. The trial area was harvested with a Kincaid 8XP plot combine on August 24th.

Crop injury was evident in Aim EC- and Cadet-treated plots 3 days after treatment (DAT) and peaked on June 10th, 14 DAT (Table). Crop injury was noted as chlorosis and speckling. Carfentrazone and fluthiacet are fast acting, contact herbicides. We hypothesized that the addition of Aim EC to Huskie, Talinor and Moxy 2E + Affinity BroadSpec, as well as the addition of Cadet to Huskie, would accelerate and improve control of mayweed chamomile. This was not the case when the initial rating was taken 3 DAT (May 30th) (Table). On June 10th, 14 DAT, all treatments containing Huskie, Talinor and Moxy 2E + Affinity BroadSpec were providing ≥80% control of mayweed chamomile (Table). Treatments containing Talinor stood out by providing ≥95% control of mayweed chamomile. The addition of Affinity BroadSpec or Aim EC to Huskie or Talinor; or Cadet to Huskie did not provide better mayweed chamomile control when compared to Huskie or Talinor applied alone. Yield data were not presented since there was a significant wild oat infestation within the trial area, especially in the third and fourth reps.

		5/30	6/10	5/30	6/10
		3 DAT	14 DAT	Mayweed chamomile	
Treatment[1]	Rate	Crop injury		control	
	fl oz/A	-------------%-------------		-------------%-------------	
Nontreated check	--	--	--	--	--
CoAct +	2.75	0 a[2]	0 a	38 a	99 a
Talinor™	13.7				
CoAct +	2.75	0 a	0 a	40 a	98 a
Talinor	13.7				
Affinity® BroadSpec	1.0 oz				
CoAct +	2.75	5 b	10 c	48 a	95 a
Talinor	13.7				
Aim® EC	0.5				
Affinity BroadSpec	1.0 oz				
Moxy® 2E	24	4 b	6 b	45 a	80 b
Aim EC	0.5				
Affinity BroadSpec	1.0 oz				
Moxy 2E	24	0 a	0 a	48 a	81 b
Affinity BroadSpec	1.0 oz				
Huskie®	13.5	5 b	6 b	38 a	86 b
Aim EC	0.5				
Huskie	13.5	0 a	0 a	43 a	85 b
Affinity BroadSpec	1.0 oz				
Huskie	13.5	4 b	6 b	48 a	86 b
Affinity BroadSpec	1.0 oz				
Aim EC	0.5				
Huskie	13.5	4 b	6 c	45 a	80 b
Cadet™	0.75				
Huskie	13.5	0 a	0 a	40 a	85 b

[1] All treatments, excluding the nontreated check, were tank mixed with NIS at 0.25% v/v. Treatments were applied 5/27/20.

[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 Weed Management in Fallow Using Weed Sensing Spray Technology

L.S. Fields, D. Appel, I.C. Burke

The objective of this study was to evaluate the effectiveness of herbicide application using weed sensing spray technology compared to broadcast application during the fallow season with multiple herbicides. The sprayer tested operates by detection of differential reflection of chlorophyll facilitated by infrared radiation and is considered a light-activated, sensor-controlled spray technology. By detecting chlorophyll in the field, weed sensing spray technologies [in this trial, a WEED-IT (www.weed-it.com)] spray only when weeds are present and thus reduce the amount of herbicide used per application or per area. Utilizing this technology in fallow rotations can effectively reduce the cost associated with herbicide application and improve application accuracy when compared to broadcast systems.

The study was established at the Wilke Research and Extension Farm in Davenport, WA. Postemergence treatments were applied to fallow ground with weed pressure, where most weeds ranged from roughly 6 to 12 inches, detailed in Table 1 and Table 2. The study was conducted in a split-plot design with 4 replications. Plots were 10' by 30' long. Herbicides were applied on April 28th, 2020 by both the weed sensing sprayer and broadcast sprayer, both pressurized by CO_2 and calibrated to deliver 29.4 or 10 GPA, respectively. Following each weed sensing application, the milliliters dispensed was calculated and compared with the milliliters dispensed from the broadcast applications. Prickly lettuce (*Lactuca serriola*), common lambsquarters (*Chenopodium album*) and tumble mustard *(Sysimbrium altissimum*) were the three prominent weed species present in the plots at the time of application.

Weed control was quantified by visual assessment as percent control 9 days after treatment (DAT). Weed density was assessed 34 DAT along with biomass for dry weight measurements.

Table 1. *Weed sensing and broadcast spray treatment application details.*

Study Application	*Weed-it*	*Broadcast*
Date	April 28, 2020	April 28, 2020
Application volume (GPA)	29.4	10
Crop stage	Fallow	Fallow
Air temperature (F)	60	60
Soil temperature (F)	50	50
Wind velocity, (mph, direction)	6, S	6, S
Cloud cover	20%	20%

Results

The trial was designed to assess the efficacy of the weed sensing sprayer compared to broadcast applications and focused on the typical weed species present in dryland wheat fallow production. Regardless of which sprayer was used, weed density, biomass harvested, and control 34 DAT were similar among treatments (Table 2, Table 3) for prickly lettuce, common lambsquarters, and tumble mustard. The weed sensor sprayer detected weeds present in the trial sufficiently to make it appear identical to a broadcast application. Weed sensing applications are as effective as broadcast applications at controlling prickly lettuce, common lambsquarters and tumble mustard.

The rate of herbicide is restricted to the per acre rate limitation on the herbicide label, and the rates used in our trial are an interpretation of the 'spot treatment' section of the respective labels. Of the products used, only RT3, Sharpen, and Gramoxone Inteon had 'spot treatment' sections, and we used the maximum spot treatment rate. Under certain conditions when weed densities are high, 'spot treatment' rates will result in a per acre rate greater than the labeled broadcast rate (and therefore mitigate any savings gained by using a weed sensing sprayer). It's critical to scout before treatment and assess total per acre coverage of green plants per acre, and then determine a suitable rate based on cost savings goals and control outcomes. The threshold for weed sensing application effectiveness based on weed densities and herbicide applied is an important next step in our research to help farmers make more informed decisions about the rates of herbicides to use under specific conditions and also determine the calculated cost and return on investment.

The weed sensing sprayer was purchased through the support of the Camp Endowment and the Crop and Soil Science department.

Table 2. *Prickly lettuce, common lambsquarters and tumble mustard biomass in response to herbicides applied broadcast or through a weed sensing sprayer in Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Trt	Appl. Method	Rate*		***Jun 1, 2020 34 DAT*** **Prickly lettuce**		**Common lambsquarters**		**Tumble mustard**	
				Biomass		***Biomass***		***Biomass***	
		lb ai A^{-1}	*Field rate*	*g m^2*		*g m^2*		*g m^2*	
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00	b	0.05	a	0.14	b
RT3 AMS	Weed-It	5.30	4% v/v 8.5 lb/100 gal	0.04	b	0.40	a	0.07	b
Brox-M Agridex	Broadcast	1.00	2 pt/A 1% v/v	0.06	b	0.00	a	0.02	b
Brox-M Agridex	Weed-It	1.00	2 pt/A 1% v/v	0.22	b	0.07	a	0.00	b
Gramoxone Inteon Agridex	Broadcast	0.50	2 pt/A 1% v/v	0.17	b	0.13	a	0.34	b
Gramoxone Inteon Agridex	Weed-It	1.18	2% v/v 1% v/v	0.08	b	0.04	a	0.18	b
Sharpen RT3 MSO	Broadcast	0.03 0.75	1.5 fl oz/A 21.3 fl oz/A 1% v/v	0.00	b	0.00	a	0.00	b
Sharpen RT3 MSO	Weed-It	0.13 4.5	6 fl oz/A 21.3 fl oz/A 1% v/v	0.10	b	0.13	a	0.73	b
Liberty Agridex	Broadcast	0.53	29 fl oz/A 1% v/v	0.15	b	0.09	a	0.25	b
Liberty Agridex	Weed-It	0.53	29 fl oz/A 1% v/v	0.85	b	0.29	a	0.12	b
Nontreated				0.85	a	0.41	a	1.30	a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 3. *Density of prickly lettuce, common lambsquarters and tumble mustard in response to herbicides applied broadcast or through a weed sensing sprayer in Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Trt	Appl. Method	Rate*		Jun 1, 2020 34 DAT Prickly lettuce Density		Common lambsquarters Density		Tumble mustard Density	
		lb ai A⁻¹	*Field rate*	*plants/m²*		*plants/m²*		*plants/m²*	
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00	b	0.11	a	0.05	b
RT3 AMS	Weed-It	5.30	4% v/v 8.5 lb/100 gal	0.05	b	0.61	a	0.04	b
Brox-M COC	Broadcast	1.00	2 pt/A 1% v/v	0.07	b	0.00	a	0.01	b
Brox-M COC	Weed-It	1.00	2 pt/A 1% v/v	0.20	ab	0.09	a	0.00	b
Gramoxone Inteon COC	Broadcast	.50	2 pt/A 1% v/v	0.14	b	0.30	a	0.14	ab
Gramoxone Inteon COC	Weed-It	1.18	2% v/v 1% v/v	0.09	b	0.13	a	0.09	b
Sharpen RT3 MSO	Broadcast	0.03 0.75	1.5 fl oz/A 21.3 fl oz/A 1% v/v	0.00	b	0.00	a	0.00	b
Sharpen RT3 MSO	Weed-It	0.13 4.5	6 fl oz/A 21.3 fl oz/A 1% v/v	0.09	b	0.16	a	0.15	ab
Liberty COC	Broadcast	.53	29 fl oz/A 1% v/v	0.11	b	0.25	a	0.18	ab
Liberty COC	Weed-It	.53	29 fl oz/A 1% v/v	0.06	b	0.35	a	0.06	b
Nontreated				0.34	a	0.27	a	0.32	a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 4. *Prickly lettuce, common lambsquarters and tumble mustard percent control in response to herbicides applied broadcast or through a weed sensing sprayer in Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

				May 7th, 2020 9 DAT		
				Prickly lettuce	**Common lambsquarters**	**Tumble mustard**
Trt	**Appl. Method**	**Rate***		***Control***	***Control***	***Control***
		lb ai A^{-1}	*Field rate*	*%*	*%*	*%*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	99 a	94 a	95 a
RT3 AMS	Weed-It	5.30	4% v/v 8.5 lb/100 gal	95 ab	84 a	86 a
Brox-M Agridex	Broadcast	1.00	2 pt/A 1% v/v	91 ab	98 a	93 a
Brox-M Agridex	Weed-It	1.00	2 pt/A 1% v/v	89 ab	88 a	90 a
Gramoxone Inteon Agridex	Broadcast	0.50	2 pt/A 1% v/v	88 ab	86 a	81 a
Gramoxone Inteon Agridex	Weed-It	1.18	2% v/v 1% v/v	88 ab	90 a	89 a
Sharpen RT3 MSO	Broadcast	0.03 0.75	1.5 fl oz/A 21.3 fl oz/A 1% v/v	98 a	100 a	100 a
Sharpen RT3 MSO	Weed-It	0.13 4.5	6 fl oz/A 21.3 fl oz/A 1% v/v	84 b	83 a	83 a
Liberty Agridex	Broadcast	0.53	29 fl oz/A 1% v/v	86 ab	85 a	84 a
Liberty Agridex	Weed-It	0.53	29 fl oz/A 1% v/v	86 ab	79 a	80 a
Nontreated				0	0	0

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Season Long Fallow Weed Management Using Weed Sensing Spray Technology and Glyphosate

L.S. Fields, D. Appel, I.C. Burke

The objective of this study was to evaluate the economic savings associated with herbicide application using weed sensing spray technology compared to broadcast applications in fallow. Weed sensing spray systems operate by detection of differential reflection of chlorophyll facilitated by infrared radiation and is considered light-activated, sensor-controlled spray technology. By detecting chlorophyll in the field, weed sensing spray technologies [in this trial, a WEED-IT (www.weed-it.com)] spray only when weeds are present. Utilizing this technology in fallow can effectively reduce the cost associated with herbicide application compared to broadcast systems.

The study was established the Wilke Research and Extension Farm in Davenport, WA. Postemergence treatments were repeatedly applied to fallow ground at two different sites, one with high weed pressure, where an average of 917 mL was dispensed following the first weed sensing application (Site 1) and one with low weed pressure where an average of just 350 mL was dispensed following the first weed sensing application (Site 2), detailed in Table 1 and Table 2. The study was conducted in a randomized complete block design (RCBD) with 4 replications. Plots were 10' by 100'. Tank-mixed glyphosate (RT3), AMS and NIS were applied June 23rd by both weed sensing and broadcast sprayers at both sites. On July 27th applications were made weed sensing only at both sites. On August 17th applications were made broadcast and weed sensing at both sites.

Glyphosate (RT3) was applied at a rate of 21.3 fl oz A^{-1} along with NIS (0.25% v/v) and AMS (10 lb/100 gal) purchased at the following costs \$19.50 gal^{-1} (RT3), \$0.27 lb^{-1} (AMS), and \$33.78 gal^{-1} (NIS) for all applications. Applications by both weed sensing and broadcast sprayers were pressurized by CO_2 and calibrated to deliver 29.4 or 10 gallon per acre, respectively. Note that the weed sensing applications occur at a higher carrier volume, influencing the amount of herbicide used by the weed sensing sprayer

Following each weed sensing application, milliliters dispensed was calculated to determine the actual product output of the weed sensing spray applications.

Results

At the high weed pressure site (Site 1), application 1 cost \$4.61 A^{-1} for the broadcast and \$8.81 A^{-1} for the weed sensing application. Application 2 did not receive a broadcast application because weed pressure did not require spraying. Application 2 weed sensing cost was \$2.79 A^{-1}. Both broadcast and weed sensing applications were made for application 3 with a cost of \$4.61 A^{-1} for the broadcast and \$2.23 A^{-1} for the weed sensing (Table 3).

At the low weed pressure site (Site 2), application 1 cost \$4.61 A^{-1} for the broadcast and \$3.36 A^{-1} for the weed sensing application. Application 2 did not receive a broadcast application because weed pressure did not require spraying. Application 2 weed sensing cost was \$4.35 A^{-1}. Both broadcast and weed sensing application were made for Application 3 with a cost of \$4.61 A^{-1} for the broadcast and \$4.44 A^{-1} for the weed sensing application (Table 3).

The cost for each application were summed to determine the total season long herbicide cost. The total cost for all broadcast applications was \$9.22 A^{-1} and the total cost for all weed sensing applications at Site was \$13.83 A^{-1} and \$12.15 A^{-1} at site 2. Despite the spot spraying action of the weed sensing sprayer, costs associated with herbicide application was still higher than when broadcast applied.

Significantly, substantially higher rates of herbicide was applied to each weed treated using the weed-sensing sprayer, and little herbicide was applied to bare ground. Although weed sensing applications are most effective at reducing costs when weed pressure is low, increasing the overall dose of herbicide to each weed treated is an additional benefit. Initial broadcast application followed by weed sensing applications mid-season would likely help to reduce herbicide costs when compared to reliance on weed sensing applications for the entire season, as would using similar rates of herbicide in the weed sensing sprayer. Carefully selecting the rate of herbicide and also scouting the area to be treated for percent cover of weeds would facilitate a balanced decision on herbicide rate, efficacy, and overall operational costs.

The weed sensing sprayer was purchased through the support of the Camp Endowment and the Crop and Soil Science department.

Table 1. *Weed sensing & broadcast application details for the high weed pressure site*

Study application	*Application 1*		*Application 2*		*Application 3*	
Date	June 23rd	June 23rd	July 27th	July 27th	August 17th	August 17th
Application method	Weed sensing	Broadcast	Weed sensing	Broadcast	Weed sensing	Broadcast
Weed size (in)	6 - 12	6 - 12	6 - 12	6 - 12	6 - 12	6 - 12
Air temperature (F)	72	72	76.7	76.7	84	84
Soil temperature (F)	70	70	72	72	76	76
Relative humidity (%)	50	50	30	30	30	30
Wind velocity (mph, direction)	5, S	5, S	6, NE	6, NE	6.4, S	6.4, S
Cloud cover	30%	30%	30%	30%	30%	30%

Table 2. *Weed sensing & broadcast application details for the low weed pressure site*

Study application	*Application 1*		*Application 2*		*Application 3*	
Date	June 23rd	June 23rd	July 27th	July 27th	August 17th	August 17th
Application method	Weed sensing	Broadcast	Weed sensing	Broadcast	Weed sensing	Broadcast
Weed size (in)	6 - 12	6 - 12	6 - 12	6 - 12	6 - 12	6 - 12
Air temperature (F)	72	72	76.7	76.7	84	84
Soil temperature (F)	70	70	72	72	76	76
Relative humidity (%)	50	50	30	30	30	30
Wind velocity (mph, direction)	5, S	5, S	6, NE	6, NE	6.4, S	6.4, S
Cloud cover	30%	30%	30%	30%	30%	30%

Table 3. *Weed sensing and broadcast application cost analysis per acre for each application*

Site	Weed pressure	Application method	***Application 1*** *June 23rd, 2020* Output	Cost	***Application 2*** *July 27th, 2020* Output	Cost	***Application 3*** *August 17th, 2020* Output	Cost	***Total*** Cost
			GPA	*\$ A^{-1}*	*GPA*	*\$ A^{-1}*	*GPA*	*\$ A^{-1}*	*\$ A^{-1}*
1	High	Broadcast	15	4.61	0	0	15	4.61	9.22
1	High	Weed sensing	10.6	8.81	3.34	2.79	2.7	2.23	13.83
2	Low	Broadcast	15	4.61	0	0	15	4.61	9.22
2	Low	Weed sensing	4	3.36	5.21	4.35	5.3	4.44	12.15

Figure 1. *Site 1 broadcast plot weed pressure 7 DAT (8/24/20)*

Figure 2. *Site 1 weed sensing plot weed pressure 7 DAT (8/24/20)*

Figure 3. *Site 2 broadcast plot weed pressure 7 DAT (8/24/20)*

Figure 4. *Site 2 weed sensing plot weed pressure 7 DAT 8/24/20)*

Postemergence Weed Management in Fallow Using Weed Sensing Spray Technology: Tank Mixes and Organic Herbicides

L.S. Fields, D. Appel, I.C. Burke

The objective of this study was to evaluate the efficacy of using weed sensing spray technology compared to broadcast application of multiple herbicides to combat troublesome weeds in fallow. This study had an emphasis on tank mixes involving saflufenacil as well as an organic herbicide, Suppress, comprised of capric and caprylic acids. The sprayer tested operates by detection of differential reflection of chlorophyll facilitated by infrared radiation and is considered a light-activated, sensor-controlled spray technology. By detecting chlorophyll in the field, weed sensing spray technologies [in this study, a WEED-IT (www.weed-it.com)] spray only when weeds are present and thus reduce the amount of herbicide used per application or per area. Utilizing this technology in fallow rotations can effectively reduce the cost associated with herbicide application and improve application accuracy when compared to broadcast systems.

The study was established at two sites, one at the Wilke Research and Extension Farm in Davenport, WA (Trial 1) and one in Ralston, WA (Trial 2). Postemergence treatments were applied to fallow ground with weed pressure, where most weeds ranged from roughly 6 to 24 inches for both trials, detailed in Table 1 and Table 2. Plots were 10' by 30' long. Herbicides were applied on June 24th (Trial 1) and July 9th (Trial 2), both by weed sensing and broadcast sprayers. Both sprayers pressurized by CO_2 and calibrated to deliver 29.4 gallons per acre. Following each weed sensing application, the milliliters dispensed was calculated and compared with the milliliters dispensed from broadcast applications. At site 1, prickly lettuce *(Lactuca serriola),* common lambsquarters *(Chenopodium album)* and tumble mustard *(Sysimbrium altissimum)* were the predominant weed species present at the time of application. At site 2 prickly lettuce *(Lactuca serriola)*, Russian thistle *(Salsola tragus)* and tumble pigweed *(Amaranthus albus)* were the predominant weed species present at the time of application. Weed control was quantified visually as percent control 7 days after treatment (7 DAT) and weed counts were taken 34 DAT along with biomass for dry weight measurements for both trials.

Table 1. *Weed sensing and broadcast application details for Trial 1 and Trial 2.*

Study application	*Trial 1*		*Trial 2*	
Date	June 24th	June 24th	July 9th	July 9th
Application method	Weed sensing	Broadcast	Weed sensing	Broadcast
Weed size (in)	12	12	6 - 12	6 - 12
Air temperature (F)	70	70	63	63
Soil temperature (F)	50	50	68	68
Relative humidity (%)	59	59	50	50
Wind velocity (mph, direction)	7, SW	7, SW	7, N	7, N
Cloud cover	0%	0%	15%	15%

Results: Site 1

RT3 applied weed sensing effectively controlled prickly lettuce (0 g m^{-2}, 0 plants m^{-2}) and tumble mustard (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control being only 47.5% (prickly lettuce) and 83.8% (tumble mustard) 7 DAT. Though RT3 broadcast applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 2, Table 3, Table 4).

Gramoxone applied broadcast effectively controlled common lambsquarters (0 g m^{-2}, 0 plants m^{-2}) and tumble mustard (0 g m^{-2}, 0 plants m^{-2}) 34 DAT. Prickly lettuce biomass following Gramoxone broadcast application was 0.010 g m^{-2} and density was 0.009 plants m^{-2} 34 DAT despite having a 100% control rating 7 DAT. Though Gramoxone weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 2, Table 3, Table 4).

Sharpen and RT3 effectively controlled all 3 predominant species when applied both broadcast and weed sensing. All biomass and density values are 0, 34 DAT (Table 2, Table 3, Table 4).

Liberty and Sharpen effectively controlled all 3 predominant species when applied both broadcast and weed sensing, though common lambsquarter biomass was 0.053 g m^{-2} and density was 0.027 plants m^{-2} 34 days after broadcast application. Despite there being common lambsquarters present 34 DAT, such was not significant when comparing broadcast and weed sensing applications (Table 2, Table 3, Table 4).

The organic herbicide, Suppress, did not effectively control any of the 3 target species. There was a significant difference in % control 7 DAT when comparing broadcast and weed sensing applications for all 3 predominant weed species. Suppress applied weed sensing % control was consistently higher compared to that of broadcast for all 3 species (Table 4). Biomass g m^{-2} and density # m^{-2} for all 3 species was not significantly different when comparing broadcast and weed sensing applications (Table 2, Table 3, Table 4).

Effect of broadcast vs. weed sensing application was assessed with a focus on the predominant weed species present in the study area. According to the density # m^{-2} and biomass g m^{-2} harvested 34 DAT, applicator and herbicide treatment does not have an effect as all treatments were not significantly different (nontreated excluded) for trial 1.

Results: Site 2

RT3 applied broadcast effectively controlled prickly lettuce (0 g m^{-2}, 0 plants m^{-2}) and tumble pigweed (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control only being 30% (prickly lettuce), though tumble pigweed control was 92.5%. Russian thistle biomass 34 days after broadcast applications was 0.005 g m^{-2} and density was just 0.009 plants m^{-2}. Though RT3 weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications (Table 5, Table 6, Table 7).

Unlike at site 1, where Gramoxone effectively controlled 2 of the 3 species when applied broadcast (Table 2, Table 3), at site 2 only tumble pigweed was effectively controlled 34 DAT (Table 5, Table 6). Though Gramoxone weed sensing applications did not control any of the 3 species 100%, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications for prickly lettuce and Russian thistle (Table 5, Table 6, Table 7). There was a significant difference between Gramoxone applied weed sensing compared to broadcast for tumble pigweed % control (Table 7).

Unlike site 1, where Sharpen and RT3 effectively controlled all 3 predominant species, at site 2, only prickly lettuce was effectively controlled following weed sensing application (Table 5, Table 6). Though prickly lettuce was the only species effectively controlled for both application methods, biomass g m^{-2}, density # m^{-2} and % control was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7).

Unlike site 1, where Liberty and Sharpen effectively controlled all 3 predominant species, at site 2, only prickly lettuce was effectively controlled following weed sensing application (Table 5, Table 6). Though prickly lettuce was the only species effectively controlled for both application methods, biomass g m^{-2}, density # m^{-2} and % control of prickly lettuce and Russian thistle was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7). There was a significant difference between Liberty and Sharpen applied weed sensing compared to broadcast for tumble pigweed % control (Table 7).

Suppress was effective at controlling prickly lettuce when applied weed sensing (0 g m^{-2}, 0 plants m^{-2}) 34 DAT, despite % control being just 25% 7 DAT. Though prickly lettuce was the only species controlled, biomass g m^{-2}, density # m^{-2} and % control of all 3 predominant species was not significantly different when comparing weed sensing and broadcast applications for all treatments (Table 5, Table 6, Table 7).

In this trial Gramoxone applied weed sensing was significantly different when compared to Gramoxone applied broadcast, where % control values were consistently higher following broadcast application 7 DAT for tumble pigweed. There was also a significant difference between Liberty and Sharpen weed sensing application compared to broadcast, where % control was consistently higher following broadcast applications 7 DAT (Table 7).

Weed sensing applications are as effective as broadcast applications at controlling prickly lettuce, Russian thistle, and tumble pigweed, with he exception of tumble pigweed control following weed sensing applications of both Gramoxone and Liberty and Sharpen. Future trials should investigate more tumble pigweed control utilizing weed sensing spray technology and Gramoxone and Liberty and Sharpen. Future trials should investigate additional herbicides and tank mixes to test their effectiveness at controlling problem weed species common to fallow. The threshold for weed sensing application effectiveness based on weed densities and herbicide applied should also be investigated.

The weed sensing sprayer was purchased through the support of the Camp Endowment and the Crop and Soil Science department.

Table 2. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard biomass. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		***July 28th, 2020 34 DAT*** **Prickly lettuce**	**Common lambsquarters**	**Tumble mustard**
				Biomass	***Biomass***	***Biomass***
		lb ai A^{-1}	*Field rate*	*g m^2*	*g m^2*	*g m^2*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.09 b	0.05 b	1.67 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00 b	0.53 b	0.00 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.01 b	0.00 b	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.33 b	1.32 b	2.03 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 b	0.00 b	0.00 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.05 b	0.00 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 b	0.00 b	0.00 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.44 b	1.21 b	6.72 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.52 b	1.29 b	1.24 a
Nontreated				2.42 a	5.28 a	10.84 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 3. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard density. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		July 28th, 2020 34 DAT Prickly lettuce Density		Common lambsquarters Density		Tumble mustard Density	
		lb ai A⁻¹	*Field rate*	*plants m²*		*plants m²*		*plants m²*	
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.01	b	0.01	b	0.02	a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00	b	0.19	b	0.00	a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.01	b	0.00	b	0.00	a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.04	b	0.11	b	0.11	a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00	b	0.00	b	0.00	a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00	b	0.00	b	0.00	a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00	b	0.03	b	0.00	a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00	b	0.00	b	0.00	a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.03	b	0.05	b	0.09	a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.07	b	0.08	b	0.05	a
Nontreated				0.22	a	0.43	a	0.20	a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 4. *Weed sensing vs. broadcast effect on prickly lettuce, common lambsquarters and tumble mustard % control. Davenport, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	**Application Method**	**Rate***		***July 1st, 2020 7 DAT*** **Prickly lettuce** *Control*	**Common lambsquarters** *Control*	**Tumble mustard** *Control*
		lb ai A^{-1}	*Field rate*	*%*	*%*	*%*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	53 b	79 bc	98 b
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	48 b	75 bc	84 bc
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	100 a	100 ab	99 ab
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	93 a	84 abc	85 ab
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	99 ab	99 ab
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	100 ab	100 ab
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	100 a	100 a	100 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	100 a	100 ab	100 ab
Suppress	Broadcast	6% v/v	115 fl oz/A	43 b	50 c	56 c
Suppress	Weed-It	6% v/v	115 fl oz/A	84 a	75 bc	89 ab
Nontreated				0 c	0 d	0 d

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 5. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed biomass. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

				August 12th, 2020 34 DAT		
				Prickly lettuce	**Russian thistle**	**Tumble pigweed**
Treatment	**Application Method**	**Rate***		***Biomass***	***Biomass***	***Biomass***
		lb ai A^{-1}	*Field rate*	*g m^2*	*g m^2*	*g m^2*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.00 a	0.01 a	0.00 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.23 a	1.75 a	0.19 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.38 a	1.44 a	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.08 a	2.11 a	0.30 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.02 a	0.49 a	0.03 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 a	0.85 a	0.85 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.09 a	1.99 a	1.82 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 a	7.11 a	0.70 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.55 a	7.16 a	3.09 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.00 a	7.35 a	1.85 a
Nontreated				0.30 a	8.56 a	3.00 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 6. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed density. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		***August 12th, 2020 34 DAT*** Prickly lettuce	Russian thistle	Tumble pigweed
				Biomass	***Biomass***	***Biomass***
		lb ai A⁻¹	*Field rate*	*plants m²*	*plants m²*	*plants m²*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	0 a	0.01 a	0.00 a
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	0.04 a	0.20 a	0.02 a
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	0.04 a	0.06 a	0.00 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	0.03 a	0.11 a	0.06 a
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.01 a	0.06 a	0.01 a
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	0.00 a	0.24 a	0.10 a
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.01 a	0.14 a	0.19 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	0.00 a	0.23 a	0.05 a
Suppress	Broadcast	6% v/v	115 fl oz/A	0.01 a	0.26 a	0.28 a
Suppress	Weed-It	6% v/v	115 fl oz/A	0.00 a	0.34 a	0.40 a
Nontreated				0.02 a	0.25 a	0.07 a

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Table 7. *Weed sensing vs. broadcast effect on prickly lettuce, Russian thistle and tumble pigweed % control. Ralston, WA 2020. Means followed by the same letter are not significantly different (α=0.05).*

Treatment	Application Method	Rate*		*July 16th, 2020 7 DAT* Prickly lettuce *Control*	Russian thistle *Control*	Tumble pigweed *Control*
		lb ai A^{-1}	*Field rate*	*%*	*%*	*%*
RT3 AMS	Broadcast	0.75	21.3 fl oz/A 8.5 lb/100 gal	30 a	33 ab	93 b
RT3 AMS	Weed-It	0.75	21.3 fl oz/A 8.5 lb/100 gal	16 a	8 b	- b
Gramoxone Inteon Agridex	Broadcast	0.5	2 pt/A 1% v/v	98 a	87 a	98 a
Gramoxone Inteon Agridex	Weed-It	0.5	2 pt/A 1% v/v	25 a	49 ab	70 b
Sharpen RT3 MSO	Broadcast	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	100 a	89 a	100 ab
Sharpen RT3 MSO	Weed-It	0.0334 0.75	1.5 fl oz/A 21.3 fl oz/A 1 % v/v	49 ab	38 ab	45 b
Liberty Sharpen Agridex	Broadcast	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	93 a	89 a	100 a
Liberty Sharpen Agridex	Weed-It	0.53 0.0044	29 fl oz/A 0.198 fl oz/A 1% v/v	33 a	69 ab	80 b
Suppress	Broadcast	6% v/v	115 fl oz/A	30 a	21 b	8 b
Suppress	Weed-It	6% v/v	115 fl oz/A	25 a	18 b	15 b
Nontreated				19 a	18 b	0 b

*For the broadcast treatments, the rate noted is the rate applied. For the treatments applied through the weed sensing sprayer, the rate listed is the equivalent broadcast rate. The actual rate applied is dependent on weed density and is much lower

Application of the WEED-IT precision sprayer for rush skeletonweed control in fallow

Mark Thorne, Jacob Fisher, Henry Wetzel, and Drew Lyon

Precision sprayers can be cost-effective tools in fallow management by applying herbicides only to weeds and not to bare ground. This can be especially important when applying high-cost herbicides or herbicides with long residual. Tordon® 22K (picloram) is an effective herbicide for control of rush skeletonweed (*Chondrilla juncea*) (Figure 1), however, there is concern that its long residual may cause yield loss. Tordon 22K is labeled for fallow applications at 16 oz/A, but in the past, it was used as a spot-spray treatment for field bindweed (a.k.a. morningglory) at rates that caused substantial yield reduction for several years following application. By using a precision applicator, the overall acreage sprayed should be less than by using a conventional broadcast sprayer; however, since rush skeletonweed is a spreading perennial, it is not clear if a precision spray application will be effective.

Figure 1. Rush skeletonweed in winter wheat one year after post-harvest Tordon 22K applications. Photo on the left is 8 oz/A; photo on right is 16 oz/A.

We initiated a trial in 2019 comparing applications of Tordon 22K using a WEED-IT precision sprayer with standard broadcast applications for rush skeletonweed control in no-till fallow. Tordon 22K was applied at 8, 16, and 32 oz/A using each application method on October 3, 2019 to rush skeletonweed in winter wheat stubble following the 2019 harvest at a field site near Hay, WA. Soil type at the site is classified as a Walla Walla silt loam, 7-25% slope, and has a pH of 6.1 and 2.1% organic matter. The WEED-IT was calibrated to apply 29.4 gpa at 5 mph if all nozzles were spraying continuously. The broadcast applications were applied at 15 gpa at 3 mph. The plots measured 10 by 35 ft, but the WEED-IT applicator only sprayed a width of 6.7 ft. The field site was managed in no-till fallow through 2020 and fall-seeded to winter wheat. Treatment efficacy was evaluated with plant density counts on April 15, 2020 in the fallow, and on October 22, 2020 in the newly emerged winter wheat crop.

Rush skeletonweed density differed across the site, therefore, each WEED-IT application would cover an area in relation to the density in each plot. The percentage of area sprayed by the WEED-IT sprayer in relation to the total area covered, was 51, 26, and 28%, for the 8, 16, and 32 oz/A rates, respectively, which translates to 4.1, 4.2, and 9.1 oz/A of actual product for each respective rate. (Table 1).

Table 1. Area sprayed and amount of Tordon 22K applied with a WEED-IT precision sprayer compared with a standard broadcast application.

Tordon 22K applied using the broadcast rate	Percent of total area sprayed with the WEED-IT sprayer	Actual product applied using WEED-IT at each rate
oz/A	%	oz/A
8	52	4.1
16	27	4.3
32	29	9.2

By April 2020, all treatments had statistically fewer plants than the nontreated check that averaged 1.5 plants/yd^2, and no statistical differences were found between the WEED-IT and broadcast applications (Table 2). By October, density in the nontreated check had increased to 2.5 plants/yd^2 but was not statistically different from either the WEED-IT or broadcast application of Tordon 22K at 8 oz/A. In contrast, densities for the 16 and 32 oz/A treatments were not statistically different from each other but were less than the 8 oz/A rate and the nontreated check. No statistical difference was found between the WEED-IT and broadcast applications at any of the three rates (Table 2).

This study indicates that applications of Tordon 22K with a precision sprayer can be equally effective compared with broadcast applications for control of rush skeletonweed through the fallow phase of the wheat/fallow rotation. Furthermore, the labeled 16 oz/A rate appears to be as effective as a 32 oz/A rate; however, cutting the labeled rate in half does not control rush skeletonweed completely through the fallow year. These treatments will be evaluated in 2021 for effect on winter wheat yield.

Table 2. Effect of Tordon 22K applications in no-till fallow on rush skeletonweed density.

		Rush skeletonweed density*	
Application method	Rate	April 15, 2020	October 22, 2020
	oz/A	------------plants/yd^2------------	
Nontreated check	0	1.5 a	2.5 a
WEED-IT	8	0.2 b	1.9 a
Broadcast	8	0.1 b	3.2 a
WEED-IT	16	0.1 b	0.8 b
Broadcast	16	0.0 b	0.7 b
WEED-IT	32	0. 1 b	0.4 b
Broadcast	32	0.0 b	0.2 b

*Means are based on four replicates per treatment. Means within each column followed by the same letter are not significantly different at the 95% probability level, which means that we are not confident that the difference is the result of treatment rather than experimental error or random variation associated with the experiment.

Rush skeletonweed control in no-till fallow

Mark Thorne and Drew Lyon

Rush skeletonweed (*Chondrilla juncea*) on land enrolled in the Conservation Reserve Program (CRP) is difficult to control after farming resumes. In the wheat/fallow cropping areas of eastern Washington, rush skeletonweed flourishes during the fallow phase of the rotation in the absence of winter wheat competition, and herbicide applications for weed control in the fallow phase have not been effective (Figure 1). Rush skeletonweed is a deep-rooted perennial that spreads by seed and rhizomes. Furthermore, few new herbicide chemistries for rush skeletonweed control in fallow or crop have been labeled in the past 40 years. Therefore, effective control must rely on older herbicides and strategic management practices.

Figure 1. Rush skeletonweed persisting in no-till fallow near Hay, WA following standard herbicide applications for no-till fallow weed control.

Trials were initiated on October 8, 2018 at sites near Hay and LaCrosse, WA. Both sites had standing winter wheat stubble from the 2018 harvest. Soil at the Hay site was a Walla Walla silt loam, 7-25% slope, with a pH of 6.0 and 3.1% organic matter, and was near 1800 ft in elevation.

Soil at the LaCrosse site was a Benge Complex silt loam, 0-15% slope, with a pH of 6.6 and 2.3% organic matter, and was 1480 ft in elevation. Initial rush skeletonweed density at the Hay site averaged 1.6 plants/yd^2 while the LaCrosse site averaged 3.2 plants/yd^2. Herbicides were applied at three different times, which included autumn following harvest when plants were near the end of flowering, early spring when plants were only in the rosette stage, and early summer when plants had started to bolt. Autumn applications were applied on October 8, 2018 at both sites. The LaCrosse site had experienced a hard freeze of 22° F on October 3, five days before the autumn applications, and bolted stems were beginning to senesce at the time of application. At the Hay site, temperatures had stayed above freezing and plants were still green and flowering. Spring treatments were applied April 18, 2019 to rosettes. Furthermore, at the spring application timing, all plots except for the 64 oz/A RT® 3 (glyphosate) treatment, were sprayed with 24 oz/A of RT 3 to control volunteer crop and winter annual weeds. Temperatures remained above freezing at both sites for at least five days after application. Summer applications were applied June 5, 2019 when plants were bolting.

Overall, the autumn applications of Tordon® 22K (picloram) and the spring applications of Stinger® (clopyralid) and Milestone® (aminopyralid) were most effective in reducing rush skeletonweed density (Table 1). At Hay, however, the only treatment statistically different from the 1.3 plants/yd^2 density of the RT 3 check was the spring application of Milestone, which averaged 0.4 plants/yd^2. At LaCrosse, the spring applications of Stinger and Milestone resulted in the lowest densities of 0.2 and 0.4 plants/yd^2, respectively (Table 1). However, at LaCrosse, the autumn applications of Stinger or Milestone, each followed by the summer application of 2,4-D LV6 were not statistically different from the Tordon 22K application. It was not evident that the summer applications of 2,4-D LV6 at bolting were effective. The least effective treatments, overall, were the autumn application of RT 3/2,4-D LV6 fb 2,4-D LV6 treatment and the spring application of 64 oz/A of RT 3 fb 2,4-D LV6. Autumn applications of Curtail® (clopyralid + 2,4-D) or Curtail/Finesse® (chlorsulfuron + metsulfuron) were also not effective. Furthermore, autumn applications, except for RT 3/2,4-D LV6, were less effective at the Hay site than at LaCrosse. This is likely a result of the Hay site not getting a frost just prior to application. The elevation and topography at the Hay site did not facilitate the accumulation of cold air from cold-air drainage that caused the hard freeze at the LaCrosse site. Other researchers have shown that frosts in autumn change the structure of storage carbohydrates going into roots of plants in the Asteraceae family, like rush skeletonweed, which results in better herbicide movement of certain herbicides into the roots. It is likely that Tordon 22K at Hay would have been more effective had there been a frost ahead of the autumn applications. Although the hard freeze at LaCrosse likely caused the plants to alter their carbohydrate structure going into the roots, the damage from the extreme cold likely reduced the amount of movement into the roots. In contrast, spring frosts at, or shortly after, application can reduce herbicide efficacy. Both sites had above freezing temperatures for at least a week following applications, which was reflected by good control through the fallow phase from the spring applications of Stinger and Milestone.

Wheat yields were above historical averages at both locations (Figure 2). The RT 3 check treatments averaged 98 and 78 bu/A at LaCrosse and Hay, respectively (Table 1). At LaCrosse, the only treatments statistically different from the RT 3 check was the autumn application of

Milestone fb 2,4-D LV6, which yielded 87 bu/A, and the spring application of Milestone/RT 3, which yielded 86 bu/A, which were lower in yield than the RT 3 check. At Hay, the only treatment statistically different from the RT 3 check was Tordon 22K, which yield 86 bu/A, and was statistically greater than the RT 3 check. At either site, Tordon 22K did not cause visible crop injury symptoms or reduced yields. Tordon 22K has long been known as an effective herbicide for rush skeletonweed control; however, in the past it has been applied at high rates for field bindweed (a.k.a. morningglory) control and its long soil residual activity caused crop damage.

Figure 2. Rush skeletonweed trial in a 90-100 bu/A winter wheat crop near LaCrosse, WA.

Rush skeletonweed control in wheat/fallow cropping systems will require long-term and careful planning. An autumn application of Tordon 22K or spring applications of Stinger may be one part of the overall strategy, however, timing of these applications with relation to frosts or freezes is critical. Milestone is not currently labeled for use in fallow or crop, but at the rate applied, appears to be as effective as Stinger. In contrast, applications of RT 3 specifically for rush skeletonweed control appear to be ineffective. Control, or good suppression, in the fallow phase is one component of an overall management plan. Following up with a vigorous, competitive stand of winter wheat and effective herbicide treatments in the crop phase is also important, and it may take several rotation cycles to substantially reduce or eradicate rush skeletonweed in the infested wheat/fallow cropping areas.

See next page for Table 1.

Table 1. Effect of fallow treatments on rush skeletonweed density and wheat yield at LaCrosse and Hay, WA.

				Rush skeletonweed density***		Wheat yield****	
#	Treatment*	Rate	Time**	LaCrosse	Hay	LaCrosse	Hay
		oz/A		----plants/yd^2----		------bu/A------	
1	Stinger	10.7	Au	0.9 bc	1.8 ab	89	79
2	Milestone	1.2	Au	1.3 ab	0.9 bcde	91	82
3	Stinger fb 2,4-D LV6	10.7 fb 43	Au fb Su	0.6 cd	2.4 a	96	80
4	Milestone fb 2,4-D LV6	1.2 fb 43	Au fb Su	0.6 cd	2.2 a	87§	81
5	Curtail	64	Au	1.3 ab	2.2 a	94	82
6	Curtail/Finesse	32/0.4	Au	0.9 bc	2.0 a	100	78
7	Tordon 22K	16	Au	0.3 de	0.8 cde	90	86§
8	RT3/2,4-D LV6 fb 2,4-D LV6	64/43 fb 43	Au fb Su	2.0 a	1.6 abc	98	75
9	Stinger/RT 3	10.7/24	Sp	0.2 e	0.5 de	96	72
10	Milestone/RT 3	1.2/24	Sp	0.4 de	0.4 e	86§	77
11	RT 3 fb 2,4-D LV6	64 fb 43	Sp fb Su	1.4 ab	1.8 abc	96	83
12	RT 3 check	24	Sp	1.5 a	1.3 abcd	98	78

*Applications of Milestone and Finesse included non-ionic surfactant at 0.25% v/v.
All RT 3 applications included ammonium sulfate at 18 lb/100 gal.
"fb"=first treatment followed by a second treatment.
**Au=Autumn 2018, Sp=Spring 2019, Su=Summer2019.
**Density was measured in May 2020 in the winter wheat crop. Means are based on four replicates per treatment. Plant density means within a column for each location followed by the same letter are not significantly different at the 95% probability level, 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.
****Yield means followed by a § symbol are statistically different, either lower or higher, from the RT 3 check at the 95% probability level.

Comparison of surfactants aiding glyphosate uptake in smooth scouringrush

Mark Thorne and Drew Lyon

Control of smooth scouringrush (*Equisetum laevigatum*) with glyphosate has not been successful, especially at rates applied for general weed control in no-till fallow management (Figure 1). Smooth scouringrush has expanded its range in eastern Washington through the past two decades, especially where no-till cropping systems are practiced. It has long been known that chlorsulfuron, one of the active ingredients in Finesse® (chlorsulfuron + metsulfuron), will control smooth scouringrush for several years after application, but chlorsulfuron cannot be used in cropping systems where sulfonylurea-sensitive crops are grown, such as pulses and most canola cultivars. We have recently found that the addition of Silwet® L77 organosilicone surfactant with RT® 3 (glyphosate) applied at 96 oz/A in fallow has substantially reduced smooth scouringrush density in the following winter wheat crop. In other research, it has been shown that Silwet L77 aids the uptake of glyphosate through open stomates as opposed to through the plant epidermis layer. This may explain how Silwet L77 is facilitating the efficacy of RT 3 in smooth scouringrush in our research. However, there is some uncertainty as to the future availability of Silwet L77 in the Pacific Northwest. Kinetic® organosilicone surfactant has been presented as a replacement, but it is uncertain if Kinetic will be as effective as Silwet L77 for smooth scouringrush control. Wetcit®, a citrus acid alcohol-based surfactant has also been effective in facilitating uptake of RT 3 in smooth scouringrush. This study compares the efficacy of Kinetic and Wetcit with Silwet L77 surfactants applied with RT 3 at 96 oz/A for control of smooth scouringrush. Furthermore, these treatments are applied both during the day when stomates are open, and at night when they are mostly closed. Better efficacy with daytime applications may suggest that uptake is occurring through the open stomates.

Figure 1. Smooth scouringrush on a NW-facing slope in no-till fallow near Rosalia, WA.

The study site is on a northwest-facing slope on the Seagle farm near Rosalia, WA. The site was in no-till fallow at the time of application and was planted to winter wheat in October 2020. Soil type is a Neff-Garfield complex with 15-25% slope and a silt loam texture and has a pH of 5.9 and organic matter of 2.7%. Plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. All herbicide treatments were applied on July 6, 2020 with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. Spray output was 15 gpa at 25 psi. The RT 3 applications were applied at 96 oz/A, Finesse was applied at 0.5 oz/A, Silwet L77 and Kinetic were applied at 0.5% v/v, and Wetcit was applied at 0.78% v/v. Initial smooth scouringrush density averaged 282 stems/yd^2. Daytime treatments were applied between 12:00 and 12:30 p.m. Nighttime applications were between 9:40 and 10:00 p.m. Nightime applications were initiated after all surrounding WSU Ag WeatherNet stations reported 0 watts/$meter^2$ solar radiation. Visibility during nightime applications was aided by the use of a small light attached to a hat brim. Soil temperature at 2 inch depth was 67° F during the daytime applications, and 72° during the nightime applications.

Visual ratings of herbicide control were made 30 and 60 days after treatment (DAT). At 30 DAT, very little stem discoloration or height difference could be seen between treated plots and the nontreated check plots. (Table 1). This is not uncommon for applications on north-facing slopes (personal observations) where temperatures may be cooler and solar radiation less direct than on flats or southern exposures. At 30 DAT, rating for the daytime applition of RT 3 with Silwet L77 was statistically greater than all other treatments, but only averaged 17% injury compared with the nontreated check (Table 1). Both the nighttime application of RT 3 with Silwet L77 and the daytime application of RT 3 with Kinetic averaged 11% control; however the nightime application with Kinetic average only 6% control and was statistically less effective than the daytime application. By 60 DAT, control symptoms were more visible and included stem yellowing and stunted growth (Figure 2). There was no statistical difference between daytime applications with Silwet L77, Kinetic, or Wetcit. Both nightime applications of RT 3 with Silwet L77 or Kinetic were less effective than their corresponding daytime applications; however, there was no statistical difference between the day or night applications of Wetcit (Table 1). Very little symptoms were seen with either day or night applications of RT 3 alone or with Finesse. Finesse was included as a reference treatment for comparison during the 2021 crop year because of its known effectiveness in controlling smooth scouringrush; however, it does not cause considerable stem injury symptoms during the year of application.

Visual assessments indicate that Kinetic may be as effective as Silwet L77 in aiding uptake of RT 3, and that applications of these two treatements during the day are more effective than during night when stomates are closed. However, the lack of difference between day and night applications of RT 3 with Wetcit suggests it may be facilitating a different mechanism of RT 3 uptake than through open stomates. Stem density measurements in the 2021 wheat crop will fully demonstrate the efficacy of these applications.

See next page for Table 1.

Table 1. Visual control rating of smooth scouringrush following herbicides applications comparing three surfactants in no-till fallow.

#	Herbicide	Surfactant	Timing	Visual control ratings*	
				30 DAT	60 DAT
				percent of check	
1	Nontreated check	---	---	0	0
2	RT 3	none	day	5 c	23 de
3	RT 3	none	night	5 c	20 de
4	RT 3	Silwet L77	day	17 a	47 a
5	RT 3	Silwet L77	night	11 b	27 cd
6	RT 3	Kinetic	day	11 b	40 ab
7	RT 3	Kinetic	night	6 c	22 de
8	RT 3	Wetcit	day	9 bc	40 ab
9	RT 3	Wetcit	night	7 bc	32 bc
10	Finesse	Silwet L77	day	5 c	18 e

*Means are based on four replicates per treatment. Means within each column followed by the same letter are not significantly different at the 95% probability level, 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.

Figure 2. Smooth scouringrush stem yellowing from application of RT 3 plus Silwet L77.

Efficacy of Silwet® L77 organosilicone surfactant with RT® 3 glyphosate applied in no-till fallow for control of smooth scouringrush in the following winter wheat crop.

Mark Thorne and Drew Lyon

Control of smooth scouringrush (*Equisetum laevigatum*) in fallow has been a challenge for producers, especially in no-till systems (Figure 1). Standard fallow applications of glyphosate containing herbicides, such as RT 3, have mostly been ineffective. Applications of synthetic auxin herbicides, such as MCPA or 2,4-D, will quickly turn stems black but do not reduce the presence or abundance of smooth scouringrush in the following year. Smooth scouringrush is an ancient species dating back about 350 million years. It is unique among land plants in that it has no leaves, and its stems contain a high concentration of silica compared with most other plants. Smooth scouringrush is also a very deep-rooted plant with extensive vertical rhizomes. Previous research has shown that the organosilicone surfactant Silwet L77 increases glyphosate uptake by mass flow through the stomates as opposed to movement through the stem epidermis. This report follows up on treatments that were applied in fallow in 2019.

Figure 1. Dense patches of smooth scouringrush in fallow near Steptoe, WA.

Trial locations were at the Palouse Conservation Field Station (PCFS) near Pullman, WA, the Hall farm near Steptoe, WA, and the Camp farm near Edwall, WA. Soil pH and organic matter was 5.1 and 3.3% at PCFS, 5.0 and 2.7% at Steptoe, and 5.0 and 2.9% at Edwall, respectively. Initial densities in 2019 averaged 67, 125, and 370, stems/yd^2 at Edwall, PCFS, and Steptoe, respectively. All treatments were applied in 2019 near the end of each month from May through August, except for the first application at Steptoe, which was applied June 11, 2019. Experimental design was a split-plot randomized complete block, with three sub-plot treatments per main plot, and four application times. Main plots were the application times and the sub-plot treatments were the herbicide treatments of RT 3 with no added surfactant, RT 3 with Silwet L77, and no herbicide. Main-plots at Steptoe and Edwall measured 10 by 30 ft with sub-plots measuring 10 by 10 ft. Due to limited area, PCFS main plots were 6.7 by 15 ft with 6.7- by 5-ft sub-plots. Herbicides were applied with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. At PCFS, two of the six nozzles were blocked to accommodate the narrower plot width. Spray output was 15 gpa at 25 psi. In July 2020, all treatments were assessed in the winter wheat crop, approximately a year after the herbicide applications, by counting stems in sample quadrats in each sub-plot. Stem density is presented as stems/yd^2 (Table 1).

Smooth scouringrush density at each location differed in response to herbicide treatment and timing of application. Furthermore, each location differed in its topography and aspect. The PCFS location had a south exposure and was located at the bottom of a gentle slope. This location was the warmest of the three and had warmer soil temperatures at each application time. The Edwall site was in a northwest-facing draw with a gentle slope and moist soil much of the year. The Steptoe site was on a steep north-facing slope. These differences likely had an impact on the growth of the plants, and possibly the efficacy of the treatments.

Figure 2. Effect of RT 3 + Silwet L77 (foreground) vs. RT 3 alone and no herbicide one year after treatment.

Applications of RT 3 + Silwet L77 resulted in fewer stems than RT 3 alone (Figure 2) at all locations and application times, except for the May application at PCFS (Table 1). The May PCFS applications of RT 3 alone and RT 3 + Silwet L77 resulted in 8 and 2 stems/yd^2, respectively, compared with 63 stems/yd^2 for the nontreated check. Furthermore, the RT 3 alone application statistically reduced stem density in only three other instances compared with the nontreated check, the July applications at Edwall and Steptoe, and the August application at Steptoe (Table 1). In addition, the effect of RT 3 alone was much less consistent and resulted in a high amount of variability (data not shown). This variability is the reason why the RT 3 alone treatment is not statistically different than the nontreated check, even though the means appear very different. In contrast, the response from RT 3 + Silwet L77 was much more consistent and less variable. The poor response of RT 3 alone is consistent with previous research and grower reports and is likely due to the inability of smooth scouringrush to uptake enough of the herbicide to make a difference the following year. This barrier is diminished by adding Silwet L77. The application of RT 3 + Silwet L77 could be a good alternative to using long residual herbicides such as Glean (chlorsulfuron) and Finesse (chlorsulfuron + metsulfuron), which are known to control smooth scouringrush, but cannot be applied for at least 36 months prior to planting susceptible crops such as pulses or non-sulfonylurea resistant canola (see labels for plantback restrictions).

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

			Smooth scouringrush density*		
Time	Treatments	Rates	Edwall	PCFS	Steptoe
		oz/A + % v/v	-----------stems per square yard-----------		
May	None	-	339 a	63 a	280 a
May	RT 3 alone	96	209 a	8 b	143 a
May	RT 3 + Silwet L77	96 + 0.25	79 b	2 b	12 b
June	None	-	276 a	54 a	241 a
June	RT 3 alone	96	189 a	13 a	91 a
June	RT 3 + Silwet L77	96 + 0.25	38 b	0 b	16 b
July	None	-	184 a	146 a	260 a
July	RT 3 alone	96	89 b	67 a	165 b
July	RT 3 + Silwet L77	96 + 0.25	40 c	2 b	67 c
August	None	-	134 a	133 a	263 a
August	RT 3 alone	96	73 a	99 a	158 b
August	RT 3 + Silwet L77	96 + 0.25	29 b	8 b	38 c

*Means are based on four replicates per treatment. Means within a column for each application time followed by the same letter are not significantly different at the 95% probability level, 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.

Smooth scouringrush control in winter wheat following applications of glyphosate with four surfactants in fallow.

Mark Thorne and Drew Lyon

Control of smooth scouringrush (*Equisetum laevigatum*) in no-till fallow with glyphosate herbicides has been largely unsuccessful, especially at applications rates intended for annual weed control. We compared four different surfactants with RT® 3 glyphosate herbicide applied at 96 oz/A during the 2019 no-till fallow phase of a wheat/fallow rotation for control of smooth scouringrush into the following winter wheat crop. Surfactants were Silwet® L77, Spray Guard®, Crop Oil-M®, and Wetcit®. Silwet L77 is an organosilicone non-ionic surfactant. Spray Guard is a water conditioning and deposition aid that contains ammonium sulfate (2 lbs NH_4SO_4/gallon) and phosphoric acid. Crop Oil-M is a petroleum-based surfactant, and Wetcit is a citrus, alcohol-based surfactant. In related studies, we have found that Silwet L77 has increased efficacy of RT 3 at the 96 oz/A rate. This trial compares surfactant options to Silwet L77.

Figure 1. Nontreated smooth scouringrush in winter wheat.

The study site was located on the Hall farm near Steptoe, WA. The field is in a three-year rotation of no-till fallow/winter wheat/spring wheat. Soil pH and organic matter was 5.0 and 2.7%, respectively. Initial smooth scouringrush density averaged 370 stems/yd^2. Plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. All herbicide treatments were applied on June 9, 2019 with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. Spray output was 15 gpa at 25 psi. Stem density was measured in each plot in the 2020 winter wheat crop on July 17, 2020 just prior to harvest (Figure 1).

Smooth scouringrush in the 2020 winter wheat crop averaged 167 stems/yd^2 following the 2019 application of RT 3 + Spray Guard and was least effective compared with the other three surfactant treatments (Table 1). In a neighboring trial, RT 3 without any surfactant resulted in

143 stems/yd^2, suggesting that Spray Guard is not aiding RT 3 uptake in smooth scouringrush. The RT 3 + Crop Oil-M treatment averaged 61 stems/yd^2 and reduced density by 63% compared with RT 3 + Spray Guard. The RT 3 + Crop Oil-M treatment was not statistically different from RT 3 + Wetcit, which had a density of only 35 stems/yd^2. The RT 3 + Silwet L77 treatment had the lowest density of 21 stems/yd^2 but was not statistically different from RT 3 + Wetcit.

This trial supports our findings that Silwet L77 is a very effective surfactant when added to RT 3 for control of smooth scouringrush; however, Wetcit appears to be a reasonable alternative. It is again apparent that an effective surfactant is critical for smooth scouringrush control when applying RT 3 herbicide.

Table 1. Smooth scouringrush control with RT 3 herbicide and four different surfactants applied in the 2019 no-till fallow phase of a wheat/fallow rotation and measured during the 2020 winter wheat crop.

Herbicide + Surfactant	Rate	Scouringrush density*
	oz/A + %v/v	stems/yd^2
RT 3 + Spray Guard	96 + 0.75	167 a
RT 3 + Crop oil	96 + 0.75	61 b
RT 3 + Wetcit	96 + 0.5	35 bc
RT 3 + Silwet	96 + 0.25	21 c

*Means are based on four replicates per treatment. Means within a column followed by the same letter are not significantly different at the 95% probability level, 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.

Smooth scouringrush control with Glyphosate and Finesse® applied in fallow

Mark Thorne and Drew Lyon

Smooth scouringrush (*Equisetum laevigatum*) control in wheat/fallow rotations in eastern Washington has been difficult because of limited effective herbicide options (Figure 1). In different studies, we have shown that applications of either Finesse (chlorsulfuron + metsulfuron) or RT® 3 (glyphosate) during the fallow year can control smooth scouringrush into the following crop year; however, RT 3 has only been effective when applied at a high rate and with Silwet® L77 organosilicone surfactant. In contrast, Finesse is effective for at least two years after application, but when applied alone, does not control other weeds that might be present in the fallow. This study examines the effect of Finesse and RT 3 applied alone or in combination at different rates of RT 3.

Figure 1. Smooth scouringrush in fallow near Dayton, WA.

The study sites are located on the Lambertt farm near Dayton, WA, and the Hall farm near Steptoe, WA. The fields were in the no-till fallow phase of wheat/fallow rotations. The Dayton site is on a 30-40% northwest facing slope with a Walla Walla silt loam well-drained soil. Soil pH measured 5.4 and organic matter measured 2.1%. The Steptoe site is on low-lying flat with a Covello silt loam that is sometimes inundated with water during winter or early spring. Soil pH measured 5.8 and organic matter measured 2.9%. Initial smooth scouringrush density averaged 326 and 279 stems/yd^2 at the Dayton and Steptoe sites, respectively.

At each site, plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. Herbicide treatments were applied on July 6, 2019 at both locations with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO_2 backpack at 3 mph. Spray output was 15 gpa at 25 psi. Visual ratings were made 14, 28, and 42 days after treatment (DAT) and assessed the effect of the herbicides in relation to plants in nontreated check plots. Injury symptoms included changes in stem color ranging from light green to yellow or light tan, and reduction in height compared to nontreated plants.

The response to the herbicide treatments differed dramatically at each site. Symptoms were much slower to develop at Dayton than at Steptoe. Control ratings 14 DAT at Dayton did not exceed 40% of the nontreated plots but reached 88% at Steptoe (Table 1). This may be partly related to soil conditions as soil temperatures in the top 2 inches at the time of application measured 67° F at Dayton and 90° F at Steptoe. This trend continued as injury symptoms never exceeded 70% at Dayton, even at 42 DAT, but at Steptoe the most effective treatments exceeded 90% by 28 DAT. By 42 DAT at Dayton the most effective treatments were the 64 or 96 oz/A rates of RT 3 + Finesse, or the 96 oz/A rate of RT 3 alone, which averaged 53 to 66% control (Table 1). In contrast, at Steptoe, control with the 96 oz/A rate of RT 3 alone averaged 84% but was statistically less effective than either the 64 or 96 oz/A rates of RT 3 + Finesse, which averaged 92 and 94% control, respectively. At Dayton, the 64 oz/A rate of RT 3 + Finesse was statistically better than the 64 oz/A RT 3 alone, but at Steptoe no statistical difference was found between these two treatments. However, at Steptoe, the 32 oz/A rate of RT 3 + Finesse was statistically more effective than the 32 oz/a rate alone. No statistical differences between the 32 oz/A rate of RT 3 alone and Finesse alone was found at either location.

Figure 2. In the foreground, control of smooth scouringrush in fallow with 96 oz/A of RT 3 plus 0.5 oz/A Finesse at Steptoe, WA. Back right plot is a nontreated check.

Control of smooth scouringrush in fallow is greater with the higher rates of RT 3 and with the addition of Finesse (Figure 2). Furthermore, these treatments all contained Silwet L77, which is critical for the RT 3 to be effective. These treatments will be evaluated in the 2021 winter wheat crops. Finesse-treated plots are expected to contain very little smooth scouringrush, but it will be informative to see the effectiveness of the combinations of Finesse and RT 3 at different rates.

See next page for Table 1.

Table 1. Visual assessment of smooth scouringrush control following applications of RT 3 and Finesse in fallow.

Location/Treatments*	Rates	Visual control ratings		
		14 DAT	28 DAT	42 DAT
	oz/A	percent of nontreated check**		
Dayton, WA				
Nontreated check	none	0	0	0
RT 3	32	8 c	10 e	19 b
Finesse	0.5	11 c	21 d	25 b
RT 3 + Finesse	32 + 0.5	19 b	33 c	33 b
RT 3	64	11 c	25 d	27 b
RT 3 + Finesse	64 + 0.5	24 b	51 b	61 a
RT 3	96	19 b	40 c	53 a
RT 3 + Finesse	96 + 0.5	39 a	65 a	66 a
Steptoe, WA				
Nontreated check	none	0	0	0
RT 3	32	53 d	64 d	51 c
Finesse	0.5	10 e	52 e	53 c
RT 3 + Finesse	32 + 0.5	75 c	79 c	84 b
RT 3	64	83 ab	85 bc	83 b
RT 3 + Finesse	64 + 0.5	79 bc	91 ab	92 a
RT 3	96	85 a	87 abc	84 b
RT 3 + Finesse	96 + 0.5	88 a	92 a	94 a

*All herbicide treatments included Silwet L77 surfactant at 0.5% v/v.
**Means are based on four replicates per treatment. Means within a column for each location followed by the same letter are not significantly different at the 95% probability level, 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 preemergence herbicides for the control of Russian-thistle in chemical fallow
Henry Wetzel, Mark Thorne and Drew Lyon

A trial was established on chemical fallow ground on the Hennings Farm near Ralston, WA to evaluate timings of preemergence herbicides for the control of Russian-thistle. The objective of the study was to evaluate various herbicides applied preemergence to reduce selection pressure for resistance to glyphosate and paraquat, the two most common herbicides used to control Russian-thistle postemergence. Glyphosate-resistant Russian-thistle plants have been documented in Washington, Oregon and Montana.

The chemical fallow period followed late planted winter wheat. The trial area was sprayed with RT 3® (glyphosate) and Spray Prep™ (48 fl oz/A + 2 qts/100 gal) at the time of the initial application on November 21, 2019. This was to control volunteer wheat, downy brome and tumble mustard. The November application will be referred to as the late fall application timing. Treatments were applied with a CO_2-powered backpack sprayer set to deliver 10 gpa at 53 psi at 2.3 mph. The air temperature was 41°F, relative humidity was 61% and the wind was out of the southwest at 4 mph. The second application occurred on February 21, 2020, which will be referred to as the late winter application timing. Treatments were applied with a CO_2-powered backpack sprayer set to deliver 10 gpa at 53 psi at 2.3 mph. The air temperature was 47°F, relative humidity was 33% and the wind was out of the south at 5 mph. The trial area was void of vegetation at the late winter application timing, so RT 3 was not applied. After the May 14th and June 9th rating dates, the trial area was sprayed with RT 3 plus Spray Prep (48 fl oz/A + 2 qts/100 gal) and RT 3 (32 fl oz/A), respectively to control Russian-thistle. After the July 15th rating date, Russian-thistle plants were hand-rouged since the population was low. Soil at this site is a silt loam with 1.9% organic matter and a pH of 5.6.

Russian-thistle was the only broadleaf weed that was uniformly dispersed throughout the trial area for the duration of the trial; however, few seedlings emerged between the June and July sample dates. On the initial May 14th rating date, all treatments were providing excellent control of Russian-thistle, except TriCor® DF applied in the late fall. Over the remainder of the trial period, all treatments continued to provide excellent control of Russian-thistle except TriCor DF applied in late fall or late winter. The results of this trial suggest that preemergence herbicides can provide an alternative means of controlling Russian-thistle in chemical fallow and may become necessary as glyphosate-resistant Russian-thistle becomes more prevalent.

			Russian-thistle plants per square yard		
Treatment	Rate	Application Timing	5/14	6/9	7/15
	(oz/A)				
Nontreated Check			2.74 a[1]	1.39 a	0.03 bc
Spartan® Charge	8 fl oz	Late fall	0.01 c	0.00 b	0.00 c
Spartan Charge	8 fl oz	Late winter	0.02 c	0.00 b	0.00 c
Spartan Charge	4 fl oz fb 4 fl oz	Late fall fb Late winter	0.00 c	0.00 b	0.00 c
Fierce®	4.5	Late fall	0.02 c	0.00 b	0.02 bc
Fierce	4.5	Late winter	0.16 c	0.02 b	0.01 bc
Fierce	2.25 fb 2.25	Late fall fb Late winter	0.05 c	0.00 b	0.00 c
TriCor® DF	10.5	Late fall	1.15 b	1.52 a	0.08 a
TriCor DF	10.5	Late winter	0.00 c	0.05 b	0.04 b
TriCor DF	5.25 fb 5.25	Late fall fb Late winter	0.05 c	0.30 b	0.02 bc
Authority® MTZ DF	10	Late fall	0.06 c	0.01 b	0.00 c
Authority MTZ DF	10	Late winter	0.02 c	0.00 b	0.01 bc
Authority MTZ DF	5.0 fb 5.0	Late fall fb Late winter	0.05 c	0.01 b	0.00 c

[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.

Postharvest control of Russian-thistle with herbicides
Henry Wetzel and Drew Lyon

A study was conducted at the Lind Dryland Research Station near Lind, WA to evaluate herbicides for the control of Russian-thistle following the harvest of spring wheat. The objective was to evaluate three herbicide application timings, one, two and three weeks after harvest to determine when would be the best time to apply herbicides to get the best control of Russian-thistle, postharvest.

Postemergence herbicides were applied on 8/4, 8/11 and 8/18/2020, which corresponded to one, two and three weeks after harvest. RT 3® (glyphosate) plus ammonium sulfate (64 fl oz/A + 17 lb/100 gal) were applied at 10 GPA, whereas Maestro® 4EC + TriCor® 75DF (16 fl oz + 10.67 oz/A) and Gramoxone® SL 2.0 + NIS (48 fl oz/A + 0.25% v/v) were applied at 20 GPA. Environmental conditions for the 8/4 application were an air temperature of 86°F, relative humidity 26% and the wind was out of the west at 6 mph. There was an average of 2.5 Russian-thistle plants per square yard in the nontreated check plots. Plants were 13.5-in-diameter and 12-in-height. The wheat stubble height (10.5 in) was uniform across the trial area. As noted in the height of the Russian-thistle, the plants were beginning to grow above the height of the wheat stubble. Environmental conditions for the 8/11 application were an air temperature of 74°F, relative humidity 28% and the wind was out of the southwest at 6 mph. Environmental conditions for the 8/18 application were an air temperature of 87°F, relative humidity 36% and the wind was out of the southwest at 4 mph.

The last time it rained prior to the trial initiation (8/4) was July 1st when the trial area received 0.36 inches of rain. It did not rain again until September 19th, when the trial area received 0.05 inches or rainfall. This was 2 days after the final rating was taken. During this time period, the lack of rainfall is not uncommon in this area of eastern WA. Air temperatures were average to below average during the trial period.

When RT 3 was applied one-week (8/4) after harvest, plants did not exhibit injury symptoms until 14 days after treatment (DAT) (Table). However, by 21 DAT, plants were almost completely killed with RT 3. Plants treated with either Maestro 4EC + TriCor 75DF or Gramoxone SL 2.0, exhibited injury symptoms 7 DAT (Table). By the last rating date, Gramoxone SL 2.0 provided better Russian-thistle control than Maestro 4EC + TriCor 75DF, but neither of these treatments provided the level of control that RT 3 did.

The Maestro 4EC + TriCor 75DF and Gramoxone SL 2.0 provided quick activity on Russian-thistle when they were applied 14 or 21 days after harvest (Table), which was similar to what they did when applied 7 days after harvest (Table). RT 3 applied two or three weeks after harvest acted more slowly than when it was applied one week after harvest, and by the last rating date, control with RT 3 was not greater than with the other herbicide treatments (Table). These results suggest that glyphosate should be applied within a week after harvest, before plant growth slows as a result of drought stress. However, contact herbicides such as Gramoxone SL 2.0 and Maestro 4EC + TriCor 75DF worked better when applied two and three weeks after harvest, when drought stress likely limited regrowth. We plan to repeat this trial in 2021.

		Treatments were applied 1 week after harvest (8/4)					
		8/11	8/18	8/25	8/31	9/9	9/17
Treatment	Rate	Russian-thistle control					
	fl oz/A	%					
Maestro® 4EC + TriCor® 75DF	16 + 10.67 oz	85 b[1]	86 a	89 b	79 c	75 c	74 c
RT 3® + AMS	64 + 17 lb/100 gal	0 c	75 a	99 a	100 a	100 a	100 a
Gramoxone® SL 2.0	48 + 0.125% v/v	91 a	85 a	91 b	86 b	94 b	91 b
		Treatments were applied 2 weeks after harvest (8/11)					
Maestro 4EC + TriCor 75DF	16 + 10.67 oz	--	76 b	91 a	84 b	83 a	80 a
RT 3 + AMS	64 + 17 lb/100 gal	--	0 c	15 b	45 c	90 a	95 a
Gramoxone SL 2.0	48 + 0.125% v/v	--	94 a	98 a	95 a	95 a	95 a
		Treatments were applied 3 weeks after harvest (8/18)					
Maestro 4EC + TriCor 75DF	16 + 10.67 oz	--	--	91 a	84 b	83 a	80 a
RT 3 + AMS	64 + 17 lb/100 gal	--	--	15 b	45 c	90 a	95 a
Gramoxone SL 2.0	48 + 0.125% v/v	--	--	98 a	95 a	95 a	95 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.

Preharvest Chickpea and Weed Desiccation

I.C. Burke

In the fall of 2020, a chickpea herbicide trial was conducted to evaluate alternatives to glyphosate for preharvest dessication. Glyphosate use continues to lose favor among chickpea processors. The objective was to compare RT3 (glyphosate) to alternative contact herbicides Gramoxone, Liberty, Reviton, and Sharpen.

The study was established at the Palouse Conservation Field Station near Pullman, WA. Treatments were applied when the chickpea were ~50% naturally desiccated and weeds were green but active growth was reduced. Treatments were applied with a CO_2 powered backpack sprayer and a 5 ft boom with 4 Teejet 11002VS nozzles with an effective spray pattern of 6 ft and calibrated to deliver 15 gallons per acre (GPA). The study was conducted in a randomized complete block design with 4 replications. Plots were 8 ft by 25 ft long. Treatments were assessed for desiccation, regrowth, and yield. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

Table 1. *Treatment application details*

Study Application	
Date	September 1, 2020
Application volume (GPA)	15
Timing	Pre-harvest
Crop Stage	~50% Desiccated
Air temperature (˚F)	81
Soil temperature (˚F)	63
Wind velocity (mph, direction)	3.7, N
Cloud Cover	30

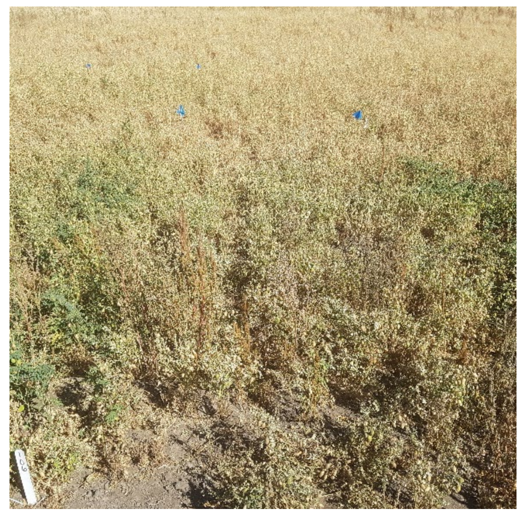


Figure 1. Chickpea had a noticeable off white appearance one week after treatment with Liberty plus Sharpen applied at 25 GPA.

Results

Desiccation of chickpea was variable, and similar among treatments. The numerically greatest desiccation occurred when chickpea were treated with RT3 at 15 GPA, or Liberty plus Sharpen at 25 GPA, or Liberty plus tiafenacil at 25 GPA. Overall regrowth was limited, not greater than 13%, and less than the nontreated. Yield on the site was variable and similar among treatments.

Recent research has indicated that PROTOX inhibitors like Sharpen and Reviton (a new herbicide from Helm containing the active ingredient tiafenacil, a very similar herbicide to Sharpen or saflufenacil) synergize with Liberty at very low doses. In this experiment, Reviton applied alone resulted in numerically less desiccation. When Reviton was applied in mixture with Liberty at 25 GPA, the mixture resulted in numerically similar desiccation to RT3, and was similar to Liberty plus Sharpen. It's not likely that the preharvest applications of herbicides affected yield.

Desiccation was numerically less when applied at 15 GPA, indicating that coverage is critical for desiccation with contact herbicides used in this study. Reviton appears to be similar to Sharpen when applied in mixture with Liberty. The mixtures of Liberty and Sharpen or Reviton appear to be alternative treatments to glyphosate for chickpea desiccation.

Table 1. Chickpea desiccation, regrowth, and yield in response to herbicide treatment applied preharvest, at the Palouse Conservation Field Station, Pullman, WA, in 2020.

Treatment	Carrier Volume	Rate		Desiccation		Regrowth		Yield	
				Sept 23, 2020		Sept 23, 2020		Sept 23, 2020	
	GPA			%		%		%	
Nontreated				0	b	52	a	1700	a
Roundup-RT3 NIS	15	0.77 0.25	lb ai/a % v/v	95	a	7	b	1685	a
Reviton MSO	15	0.0332 0.5	lb ai/a % v/v	82	a	5	b	1555	a
Gramoxone SL 2.0 MSO	15	0.5 0.5	lb ai/a % v/v	80	a	12	b	2135	a
Liberty Sharpen MSO	15	0.53 0.0044 1	lb ai/a lb ai/a % v/v	83	a	12	b	1970	a
Liberty Reviton MSO	25	0.53 0.0332 1	lb ai/a lb ai/a % v/v	90	a	7	b	2000	a
Reviton MSO	25	0.0332 0.5	lb ai/a % v/v	73	a	13	b	1870	a
Gramoxone SL 2.0 MSO	25	0.5 0.5	lb ai/a % v/v	90	a	12	b	2000	a
Liberty Sharpen MSO	25	0.53 0.0044 1	lb ai/a lb ai/a % v/v	98	a	3	b	1520	a
Liberty Reviton MSO	25	0.53 0.0332 1	lb ai/a lb ai/a % v/v	98	a	0	b	1910	a

Birdsrape mustard control in chickpeas with soil-applied herbicides

Henry Wetzel and Drew Lyon

A study was conducted on the Filan Brother's Farm in Dixie, WA to control birdsrape mustard in chickpeas. The emphasis on this trial was to evaluate early preplant herbicides. Snow came off the field early, which allowed us to get out early and establish the trial. Preplant herbicides were applied on March 19, 2020 with a CO_2-powered backpack sprayer set to deliver 15 gpa at 50 psi at 2.3 mph. The air temperature was 60°F, relative humidity was 38% and the wind was out of the northwest at 2 mph. The soil at this site is an Athena silt loam with 2.9% organic matter and a pH of 5.4. RT 3® (glyphosate) was applied at 40 fl oz/a on April 2nd and 14th in order to control volunteer wheat and birdsrape mustard seedlings that germinated prior to planting. The trial area was direct seeded to 'Dylan' chickpeas on April 25th. Their planter had a harrow attached to it to aid in row closure. Postplant preemergence herbicides were applied on April 28th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 51 psi at 2.3 mph. The air temperature was 74°F, relative humidity was 29% and the wind was calm. The trial area was harvested with a Kincaid 8XP plot combine on September 1st.

Nine days after the preplant herbicides were applied, the trial area received 0.37 inches of rainfall over a five day period. From the date of application to planting, 37 days, the trial area received 0.64 inches of rainfall. This rainfall pattern suggests that the preplant herbicides may not have been activated well. However, two days after the post plant preemergence herbicides were applied, over a two day period the trial area received 0.56 inches of rainfall and then again four days later 0.61 inches of rainfall. All products evaluated in this trial provided excellent control of birdsrape mustard and common lambsquarters (Table). While the data is not presented, all treatments provided $\geq$98 percent control of common lambsquarters. Without having standalone preplant herbicide treatments to compare to, the products evaluated at the post plant preemergence herbicide treatment timing were sufficient to provide outstanding control of birdsrape mustard and common lambsquarters. None of the treatments that were evaluated influenced yield (mean 1,700 lb/a) or 100-seed weight (53.5 g) when compared to the nontreated checks. The season-long control we achieved in this trial is not typical of the grower experience in the region. We are not sure if we just got lucky with the weather or if we have solved the problem. We plan to repeat this study in 2021.

			6/12	9/1
		Application	BRSRA[2]	
Treatment	Rate	timing (s)[1]	control	Yield
	fl oz/A	2020	%	lb/a
Nontreated Check	--	--	--	1520 a
Sharpen®	2.0	4/28	99 a[3]	1790 a
Valor® SX	2.0 oz	4/28		
Sharpen	2.0	4/28	93 a	1620 a
Pursuit®	3.0	4/28		
Sharpen	2.0	4/28	100 a	1710 a
TriCor® DF	8.0 oz	4/28		
Sharpen	1.0	3/19	100 a	1760 a
Sharpen	2.0	4/28		
Valor SX	2.0 oz	4/28		
Sharpen	1.0	3/19	98 a	1630 a
Sharpen	2.0	4/28		
Pursuit	3.0	4/28		
Sharpen	1.0	3/19	100 a	1710 a
Sharpen	2.0	4/28		
TriCor DF	8.0 oz	4/28		
Tripzin™ ZC	29.0	3/19	99 a	1860 a
Sharpen	2.0	4/28		
Valor SX	2.0 oz	4/28		
Tripzin ZC	29.0	3/19	96 a	1830 a
Sharpen	2.0	4/28		
Pursuit	3.0	4/28		
Tripzin ZC	29.0	3/19	96 a	1820 a
Sharpen	2.0	4/28		
TriCor DF	8.0 oz	4/28		
Compound X	--	3/19	100 a	1790 a
Sharpen	2.0	4/28		
Valor SX	2.0 oz	4/28		
Compound X	--	3/19	98 a	1470 a
Sharpen	2.0	4/28		
Pursuit	3.0	4/28		
Compound X	--	3/19	100 a	1600 a
Sharpen	2.0	4/28		
TriCor DF	8.0 oz	4/28		

[1] Pre-plant (3/19), Chickpeas were planted (4/25), Post plant preemergence (4/28)

[2] BRSRA (birdsrape mustard)

[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.

Birdsrape mustard control in chickpeas with experimental compound X

Henry Wetzel and Drew Lyon

A study was conducted on the Filan Brother's Farm in Dixie, WA to control birdsrape mustard in chickpeas. The emphasis on this trial was to evaluate the optimal timing to use herbicide compound X in a program approach to control birdsrape mustard. We don't typically withhold the identity of herbicides used in our studies, but we were in search of something that might work to control birdsrape mustard in chickpeas and the company did not want us to reveal what active ingredient we were using.

Snow came off the field early which allowed us to get out early and establish the trial. Preplant herbicides were applied on March 19, 2020 with a CO_2-powered backpack sprayer set to deliver 15 gpa at 50 psi at 2.3 mph. The air temperature was 60°F, relative humidity was 38% and the wind was out of the northwest at 2 mph. The soil at this site is an Athena silt loam with 2.9% organic matter and a pH of 5.4. RT 3® (glyphosate) was applied at 40 fl oz/a on April 2nd and 14th in order to control volunteer wheat and birdsrape mustard seedlings that germinated prior to planting. The trial area was direct seeded to 'Dylan' chickpeas on April 25th. Their planter had a harrow attached to it to aid in-row closure. Postplant preemergence herbicides were applied on April 28th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 51 psi at 2.3 mph. The air temperature was 74°F, relative humidity was 29% and the wind was calm. Postemergence herbicides were applied on June 12th with a CO_2-powered backpack sprayer set to deliver 15 gpa at 50 psi at 2.3 mph. The air temperature was 75°F, relative humidity was 48% and the wind was calm. Chickpeas were 6 to 8 nodes, 13 to 15 inches in height and just beginning to flower. The trial area was harvested with a Kincaid 8XP plot combine on September 1st.

Nine days after the preplant preemergence herbicides were applied, the trial area received 0.37 inches of rainfall over a five day period. From the date of application to planting, 37 days, the trial area received 0.64 inches of rainfall. This rainfall pattern suggests that the preplant herbicides may not have been activated well. However, two days after the post plant preemergence herbicides were applied, over a two day period the trial area received 0.56 inches of rainfall and then again four days later 0.61 inches of rainfall. In 2019, we observed birdsrape mustard seedlings to continue to emerge into mid-June. This pattern was not developing, but we continued to wait to apply the postemergence products, until the chickpeas began to flower. In hindsight, the timing was too late, as plants that were treated with Ultra Blazer® were significantly injured and resulted in yields significantly lower than the nontreated check plots (Table). Birdsrape mustard plants that were emerged at the time of the postemergence applications were large. These products did not kill the plants but significantly reduced their stature compared to the nontreated checks. All treatment combinations evaluated in this trial provided excellent control of birdsrape mustard and common lambsquarters (Table). While the data is not presented, all treatments provided $\geq$99 percent control of common lambsquarters.

Compound X performed equally well regardless of application timing. We will continue to evaluate Compound X in the hope that it may one day be labeled for use in chickpea for birdsrape mustard control. The season-long control we achieved in this trial with Sharpen® + Valor® SX is not typical of the grower experience in the region. We are not sure if we just got lucky with the weather or if we have solved the problem. We plan to repeat this study in 2021.

			6/19	7/2	7/2	9/1	9/14
		Application			BRSRA[3]		
Treatment	Rate	timing (s)[2]	Crop Injury		control	Yield	100-seed wt
	fl oz/a	2020	----------%---------		%	lb/a	(g)
Nontreated Check	--	--	--	--	--	1390 c	52.3 b-d
Sharpen®	2.0	4/28	0 a	0 a	94 ab[4]	1620 bc	53.8 a-d
Valor®SX	2.0 oz	4/28					
Sharpen	2.0	4/28	0 a	0 a	95 ab	1820 ab	54.3 a
Valor SX	2.0 oz	4/28					
Tough®5EC + NIS[1]	24	6/12					
Sharpen	2.0	4/28	58 b	42 b	99 ab	1040 d	51.9 d
Valor	2.0 oz	4/28					
Ultra Blazer® + NIS	24	6/12					
Compound X	--	3/19	0 a	0 a	91 b	1860 a	53.8 a-d
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Compound X	--	3/19	0 a	0 a	91 b	1860 a	53.5 a-d
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Tough 5EC + NIS	24	6/12					
Compound X	--	3/19	60 b	48 c	100 a	920 d	52.0 cd
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Ultra Blazer + NIS	24	6/12					
Compound X	--	3/19	0 a	0 a	95 ab	1890 a	54.8 a
Compound X	--	4/28					
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Compound X	--	3/19	0 a	0 a	99 ab	1810 ab	53.4 a-d
Compound X	--	4/28					
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Tough 5EC + NIS	24	6/12					
Compound X	--	3/19	60 b	45 ab	100 a	860 d	52.1 b-d
Compound X	--	4/28					
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Ultra Blazer + NIS	24	6/12					
Compound X	--	4/28	0 a	0 a	98 ab	1910 ab	53.9 a-d
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Compound X	--	4/28	0 a	0 a	100 a	1770 ab	54.0 ab
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Tough 5EC + NIS	24	6/12					
Compound X	--	4/28	60 b	43 b	100 a	920 d	52.0 cd
Sharpen	2.0	4/28					
Valor SX	2.0 oz	4/28					
Ultra Blazer + NIS	24	6/12					

[1] NIS was applied at the rate of 0.25% v/v

[2] Pre-plant (3/19), Chickpeas were planted (4/25), Post plant preemergence (4/28), Postemergence (6/12)

[3] BRSRA (birdsrape mustard)

[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 Storm for Crop Safety and Efficacy in Winter Pea

I.C. Burke

In the spring of 2020, a winter or fall seeded pea herbicide trial was conducted to evaluate Storm for safety and for efficacy on mayweed chamomile, prickly lettuce, and tumble mustard. Current options for managing mayweed chamomile, prickly lettuce, and tumble mustard are limited to preemergence herbicides that seldom control weeds until crop canopy – a period of time that can often exceed 8 months. A postemergence herbicide with activity on mayweed chamomile, prickly lettuce, and tumble mustard would substantially improve in crop and rotational weed management in an emerging and important crop, winter pea.

Figure 1. Pea and mayweed chamomile response to Storm .

Table 1. *Treatment application details.*

Study Application	
Date	April 28, 2020
Application volume (GPA)	15
Timing	Postemergence
Crop Stage	3 to 5 Tendril
Air temperature (˚F)	51
Soil temperature (˚F)	49
Wind velocity (mph, direction)	4.5, N
Cloud Cover	30

The study was established near Davenport, WA. Treatments were applied when the pea had 3 to 5 tendrils. Treatments were applied with a CO_2 powered backpack sprayer and a 5 ft boom with 4 Teejet 11002VS nozzles with an effective spray pattern of 6 ft and calibrated to deliver 15 gallons per acre (GPA). The study was conducted in a randomized complete block design with 4 replications. Plots were 8 ft by 30 ft long. Treatments were assessed for weed control, weed density, and yield (yield data is not yet final as of this writing). Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

Results

Winter pea response to Storm was characterized by reddish spots on the leaves that increased with rate and surfactant aggressiveness. The injury was transient and the winter pea quickly outgrew the injury. Storm, containing the contact herbicide active ingredients acifluorfen and basagran, inhibits both PROTOX and Photosystem II, which causes rapid leaf burn and necrosis in sensitive plants. Winter pea appears to be tolerant to Storm, particularly at typical use rates with of 24 oz/A or less when applied with nonionic surfactant.

Control of mayweed chamomile was variable, and in general, the larger the plant the less likely Storm was to be lethal, regardless of rate. Although statistically similar, control of mayweed chamomile increased with rate of Storm. Timing and temperature of application may have an affect on treatment outcome. In other research, spring pea was more sensitive to Storm, which is attributed to higher temperatures at application. Mayweed chamomile may respond to Storm similarly, with greater control occurring at higher temperatures.

Complete control of tumble mustard was achieved with Storm and comparison treatments, regardless of the rate of Storm. In other trials conducted by Dr. Drew Lyon, Storm did not control flixweed. Scouting for weed species will be critical for determining Storm rate and timing of application.

Table 1. Winter pea injury, Mayweed chamomile and tumble mustard control in response to increasing rates of Storm with different surfactants in a trial located near Davenport, WA, in 2020.

Treatment	Rate		Injury		Mayweed Chamomile Control		Tumble Mustard Control	
			5/7/2020		6/4/2020		6/4/2020	
			%		%		%	
Nontreated			0	d	0	c	0	b
Nontreated – Weed Free			0	d	99	a	99	a
Storm NIS	16 0.25	fl oz/A % v/v	9	c	68	b	97	a
Storm NIS	24 0.25	fl oz/A % v/v	10	c	74	b	99	a
Storm NIS	48 0.25	fl oz/A % v/v	10	c	79	b	99	a
Storm COC	16 1	fl oz/A % v/v	21	b	81	b	99	a
Storm COC	24 1	fl oz/A % v/v	29	a	76	b	99	a
Storm COC	48 1	fl oz/A % v/v	30	a	81	b	99	a
Rhomene NIS	0.5 0.25	pt/A % v/v	21	b	69	b	99	a
Rhomene Metribuzin NIS	0.5 0.25 0.25	pt/A lb/a % v/v	23	b	64	b	99	a

[1] NIS, Nonionic surfactant; COC, Crop oil concentrate surfactant.

Evaluation of Storm® and Ultra Blazer® for the control of tansy mustard in fall-sown peas

Henry Wetzel and Drew Lyon

A trial was established at the Claassen Farm near Ritzville, WA to evaluate Storm and Ultra Blazer for the postemergence control of tansy mustard in fall-sown peas. Storm contains both bentazon (group 6) and acifluorfen (group 14), and Ultra Blazer contains only acifluorfen. Both of these active ingredients do not have the ability to move systemically within the target weed species and are known as contact herbicides. Treatments were applied on April 1st with a CO_2-powered backpack sprayer set to deliver 15 gpa at 45 psi at 2.3 mph. The air temperature was 43 °F, relative humidity was 49% and the wind was out of the west at 5 mph. The soil at this site is a Ritzville silt loam with 1.5% organic matter and a pH of 5.3.

At the time of the application, tansy mustard plants were large and abundant. Plants were 0.5 to 8.0 inches in diameter and 0.5 to 3.0 inches in height, with a mean diameter and height of 3.5 inches and 1.0 inch, respectively. There were an average of 14 tansy mustard plants per square foot in the nontreated check plots. Fifteen days after treatment (4/16), crop injury was evident among all treatments applied. Storm- and Ultra Blazer-treated plots exhibited the highest level of injury. However, the injury was short lived, and plants were nearly recovered on April 30th, 29 days after treatment. Fifteen days after treatment (4/16), the three rates of Ultra Blazer and Storm applied at 24 fl oz/A were providing better tansy mustard control than the standard treatment, Vulture™ (imazamox, group 2). When evaluated 44 days after treatment (5/14), Vulture was providing much better control than the previously mentioned treatments. Temperatures were below average for the duration of the study. April was a relatively dry month where rainfall events on 5/20 (0.67 in) and 5/30 + 5/31 (0.67 + 0.21 in) were above average. Even though Vulture appeared to be providing the best control of tansy mustard, at the conclusion of the study the plants did not die and produced seed possibly because of the favorable environmental conditions for plant growth. Had these treatments been applied in the fall shortly after the tansy mustard emerged, we may have seen more effective control from the products evaluated.

		4/16	4/30	4/16	5/14
Treatment	Rate	Crop Injury		Tansy Mustard Control	
	fl oz/A	---------------%---------------		---------------%---------------	
Nontreated Check	--	--	--	--	--
Vulture + Synurgize + COC	4.0 + 2.0 qts/100 gal + 1.0% v/v	4 a[2]	0 a	55 cd	91 a
Rhomene® MCPA + Metribuzin 75DF[1]	12.0 + 5.33 oz + 0.25% v/v	13 b	3 ab	44 d	45 cd
Ultra Blazer[1]	12.0 + 0.25% v/v	18 bc	0 a	71 a-c	51 b-d
Ultra Blazer[1]	16.0 + 0.25% v/v	21 c	0 a	73 a-c	63 bc
Ultra Blazer[1]	24.0 + 0.25% v/v	21 c	5 b	83 a	70 b
Storm[1]	16.0 + 0.25% v/v	13 b	0 a	59 b-d	35 d
Storm[1]	24.0 + 0.25% v/v	15 bc	0 a	75 ab	70 b

[1] Treatment includes NIS at 0.25% 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.

Evaluation of preemergence herbicides for the control of tumble mustard in fall-sown peas

Henry Wetzel and Drew Lyon

A field study was conducted at the Lind Dryland Research Station near Lind, WA to evaluate crop safety and broadleaf weed control in fall-sown peas with various herbicides. The study area followed a fallow period. 'Blaze' fall-sown peas were seeded on August 28, 2019 at the rate of 110 lb/A with a Valmar air seeder, with a modified deep furrow configuration, on a 12-inch row spacing. Seeds were placed 2 inches into moist soil. Soil at this site is a silt loam with 1.1% organic matter and a pH of 6.4. On August 30th, treatments were applied with a CO_2-powered backpack sprayer set to deliver 15 gpa at 48 psi at 2.3 mph. The air temperature was 83°F, relative humidity was 36% and the wind was out of the southwest at 6 mph. At the time of application, the peas had just begun imbibing water from the soil. The trial area was harvested with a Kincaid 8XP plot combine on July 14, 2020.

Winter annual broadleaf weeds have been the most problematic weeds in fall-sown winter peas. They can emerge with the crop, and they compete with the crop longer than warm season weeds that emerge in the spring. Tumble mustard was the predominant species present in this study and occurred at a moderate level. Tansy mustard was present at a very low level.

Two rainfall events on the 9th and 11th of August, totaled 0.65 inches, and another 0.52 inches was received on September 8th, which must have triggered germination of downy brome as it significantly infested the trial site. On October 10th, the trial area was sprayed with 5.33 fl oz/a of Section® Three (clethodim) plus McGregor's Crop Oil M (1% v/v) to control the downy brome. The September 8th rain event was enough to activate the broadleaf herbicides in a timely fashion. These rainfall events were not enough to germinate broadleaf weeds after the crop emerged and the field dried out mid-September through the end of November. The trial area began to pick up regular precipitation in December and in general the site experienced an open winter, suggesting that tumble mustard may have emerged late winter or early spring.

Crop injury was not observed with any of the treatments in this study. The majority of the treatments in this study provided good to excellent control of the tumble mustard (Table). The exceptions were Valor® SX + Dual Magnum®, BroadAxe® XC and Spartan® Charge, which provided fair control. Compound X is a product that is currently in development, but the parent company prefers to keep its identity confidential. There was a significant difference among the two rates evaluated, and the higher rate of 4.1 fl oz/a provided fair control. None of the treatments affected yield when compared to the nontreated check.

		4/16	5/14	7/14
		Tumble mustard		Yield
Treatment	Rate	control		
	fl oz/a	--------------%-------------		lb/A
Nontreated Check	--	--	--	1570 a
Spartan® Charge	7.75	39 c[1]	54 ef	1850 a
Authority® Supreme	11.6	83 ab	85 a-c	2490 a
BroadAxe® XC	32.0	43 c	61 d-f	1930 a
Pursuit®	3.0	99 a	95 a	2170 a
Pursuit + Lorox® DF	3.0 + 20.0 oz	98 a	93 a	2140 a
Sharpen® + TriCor® DF	2.0 + 8.0 oz	94 ab	84 a-c	2040 a
Sharpen + TriCor DF + Lorox DF	2.0 + 8.0 oz + 20.0 oz	98 a	96 a	2090 a
Valor® SX + Dual Magnum®	2.0 oz + 21.0	74 b	74 b-d	2040 a
Prowl® H_20 + TriCor DF	32.0 + 8.0 oz	91 ab	90 ab	1980 a
Compound X	2.5	40 c	43 f	2070 a
Compound X	4.1	81 ab	68 c-e	1870 a

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

Precipitation data (September 1, 2019 to August 31, 2020) from the Palouse Conservation Field Station

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2019	(in.)	2019	(in.)	2019	(in.)	2019	(in.)
9/6	0.14	10/9	0.15	11/13	0.04	12/8	0.10
9/9	0.17	10/17	0.09	11/15	0.01	12/11	0.09
9/10	0.07	10/19	0.10	11/16	0.01	12/12	0.17
9/11	0.13	10/20	1.17	11/18	0.25	12/13	0.35
9/17	0.06	10/21	0.14	11/20	0.04	12/15	0.15
9/27	0.10	10/22	0.35	Total	0.35	12/16	0.08
9/29	0.48	Total	2.04	Normal[1]	2.91	12/19	0.07
9/30	0.17	Normal[1]	1.58	Dep Norm	-2.56	12/20	0.15
Total	1.34	Dep Norm	+0.46			12/24	0.08
Normal[1]	0.77					12/28	0.06
Dep Norm	+0.57					12/30	0.23
						12/31	0.13
						Total	1.59
						Normal[1]	2.56
						Dep Norm	-0.97

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
1/1	0.20	2/2	0.13	3/8	0.11	4/1	0.09
1/3	0.13	2/5	0.24	3/26	0.06	4/5	0.14
1/6	0.20	2/6	0.80	3/29	0.18	4/6	0.17
1/7	0.34	2/7	0.99	3/30	0.20	4/23	0.14
1/8	0.07	2/8	0.16	3/31	0.27	Total	0.60
1/9	0.13	2/9	0.06	Total	0.88	Normal[1]	1.75
1/11	0.50	2/16	0.37	Normal[1]	2.05	Dep Norm	-1.15
1/12	0.45	Total	2.82	Dep Norm	-1.17		
1/13	0.55	Normal[1]	1.81				
1/14	0.14	Dep Norm	+1.01				
1/15	0.13						
1/17	0.11						
1/23	0.26						
1/24	0.18						
1/26	0.12						
1/27	0.16						
1/28	0.23						
1/29	0.19						
1/30	0.23						
1/31	0.07						
Total	4.43						
Normal[1]	2.55						
Dep Norm	+1.88						

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
5/3	0.38	6/6	0.27	7/7	0.15	8/6	0.07
5/6	0.07	6/8	0.21	7/10	0.01	8/19	0.02
5/7	0.19	6/10	0.11	Total	0.16	8/20	0.04
5/12	0.05	6/13	0.05	Normal[1]	0.65	Total	0.13
5/13	0.14	6/14	0.30	Dep Norm	-0.49	Normal[1]	0.66
5/15	0.07	6/15	0.29			Dep Norm	-0.53
5/17	0.13	6/16	0.14				
5/18	0.15	6/18	0.11				
5/19	0.27	6/30	0.23				
5/20	0.42	Total	1.75				
5/21	1.24	Normal[1]	1.31				
5/26	0.1	Dep Norm	+0.44				
5/31	0.42						
Total	3.63						
Normal[1]	1.77						
Dep Norm	+1.86						

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

Precipitation data (September 1, 2019 to August 31, 2020) from the Wilke Farm, AgWeatherNet Station, Davenport

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2019	(in.)	2019	(in.)	2019	(in.)	2019	(in.)
9/6	0.10	10/17	0.14	11/9	0.06	12/7	0.42
9/8	0.16	10/18	0.11	11/12	0.05	12/12	0.46
9/9	0.24	10/19	0.34	11/15	0.07	12/19	0.36
9/16	0.35	10/20	0.06	11/17	0.16	12/21	0.05
9/17	0.10	10/21	0.18	11/19	0.16	12/31	0.13
9/18	0.22	Total	0.92	Total	0.51	Total	1.35
9/28	0.21						
Total	1.41						
Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
1/7	0.06	2/5	0.17	3/6	0.12	4/22	0.12
1/11	0.26	2/6	0.25	3/7	0.26	Total	0.19
1/19	0.06	2/7	0.13	3/25	0.08		
1/21	0.06	2/23	0.15	Total	0.54		
1/22	0.19	Total	0.72				
1/23	0.54						
1/24	0.08						
1/25	0.12						
1/26	0.06						
1/27	0.05						
1/28	0.40						
1/29	0.16						
Total	2.16						
Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
5/2	0.07	6/9	0.11	7/1	0.07	8/6	0.06
5/6	0.45	6/10	0.10	Total	0.07	Total	0.06
5/12	0.09	6/13	0.35				
5/18	0.06	6/15	0.12				
5/20	0.90	6/28	0.08				
5/30	0.40	Total	0.84				
5/31	0.41						
Total	2.43						