

2021 WSU Weed Control Report

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Disclaimer

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

Evaluation of Avadex® Microactiv™ herbicide for the control of 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 conventional winter wheat production system, and 2) Ascertain if the combination of Avadex MicroActiv with either Zidua® (Group 15), Zidua + Amber® (Group 2), Axiom® DF (Group 5 + 15) or PowerFlex® HL (Group 2) provides better grass weed control than the products applied individually.

This study was conducted on land leased and farmed by Andrew and Richard Forgarty off Five Mile Road near Walla Walla, WA. The soil at this site is an Athena silt loam with 2.8% organic matter and a pH of 5.0. Winter wheat was the previous crop. Crop residue remaining after harvest was burnt just prior to planting. The trial area was sprayed with RT 3® and Spray Prep™ at 32 fl oz/A and 2.0 qt/100 gal on October 15, 2020 and Avadex MicroActiv was applied with a CHS Primeland-owned 50 ft Valmar applicator, with a harrow behind the applicator for incorporation of the granules, on October 15th at 15 lb/A to half of the trial area by Andrew. 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 23rd & 24th, the trial area received 0.49 and 0.19 inch of rainfall that aided in the activation and additional incorporation of the herbicides. The field was seeded to the cultivar ‘LCS Jet’ with a John Deere 455 disk drill with a row spacing of 7.5-inches on October 19th. Zidua, Zidua + Amber and Axiom DF preemergence treatments were applied on October 22nd with a CO₂-powered backpack sprayer set to deliver 10 gpa at 58 psi at 2.3 mph. The air temperature was 50°F, relative humidity was 45% and the wind was out of the west at 4 mph. At that time, it appeared that additional Italian ryegrass germinated, possibly from harrowing the trial area when the Avadex MicroActiv was incorporated. Thus, the entire trial area was sprayed with RT 3® and Spray Prep™ at 32 fl oz/A and 2.0 qt/100 gal. PowerFlex HL was applied postemergence on November 24th with an air temperature of 54°F, relative humidity was 48% and the wind was out of the southwest at 4 mph. Italian ryegrass was the predominant annual grassy weed in this field. On November 24th there were an average of 58 Italian ryegrass plants per square foot in the four,

nontreated check plots. Italian ryegrass was 1-leaf and 1 inch in height and wheat was 1 to 2-leaf and 3 inches in height.

There was adequate precipitation prior to and post planting, resulting in plenty of Italian ryegrass emergence in the fall. There was no evidence of winterkill in the Italian ryegrass population. Late winter visual evaluation of the trial showed that treatment differences were very distinct because the Italian ryegrass population was so dense. Avadex MicroActiv did not control Italian ryegrass in this study (Table). Nor did it significantly improve control when applied preplant followed with either of the two best performing treatments of Zidua or Zidua + Amber. There was not a significant difference between the level of Italian ryegrass control between Zidua and Zidua + Amber, suggesting that pyrazosulfone was the active ingredient providing the best control in this study. Axiom DF and PowerFlex HL both provided poor control of Italian ryegrass. The preplant application of Avadex MicroActiv prior to the application of Axiom DF and PowerFlex HL, did not improve the level of Italian ryegrass control.

March was the beginning of reduced precipitation and April was very dry. Random areas in the trial exhibited reduced wheat growth. The plants may have been under moisture stress due to dry soil conditions. There may have been herbicide carryover, but it seemed unlikely since the previous crop was wheat. There were four days in early April that the minimum temperatures were at or slightly below freezing. This trial was situated in a swale and possibly some of the injury was from cold air stress, with the cold air settling into the trial area for a longer duration as opposed to the surrounding areas. The decision was made not to take this trial to harvest because the wheat stand was not uniform.

			4/30/21
		Application	Italian ryegrass
Treatment	Rate	Date	control
	lb/a	2020	%
Avadex MicroActiv ¹	15	10/14	5 c ⁵
Avadex MicroActiv ¹	15	10/14	78 a
Zidua ²	1.5 oz/a	10/22	
Avadex MicroActiv ¹	15	10/14	78 a
Zidua ²	1.5 oz/a	10/22	
Amber ²	0.56 oz/a	10/22	
Avadex MicroActiv ¹	15	10/14	13 b
Axiom ²	10 oz/a	10/22	
Avadex MicroActiv ¹	15	10/14	18 b
PowerFlex HL ^{3,4}	2.0 oz/a	11/24	
Zidua ²	1.5 oz/a	10/22	73 a
Zidua ²	1.5 oz/a	10/22	75 a
Amber ²	0.56 oz/a	10/22	
Axiom ²	10 oz/a	10/22	10 b
PowerFlex HL ^{3,4}	2.0 oz/a	11/24	13 b
Nontreated Check	--	--	--

¹ preplant (October 15, 2020), ²preemergence (October 22, 2020), ³postemergence (November 24, 2020) and

⁴ PowerFlex HL was tank mixed with NIS (0.5% v/v) and UAN (2.0 qt/a).

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.

Preemergence and Postemergence Herbicides for Control of Italian ryegrass (*Lolium multiflorum*) in Winter Wheat

M.R. Beaudoin and I.C. Burke



Italian ryegrass (*Lolium multiflorum*) is a problematic weed in cereal crops and grass seed crops in the Pacific Northwest (PNW). 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 gibberellic acid (GA₃) (RyzUp Smartgrass) in mixture with preemergence herbicides for improved control of Italian ryegrass in winter wheat. Applications of gibberellic acid could be used to stimulate weed seed germination, potentially mitigating the protracted germination period in the spring typical of Italian ryegrass. Preemergence applications of Zidua, Fierce, and Fierce MTZ were applied with and without gibberellic acid.

The study was seeded to winter wheat variety ‘LCS Hulk’ on October 8, 2020, using a Horsch direct seed drill. Treatments were applied preemergence to the winter wheat (Table 1). The study was arranged in a randomized complete block design with 10’ by 30’ long plots and 4 replications. Italian ryegrass percent control was assessed by visual estimation 172, 185, 192, 221 days after application (DAT), and density was assessed 194, 207, and 229 DAT using a 1/4-m² quadrat. Winter wheat was harvested using a Kincaid plot combine with a 5.74 ft wide header on August 2, 2021. 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).

The PNW experienced abnormal weather patterns for the 2021 cropping year (Figure 1). Rainfall essentially ceased well before the typical Italian ryegrass germination period. Control with a single application of Axial XL was minimal, as the study site is apparently infested with ACCase resistant Italian ryegrass. Control of Italian ryegrass preemergence applications of pyroxasulfone, metribuzin, and flumioxazin at different rates alone and in combination with GA₃ was similar (Table 2), and did not change through the season. Italian ryegrass density for nontreated and postemergence treatments of Axial XL 16.4 fl oz/A were greater than preemergence treatments (Table 3). However, yield was similar among treatments.

Gibberellic acid combined with preemergence herbicides did not improve control of Italian ryegrass in 2021. Environmental conditions such as light, water availability, soil type, and soil temperature could have an impact on the efficacy of gibberellic acid applied under field conditions. Growth chamber experiments are ongoing to understand the environmental conditions required for effective use of gibberellic acid. Other means of control such as prevention, mechanical, and cultural management methods essential tools for management of Italian ryegrass.

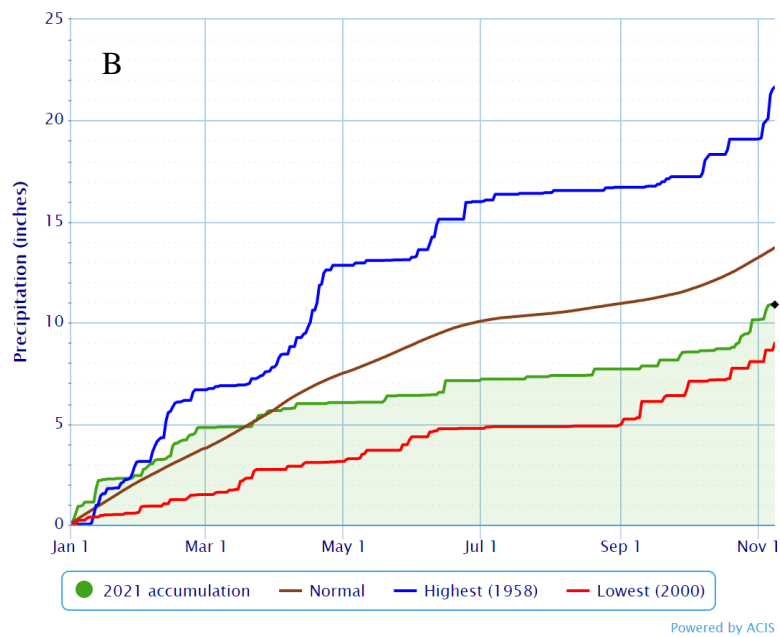
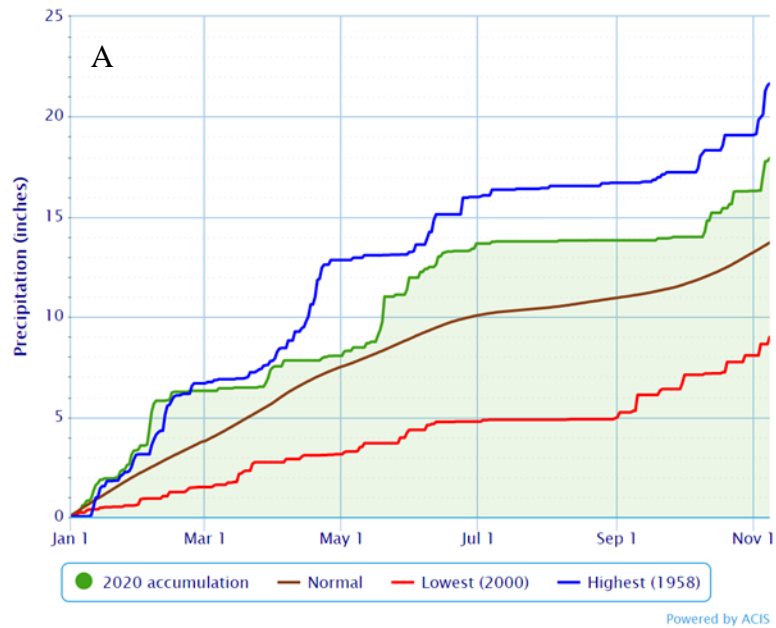


Figure 1. Precipitation weather data for Pullman, WA, during the field trial. The 2020 precipitation (A) was slightly above normal, while 2021 (B) was significantly below normal (National Weather Service).

Table 1. Environmental conditions at the time of treatment application.

Study Application	Preemergence	Postemergence
Date	10/16/2020	5/10/2021
Application Timing	10:00 AM	12:30 PM
Application volume (GPA)	15	15
Day air temperature (°F)	52	51.4
Soil temperature (°F)	50.7	55
Wind velocity (mph, direction)	5, SE	6, SE
Next rain occurred on	10/18/2021	5/20/2021

Table 2. Percent Italian ryegrass (*Lolium multiflorum*) control following the fall preemergence (PRE) application and spring postemergence (POST) application. Pullman, WA, 2021.

Treatment	Timing	Product Rate	Active Ingredient Rate lb ai/A	Control				Yield
				<i>4/13/21</i> <i>172 DAT^a</i>	<i>4/26/21</i> <i>185 DAT</i>	<i>5/3/21</i> <i>192 DAT</i>	<i>6/9/2021</i> <i>233 DAT</i>	<i>8/2/2021</i> <i>1</i>
				%				lb/A
Nontreated	-	-	-	0	0	0	0	3375
Axial XL	POST ^b	16.4 fl oz/A	0.054	0	0	0	57	3275
Zidua	PRE	1.5 oz/A	0.08	80	80	80	89	2525
Axial XL	POST	16.4 fl oz/A	0.054					
Zidua	PRE	1.5 oz/A	0.08	95	89	85	84	2810
RyzUp		1 oz/A	0.025					
Axial XL	POST	16.4 fl oz/A	0.054	91	91	82	84	3370
Fierce	PRE	3 oz/A	0.143					
Axial XL	POST	16.4 fl oz/A	0.054	89	81	81	84	2610
Fierce MTZ	PRE	16 fl oz/A	0.33					
Axial XL	POST	16.4 fl oz/A	0.054	91	84	79	86	3030
Fierce	PRE	3 oz/A	0.143					
RyzUp		1 oz/A	0.025	91	86	79	94	3775
Axial XL	POST	16.4 fl oz/A	0.054					
Fierce MTZ	PRE	16 fl oz/A	0.33	19	13	14	16	1167
RyzUp		1 oz/A	0.025					
Axial XL	POST	16.4 fl oz/A	0.054					
			<i>LSD</i>					

^a DAT = days after preemergence treatment.

^b POST, postemergence; PRE, preemergence.

Table 3. Density of Italian ryegrass (*Lolium multiflorum*) per 1 m² following fall preemergence (PRE) and spring postemergence (POST) applications in Pullman, WA, in 2021.

Treatment	Timing	Product Rate	Active Ingredient Rate lb ai/A	5/5/21 201 DAAT	5/18/21 8 DABT	6/9/21 30 DABT
				Density Plants per m ²		
Nontreated	-	-	-	122	125	54
Axial XL	POST ^a	16.4 fl oz/A	0.054	69	237	51
Zidua	PRE	1.5 oz/A	0.08	26	28	15
Axial XL	POST	16.4 fl oz/A	0.054			
Zidua	PRE	1.5 oz/A	0.08	24	50	17
RyzUp		1 oz/A	0.025			
Axial XL	POST	16.4 fl oz/A	0.054			
Fierce	PRE	3 oz/A	0.143	36	36	6
Axial XL	POST	16.4 fl oz/A	0.054			
Fierce MTZ	PRE	16 fl oz/A	0.33	35	54	4
Axial XL	POST	16.4 fl oz/A	0.054			
Fierce	PRE	3 oz/A	0.143	34	46	9
RyzUp		1 oz/A	0.025			
Axial XL	POST	16.4 fl oz/A	0.054			
Fierce MTZ	PRE	16 fl oz/A	0.33	80	34	4
RyzUp		1 oz/A	0.025			
Axial XL	POST	16.4 fl oz/A	0.054			
LSD				96	95	23

^a DAT= days after preemergence application.

^b POST, postemergence; PRE, preemergence.

Evaluation of Peak® with tank mix partners for the control of mayweed chamomile in winter wheat

Henry Wetzel and Drew Lyon

A field study was conducted on Mike Nelson's Farm near Albion, WA to assess the level of control provided by Peak and tank mix partners on mayweed chamomile in winter wheat. Peak (prosulfuron) is an ALS-inhibiting herbicide (Group 2). Mayweed chamomile populations in the PNW are resistant to many of the Group 2 herbicides (Lyon et al., 2017). While Peak is in this group, we were not aware of how widely used it had been in the area and thought it would be worth evaluating.

The soil at this site is a Palouse silt loam with 4.5% organic matter and a pH of 5.4. The field was previously in chickpeas. On September 10, 2020, the field was fertilized with 100 lb N:20 lb P:15 lb S:10 lb Cl per acre and incorporated with a cultivator. On September 29th, 'UI Magic' 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. Postemergence treatments were applied on April 20, 2021 with a CO₂-powered backpack sprayer set to deliver 10 gpa at 50 psi at 2.3 mph. The applications were made at an air temperature of 51°F and relative humidity of 29% and winds out of the southwest at 6 mph. The majority of the wheat had just begun to joint and plants were 9 inches tall. Mayweed chamomile was uniformly distributed, and its population was high across the trial area. Mayweed chamomile was only 0.5 inch in height and there were so many plants per square feet that we were unable to accurately count them.

Mayweed chamomile was not actively growing at the time of herbicide application due to cold nighttime temperatures. The initial assessments were challenging because the mayweed chamomile was small and not actively growing. There was no crop injury among any of the treatments evaluated in this trial. Peak applied at either 0.38 or 0.5 oz/a provided poor control of mayweed chamomile (Table). Initial symptoms were chlorosis and stunting. Overtime the plants grew out of the chlorosis but remained shorter than plants in the nontreated check. Orion, which contains florasulam (Group 2) and MCPA (Group 4), provided a low level of control, similar to Peak (0.38 oz/a) + Rhonox MCPA (16 fl oz/a). The two treatments that really stood out in this trial were Peak + Widematch and Peak + Curtail M. Chlorosis, twisting, stunting, necrosis and death of mayweed chamomile were observed by 3 weeks after application. These results suggest that the mayweed chamomile population was still sensitive to clopyralid (Group 4), a component of Widematch and Curtail M. Peak tank mixes with Huskie, Bromac Advanced, Colt + Salvo, and Talinor provided good control of mayweed chamomile. Mayweed chamomile grew as tall as the base of the wheat heads. It never grew above the canopy. We did not harvest the trial.

Lyon, D.J., Burke, I.C., Hulting, A.G., and J.M. Campbell (2017). Integrated management of mayweed chamomile in wheat and pulse crop production systems. Pacific Northwest Extension Publication: PNW695 <https://pubs.extension.wsu.edu/integrated-management-of-mayweed-chamomile-in-wheat-and-pulse-crop-production-systems>

		5/18	6/29
Treatment ¹	Rate	Mayweed chamomile control	
	fl oz/a	-----%-----	
Peak	0.38 oz/a	45 d ³	40 d
Peak	0.5 oz/a	40 d	35 d
Peak + Huskie	0.38 oz/a + 13.5	74 ab	85 ab
Peak + Bromac Advanced	0.38 oz/a + 25.6	71 ab	84 ab
Peak + (Colt + Salvo)	0.38 oz/a + 16.0	63 bc	88 ab
Peak + Widematch	0.38 oz/a + 16.0	73 ab	96 a
Peak + Curtail M	0.38 oz/a + 32.0	80 a	98 a
Peak + Rhonox MCPA	0.38 oz/a + 16.0	63 bc	54 cd
Peak + Talinor ²	0.38 oz/a + 13.7	83 a	86 ab
Talinor ²	13.7	75 ab	68 bc
Orion	17	50 cd	43 d

¹ All treatments were tank mixed with NIS at 0.25% v/v

² Talinor was tank mixed with CoAct + at 2.75 fl oz/a

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.

Long-term control of smooth scouringrush with Finesse® in a no-till winter wheat/fallow rotation – final evaluation

Mark Thorne, Marija Savic, Dale Whaley, and Drew Lyon.

Smooth scouringrush is a problem in no-till wheat/fallow cropping systems in the intermediate to low rainfall areas of eastern Washington (Figure 1). We evaluated long-term control with 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? This also included applications of Amber during the crop phase. Amber is similar to chlorsulfuron in molecular structure

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 may not reduce smooth scouringrush density in the following year.



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 CO₂ backpack and ground speed of 3 mph. Spray output was 15 gpa at 25 psi. Initial smooth scouringrush density averaged 202 stems/yd².

The final evaluations occurred on July 23, 2021, in no-till fallow four years after the initial treatments were applied in fallow during July 2017. Smooth scouringrush stem density was counted in each plot and is presented as number of stems/yd². The lowest stem densities were achieved with the three treatments where Finesse was applied during fallow in 2017 and 2019. (Table 2). The sequence with only Rhonox resulted in the highest stem density. Stem density was

intermediate in the two treatments where Finesse was only applied in fallow in 2017. The application of Amber in the wheat crop did not appear to make a significant contribution to smooth scouringrush control.

Overall, Finesse applied each fallow year resulted in better control than if only applied once. The greatest reduction from Finesse followed the initial application in 2017, which resulted in fewer stems to be sprayed in the 2019 fallow applications (data not shown), which may have limited the control of the 2019 applications. Amber was applied in the crop before most smooth scouringrush stems emerged, therefore foliar uptake was minimal. Delayed applications of Amber, if possible, may result in greater uptake. Rhonox did result in quick burn down, but long-term control was not evident.

Table 1. Smooth scouringrush final density in a long-term study with Finesse for control in winter wheat/no-till fallow near Omak, WA.

Cropping and herbicide sequences*				
Fallow 2017	WW 2018	Fallow 2019	WW 2020	Fallow 2021**
				stems/yd ²
Finesse	Amber	Finesse	Amber	18 d
Finesse	Amber	Finesse	Rhonox	23 cd
Finesse	Rhonox	Finesse	Rhonox	19 cd
Finesse	Amber	Rhonox	Rhonox	31 bc
Finesse	Rhonox	Rhonox	Rhonox	40 b
Rhonox	Rhonox	Rhonox	Rhonox	66 a

*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.

**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 Finesse® in winter wheat/spring wheat/no-till fallow rotations – continued.

Mark Thorne, Marija Savic, and Drew Lyon.

Smooth scouringrush is a problem in no-till wheat/fallow rotations in the intermediate to low rainfall areas of eastern Washington. In spring wheat, smooth scouringrush has the potential to be more competitive than in winter wheat as the stems can emerge close to emergence of the wheat (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.

Two trials were initiated in 2019, one near Edwall on the Camp farm and a second near Steptoe on the Hall farm. Each site is in a no-till winter wheat/spring wheat/ 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 a 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 were applied with a hand-held



Figure 1. Smooth scouringrush emerging with spring wheat.

spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO₂ 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 winter wheat/spring wheat/fallow cropping systems in eastern Washington.

Edwall and Steptoe herbicide sequences*							
Seq	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	

*Seq=sequence; 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 was measured in each plot and is presented as number of stems/yard². Identical sequences at the time of evaluation are grouped together for each analysis. All applications in 2021 were applied in the spring wheat phase of each rotation. The Edwall site had been managed without any tillage, whereas the Steptoe site was plowed following the 2020 winter wheat crop. At both Edwall and Steptoe, Finesse applied in 2019 resulted in low smooth scouringrush density in the 2021 spring wheat compared with the Rhonox only sequence (Table 2). At Steptoe, the 2020 fall plowing resulted in delayed smooth scouringrush emergence and lower density compared with Edwall; however, at both sites, smooth scouringrush had emerged by the time Amber was applied to the crop.

Spring wheat yields at Steptoe were overall higher than at Edwall as the Steptoe field site was sub-irrigated, which kept the wheat more competitive and productive given the 2021 regional drought. At Edwall, spring wheat in the Rhonox only sequence yielded 22 bu/A and was statistically lower than sequences where Finesse had been applied in 2019, which all ranged between 33 to 36 bu/A. Harvest yields at Steptoe were not different between the various herbicide sequences and ranged between 56 to 60 bu/A. Greater smooth scouringrush stem density at Edwall likely reduced wheat yield in the Rhonox only sequence, and stem density at Steptoe was apparently not great enough to reduce wheat yield.

This research continues to show that Finesse results in good control of smooth scouringrush. 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 has emerged by the time

Amber is applied, thus providing a better opportunity to test the efficacy of this herbicide than in winter wheat.

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

Herbicide sequence*	2021 density and yield measurements**	
	Smooth scouringrush stems/yd ²	Spring wheat yield bu/A
2019 - 2020 - 2021		
<i>-----Edwall-----</i>		
Finesse – Amber – Amber	2.5 b	34 a
Finesse – Amber – Rhonox	1.9 b	36 a
Finesse – Rhonox – Rhonox	3.6 b	33 a
Rhonox – Rhonox – Rhonox	92.8 a	22 b
<i>-----Steptoe-----</i>		
Finesse - Amber - Amber	0.2 b	56 a
Finesse - Amber - Rhonox	0.3 b	60 a
Finesse – Rhonox – Rhonox	0.3 b	56 a
Rhonox - Rhonox - Rhonox	9.4 a	60 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.

Evaluation of Axial® Bold plus Talinor™ in tank mix combinations with nitrogen sources for crop safety, common lambsquarters and mayweed chamomile control in spring wheat
Henry Wetzel and Drew Lyon

A field study was conducted at Nelson Farms near Albion, WA to evaluate crop safety and broadleaf and grass weed control with Axial Bold plus Talinor in tank mix combination with either UAN (32-0-0) or McGregor's liquid urea (20-0-0). The study area followed the planting of 'M-Press' winter wheat. On October 27, 2020, the field was fertilized with 100 lb N:20 lb P:15 lb S and one quart of N-Serve®



per acre, which was applied with a McGregor's ripper shooter implement. The soil at this site is a Palouse silt loam with 5.4% organic matter and a pH of 5.5. 'Ryan' spring wheat was seeded on March 28, 2021 at the rate of 105 lb/A with a JD 455 double-disc drill on a 7.5-inch row spacing. Postemergence treatments were applied on May 21th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 50 psi at 2.3 mph. The applications were made with an air temperature of 45°F and relative humidity of 47% with winds at 6 mph out of the west. The majority of the wheat had just begun to joint and plants were 13 inches tall. Mayweed chamomile was uniformly distributed, and its population was moderate across the trial area. Mayweed chamomile was 2.0-inches-tall at the time of application and had a density of less than one plant per square foot in the nontreated check plots. Common lambsquarters were uniformly distributed, and its population was high across the trial area. Common lambsquarters were 2.5-inches-tall at the time of application and had a density of 11 plants per square foot in the nontreated check plots. There were no grassy weeds present in the trial area. The trial area was harvested on July 30th with a Kincaid 8XP plot combine.

From the date of seeding (March 28th) to the day treatments were applied (May 21st), 0.57 of an inch of rain fell on the field. From the day that treatments were applied (May 21st) to the day the trial was harvested (July 30th), 0.63 of an inch of rain fell. For nearly the entire duration of the trial, the crop was under drought stress. All herbicide treatments contained Axial Bold + Talinor (Table), thus results will be discussed as to how the tank mix components influenced crop injury or broadleaf weed control. Tilt + UAN 32-treated plots exhibited the most crop injury (Table). Crop injury included bleached streaks on the uppermost leaves in the canopy. The injury symptoms did not move systemically. Minor penultimate leaf burning was observed in some wheat plants within the plots treated with Quilt Xcel or Quilt Xcel + Liquid Urea. This may have been in part due to the azoxystrobin component of the Quilt Xcel formulation. This injury was short lived and was barely noticed 14 DAT. Mayweed chamomile control was excellent and nearly complete by 14 DAT in all herbicide-treated plots. Common lambsquarters control was excellent in plots treated with Tilt + UAN 32, Quilt Xcel + Brox-M, and Miravis Ace + Brox-M (Table). The addition of UAN 32 to Axial Bold + Talinor + Tilt exhibited quicker and nearly complete control of common lambsquarters compared to the same treatment without UAN 32

(Table). In general, treatments that did not contain a nitrogen source (exceptions being Quilt Xcel + Brox-M and Miravis Ace + Brox-M) and treatments containing Liquid Urea (exception being Miravis Ace + Liquid Urea)- only provided good control of common lambsquarters when compared to Tilt + UAN 32 that provided near complete control. While the addition of UAN 32 to Axial Bold + Talinor + Tilt significantly improved common lambsquarters control, it also negatively impacted yield (Table). We have seen significant crop injury in previous trials evaluating Talinor + UAN 32. This is the first trial where we saw this treatment negatively impact yield. This may have been in part due to the unique growing season that the crop experienced and the lack of significant rainfall following the application to help the crop recover from the injury.

		5/28	6/4	7/2	6/4	7/22	
		7 DAT	14 DAT	42 DAT	14 DAT	69 DAT	7/30
		Crop injury			Common lambsquarters		124 DAP
Treatment ¹	Rate	-----%-----			control		Yield
	fl oz/A	-----%-----			-----%-----		bu/a
Nontreated Check	--	--	--	--	--	--	49 cd
Tilt + UAN-32	4.0 + 64	9 a ²	18 a	5 a	98 a	99 a	47 d
Tilt	4.0	0 d	0 b	0 b	79 cd	79 b	64 ab
Quilt Xcel	7.0	2 bc	0 b	0 b	83 cd	79 b	70 a
Trivapro	7.0	0 d	0 b	0 b	76 d	58 c	60 a-d
Miravis Ave	7.0	0 d	0 b	0 b	80 cd	80 b	56 b-d
Tilt + Liquid Urea	4.0 + 5.0 gal	0 d	0 b	0 b	84 b-d	84 b	62 a-c
Quilt Xcel + Liquid Urea	7.0 + 5.0 gal	0 d	0 b	0 b	76 d	86 b	67 ab
Trivapro + Liquid Urea	7.0 + 5.0 gal	1 cd	0 b	0 b	81 cd	84 b	61 a-c
Miravis Ave + Liquid Urea	7.0 + 5.0 gal	0 d	0 b	0 b	86 b-d	90 a	63 ab
Quilt Xcel + Brox-M	7.0 + 16	3 b	1 b	0 b	94 ab	99 a	71 a
Miravis Ave + Brox-M	7.0 + 16	0 d	0 b	0 b	89 a-c	100 a	71 a

¹ With the exception of the nontreated check, all treatments were tank mixed with CoAct+ + Talinor + Axial Bold at 3.2 + 16 + 15 fl oz/a.

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

Evaluation of Axial® Bold plus Huskie® in tank mix combinations for common lambsquarters and mayweed chamomile control in spring wheat

Henry Wetzel and Drew Lyon

A field study was conducted at Nelson Farms near Albion, WA to evaluate crop safety and broadleaf and grass weed control with Axial Bold plus Huskie and additional herbicide combinations. The study area followed the planting of 'M-Press' winter wheat. On October 27, 2020, the field was fertilized with 100 lb N:20 lb P:15 lb S and one quart of N-Serve® per acre, which was applied with a McGregor's ripper shooter implement.



The soil at this site is a Palouse silt loam with 5.4% organic matter and a pH of 5.5. 'Ryan' spring wheat was seeded on March 28, 2021 at the rate of 105 lb/A with a JD 455 double-disc drill on a 7.5-inch row spacing. Postemergence treatments were applied on May 14th with a CO₂-powered backpack sprayer set to deliver 10 gpa at 49 psi at 2.3 mph. The applications were made with an air temperature of 66°F and relative humidity of 44% under calm conditions. The majority of the wheat had just begun to joint and plants were 11 inches tall. Mayweed chamomile was uniformly distributed, and its population was moderate across the trial area. Mayweed chamomile was 1.5- inches- tall at the time of application and had a density of 4 plants per square foot in the nontreated check plots. Common lambsquarters were uniformly distributed, and its population was high across the trial area. Common lambsquarters were 2.0-inches-tall at the time of application and had a density of 22 plants per square foot in the nontreated check plots. There were no grassy weeds present in the trial area. The trial area was harvested on July 30th with a Kincaid 8XP plot combine.

From the date of seeding (March 28th) to the day treatments were applied (May 14th), 0.42 of an inch of rain fell on the field. From the day that treatments were applied (May 14th) to the day the trial was harvested (July 30th), 0.78 of an inch of rain fell. For nearly the entire duration of the trial, the crop was under drought stress. Axial Bold (15 fl oz/a) and Huskie (12.8 fl oz/a) were each applied as individual treatments to evaluate if crop injury occurred with the Axial Bold + Huskie tank mix (data not shown). There was no crop injury observed with any of the treatments in this study. All treatments, except Starane Flex + Rhonox MCPA, provided excellent control of common lambsquarters 28 DAT (Table). On the final rating date, July 22nd, 9 days prior to harvest, all treatments provided near complete control of common lambsquarters. Talinor provided excellent control of mayweed chamomile; Huskie, Huskie + Rhonox MCPA and Huskie FX provided good control; and Starane Flex + Rhonox MCPA provided poor control of mayweed chamomile 28 DAT (Table). On the final rating date, July 22nd, 9 days prior to harvest, treatments were performing similar to their 28 DAT rating in regard to mayweed chamomile control. The poor performance of the Starane Flex + Rhonox MCPA treatment suggests a Group

2 resistant population of mayweed chamomile. There were no significant differences for yield or test weight among nontreated and herbicide treated plots. The average yield and test weight among all plots was 67 bu/a and 56.5 lb/bu, respectively.

		6/11	7/22	6/11	7/22
		28 DAT	69 DAT	28 DAT	69 DAT
		Common lambsquarters		Mayweed chamomile	
Treatment ¹	Rate	control		control	
	fl oz/A	-----%-----		-----%-----	
Huskie + AMS	12.8 + 0.5 lb/a	96 a ³	100 a	79 b	83 b
Huskie + AMS + Rhonox MCPA	12.8 + 0.5 lb/a + 8.0	99 a	99 a	73 b	74 b
Huskie FX + AMS	15.5 + 0.5 lb/a	100 a	100 a	68 c	81 b
Talinor + CoAct + ²	13.7 + 2.75	98 a	99 a	96 a	99 a
Starane Flex + Rhonox MCPA ²	13.5 + 8.0	63 b	99 a	55 d	57 c

¹ All treatments were tank mixed with Axial Bold at 15 fl oz/a.

² Treatments were tank mixed with NIS at 0.25% v/v

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

Evaluation of a new formulation of Batalium™ herbicide for crop safety and the control of mayweed chamomile in spring wheat

Henry Wetzel and Drew Lyon

Batalium contains bromoxynil (Group 6), fluroxypyr (Group 4) and flucarbazone (Group 2). Batalium is not labeled for the control of mayweed chamomile, but we wanted to evaluate the new formulation to determine its efficacy. A field study was conducted at Duane Oehlwein's farm near Egypt, WA. The soil at this site is a Hanning silt loam with 4.5% organic matter and a pH of 6.1. On April 12, 2021, 'Louise' spring wheat was planted with a Morris no-till drill with Anderson



openers on a 12-inch row spacing at a rate of 68 lb seed per acre. Postemergence treatments were applied on June 9th with a CO₂-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 southeast with an air temperature of 55°F and relative humidity of 59%. Most of the wheat had 2 tillers and plants were 15 inches tall. Mayweed chamomile was uniformly distributed, and its population was high across the trial area. Mayweed chamomile was 2.5- inches- tall and 2.25- inches- wide at the time of application and had a density of 8 plants per square foot in the nontreated check plots. The trial was not taken to harvest.



Figure 2. Mayweed chamomile beginning to flower in the nontreated check plots on June 23rd (14 DAT)

From April 1st to July 31st, the trial area received 0.93 inches of rainfall. For nearly the entire duration of the trial, the crop was under drought stress. However, with the wheat planted early and the trial area bordering a grass water way, it was a nice stand of wheat and a dense, uniform population of mayweed chamomile developed, most likely supported by deep soil moisture. Wild oats were also present in the trial area but not uniformly enough dispersed to be able to take a rating on them. When the treatments were applied, mayweed chamomile plants were larger than preferred for optimum control.

Mayweed chamomile was beginning to initiate flowers 14 DAT throughout the trial area (Figure 1). Early flowering may have been incited as a result of the drought stress and above average temperatures. At 14 DAT, the spring wheat was nearly fully headed. Mayweed chamomile never grew above the height of the spring wheat canopy. Despite the environmental conditions, there was no visible crop injury associated with any of the treatments. Batalium did not control

mayweed chamomile (Table). Tank mix partners with Batalium did not significantly improve control. The only treatment that provided commercially acceptable control of mayweed chamomile was Axial Bold + Huskie. The clopyralid (Group 4) component of Stinger and WideARmatch has provided very good control of mayweed chamomile in other studies. Mayweed chamomile treated with Batalium + Stinger and Everest 3.0 + WideARmatch were significantly twisted, stunted and on the final rating date (7/22), flowers were less noticeable than in the nontreated check plots. In this trial, the lack of control from the clopyralid component of the two treatments may have been influenced the growth stage of mayweed chamomile, environmental conditions, or some combination of the two factors.

		7/21
		42 DAT
		Mayweed chamomile
Treatment ¹	Rate	control
	fl oz/A	%
Batalium	13.7	38 d ²
Batalium + Audit 1:1	13.7 + 0.4 oz/A	43 cd
Batalium + Paridy	13.7 + 6.4	48 b-d
Batalium + Stinger	13.7 + 4.0	50 b-d
Batalium + Starane Ultra	13.7 + 5.75	45 b-d
Batalium + Weedone LV4 EC	13.7 + 8.0	40 cd
Batalium + Rhonox MCPA	13.7 + 8.0	48 b-d
Batalium + Evito	13.7 + 1.0	40 cd
Huskie + Axial XL	13.5 + 16.4	78 a
PerfectMatch	16.0	55 bc
Everest 3.0 + WideARmatch	2.0 + 14.0	60 b

¹ With the exception of the nontreated check, treatments were tank mixed with NIS and AMS 0.25% v/v and 8.5 lb/100 gal, respectively.

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.

Italian ryegrass seed shatter in spring wheat

Mark Thorne, Marija Savic, Drew Lyon

Italian ryegrass (*Lolium multiflorum*) is a serious weedy threat to crop production in parts of the Pacific Northwest. In addition to high competitiveness with crops, it is now resistant to most herbicides that were once effective for its control. Another mechanism that has contributed to its persistence is the tendency for seeds to disarticulate (shatter) soon after seed maturity (Figure 1) and well before crop harvest. This presents a problem as only seeds left on the plant potentially could be captured in the combine grain tank, or better yet, managed with a harvest weed seed control system (See PNW730, Harvest Weed Seed Control: Applications for PNW Wheat Production Systems) such as an integrated impact mill system like the Seed Terminator or Harrington Seed Destructor

Italian ryegrass seed shatter in spring wheat - Pullman



Figure 3. Italian ryegrass in spring wheat.

We began monitoring Italian ryegrass seed shatter rates here on the Palouse in 2017 in winter wheat. The data presented below is from spring wheat grown in 2020. Seed shatter in winter wheat averaged about 60% at harvest. We wanted to see if seed shatter rates are different in spring wheat. In 2020, locations on the Fleener farm and the WSU Cook research farm near Pullman, WA were selected. At each location, sampling began when it was evident that most of the florets had finished anthesis (flowering and seed set) and were filling seeds. Ten Italian ryegrass plants were randomly collected from a northeast facing slope, a draw bottom, and a southwest facing slope. Sampling occurred weekly until the wheat crop was ripe, and harvest had

begun. From each plant, the number of tillers and spikelets per tiller were counted. The spikelet is the smallest seed containing unit on a grass plant. All seeds were hand-threshed, and the chaff and unfilled florets were removed. For each sample, seeds were weighed, sub-sampled, and counted to determine the average number of seeds remaining in the spikelets for each plant. In the first two weeks, a representative intact spikelet on each plant was removed from the stem and all florets counted to get an estimate of the potential number of seeds per spikelet if all florets filled; however, it was uncommon for all florets to fill. From all our collections, the total number of florets per spikelet consistently averaged around 12.

The 2020 sampling found that on July 15, most of the florets were not filled at each topographical position (Figure 2). Maximum fill did occur by July 27, but no statistical difference occurred between positions. By August 5, shatter was greatest on the southwest facing position and averaged 3.9 seeds per spikelet, which was a 49% shatter rate for that position. On August 12, seed shatter had significantly increased at all three positions with the southwest position having greater shatter than the northeast. By August 18, there was no statistical change in number of seeds per spikelet for each position, but the southwest position still had greater shatter (fewer seeds per spikelet) than the northwest position. By August 18, or harvest, the southwest position had a shatter rate of 75%, while the draw bottom and the northwest positions had shatter rates of 69 and 61%, respectively. If Italian ryegrass seed management is to be successful, strategies will be needed to collect or destroy the seed before a majority of the seed has shattered.

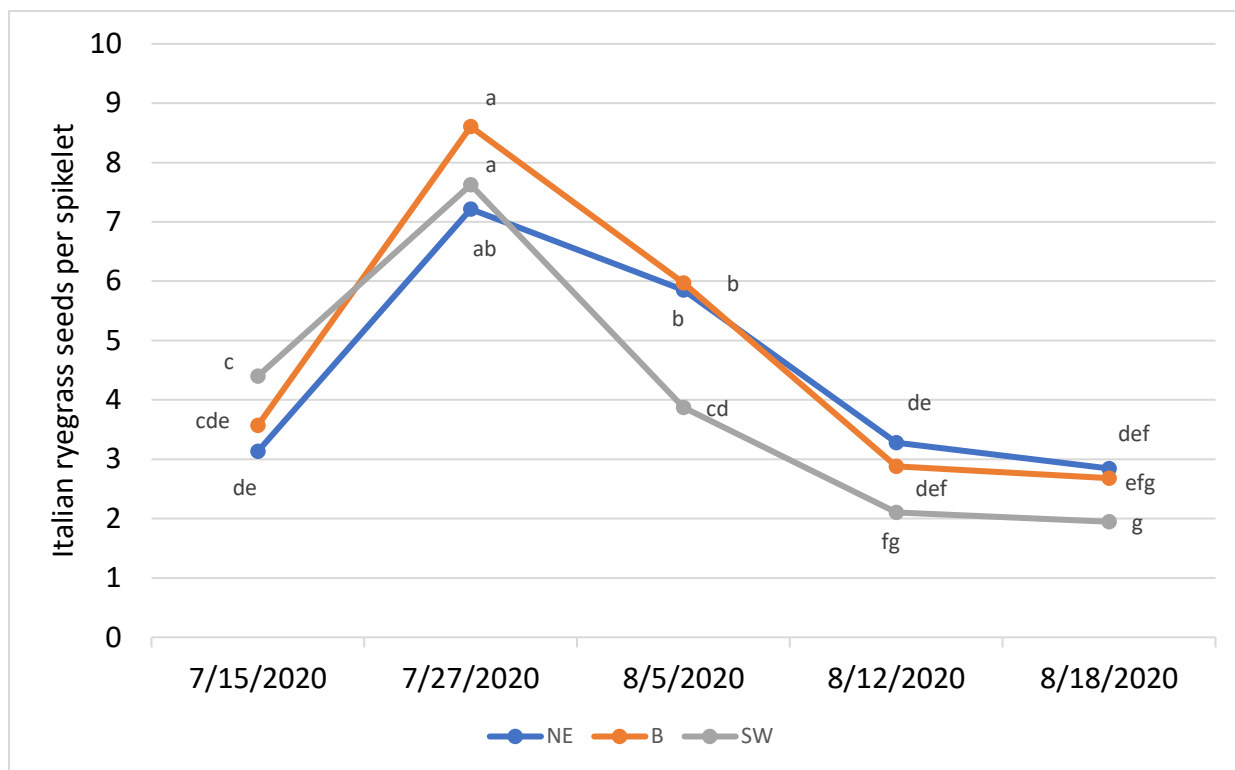


Figure 2. Italian ryegrass seed shatter from seed fill to spring wheat harvest at three different field positions: NE=northeast facing slope, B=draw bottom, SW=southwest facing slope. Data points with the same letter are not statistically different.

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 (two, nine and sixteen days 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 7/16, 7/23 and 7/30/2021, which

corresponded to two, nine and sixteen days after harvest. RT 3[®] (glyphosate) plus ammonium sulfate (AMS) (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 7/16 application were an air temperature of 88°F, relative humidity 22% and the wind was out of the southwest at 8 mph. There was an average of 2.75 Russian-thistle plants per square yard in the nontreated check plots. Plants were 14-in-diameter and 8-in-height. The wheat stubble height (10 in) was uniform across the trial area. As noted in the height of the Russian-thistle, the plants had not grown above the height of the wheat stubble as it had only been two days since the trial area was harvested. Environmental conditions for the 7/23 application were an air temperature of 79°F, relative humidity 22% and the wind was out of the southwest at 8 mph. Environmental conditions for the 7/30 application were an air temperature of 93°F, relative humidity 22% and the wind was out of the east at 6 mph.

Very dry conditions occurred at the trial site from March 1st through the final rating date of August 20th. During that entire time, the trial site received only 0.55 inches of rainfall, with 0.35 inches falling between August 1st and the 18th. During the time that the trial occurred, the lack of rainfall is not uncommon in this area of eastern WA. However, the lack of precipitation prior to the initiation of the trial is very uncommon. Air temperatures were above average in June, July and August.

Maestro 4EC + TriCor 75DF provided a moderate level of control when applied 2 days after harvest (DAH) (7/16) (Table). Twenty-eight days after treatment (DAT) (8/13), it was noted that regrowth was occurring in some of these treated plants. Regrowth may have been supported by the 0.19 inches of rain that fell on August 1st. By 35 DAT, this treatment was not providing acceptable control of Russian-thistle (Table). Maestro 4EC + TriCor 75DF applied 9 DAH (7/23) or 16 DAH (7/30) provided better control than when applied 2 DAH (Table).

Gramoxone SL 2.0 + NIS applied 2 DAH or 16 DAH exhibited quick activity on Russian-thistle and provided very effective control (Table). It is unknown why control with this treatment

applied at 9 DAH was not as good (Table), especially when the environmental conditions at the time of application were not much different among the three application timings.

The activity of RT 3 + AMS was very slow, taking 3 weeks to see a respectable level of control when applied 2 or 9 DAH (Table). When the final rating was taken, 8/20 (37 DAH), both of these application timings of RT 3 + AMS provided very good control of Russian-thistle (Table). The activity of RT 3 + AMS was even slower when applied 16 DAH. A treatment affect may have been noted if ratings continued for another 7 to 14 days. Rainfall events of 0.19, 0.13 and 0.03 inches that came 1, 17 & 18 DAT did not seem to influence the efficacy of RT 3 + AMS applied on 7/30 (16 DAH).

On the last rating date (8/20), the greatest control of Russian-thistle was provided by Gramoxone SL 2.0 + NIS applied 2 or 16 DAH, RT3 + AMS applied 2 or 9 DAH, and Maestro 4EC + TriCor 75DF 16 DAH. There appears to have been a trend for the RT3 (a translocated herbicide) + AMS to work better at the earlier application times, when plants may have been less drought-stressed, and for the two contact herbicide treatments, Gramoxone SL 2.0 + NIS and Maestro 4EC + TriCor 75 DF, to work better at the later application times, when plants were likely experiencing greater drought stress.

		Treatments were applied 2 days after harvest (7/16)				
		7/23	7/30	8/9	8/13	8/20
Treatment	Rate	-----Russian-thistle control-----				
	fl oz/A	-----%-----				
Maestro [®] 4EC + TriCor [®] 75DF	16 + 10.67 oz	63 b ¹	74 a	70 b	72 b	33 b
RT 3 [®] + AMS	64 + 17 lb/100 gal	0 c	25 b	74 b	70 b	83 a
Gramoxone [®] SL 2.0 + NIS	48 + 0.125% v/v	96 a	91 a	89 b	91 a	88 a
		Treatments were applied 9 days after harvest (7/23)				
Maestro 4EC + TriCor 75DF	16 + 10.67 oz	--	83 a	89 a	83 a	74 b
RT 3 + AMS	64 + 17 lb/100 gal	--	0 b	63 b	71 a	90 a
Gramoxone SL 2.0 + NIS	48 + 0.125% v/v	--	75 a	83 a	86 a	78 b
		Treatments were applied 16 days after harvest (7/30)				
Maestro 4EC + TriCor 75DF	16 + 10.67 oz	--	--	90 a	89 a	89 a
RT 3 + AMS	64 + 17 lb/100 gal	--	--	21 b	33 b	48 b
Gramoxone SL 2.0 + NIS	48 + 0.125% v/v	--	--	94 a	96 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.

Comparison of RT[®] 3 and surfactants for control of smooth scouringrush – one year after treatment

Mark Thorne, Marija Savic, and Drew Lyon

Applications of RT 3 (glyphosate) to smooth scouringrush (*Equisetum laevigatum*) in chemical fallow have resulted in inconsistent control, especially at rates used for general weed control in no-till fallow management (Figure 1). We have recently found that the addition of Silwet[®] L77 organosilicone surfactant with RT 3 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.

This may explain how Silwet L77 is facilitating the efficacy of RT 3 in smooth scouringrush in our research. In general, stomates are closed at night and open periodically during the day to obtain CO₂ from the surrounding air. We hypothesized that if stomatal uptake is the primary route of RT 3 uptake in smooth scouringrush, and Silwet L77 facilitates this uptake, then control should be greater if RT 3 plus Silwet L77 is applied during the day rather than at night.



Figure 4. Smooth scouringrush on a NW-facing slope in no-till fallow near Rosalia, WA.

In 2020, we applied RT 3 during the day and at night to smooth scouringrush growing 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 content 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 CO₂ backpack at 3 mph. Spray output was 15 gpa at 25 psi. All RT 3 applications were applied at 96 oz/A. Surfactants compared were Silwet L77 and Kinetic, both organosilicone surfactants applied at 0.5% v/v, and Wetcit, a non-organosilicone surfactant applied at 0.78% v/v. Finesse was applied at 0.5 oz/A as

a positive control because it has been shown to be very effective for smooth scouringrush control. Initial smooth scouringrush density in 2020 averaged 282 stems/yd². Daytime treatments were applied between 12:00 and 12:30 p.m. Nighttime applications were between 9:40 and 10:00 p.m. Nighttime applications were initiated after all surrounding WSU Ag WeatherNet stations reported 0 watts/meter² solar radiation. Soil temperature at 2 inch depth was 67° F during the daytime applications, and 72° during the nighttime applications.

In July 2021, one year after treatments were applied, stem densities were counted in two 1-meter quadrats per plot to assess treatment efficacy. Overall, control from the 2020 mid-day applications was less than expected and may have been due to moisture stress, which would have caused stomates to close, and/or an increased rate of spray droplet evaporation from the stems. However, the daytime application of RT 3 plus Kinetic resulted in a 55% reduction in stem density compared with the same treatment applied at night (Table 1). In contrast, day and night applications of RT 3 plus Silwet L77 were not statistically different. Silwet L77 is a straight organosilicone surfactant that substantially reduces spray droplet surface tension on the stems, thus may increase evaporation rate. Kinetic is a blend of an organosilicone and nonionioic surfactants and may result in a slower evaporation rate. Applications of RT 3 alone and with Wetcit were not affected by the day or night timing. Results of this trial suggest that there is a relationship between uptake, and subsequent control of smooth scouringrush with RT 3, with stomatal opening; however, plant stress and weather conditions at the time of application may influence herbicide efficacy.

Table 1. Smooth scouringrush stem density in winter wheat one year after herbicide applications.

#	Herbicide	Surfactant	Timing	Smooth scouringrush stems/yd ²
1	Nontreated check	---	---	115 a
2	RT 3	none	day	109 ab
3	RT 3	none	night	104 ab
4	RT 3	Silwet L77	day	59 bcd
5	RT 3	Silwet L77	night	82 abc
6	RT 3	Kinetic	day	49 cd
7	RT 3	Kinetic	night	110 a
8	RT 3	Wetcit	day	73 abc
9	RT 3	Wetcit	night	78 abc
10	Finesse	Silwet L77	day	38 d

*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.

Comparison of RT[®] 3 and surfactants for control of smooth scouringrush during a drought year – 2021

Mark Thorne, Marija Savic, and Drew Lyon

Control of smooth scouringrush (*Equisetum laevigatum*) in chemical fallow with glyphosate has been difficult, especially at the rates used for general weed control in no-till fallow management (Figure 1). However, drought and high temperatures can reduce efficacy of glyphosate in many weed species, and smooth scouringrush is no exception. We have found that the addition of Silwet[®] L77 organosilicone surfactant with RT 3 applied at 96 oz/A in fallow can substantially reduce smooth scouringrush density in the following winter wheat crop. The mechanism of action for organosilicone surfactants is reduced spray droplet surface tension on leaves, which facilitates movement of the spray solution across the leaf/stem surface and into open stomates where the herbicide can be more easily absorbed. Reduction of spray droplet surface tension also leaves the herbicide solution susceptible to quicker evaporation. In either situation, if the stomate is closed and/or the spray solution evaporates before it can be taken up the plant, control is lost.



Figure 5. A sea of smooth scouringrush in no-till fallow.

In general, plants open their stomates during the day to obtain CO₂ from the surrounding air, but close stomates at night. To test the hypothesis that organosilicone surfactants facilitate herbicide uptake through open smooth scouringrush stomates, we applied RT 3 during the day and at night to smooth scouringrush in three different trial sites in eastern Washington. Locations were near Rock Lake, WA on the Seagle farm and Reardan, WA on the Carstens farm. All sites were in no-till fallow at the time of application and were planted to winter wheat in October 2021. The Rock Lake site was a slight northwest facing slope on a Uhlig silt loam soil with pH of 5.5 and 3.75% organic matter in the top 6 inches. The Reardan site was

on a northwest facing slope on an Athena silt loam soil with pH of 4.9 and 2.4% organic matter in the top 6 inches. Plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. Herbicide treatments were applied at 9:30am on July 12, 2021, at Rock Lake and at 12:15pm at one Reardan site (Reardan A). At a second Reardan site (Reardan B), night treatments were applied August 9, 2021, while day treatments were applied at 10:40am the following day. Nighttime applications were initiated in the evenings after all surrounding WSU Ag WeatherNet stations reported 0 watts/meter² solar radiation. All applications were made with a hand-held spray boom with six TeeJet® XR11002 nozzles on 20-inch spacing and pressurized with a CO₂ backpack at 3 mph. Spray output was 15 gpa at 25 psi. All RT 3 applications were applied at 96 oz/A. Organosilicone surfactants compared were Silwet L77 and Kinetik® applied at 0.5% v/v, and Sil-Coat® applied at 0.375% v/v. Wetcit®, a non-organosilicone surfactant, was applied at 0.78% v/v. Finesse was applied at 0.5 oz/A as a positive control because it has been shown to be very effective for smooth scouringrush control. Initial smooth scouringrush density at Rock Lake averaged 271 stems/yard². Initial density at the two Reardan sites averaged 213 stems/yard².

Visual ratings of treatment efficacy 45 days after treatment (DAT) differed at all three trials. At Rock Lake, the day application of RT 3 plus Sil-Coat averaged 44% control and was statistically higher than the night applications that averaged only 15% control; however, there was no difference between day and night for the other two organosilicone surfactants, Silwet L77 and Kinetik (Table 1). Finesse resulted in the best control at 46%. The Reardan A applications were made 3 hours after the Rock Lake applications, after air temperature had risen from 80° to the low 90°s F and relative humidity dropped from 30% to less than 20%. At Reardan A, there were no differences between day and night applications for any surfactant, and percent control was low for all treatments, including Finesse. This would suggest that the smooth scouringrush plants had shut down under heat and potentially drought stress. A month later at the Reardan B trial, the night applications of Silwet L77 and Sil-Coat resulted in better control than their corresponding day applications. The night application of RT 3 plus Silwet L77 average 82% control and was substantially better than the day application at 14% control. Likewise for Sil-Coat, the night and day applications averaged 63 and 31% control, respectively, and were statistically different (Table 1). These results suggest that either smooth scouringrush was opening stomates at night after plant water status and temperature had improved, or the night applications did not experience spray droplet evaporation. However, day application of RT 3 alone was greater than the night application, suggesting that faster evaporation with Silwet L77 and Sil-Coat might have had an impact.

Overall, these results indicate that weather and plant water/temperature status are important considerations for herbicide control of smooth scouringrush. It is important to note that other applications we made in 2021, prior to the July high temperatures, of 96 oz/A of RT 3 plus Silwet L77 or Kinetik yielded excellent control between 80 and 100% burn down after 30 days. More work needs to be done with smooth scouringrush control in relation to soil and air temperature and moisture.

Table 1. Smooth scouringrush control rated visually 45 days after treatments (DAT) were applied in no-till fallow.

Herbicide	Surfactant	Timing	Smooth scouringrush control – 45 DAT		
			Rock Lake	Reardan A	Reardan B
			----- % -----		
Nontreated check	---	---	---	---	---
RT 3	none	day	27 bcd	10 c	33 d
RT 3	none	night	13 b	15 bc	15 e
RT 3	Silwet L77	day	35 abc	17 bc	14 f
RT 3	Silwet L77	night	24 cd	23 ab	82 a
RT 3	Kinetic	day	26 cd	26 ab	33 d
RT 3	Kinetic	night	16 d	34 a	33 d
RT 3	Sil-Coat	day	44 ab	25 ab	31 de
RT 3	Sil-Coat	night	15 d	16 bc	63 b
RT 3	Wetcit	day	27 bcd	24 ab	40 cd
RT 3	Wetcit	night	24 cd	23 ab	53 bc
Finesse	Silwet L77	day	46 a	8 c	35 d

*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.

Efficacy of Silwet® L77 organosilicone surfactant with RT® 3 glyphosate applied in no-till fallow for control of smooth scouringrush – 2 years after treatment.

Mark Thorne, Marija Savic, and Drew Lyon

Control of smooth scouringrush (*Equisetum laevigatum*) in fallow has been a challenge for producers, especially in no-till systems (Figure 1). In 2019 we initiated trials in no-till fallow comparing RT 3 plus Silwet L77 surfactant with applications of RT 3 with no added surfactant. Smooth scouringrush is also a very deep-rooted plant with extensive vertical rhizomes and it was unclear how long control from applications would persist. Treatments were evaluated in the 2020 winter wheat crops, and again in 2021, two years after the applications.

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/yd² 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 CO₂ 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 June 2021, stem densities were re-counted in all plots at each site. The Edwall and PCFS sites were growing spring wheat, and the Steptoe site was in spring barley.

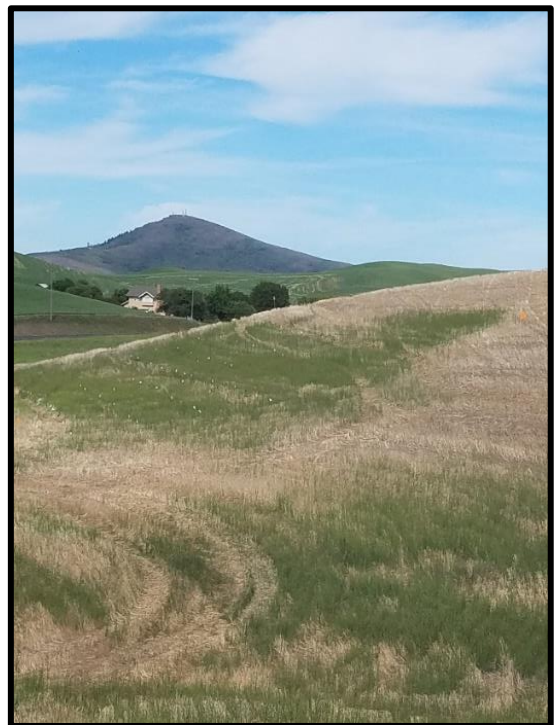


Figure 6. Dense patches of smooth scouringrush in fallow near Steptoe, WA.

In June 2021, stem densities were counted in two 1-meter quadrats per plot. Overall, smooth scouringrush densities in 2021, two years after applications, were lower following RT 3 plus

Silwet L77 compared with RT 3 alone (Table 1). The only exceptions were the May and August applications at Edwall where no statistical differences existed between treatments. The best results were seen with the May and June applications at PCFS and the June application at Steptoe where densities were 2, 0, and 4 stems/yard², respectively. The July applications at PCFS and Steptoe were also an exception as the RT 3 plus Silwet L77 were not statistically different from RT 3 alone. Clearly, there are differences in efficacy relative to timing of application and location for smooth scouringrush control with RT 3 plus Silwet L77. 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 (Figure 1). 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. Organosilicone surfactants, like Silwet L77, function by substantially reducing spray drop surface tension on a leaf or stem, resulting in mass flow of the spray solution across the surface. Other research has shown that this mass flow facilitates the movement of the spray solution into open stomates where herbicide uptake can more readily occur. The downside of low surface tension and mass flow is that the spray solution is susceptible to faster evaporation off the surface, thus reducing uptake. It is likely that plant water status and soil and weather conditions could influence the amount of herbicide getting into the plant, thus effecting control.



Figure 2. Effect of RT 3 plus Silwet L77 two years after application.

The application of RT 3 plus an organosilicone surfactant 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 2021, two years after treatments were applied in 2019 from May through August at three locations in eastern Washington.

Time	Treatments	Rates oz/A + % v/v	Smooth scouringrush density*		
			Edwall	PCFS	Steptoe
			-----stems/yd ² -----		
May	None	-	149 a	72 a	239 a
May	RT 3 alone	96	149 a	20 a	79 b
May	RT 3 + Silwet L77	96 + 0.25	83 a	2 b	21 c
June	None	-	152 a	71 a	153a
June	RT 3 alone	96	142 a	22 a	83 a
June	RT 3 + Silwet L77	96 + 0.25	31 b	0 b	4 b
July	None	-	185 a	141 a	217 a
July	RT 3 alone	96	90 a	51 b	117 ab
July	RT 3 + Silwet L77	96 + 0.25	35 b	27 b	74 b
August	None	-	69 a	145 a	217 a
August	RT 3 alone	96	61 a	115 a	117 a
August	RT 3 + Silwet L77	96 + 0.25	48 a	20 a	74 b

*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.

Long-term control of smooth scouringrush control with RT 3[®] and Finesse[®] in wheat/fallow cropping systems

Mark Thorne, Marija Savic, and Drew Lyon

Smooth scouringrush (*Equisetum laevigatum*) control in wheat/fallow rotations in eastern Washington has been difficult because of limited effective herbicide options. In different studies, we have shown that applications of Finesse (chlorsulfuron + metsulfuron) can have activity on smooth scouringrush at least a year after application; however, tank mixing RT 3 (glyphosate) with Finesse in fallow-year applications may increase control of smooth scouringrush into the following crop year and beyond. RT 3 has been effective when applied at a high rate and with an organosilicone surfactant. In contrast, Finesse is effective for at least two years after application, but when applied alone, does not control some 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 one year after application in fallow.

Study trials were initiated in 2020 on the Lambert farm near Dayton, WA, and the Hall farm near Steptoe, WA. The Dayton site is on a 30-40% northwest facing slope with a Walla Walla silt loam well-drained soil with pH 5.4 and 2.1% soil organic matter in the top 6 inches. 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% in the top 6 inches. Treatments were applied July 6, 2020, in no-till fallow at the Dayton and Steptoe sites. All plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment. All treatments were applied with a hand-held spray boom with six TeeJet[®] XR11002 nozzles on 20-inch spacing and pressurized with a CO₂ backpack at 3 mph. Spray output was 15 gpa at 25 psi. All treatments included an organosilicone surfactant (Silwet[®] L77). Initial smooth scouringrush density in 2020 averaged 326 and 279 stems/yard² at the Dayton and Steptoe sites, respectively. In October 2020 the Dayton and Reardan sites were seeded to winter wheat.



Figure 1. Wheat row on left with smooth scouringrush not treated in 2020 compared with Finesse treated row on the right.

In July 2021, winter wheat at Dayton and Steptoe was ripening when smooth scouringrush stems were counted in two 1-meter quadrats per plot, one year after treatment. At Dayton, the nontreated check plots averaged 122 stems/yard² in the 2021 winter wheat, 37% of the initial

density, which illustrates that winter wheat is somewhat competitive with smooth scouringrush. This difference was even more dramatic at Steptoe (Table 1). At both locations, the weakest treatment was 32 oz/A of RT 3, which was 55% of the nontreated check at Dayton, and 3% at Steptoe. All treatments with Finesse resulted in zero stems in the winter wheat (Figure 1). At Dayton, the 64 and 96 oz/A rates of RT 3 with no Finesse resulted in 30 and 23 stems/yard² but at Steptoe, all treatments except the 32 oz/A RT 3 had zero stems/yard². The treatments applied in 2020 at Dayton were much slower to show symptoms compared with the Steptoe and this difference was likely related to soil temperature and moisture differences at the time of application. The Steptoe site had warmer soil temperature at application and was located on low-lying flat with the potential for adequate soil water. In contrast, the Dayton site was on the upper part a steep north-facing slope and had cooler temperatures at application. It is difficult to determine if RT 3 aided Finesse since all applications with Finesse resulted in zero stems, however, stem counts will be taken again in 2022 to see if other treatment differences begin to show over time.

Table 1. Smooth scouringrush density in winter wheat one year after applications of RT 3 and Finesse in fallow at Dayton and Steptoe, WA.

Treatments	Rates*	Smooth scouringrush stem density – July 2021**	
		Dayton	Steptoe
		stems/yd ²	
Nontreated check	none	122 a	29 a
RT 3	32	67 b	1 b
Finesse	0.5	0 d	0 c
RT 3 + Finesse	32 + 0.5	0 d	0 c
RT 3	64	30 c	0 c
RT 3 + Finesse	64 + 0.5	0 d	0 c
RT 3	96	23 c	0 c
RT 3 + Finesse	96 + 0.5	0 d	0 c
Initial stem density - 2020		326	279

*All herbicide treatments included Silwet L77 organosilicone surfactant at 0.5% v/v. Rates of RT 3 are in fluid oz/A; Finesse rate is in dry oz/A.

**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.

Long-term control of smooth scouringrush control with RT 3[®] and Finesse[®] applied in wheat/fallow cropping systems – replicated in 2021.

Mark Thorne, Marija Savic, and Drew Lyon

In 2021, we replicated a trial evaluating smooth scouringrush (*Equisetum laevigatum*) control in wheat/fallow rotations in eastern Washington with RT 3 (glyphosate) and Finesse. Smooth scouringrush has been very difficult to control, especially in no-till cropping systems as most herbicides have been ineffective (Figure 1). Finesse (chlorsulfuron + metsulfuron) can have activity on smooth scouringrush at least a year after application, and RT 3 has been effective when applied at a high rate and with an organosilicone surfactant. This study examines the effect of Finesse and RT 3 applied alone or in combination at different rates of RT 3 applied in fallow.

This trial was initiated July 9, 2021, in fallow near Reardan, WA on the Carstens farm. The Reardan site is on a northwest facing slope with an Athena silt loam soil and pH of 4.9 and 2.4% organic matter in the top 6 inches. All plots measured 10 by 30 ft and were arranged in a randomized complete block design with four replications per treatment.

Treatments were applied with a hand-held spray boom with six TeeJet[®] XR11002 nozzles on 20-inch spacing and pressurized with a CO₂ backpack at 3 mph. Spray output was 15 gpa at 25 psi. All treatments included an organosilicone surfactant (Silwet[®] L77). Initial smooth scouringrush density averaged 248 stems/yd². In October 2021 the site was seeded to winter wheat.

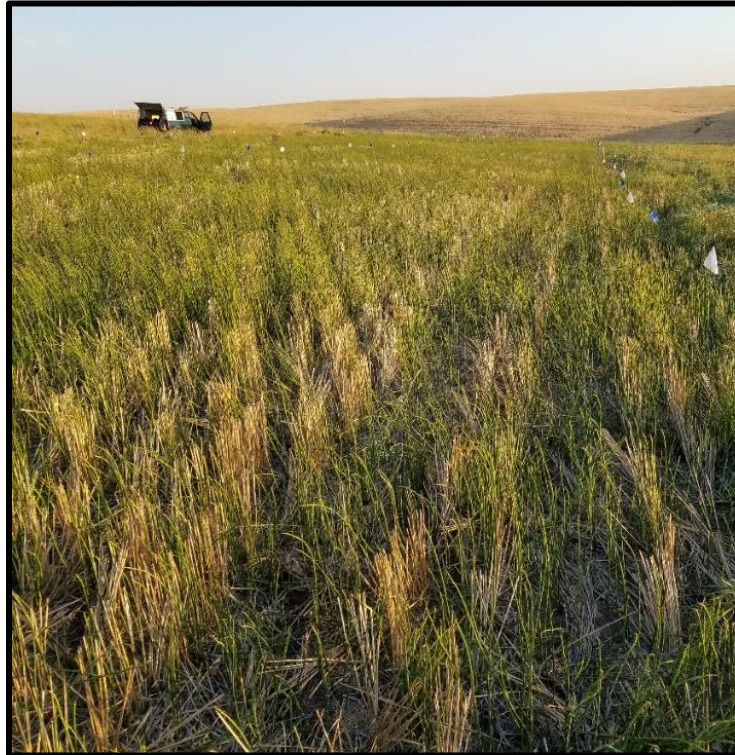


Figure 7. Smooth scouringrush in winter wheat fallow near Reardan, WA.

Visual evaluations were made at 15, 30, and 45 days after treatment (DAT) following application. At each evaluation, the greatest visual control was seen with the 96 oz/A rate of RT 3 plus Finesse and reached 93% by 45 DAT (Table 1). Visual symptoms included stunting of growth and discoloration from light green to straw color. Furthermore, at each visual rating, no difference was seen between the 96 oz/A rate of RT 3 alone and the 64 oz/A rate of RT 3 plus Finesse, suggesting that by adding Finesse the rate of RT 3 could be reduced, even to 32 oz/A. However, the 32 oz/A rate of RT 3 alone provided very little control, which has been a common

issue for smooth scouringrush control in chemical fallow management. Stem density will be measured in 2022 to assess control one year after treatment.

Table 1. Smooth scouringrush control visually rated 15, 30, and 45 days after treatment (DAT) with RT 3 and Finesse in fallow at Reardan, WA in 2021.

Treatments	Rates*	Visual control ratings**		
		15 DAT	30 DAT	45 DAT
	oz/A		% control	
Nontreated check		0 -	0 -	0 -
RT 3	32	5 d	9 d	22 d
Finesse	0.5	15 cd	26 c	43 c
RT 3 + Finesse	32 + 0.5	17 c	35 c	65 b
RT 3	64	9 cd	23 cd	44 c
RT 3 + Finesse	64 + 0.5	34 b	59 b	77 b
RT 3	96	31 b	60 b	78 b
RT 3 + Finesse	96 + 0.5	58 a	88 a	93 a

*All herbicide treatments included Silwet L77 organosilicone surfactant at 0.5% v/v.

Rates of RT 3 are in fluid oz/A; Finesse rate is in dry oz/A.

**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.

Rush skeletonweed control with Tordon 22K in no-till fallow is affected by application method, herbicide rate, and field conditions.

Mark Thorne, Marija Savic, and Drew Lyon

Control of rush skeletonweed (*Chondrilla juncea*) in winter wheat/no-till fallow cropping systems was evaluated by comparing fall and spring applications of Tordon® 22K (picloram) using a WEED-IT™ precision sprayer and a broadcast application. Precision sprayers can be effective at spot spraying weeds in fallow, thus reducing chemical inputs compared to a complete coverage broadcast spray application. Furthermore, Tordon 22K is labeled for fallow applications at 16 oz/A and is an effective herbicide for controlling rush skeletonweed. However, Tordon 22K applied at high rates in fallow can result in subsequent crop injury.



Rush skeletonweed initiating flowering in no-till winter wheat stubble during July 2021.

A fall-applied trial was initiated in October 2020 near LaCrosse in winter wheat stubble. Spring-applied trials were initiated in May 2021, near LaCrosse and Hay, both in no-till fallow following 2020 winter wheat. Tordon 22K was applied at 8, 16, and 32 oz/A with the broadcast applicator and the WEED-IT applicator, if set to spray in the continuous mode. The broadcast application spray volume was 15 gpa at 3 mph. The WEED-IT continuous application spray volume was 29.4 gpa at 5 mph ground speed; however, the total output per plot in spot-spray mode depended on the density of rush skeletonweed and the volume sprayed per plot was

measured to determine the area sprayed per plot and the application rate of Tordon 22K. Soil type at the LaCrosse site was classified as a Bengé Complex and had a pH of 5.9 and organic matter content of 2.1% in the top 6 inches. Soil type at the Hay site was a Walla Walla silt loam and had a pH of 5.9 and organic matter content of 2.4% in the top six inches. All plots measured 10 by 35 ft, but the WEED-IT applicator only sprayed a width of 6.7 ft through the center of each plot. Rush skeletonweed plants were counted in a 6.7-ft strip through each plot at the time of application to establish a baseline density. Treatment efficacy was evaluated in July 2021 by re-counting rush skeletonweed plants in each plot prior to summer no-till fallow burn-down herbicide applications.

Dry fall conditions in 2020 and cold winter and early spring temperatures in 2021 reduced emergence of rush skeletonweed rosettes compared with previous years. The number of plants available for herbicide application by the WEED-IT applicator were few in both fall and spring applications, but especially in spring. Consequently, the broadcast applications outperformed the WEED-IT applications in the fall-applied trial, but all fall applications did reduce rush skeletonweed density compared with the nontreated check (Table 1). Rate was also a prevailing factor with the fall WEED-IT applications as the 16 and 32 oz/A rates resulted in the lowest densities. Emergence of rosettes in spring 2021 was delayed until late April and May due to cold, dry soil conditions. Furthermore, many rosettes quickly initiated bolting within a couple weeks of emergence. This is problematic for spring-applied herbicides because very little long-term control has been observed from applications once bolting begins in spring or early summer. Consequently, very few differences in application method were found with spring applications by the summer 2021 count. However, the 16 and 32 oz/A broadcast rates and the 32 oz/A WEED-IT rate resulted in fewer rush skeletonweed plants compared with the nontreated check by the summer 2021 count at LaCrosse (Table 1). At Hay, none of the treatments had lower plant densities than the nontreated check as bolting was further along at time of spring applications compared with LaCrosse.

The WEED-IT applications were consistently lower in amount of product applied compared with the broadcast applications (Table 2). The fall WEED-IT applications ranged between 21 and 27% of the full Tordon 22K broadcast rate per acre. The spring WEED-IT applications ranged between 5 and 19% of the full broadcast rates; however, the reduced coverage rates also reflect the low rush skeletonweed emergence at the time of application. None of the WEED-IT applications exceeded the labeled 16 oz/A rate. Since Tordon 22K has soil activity, more control may occur from the broadcast applications into the next crop phase. It is evident that the WEED-IT precision applicator may be better suited to years with a higher percentage of potential weed emergence prior to application as only emerged plants will be treated compared to complete area coverage with a broadcast applicator. These trials will be harvested for wheat yield in 2022. An identical trial initiated in the fall of 2019 was harvested for yield in 2021 and no differences were found between treatments.

Table 1. Effect of fall- and spring-applied Tordon 22K on rush skeletonweed density in no-till fallow comparing WEED-IT and broadcast applications.

Application method	Rate oz/A	Rush skeletonweed density measured in July 2021*		
		Fall applied LaCrosse 2020	Spring applied LaCrosse 2021	Spring applied Hay 2021
		-----plants/yd ² -----**		
Nontreated check	0	2.2 a	1.3 a	0.5 b
WEED-IT	8	0.9 b	0.9 ab	0.6 b
Broadcast	8	0.3 cd	0.9 ab	0.9 a
WEED-IT	16	0.3 c	0.9 ab	0.4 b
Broadcast	16	0.1 de	0.6 bc	0.5 b
WEED-IT	32	0.4 c	0.6 bc	0.5 b
Broadcast	32	0.0 e	0.3 c	0.3 b

*Applications were made in October 2020 at LaCrosse and May 2021 at LaCrosse.

**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.

Table 2. Amount of Tordon 22K applied with a WEED-IT precision sprayer compared with a standard broadcast application.

Amount of Tordon 22K applied		Percent of broadcast rate applied using the WEED-IT applicator
Broadcast	WEED-IT	
oz/A	oz/A	
<i>Fall 2020 applied - LaCrosse</i>		
8	2.1	26
16	3.4	21
32	8.7	27
<i>Spring 2021 applied - LaCrosse</i>		
8	0.9	11
16	1.9	12
32	1.6	5
<i>Spring 2021 applied - Hay</i>		
8	1.3	16
16	3.0	19
32	3.8	12

Evaluation of Storm for Crop Safety and Efficacy in Winter Pea

I.C. Burke

In the spring of 2021, two winter or fall seeded pea herbicide trials were conducted to evaluate Storm for crop safety and broadleaf weed efficacy. Broadleaf weed management in winter pea is mostly achieved through the use of preemergence herbicides. Storm, the prepacked mixture of bentazon plus acifluorfen, would substantially improve in crop and rotational weed management in an emerging and important crop, winter pea. Storm is currently a category A priority registration for pea for IR4.



Figure 8. Pea response to Storm. Injury, where observed, was transient and did not affect yield.

Two studies were established, one near Ralston, WA and a second near Almira, WA. Treatments were applied when the pea had 3 to 5 tendrils. Treatments were applied with a CO₂ 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 28 ft long. Treatments were assessed for injury, weed control, and yield. Data was subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

Results

The overall growing conditions were characterized by moderate to severe drought. No rainfall occurred during the time between application and harvest. Despite the moisture conditions, crop response was similar to previous

Table 1. Treatment application information for the trial in Almira, WA, in 2021.

Date	May 4, 2021
Application volume (GPA)	15
Timing	Postemergence
Crop Stage	3 to 5 Tendril
Air temperature (°F)	57
Soil temperature (°F)	52
Wind velocity (mph, direction)	6, NW
Cloud Cover	5

Table 1. Treatment application information for the trial in Ralston, WA, in 2021.

Date	April 28, 2021
Application volume (GPA)	15
Timing	Postemergence
Crop Stage	3 to 5 Tendril
Air temperature (°F)	57
Soil temperature (°F)	54.4
Wind velocity (mph, direction)	5.4, SW
Cloud Cover	5

experiments. 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 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. Timing and temperature of application may have an effect on treatment outcome. In other research, spring pea was more sensitive to Storm, which is attributed to higher temperatures at application. However, applications for weed management in winter pea occur much earlier than typical spring pea herbicide applications.

The experiment in Almira was weed free, likely due to the lack of rainfall. Flixweed was the dominant weed species in Ralston, and is a troublesome weed in crop-fallow production south of Ritzville. Flixweed control appeared to be related to the size of the weed, and further research is needed to determine the maximum size of flixweed control with Storm. The cohort of flixweed in the Ralston experiment were relatively uniform, and responded to surfactant, with crop oil concentrate combined with Storm resulting in increased flixweed control. Treatments with COC and Storm at 16 oz/A resulted in acceptable weed control and crop safety. In previous research, the use of COC improved control of mayweed chamomile.

Storm appears to be a safe and effective product for use for weed control in winter pea in Washington.

Table 1. Winter pea injury and yield in response to increasing rates of Storm with different surfactants in a trial located near Almira, WA, in 2021.

Treatment ¹	Rate		Injury 5/12/2021	Injury 6/10/2021	Yield	
			%	%	lb/A	
Nontreated			0 f	0 a	1910	ab
Nontreated – Weed Free			0 f	0 a	1870	ab
Storm	16	fl oz/A	8 ef	0 a	2380	a
NIS	0.25	% v/v				
Storm	24	fl oz/A	13 de	0 a	2190	ab
NIS	0.25	% v/v				
Storm	48	fl oz/A	21 cd	0 a	2110	ab
NIS	0.25	% v/v				
Storm	16	fl oz/A	20 cd	0 a	2180	ab
COC	1	% v/v				
Storm	24	fl oz/A	25 bc	0 a	2040	ab
COC	1	% v/v				
Storm	48	fl oz/A	33 b	0 a	1850	ab
COC	1	% v/v				
Rhomene	0.5	pt/A	45 a	34 b	1680	b
NIS	0.25	% v/v				
Rhomene	0.5	pt/A	9 ef	0 a	1990	ab
Metribuzin	0.25	lb/a				
NIS	0.25	% v/v				

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

Table 2. Winter pea injury, Mayweed chamomile and tumble mustard control in response to increasing rates of Storm with different surfactants in a trial located near Ralston, WA, in 2021.

Treatment ¹	Rate		Injury		Flixweed Control		Yield ²
			%		%		Lb/A
Nontreated			0	c	0	b	830
Nontreated – Weed Free			0	c	100	a	990
Storm	16	fl oz/A	0	c	64	ab	1070
NIS	0.25	% v/v					
Storm	24	fl oz/A	0	c	79	a	890
NIS	0.25	% v/v					
Storm	48	fl oz/A	0	c	64	ab	1060
NIS	0.25	% v/v					
Storm	16	fl oz/A	9	bc	91	a	980
COC	1	% v/v					
Storm	24	fl oz/A	8	bc	87	a	1180
COC	1	% v/v					
Storm	48	fl oz/A	14	ab	93	a	1220
COC	1	% v/v					
Rhomene	0.5	pt/A	21	a	53	ab	1130
NIS	0.25	% v/v					
Rhomene	0.5	pt/A					
Metribuzin	0.25	lb/a	6	bc	83	a	940
NIS	0.25	% v/v					

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

² No differences between treatments for yield.

Italian ryegrass control in spring canola combining multiple modes of action

Mark Thorne, Marija Savic, Henry Wetzell, and Drew Lyon

Italian ryegrass resistance to glyphosate is a concern for canola producers using RR cultivars specifically for control of Italian ryegrass. Resistance has occurred in southern U.S. states and California from repeated use of glyphosate on RR crops or in orchards. To delay or avoid resistance, management that incorporates different control approaches, including multiple herbicide modes of action, is highly recommended (Figure 1). Italian ryegrass is a cool-season annual to short-lived perennial grass weed that has developed a strong foothold in the Palouse region within the last 30 years. In this 30-year period, Italian ryegrass has developed resistance to all Group 1 (ACCase inhibitors) herbicides, e.g., clethodim, Hoelon[®], Poast[®], Assure[®], Axial[®], and Group 2 (ALS inhibitors) herbicides, e.g., Osprey[®], Outrider[®], Amber[®], PowerFlex[®], or Beyond[®].



Figure 9. Italian ryegrass sprayed with Liberty on left, nontreated on right.

In this region, Italian ryegrass resistance to glyphosate is not yet present; therefore, RR canola remains an effective tool. For non-Truflex[™] RR varieties, a single application cannot exceed 16 oz/A, and total application cannot exceed 22 oz/A up to the 6-leaf stage. Since these rates are lower than recommended for Italian ryegrass control in fallow, there is the chance for incomplete control, especially in dense stands or when applied to larger ryegrass plants. Low rates that result in incomplete control can lead to glyphosate resistance. In contrast, Roundup PowerMAX can be applied to RR Truflex[™] canola at 44 oz/A for a single early application when the canola has up to 3 leaves, or at 22 oz/A in two split applications with the last application occurring up to the time of flower initiation. These higher rates are less likely to result in incomplete control of Italian ryegrass.

To reduce dependency on glyphosate for Italian ryegrass control, other strategies need to be incorporated. Potential options include preemergence applications of trifluralin (Treflan[®] TR-

10), which can control Italian ryegrass up to about 70%, but requires rainfall following application for activation. Pronamide (Kerb[®]), which is currently not labeled for use in canola, has the same mode of action as trifluralin and needs rain for soil activation. Liberty Link[®] (LL) canola is resistant to glufosinate (Liberty[®]), which applied post-emergence can give about 90% control of Italian ryegrass, particularly if the ryegrass is in the 1-2 leaf stage. While Liberty is a non-systemic contact herbicide and can be less effective on grasses than glyphosate, using a LL canola and combining Liberty with a soil active herbicide may be an effective option.

See Table 1 for application dates, rates, and timing. Applications were made in both tilled and non-tilled soil; however, planting method was not statistically different for any of the measurements taken, therefore all data were combined for analysis (Table 1). Results from this year's trial were affected by regional drought conditions; however, several key pieces of information emerged. Overall, glyphosate applications were most effective at controlling Italian ryegrass. Control of Italian ryegrass was 100% for the EPOST (early postemergence) or the EPOST plus LPOST (late postemergence) split applications of Gly Star 5 Extra (glyphosate). The single LPOST applications were slightly less effective and a few Italian ryegrass plants produced seed by harvest. The Liberty applications were less effective than Gly Star 5 Extra; however, Italian ryegrass canopy cover (abundance) was similar to the Gly Star 5 Extra applications that resulted in less than 100% control. Treflan TR-10 PPI followed by EPOST Liberty was visually better than the EPOST Liberty treatment without Treflan TR-10. Also, more Italian ryegrass plants produced seed by harvest following the LPOST Liberty treatment than the EPOST treatments. Furthermore, the dry year was not conducive for the soil active herbicides, Treflan TR-10, Kerb, and Aatrex.

Canola yield was reduced by at least 50% from the previous year because of the dry spring conditions, and it was observed that some of the Gly Star 5 Extra applications resulted in reduced yield compared with the EPOST Liberty treatments (Table 1). Furthermore, harvest for all canola treated with Gly Star 5 Extra was delayed three weeks compared with the Liberty treated canola. This was especially evident in the no-till plots. Furthermore, yield of the TT and Non-GM canola were low compared with the highest yielding RR/LL plots. Overall, the no-till planted canola was a little slower to emerge because the seed zone soil was about 5° F cooler at planting compared with the tilled soil, and this also delayed flowering by a few days.

Overall, the early or split applications of Gly Star 5 Extra resulted in the best control and were more effective than Gly Star 5 Extra applied only LPOST, or the Liberty applications; however, the canola sprayed with the early Liberty applications yielded higher than Gly Star 5 Extra alone. The TT and Non-GM canola emerged and flowered a little faster than the RR/LL canola but resulted in lower yields and very little Italian ryegrass control. Unfortunately, the soil active herbicides were not effective because of the lack of rainfall following application.

Table 1. Applications to three different canola cultivars for Italian ryegrass control with multiple modes of action.

Trt	Dates for each operation, and canola stage at each date or operation									
	04/23/21	04/21/21	04/23/21	05/26/21	06/01/21	06/08/21	6/23/21	Canola Harvest ⁷		
	Canola Planted ¹	PPI ²	PRE ³	Canola 3-4 leaves EPOST ⁴	Canola 5-6 leaves LPOST ⁵	Canola Bolting LPOST ⁶	Italian Ryegrass Control	Italian Ryegrass Cover	Italian Ryegrass with Seed	Canola Yield
							(%)	(%)	(%)	(lb/A)
1	RR/LL	-	-	Gly Star (50)	-	-	100 a	0 ef	0 c	1120 bcd
2	RR/LL	-	-	-	-	Gly Star (25)	88 b	6 cd	0.4 c	1160 bc
3	RR/LL	-	-	Gly Star (25)	-	Gly Star (25)	100 a	2 def	0 c	1150 bcd
4	RR/LL	Treflan	-	Gly Star (50)	-	-	100 a	0 f	0 c	1290 ab
5	RR/LL	Treflan	-	-	-	Gly Star (25)	93 b	6 cd	0.4 c	1260 ab
6	RR/LL	-	-	Liberty	clethodim	None	67 c	5 cde	54 b	1490 a
7	RR/LL	Treflan	-	Liberty	-	none	84 b	4 cde	61 b	1480 a
8	RR/LL	Treflan	-	-	-	Liberty	59 c	12 bc	80 a	1300 ab
9	TT	-	Aatrex	clethodim	-	-	8 d	22 ab	84 a	942 d
10	TT	-	Aatrex	clethodim + Wetcit	-	-	10 d	27 a	85 a	1020 cd
11	TT	-	Kerb	Aatrex	-	-	11 d	25 a	85 a	1090 bcd
12	NonGM	Treflan	-	clethodim	-	-	15 d	17 ab	85 a	975 cd
13	NonGM	-	-	-	-	-	0	31 a	85 a	983 cd

¹RR/LL canola (InVigor LR344 PC) is resistant to both Gly Star 5 Extra (glyphosate) and Liberty (glufosinate) herbicides; TT canola (Rubisco RUBSCT20215) is tolerant of triazine herbicides, e.g., atrazine, simazine, metribuzin; Non-GM (Photosyntech NCC1010s) is a non-GMO canola. All canola varieties were planted at 12 seeds/ft² with a no-till drill on 12 in. spacing.

²Treflan TR-10 (trifluralin) was applied preplant incorporated (PPI) (2x harrow 180°) at 7.5 lb/A.

³Aatrex (atrazine) was applied PRE (post-plant preemergence) at 32 oz/A; Kerb was applied at 20 oz/A.

⁴EPOST (early postemergence) Gly Star was applied at 50 and 25 oz/A; Liberty was applied at 22 oz/A; clethodim was applied at 6 oz/A plus crop oil concentrate at 1% v/v; Aatrex was applied at 16 oz/A plus crop oil concentrate at 1% v/v; Wetcit surfactant was applied at 0.78% v/v.

⁵LPOST (late postemergence) clethodim was applied at 6 oz/A.

⁶LPOST Gly Star was applied at 25 oz/A; Liberty was applied at 22 oz/A. Glyphosate and Liberty applied with NH₄ SO₄ at 17 lb/100 gal.

⁷Italian ryegrass cover is percent of canopy covering the ground; Italian ryegrass with seed is percent of remaining plants that produced seed. Numbers followed by the same letter in each column are not statistically different (P≤0.05). Canola was harvested on 7/30/21 and 8/19/21.

Seed Bank Management for Italian Ryegrass in Eastern WA

Lyman, K.C. & I.C. Burke

Seed bank management for Italian ryegrass is critical component of an integrated management system. However, little is known of the seedbank longevity of Italian ryegrass in Washington. The objective of this study is to evaluate the efficacy of control on Italian ryegrass germination with applied chemical methods within a high rainfall zone in eastern Washington over a two-year cropping period. Italian ryegrass is becoming more prevalent and widespread within Eastern Washington, with higher rates of resistance to numerous herbicide modes of action. The preemergence herbicide indaziflam was used to prevent the germination of Italian ryegrass seedlings at the WSU Cook Agronomy farm, near Pullman WA. and near Almota, WA. Additionally, indaziflam was used within the wheat production system to gain an understanding of residual effects that the active ingredient of indaziflam has on the crop safety for eastern Washington dryland crops.

Two identical studies were established at the WSU Cook Agronomy farm near Pullman and the other trial near Almota, WA. The study was conducted in a randomized complete design with 4 replications and 3 different treatments among the repetitions. Each plot measured to be 30' by 35'. In year 1, indaziflam was applied postemergence to soft white spring wheat varieties that were infested with Italian ryegrass at both locations within the direct-seeding systems. For both trials, indaziflam treatments were applied with Axial Bold and NIS on May 8th of 2020 at the 2 to 3 tiller stage of the spring wheat (Table 1). Treatments were applied using a CO₂ powered backpack sprayer calibrated to 15 gallons per acre, at 3 mph. Italian ryegrass seedlings were barely emerged from the soil, if not emerged. Soil seedbank samples were collected from the trial site before planting and after harvest. Italian ryegrass density was assessed for both trials 1 month after treatment and before harvest from a 1-m² quadrant place randomly at two sites per plot. Harvest at the WSU Cook Agronomy study began on September 3, 2020 and harvest began on August 27, 2020 at Almota. A Wintersteiger plot combine with a 5-ft header was used to harvest plots. One day after harvest, the labeled bags were weighed and recorded.

For the second cropping year, dryland rotational small grain and broadleaf crops were planted to assess effects from the preemergence application of indaziflam applied the previous season. Each main plot was divided into 5 sub plots, measuring approximately 7 feet wide and 35 feet long. The crop varieties that were seeded, date seeded and harvested are displayed in Table 2. Soil seedbank samples were collected from the main plots before planting and from each sub-plot after harvest for later analysis of the Italian ryegrass seedbank. Italian ryegrass densities were assessed with 2 1-m² quadrats place randomly in each sub-plot. Italian ryegrass densities were assessed at planting and before harvest (Figures 2 and 3). Weekly assessments of percent Italian ryegrass control, crop injury and crop stand density for wheat, canola, barley, chickpea and fallow was recorded for each site location (Tables 3 and 4). All crops were harvested with a Kincaid plot combine at a single 5-foot swath, bagged and weighed and then analyzed for yield. Figures 4 through 8 correspond to each crop within each indaziflam treatment at the Almota site and Figures 9 through 13 correspond to each crop among each treatment at the Pullman site.

Throughout the second cropping year, general maintenance applications occurred for each of the crops planted that required maintenance. All pesticides were applied with a backpack CO₂ powered boom sprayer. In the fall of 2020 before planting, pyroxasulfone was applied at 2 oz/A plus glyphosate at 24 oz/A plus nonionic surfactant to control emerged weeds and augment

remaining weeds before the winter wheat was planted. Once planted and emerged, winter wheat was fertilized by streaming UAN at a 50/50 ratio with water. In the spring of 2021 before planting of each spring crop, glyphosate was applied at 24 fluid ounces per acre with nonionic surfactant to kill weeds that have emerged in the early spring. After spring planting and adequate emergence of each spring crop, UAN was applied by streaming at 50/50 ratio with water. No spring application for winter wheat was applied due to poor emergence. Canola was applied once with the suggested glyphosate product that was Roundup PowerMax at 22 fluid ounces per acre with nonionic surfactant to control the emerged Italian ryegrass within the crop. Barley was applied with pinoxaden at 15 fluid ounces per acre to control wild oats and pyrasulfotole plus bromoxynil at 13.5 fluid ounces per acre to control certain broadleaves like prickly lettuce and common lambsquarters. Chickpeas were applied with clethodim at 6 fluid ounces per acre to control wild oats. Chemical fallow was applied once with glyphosate at 24 fluid ounces per acre with nonionic surfactant to control all weeds to allow the ground to lay idle.

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). There was no significant difference between treatments for either site. Early preemergence (PRE) application timings had no significant differences in weed control, crop injury and yield. Field research with treatments including indaziflam are being conducted to understand how herbicide efficacy can differ from year to year as climatic conditions change in dryland cropping systems in eastern Washington.

The Pacific Northwest experienced abnormal weather patterns for the 2021 cropping year. Precipitation for the 2021 cropping season was lower than previous years. The 2021 drought limited the number of growing degree days for the crops grown and the germination rate of Italian ryegrass within the seedbank compared to a normal cropping season (Figure 1). Overall densities of Italian ryegrass was low and variable, with greater densities observed in particular replications in Almota and Pullman (Figures 2 and 3). Winter wheat stands were marginal due to a planter error, and were rated as injury (Tables 2 and 3). Spring broadleaf crops were not affected by the previous year's treatment of Esplanade, regardless of rate. Italian ryegrass control was assessed, although the drought conditions caused typical postemergence treatments applied to each crop in Pullman to fail. The 3 oz/A rate of Esplanade applied the previous season appeared to control Italian ryegrass more effectively than the lower rate or the nontreated in each crop, although the effect was not significant. Yield of the various crops was highly variable, and very low in Pullman (Tables 6 and 7). The variability precluded any conclusions based on the applications of Esplanade. Overall, Esplanade appears to be a potentially useful component of an integrated Italian ryegrass management system, particularly when rotations include broadleaf crops.

Table 1. Crops and varieties that were used in the field trials in Almota and Pullman, along with seeding and harvest dates.

		Almota		Pullman	
Crop	Variety	Seeding Date	Harvest Date	Seeding Date	Harvest Date
Winter Wheat	Hulk	Oct. 8, 2020	Aug. 4, 2021	Oct. 15, 2020	Aug. 12, 2021
Barley	WSU 12075-026	Apr. 15, 2021	Aug. 4, 2021	May 3, 2021	Sept. 2, 2021
Canola	Truflex	Apr. 15, 2021	Aug. 31, 2021	May 3, 2021	Sept. 8, 2021
Chickpea	Sierra	Apr. 15, 2021	Aug. 20, 2021	May 3, 2021	Sept. 2, 2021
Fallow	-	-	-	-	-

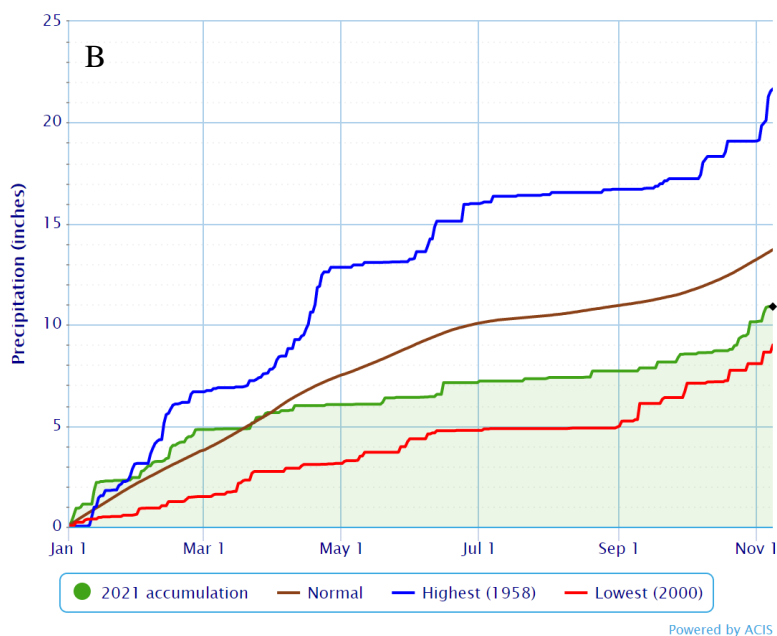
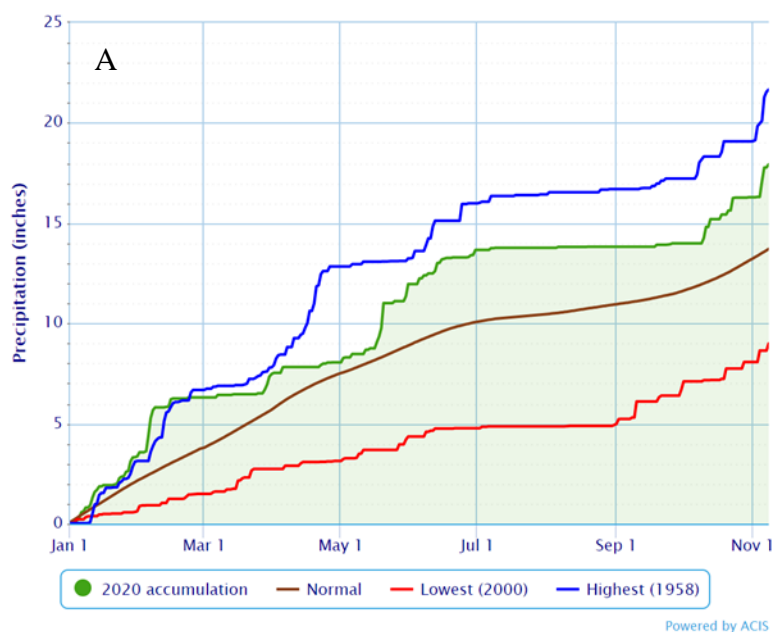


Figure 1. Precipitation data for Pullman and Almota area for 2020 (A) and 2021 (B), indicating the well below average moisture conditions for 2021. Weather data provided by the National Weather Service.

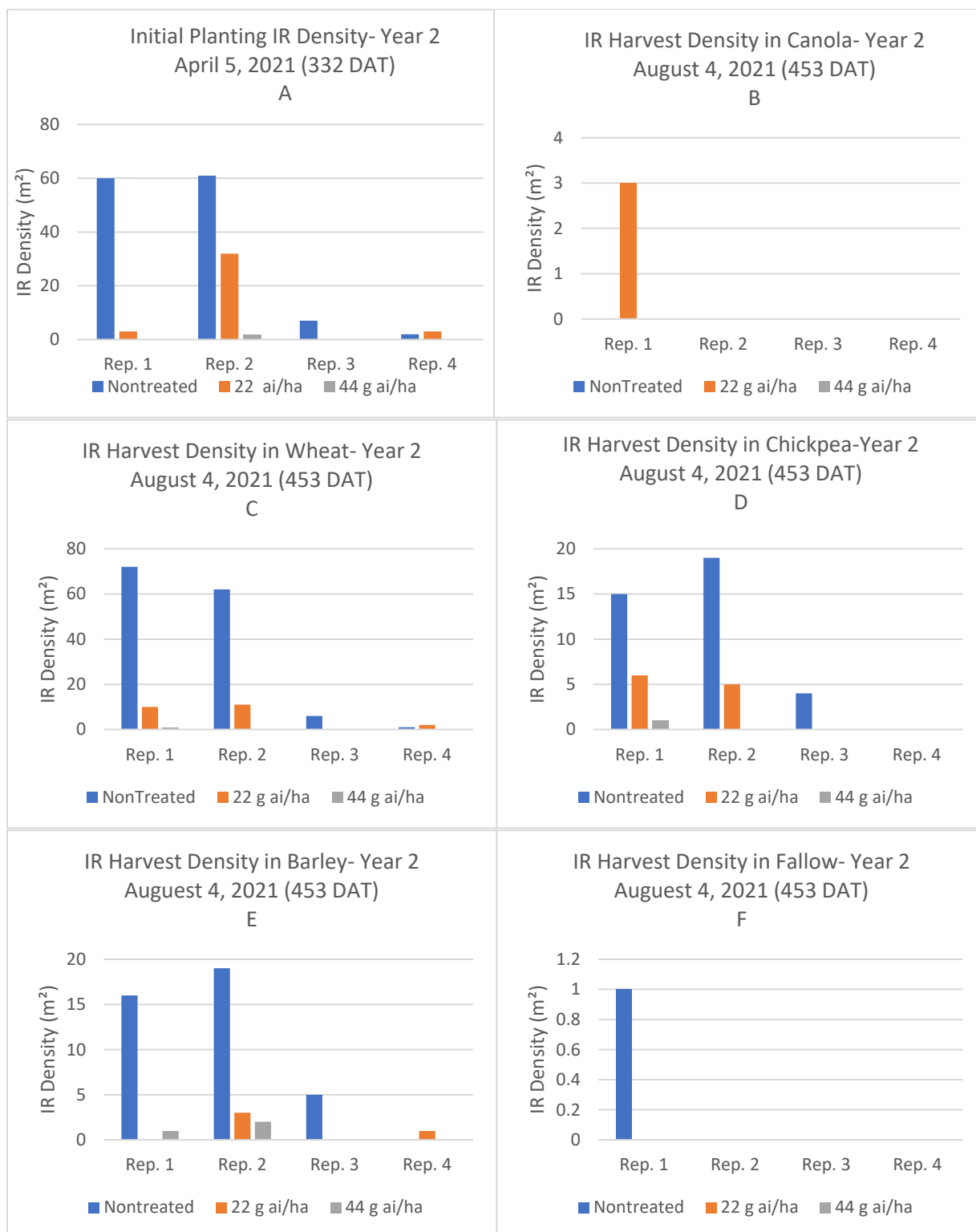


Figure 2. Italian ryegrass (IR) density/m² among treatments before planting and harvest events for Year-2, near Almota, WA. Initial IR density before planting at 332 Days after treatment (DAT) (Chart A). IR Density at 453 DAT (harvest) for canola, wheat, chickpea, barley and fallow systems (Charts B-F).

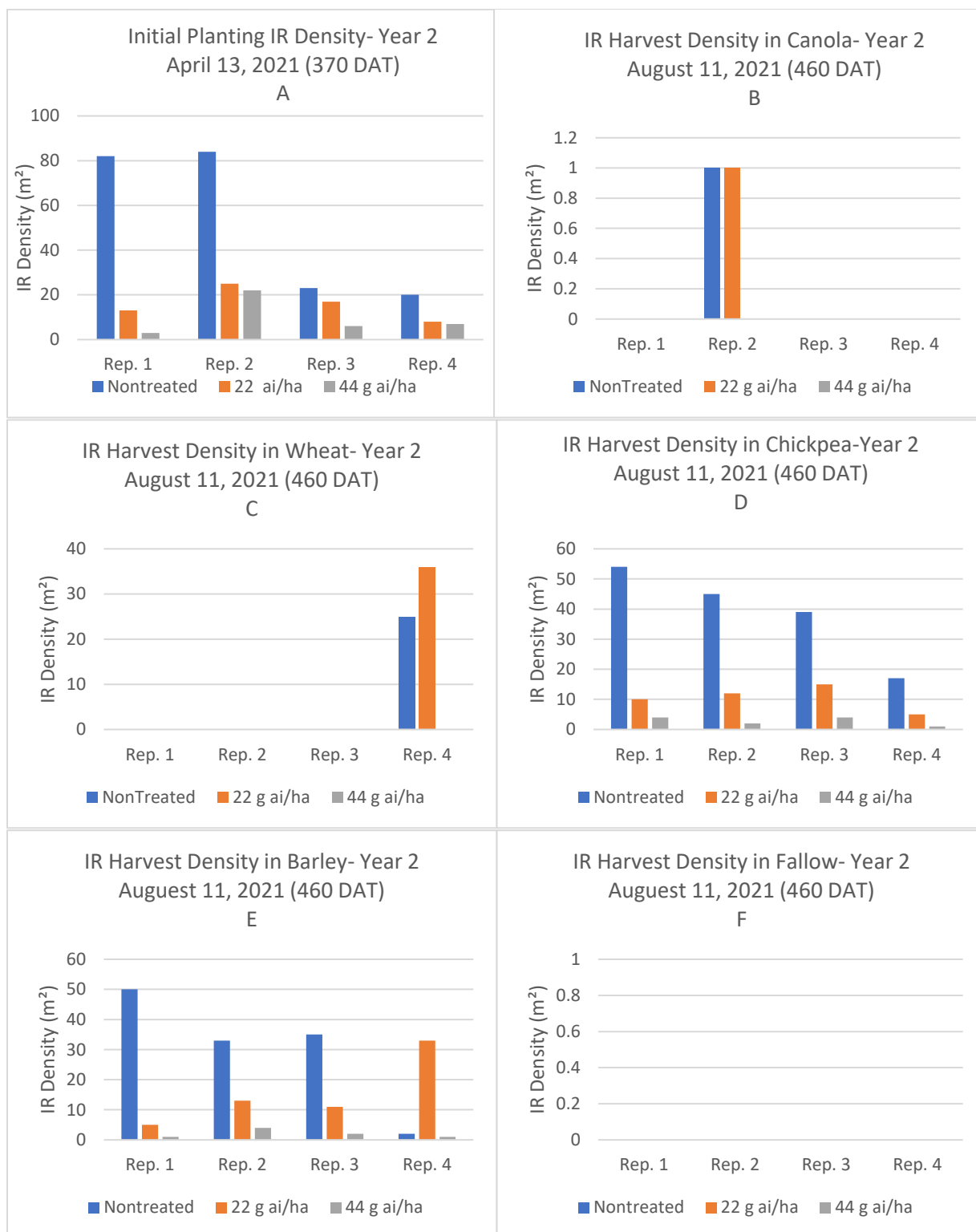


Figure 3. Italian ryegrass (IR) density/m² among treatments before planting and harvest events for Year-2, near Pullman, WA. Initial IR density before planting at 370 Days after treatment (DAT) (Chart A). IR Density at 460 DAT (harvest) for canola, wheat, chickpea, barley and fallow systems (Charts B-F).

Table 2. Crop injury for wheat, canola, barley, and chickpea following the Esplanade application applied to spring wheat the previous crop season, near Almota, WA.

Crop	Date	DAT ²	Treatment			LSD
			Nontreated 0 fl oz/A 0 g ai/ha	Esplanade 1.5 fl oz/a 22 g ai/ha	Esplanade 3 fl oz/a 44 g ai/ha	
			%			
Wheat	6/2/2021	390	34	14	44	<i>ns</i>
	6/24/2021	412	42	24	20	<i>ns</i>
	8/4/2021	453	31	36	35	<i>ns</i>
Canola	6/2/2021	390	1	9	15	8
	6/24/2021	412	14	11	13	<i>ns</i>
	8/4/2021	453	10	10	9	<i>ns</i>
Barley	6/2/2021	390	2	6	11	10
	6/24/2021	412	5	9	14	8
	8/4/2021	453	9	10	12	<i>ns</i>
Chickpea	6/2/2021	390	0	0	5	<i>ns</i>
	6/24/2021	412	1	1	0	<i>ns</i>
	8/4/2021	453	11	5	6	<i>ns</i>

Table 3. Crop injury for wheat, canola, barley, and chickpea following the Esplanade application applied to spring wheat the previous crop season, near Pullman, WA.

Crop	Date	DAT ²	Treatment			LSD
			Nontreated 0 fl oz/A 0 g ai/ha	Esplanade 1.5 fl oz/a 22 g ai/ha	Esplanade 3 fl oz/a 44 g ai/ha	
			%			
Wheat	6/09/2021	397	87	62	75	<i>ns</i>
	6/23/2021	411	100	87	87	<i>ns</i>
	8/09/2021	458	100	80	81	<i>ns</i>
Canola	6/09/2021	397	10	5	2	<i>ns</i>
	6/23/2021	411	14	16	12	<i>ns</i>
	8/09/2021	458	9	6	0	<i>ns</i>
Barley	6/09/2021	397	7	9	6	<i>ns</i>
	6/223/2021	411	11	7	16	<i>ns</i>
	8/09/2021	458	7	9	14	<i>ns</i>
Chickpea	6/09/2021	397	0	0	0	<i>ns</i>
	6/23/2021	411	0	0	0	<i>ns</i>
	8/09/2021	458	2	0	5	<i>ns</i>

Table 4. Italian ryegrass control for wheat, canola, barley, and chickpea following the Esplanade application applied to spring wheat the previous crop season, near Almota, WA.

Crop	Date	DAT ²	Treatment			<i>LSD</i>
			Nontreated	Esplanade	Esplanade	
			0 fl oz/A 0 g ai/ha	1.5 fl oz/a 22 g ai/ha	3 fl oz/a 44 g ai/ha	
			%			
Wheat	6/2/2021	390	40	82	96	<i>ns</i>
	6/24/2021	412	39	67	77	<i>ns</i>
	8/4/2021	453	41	74	90	<i>ns</i>
Canola	6/2/2021	390	100	100	100	<i>ns</i>
	6/24/2021	412	100	100	100	<i>ns</i>
	8/4/2021	453	95	94	95	<i>ns</i>
Barley	6/2/2021	390	52	86	97	<i>ns</i>
	6/24/2021	412	42	76	90	<i>ns</i>
	8/4/2021	453	56	84	86	<i>ns</i>
Chickpea	6/2/2021	390	55	85	97	<i>ns</i>
	6/24/2021	412	57	76	91	<i>ns</i>
	8/4/2021	453	50	70	92	<i>ns</i>
Fallow	6/2/2021	390	49	77	92	<i>ns</i>
	6/24/2021	412	47	75	90	<i>ns</i>
	8/4/2021	453	94	97	95	<i>ns</i>

Table 5. Italian ryegrass control for wheat, canola, barley, and chickpea following the Esplanade application applied to spring wheat the previous crop season, near Pullman, WA.

			Treatment			
			Nontreated 0 fl oz/A 0 g ai/ha	Esplanade 1.5 fl oz/a 22 g ai/ha	Esplanade 3 fl oz/a 44 g ai/ha	
Crop	Date	DAT ²	————— % —————			LSD
Wheat	6/09/2021	397	51	7	54	ns
	6/23/2021	411	0	2	2	ns
	8/09/2021	458	0	2	12	ns
Canola	6/09/2021	397	80	59	75	ns
	6/23/2021	411	95	95	95	ns
	8/09/2021	458	95	94	99	ns
Barley	6/09/2021	397	80	56	67	ns
	6/23/2021	411	57	37	56	ns
	8/09/2021	458	51	30	56	ns
Chickpea	6/09/2021	397	84	59	80	ns
	6/23/2021	411	60	27	57	ns
	8/09/2021	458	59	45	57	ns
Fallow	6/09/2021	397	77	41	72	ns
	6/23/2021	411	83	63	80	ns
	8/09/2021	458	86	69	81	ns

Table 6. Yield for wheat, canola, barley, chickpea following the preemergence application of Esplanade in spring wheat the previous cropping season, near Almota, WA.

Treatment	Rate		Wheat	Chickpea	Barley	Canola
	Oz/A	g ai/A				
Nontreated	0	0	922	844	1015	140
Esplanade	1.5	22	567	832	623	68
Esplanade	3	44	111	1461	725	69
<i>LSD</i>			<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>

Table 7. Yield for wheat, canola, barley, chickpea following the preemergence application of Esplanade in spring wheat the previous cropping season, near Pullman, WA.

Treatment	Rate		Wheat	Chickpea	Barley	Canola
	Oz/A	g ai/A				
Nontreated	0	0	0	169	403	72
Esplanade	1.5	22	23	94	280	70
Esplanade	3	44	113	114	327	82
<i>LSD</i>			<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>

Precipitation data (September 1, 2020 to August 31, 2021) from the Palouse Conservation Field Station

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
9/20	0.09	10/11	0.31	11/6	1.13	12/9	0.11
9/26	0.05	10/12	0.48	11/7	0.19	12/11	0.06
9/27	0.02	10/13	0.14	11/8	0.12	12/12	0.18
Total	0.16	10/14	0.31	11/10	0.09	12/14	0.09
Normal ¹	0.77	10/18	0.04	11/11	0.22	12/16	0.05
Dep Norm	▼ -0.61	10/19	0.18	11/13	0.11	12/17	0.26
		10/22	0.15	11/14	0.35	12/19	0.09
		10/24	0.69	11/15	0.05	12/20	0.44
		Total	2.30	11/19	0.13	12/21	0.41
		Normal ¹	1.58	11/25	0.20	12/22	0.12
		Dep Norm	▼ +0.72	Total	2.72	12/26	0.14
				Normal ¹	2.91	12/27	0.06
				Dep Norm	-0.19	12/30	0.18
						12/31	0.61
						Total	▼ 2.85
						Normal ¹	▼ 2.56
						Dep Norm	▼ +0.29
Date	Precip	Date	Precip	Date	Precip	Date	Precip
2021	(in.)	2021	(in.)	2021	(in.)	2021	(in.)
1/1	0.10	2/2	0.10	3/22	0.23	4/5	0.11
1/3	0.68	2/3	0.21	3/23	0.09	4/11	0.09
1/5	0.34	2/4	0.05	3/25	0.23	4/25	0.06
1/7	0.17	2/5	0.15	3/29	0.14	Total	0.27
1/12	0.31	2/7	0.05	Total	0.72	Normal ¹	1.75
1/13	0.71	2/8	0.08	Normal ¹	2.05	Dep Norm	-1.48
1/16	0.05	2/9	0.05	Dep Norm	-1.33		
1/26	0.06	2/13	0.09				
1/30	0.05	2/14	0.10				
Total	2.64	2/15	0.28				
Normal ¹	2.55	2/16	0.32				
Dep Norm	▼ +0.09	2/17	0.11				
		2/19	0.22				
		2/23	0.16				
		2/26	0.25				
		2/27	0.10				
		Total	2.40				
		Normal ¹	1.81				
		Dep Norm	▼ +0.59				
Date	Precip	Date	Precip	Date	Precip	Date	Precip
2021	(in.)	2021	(in.)	2021	(in.)	2021	(in.)
5/20	0.15	6/12	0.08	7/1	0.05	8/1	0.06
Total	0.20	6/15	0.08	7/28	0.01	8/4	0.18
Normal ¹	1.77	6/16	0.42	Total	0.06	8/21	0.39
Dep Norm	▼ -1.57	Total	0.58	Normal ²	0.46	Total	0.68
		Normal ¹	1.31	Dep Norm	▼ -0.40	Normal ²	0.47
		Dep Norm	▼ -0.73			Dep Norm	▼ +0.21

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

²Normal precipitation values are based on the 1990 to 2020 record period, kept by the National Weather Service.

Precipitation data (September 1, 2020 to August 31, 2021) from the Wilke Farm, AgWeatherNet Station, Davenport

Date	Precip	Date	Precip	Date	Precip	Date	Precip
2020	(in.)	2020	(in.)	2020	(in.)	2020	(in.)
9/19	0.10	10/10	0.22	11/5	0.20	12/11	0.07
9/23	0.16	10/11	0.32	11/10	0.07	12/15	0.13
9/25	0.24	10/13	0.24	11/13	0.24	12/16	0.09
Total	0.58	10/18	0.05	11/15	0.13	12/19	0.17
		10/26	0.07	11/16	0.16	12/21	0.17
		Total	0.91	11/18	0.14	12/31	0.66
				11/23	0.10	Total	1.39
				11/30	0.08		
				Total	1.22		
Date	Precip	Date	Precip	Date	Precip	Date	Precip
2021	(in.)	2021	(in.)	2021	(in.)	2021	(in.)
1/1	0.06	2/15	0.12	3/24	0.07	4/22	0.15
1/2	0.26	Total	0.21	Total	0.08	4/24	0.22
1/4	0.06					Total	0.39
1/6	0.06						
1/11	0.19						
1/12	0.54						
1/13	0.08						
1/27	0.10						
1/31	0.11						
Total	2.38						
Date	Precip	Date	Precip	Date	Precip	Date	Precip
May 2021	(in.)	2021	(in.)	July 2021	(in.)	2021	(in.)
Total	0.03	6/9	0.07	Total	0.02	8/17	0.10
		6/12	0.09			Total	0.10
		6/15	0.33				
		Total	0.49				