

# 2023 WSU Weed Control Report

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**Cover photo: Pullman, WA looking south from Kamiak Butte. Photo taken by Mark Thorne**

## **Off-label or Experimental-Use 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.**

## **Statistical Inference**

**Statistical inference is the process of drawing conclusions from experimental data that can be applied to a larger population or landscape. In our research, we replicate treatments in each trial to provide the variability needed to determine if differences are real or occur just by chance. While lack of statistical difference may indeed result from similar treatment effects or outcomes, e.g., a 100 lb/A fertilizer rate produced a similar yield to 101 lb/A, differences can also result from experimental or random error associated with the trial. We normally recognize statistical significance at the 95% probability level, which means there is a 95% probability that observed differences represent actual treatment effects and are not due to chance. This is indicated in our reports with the symbols  $P \leq 0.05$  or  $\alpha = 0.05$ . We typically show statistical differences between treatments with the use of alphabetical letters. Treatment means that are statistically similar will be followed the same letter.**



## **Effect of Pronamide (Kerb®) Herbicide on Winter Wheat Yield in the Year Following Applications for Italian Ryegrass Control in Spring Canola**

Mark Thorne and Drew Lyon

Pronamide herbicide has been considered for use in controlling Italian ryegrass in spring canola; however, the plant back interval to winter wheat is unknown and a concern for crop safety. Pronamide is effective for controlling Italian ryegrass in labeled crops, but it is not currently labeled for use in wheat or canola. Pronamide is a Group 3 herbicide that controls seedlings as they germinate; however, if pronamide is still present in the soil when winter wheat is seeded in the fall, it will also damage or kill the germinating wheat.

Breakdown of pronamide in the soil is primarily through microbial degradation; however, summer precipitation is limited in the inland Pacific Northwest, which often results in slower microbial degradation of herbicide than elsewhere in the US where summer precipitation is common. Furthermore, during fall and winter when precipitation is more likely, soil temperatures are low, which also slows microbial activity. Other Group 3 herbicides, e.g., trifluralin and ethalfluralin, have safely been used for Italian ryegrass control in spring canola, but it is unclear if pronamide can also be included as an additional herbicide option in the inland Pacific Northwest. Italian ryegrass is a serious problem weed, and it has evolved resistance to most herbicides used for grass weed control in the region. In recent years, many growers have incorporated glyphosate-resistant spring canola into their production systems to control Italian ryegrass, but sole reliance on glyphosate (Group 9) risks selection for glyphosate-resistant Italian ryegrass biotypes. Having sites of action, other than glyphosate, that are effective in controlling Italian ryegrass is critical for crop production in the region.

The objective of this study was to evaluate the crop safety of pronamide in spring canola and the subsequently planted winter wheat crop in the inland Pacific Northwest. We established a trial in 2021 on the WSU Cook Farm near Pullman, WA. Kerb SC (pronamide @ 3.3 lb ai/gal) herbicide was applied at two rates (1.25 and 2.5 pints/A) on November 8, 2021, and on March 10, 2022, ahead of spring canola seeding on May 20, 2022. The experimental design was a randomized complete block with 10- by 50-ft plots and six replicates per treatment. Kerb treatments were applied with a CO<sub>2</sub>-pressurized backpack sprayer at a volume output of 15 gpa.

The spring canola crop was harvested on September 5, 2022. The plot area was then cultivated 2-3 inches deep and harrowed to spread residue and loosen the soil so that winter wheat seed could be planted at least 1½ inches deep below the surface. The trial area was fertilized on October 10, 2022, with 145-22-22-23 lb/A N-P-K-S and then seeded on October 20, 2022, with 100 lb/A of 'Sockeye' winter wheat using a Great Plains drill with 10-inch row spacing. Huskie® and MCPA herbicides were applied for broadleaf weed control in the spring of 2023. All plots were harvested in August 2023 with a small plot harvester. Grain samples were bagged, cleaned, and weighed to determine crop yield, which was then reported on a 12% moisture basis.

Crop injury was not seen in the 2022 spring canola crop (data not shown); however, injury to the 2023 winter wheat crop was evident early in the spring as the treated plots had sparse wheat stands (Figure 1).



**Figure 1.** Kerb injury to winter wheat. Photo taken April 26, 2023.

Precipitation in 2023 was low, therefore, the nontreated check treatment yielded only 74 bu/A (Table 1), which was consistent with other yields in the area; however, all Kerb treatments reduced yields even further. Fall-applied Kerb at 1.25 pints/A resulted in 57 bu/A yield, while fall-applied Kerb at 2.5 pints/A and the spring-applied 1.25 pints/A rate resulted in wheat yields of 44 and 40 bu/A, respectively. The greatest yield reduction was from the spring-applied Kerb at 2.5 pints/A. The reduction of wheat yield indicates that rate and time are critical for the breakdown of the herbicide. Fall-applied Kerb had approximately 12 months to degrade before winter wheat was seeded and began to germinate, while the spring-applied Kerb had only seven months to degrade. Furthermore, with each timing, the higher rate of Kerb resulted in more yield loss than the lower rate.

Although Kerb appears safe to use in spring canola for Italian ryegrass control, should it be labeled for this use, winter wheat should not be planted in the fall following spring canola harvest in the inland Pacific Northwest

**Table 1.** Winter wheat yield following Kerb applications in spring canola.

| Treatment           | Application rates | Application date | Winter wheat yield* |
|---------------------|-------------------|------------------|---------------------|
|                     | pt/A              |                  | bu/A                |
| Nontreated control  | --                | --               | 74 a                |
| Kerb SC (pronamide) | 1.25              | Nov 8, 2021      | 57 b                |
| Kerb SC (pronamide) | 2.5               | Nov 8, 2021      | 44 c                |
| Kerb SC (pronamide) | 1.25              | Mar 10, 2022     | 40 c                |
| Kerb SC (pronamide) | 2.5               | Mar 10, 2022     | 13 d                |

\*Means followed by the same letter are not statistically different.



## Long-term Control of Smooth Scouringrush with Finesse® and RT 3® in Wheat Cropping Systems Two Years After Treatment at Reardan, WA

Mark Thorne, Marija Savic, and Drew Lyon

In 2021, we initiated a trial near Reardan, WA comparing applications of RT 3 and Finesse for control of smooth scouringrush in a wheat/fallow cropping system (Figure 1). Smooth scouringrush has been very difficult to control, especially in no-till cropping systems, as the routine herbicide applications for annual weed control in fallow have been ineffective. Previous research has shown that Finesse (chlorsulfuron + metsulfuron) can have activity on smooth scouringrush at least two years after application, and RT 3 (glyphosate) has been effective when applied at high rates 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 in the fallow phase of the grower's crop rotation for three years following application.



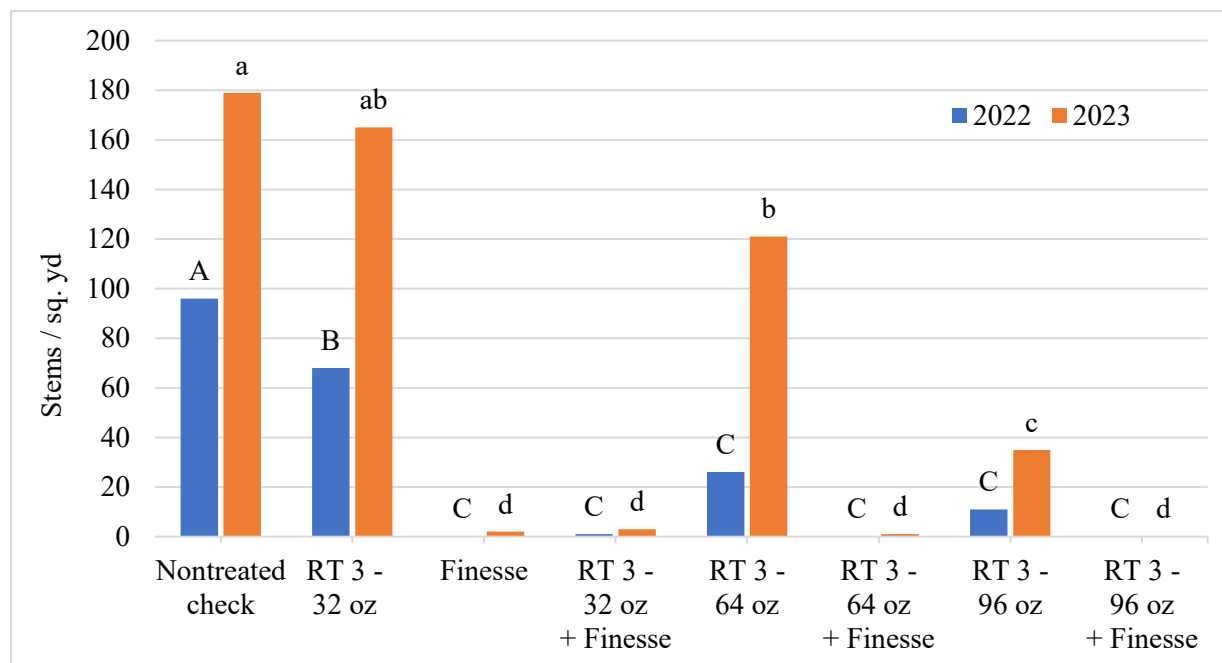
**Figure 1.** Smooth scouringrush in 2023 spring wheat stubble two years after 2021 applications.

The trial was initiated on July 9, 2021, in no-till 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 measure 10 by 30 ft and are arranged in a randomized complete block design with four replications per treatment. Treatments were applied

with a hand-held spray boom with six TeeJet® AIXR110015 nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack at 3 mph. Spray output was 15 gpa at 40 psi. All treatments included an organosilicone surfactant (Silwet® L77). Initial smooth scouringrush density averaged 248 stems/yd<sup>2</sup> in July 2021. In 2022, the field was in winter wheat, and in 2023 was in spring wheat.

Smooth scouringrush control was evaluated two years after application on August 18, 2023. Evaluations were made by counting stems in two 1.2-yd<sup>2</sup> quadrats per plot. All treatments with Finesse were still very effective and averaged 96% control in 2023 compared to about 100% control in 2022 (Figure 2). In contrast to 2022, there was no difference in 2023 between the nontreated check and RT 3 alone at 32 oz/A. Also, RT 3 at 96 oz/A averaged 35 stems/yd<sup>2</sup> in 2023 and was statistically less effective than all treatments with Finesse. The biggest difference from 2022 was an increase in density in the nontreated check and RT 3 alone at 32 and 64 oz/A, which may suggest that spring wheat is less competitive with smooth scouringrush than winter wheat. The effectiveness of Finesse makes it difficult to determine if there is any benefit from adding RT 3 for smooth scouringrush control; however, a tank mix of RT 3 and Finesse in fallow may be desirable to control smooth scouringrush as well as other common weeds present at the time of application. Finesse is likely a better choice for long-term control of smooth scouringrush than RT 3 alone; however, RT 3 alone may be a better choice if sensitive crops such as canola or pulses are included in the rotation.

**Figure 2.** Smooth scouringrush stem density in 2022 and 2023 following treatments applied during July 2021 in fallow at Reardan, WA.\*



\*All herbicide treatments included Silwet L77 organosilicone surfactant at 0.5% v/v. Finesse is applied at 0.5 oz/A. Means represented by each column are based on four replicates per treatment. Columns with the same letter for each year are not significantly different at the 95% probability level, which may have resulted from similar treatment effects, but can also result from experimental or random error associated with the trial.



## **Long-term Control of Smooth Scouringrush with Finesse® and RT 3® in Wheat Cropping Systems Three Years After Treatment at Dayton and Steptoe, WA**

Mark Thorne, Marija Savic, and Drew Lyon

Smooth scouringrush control in wheat/fallow rotations in eastern Washington (Figure 1) has been difficult because of limited effective herbicide options. In other studies, we have shown that applications of chlorsulfuron, one of the active ingredients in Finesse (chlorsulfuron + metsulfuron), can have activity on smooth scouringrush at least two years 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 all weeds that may 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 up to three years after application in fallow.



**Figure 1.** Smooth scouringrush in fallow (left) and in winter wheat (right).

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 a 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 CO<sub>2</sub> 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/yd<sup>2</sup> at the Dayton and Steptoe sites, respectively. In 2022, winter wheat was seeded on the Dayton site and harvested in 2023. The Steptoe site was in fallow during 2023.

In 2023, smooth scouringrush density was assessed at each location by counting stems in two 1.2-yd<sup>2</sup> quadrats per plot. At the Dayton site, all treatments that included Finesse averaged 86% fewer stems than the nontreated check (Figure 2). There was no difference in stem density between the nontreated check and either the 32 or 64 oz/A rate of RT 3 applied alone; however, the 96 oz/A rate had fewer stems than the nontreated check (Figure 3). At Steptoe, the treatments with Finesse averaged 99.6% less density than the nontreated check, and RT 3 alone at 96 oz/A was not different from Finesse alone or Finesse plus RT 3 at 32 oz/A. Furthermore, RT 3 at 32 oz/A was 86% less dense than the nontreated check.

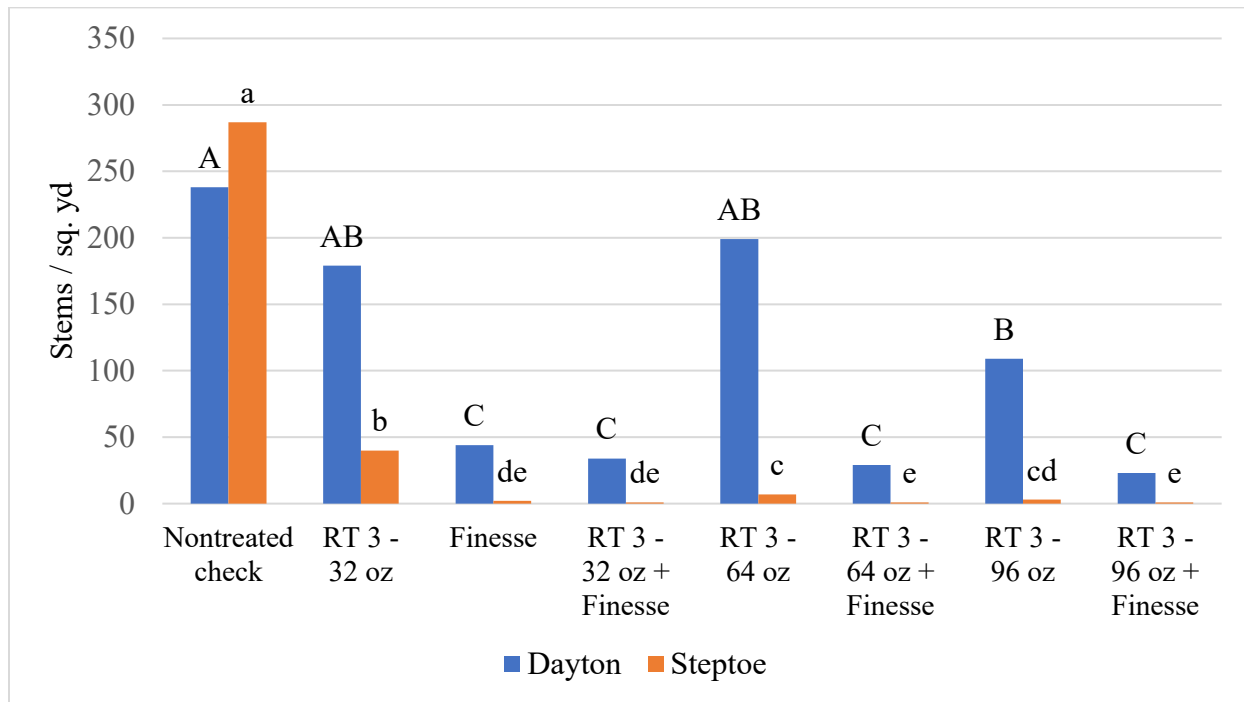


**Figure 2.** Smooth scouringrush in winter wheat near Dayton. Foreground treated with Finesse in 2020.

At both locations, Finesse applications were still providing good to excellent control of smooth scouringrush three years after treatment. RT 3 alone may be less effective over time but can be effective when applied at 96 oz/A in late spring or early summer with an organosilicone surfactant. Previous research has shown that good control can be achieved when RT 3 is applied in late June at 96 oz/A with an organosilicone surfactant providing stems are not in drought or heat stress. In our research, Finesse continues to be the most effective herbicide for smooth scouringrush control, but RT 3 alone may be an effective alternative to Finesse if sensitive crops like canola or pulses are to be grown in the year or two following application.



**Figure 3.** Smooth scouringrush density three years after applications of Finesse and RT 3 in fallow at Dayton and Steptoe, WA.\*



\*All herbicide treatments included Silwet L77 organosilicone surfactant at 0.5% v/v. Rates of RT 3 are in fluid oz/A; Finesse was applied at 0.5 oz dry granules/A. Columns for each location with the same letter are not significantly different ( $P \leq 0.05$ ).

## **Long-term Control of Smooth Scouringrush with Finesse® in Winter Wheat/Spring Wheat/No-till Fallow Cropping Systems**

Mark Thorne 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 near the same time as the wheat; however, in winter wheat stem emergence often occurs as the wheat plants are jointing and may miss early herbicide applications (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 continued long-term control? Furthermore, this study evaluates the application of Amber during the crop phases. Amber is molecularly similar to chlorsulfuron and is hypothesized to be a bridge application between the two fallow Finesse applications. Rhonox is a synthetic auxin herbicide (Group 4) that is used for broadleaf weed control in both fallow and grass crops and is effective for quick burndown of smooth scouringrush stems but long-term control is questionable.



**Figure 1.** Smooth scouringrush stems emerging in winter wheat near Edwall, WA.

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 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 are applied with a hand-held spray boom with six nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack. Spray output in 2019-2021 was 15 gpa at 25 psi through TeeJet® XR11002 nozzles at 3 mph. In 2022, spray output was 15 gpa at 40 psi through TeeJet AIXR10015 nozzles at 3 mph. 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.

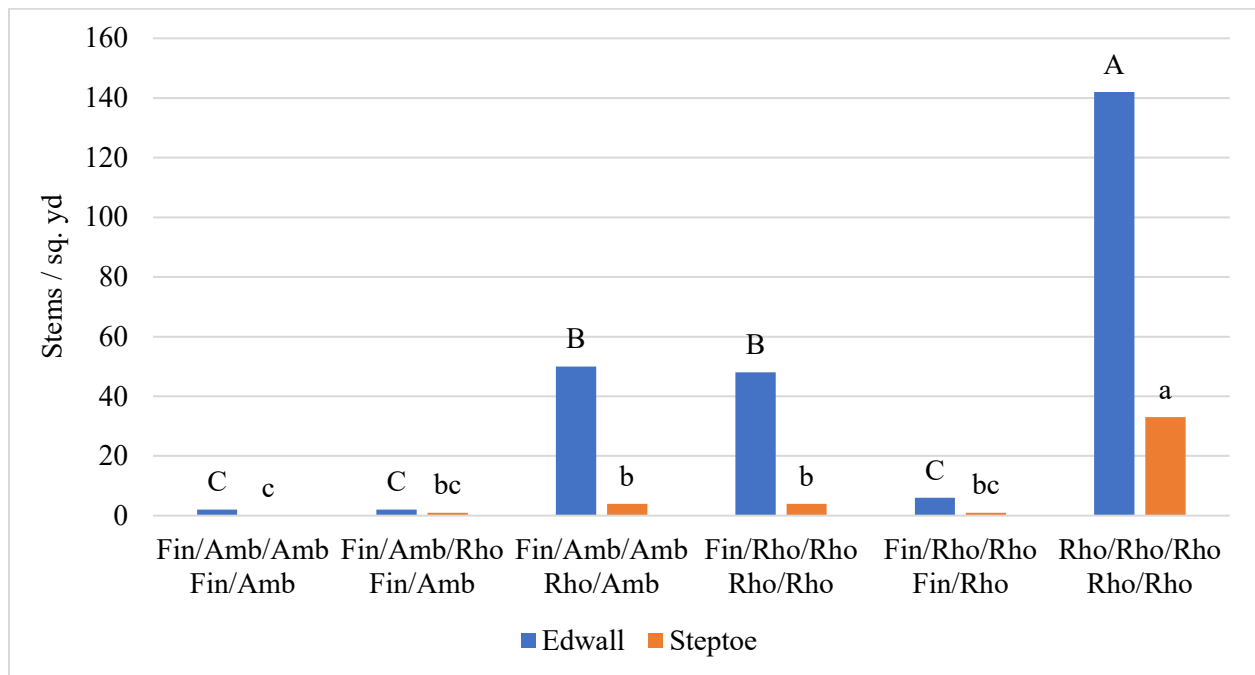
Amber (triasulfuron) is applied at 0.56 oz/A.

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.

In July 2023, smooth scouringrush stem density was assessed in winter wheat before harvest at both locations. This evaluation followed fallow applications in 2022, which marked the beginning of the second rotation cycle of the study that began in 2019 (Table 1). Smooth scouringrush stems were counted in two 1.2-yd<sup>2</sup> quadrats per plot. Stem densities were greatest in the treatment where only Rhonox was applied each year, which further shows that Rhonox is not effective for long-term control (Figure 2). At the Edwall site, all treatments with Finesse applied in 2022 had the lowest stem density in 2023. At the Steptoe site, only the treatment with Finesse in both fallow years and Amber in the crop years had significantly less stem density than the treatments without Finesse in 2022; however, the Steptoe site had flooded over winter which appeared to have reduced emergence. At both locations, it was evident that a single application of Finesse was still effective after three years, but that continued control requires a second Finesse application in a subsequent fallow year. Also, Amber applied in the crop phases did not appear to affect smooth scouringrush density (Figure 2). Winter wheat yields at both locations were in the 100 bu/A range (data not shown); however, smooth scouringrush density in the nontreated check at Edwall was great enough (Figure 2) to reduce yield down to 85 bu/A compared to the highest average yield of 101 bu/A. At Steptoe, there were no differences in yield across treatments.

**Figure 2.** Smooth scouringrush stem density in 2023 winter wheat in a long-term herbicide rotation study that began in 2019 at Edwall and Steptoe, WA.\*



\*Herbicide sequences for each rotation are listed below each set of corresponding columns and coded as follows: Fin=Finesse; Amb=Amber; Rho=Rhonox. Means associated with each column are based on four replicates per treatment combined over two locations. Columns for each location with the same letter are not significantly different at the 95% probability level, which may have resulted from similar treatment effects, but also from experimental or random error associated with the trial.

## Winter Wheat Yield Following Treflan® Applied the Previous Year in Spring Canola

Mark Thorne and Drew Lyon

Italian ryegrass is a cool-season annual to short-lived perennial grass that has become a major weed in the higher rainfall region of eastern Washington within the last 30 years. 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®, and Beyond®. Currently, growers have included glyphosate-resistant spring canola in their rotations so they can control Italian ryegrass in the canola crop with glyphosate. Resistance to glyphosate has occurred in other areas but is not yet widespread in eastern Washington. Concern over developing glyphosate resistance in Italian ryegrass has prompted research into using herbicides with sites of action different from glyphosate in spring canola.

Treflan (trifluralin) is a Group 3 dinitroaniline herbicide used for preemergence control of grass and broadleaf weeds, including Italian ryegrass, in many crops. Its mode of action is to inhibit mitosis in the developing root tips by binding to tubulin, thus interfering with the formation of microtubules critical for cell division. Treflan can be effective if applied and incorporated into the soil before weed seeds germinate. Following incorporation, adequate precipitation is needed to move Treflan into the soil water where it can be taken up by seedling roots. Treflan also has soil residual activity that can injure sensitive crops if they are planted too soon after application. Treflan is labeled for preplant incorporated application in wheat, but only if the wheat is planted below the zone of herbicide incorporation. Planting winter wheat following spring canola where Treflan has been applied has raised concerns regarding residual carryover damage to the wheat crop and labeling between products is not consistent regarding the rotational interval.

In 2022, we compared herbicides for Italian ryegrass control in spring canola at the WSU Cook Agronomy Farm near Pullman, WA (Table 1). Treatments included Treflan HFP by itself and in combination with PowerMax (glyphosate) and Liberty 280 SL (glufosinate) in 10 by 30 ft plots with four replications per treatment. In addition, Kerb® SC (pronamide) was included as an experimental Group 3 treatment. In the fall of 2022, winter wheat was planted over the study site with a Horsch direct-seed drill. In August 2023, we harvested winter wheat from all plots with a small plot harvester. Samples were cleaned and weighed for yield.

We found no statistically significant yield loss caused by Treflan applied in the previous spring crop as all applications with Treflan grouped with the highest yielding treatments (Table 1). This is congruent with a similar comparison in 2022 where no winter wheat yield loss was caused by Treflan applied the previous year.

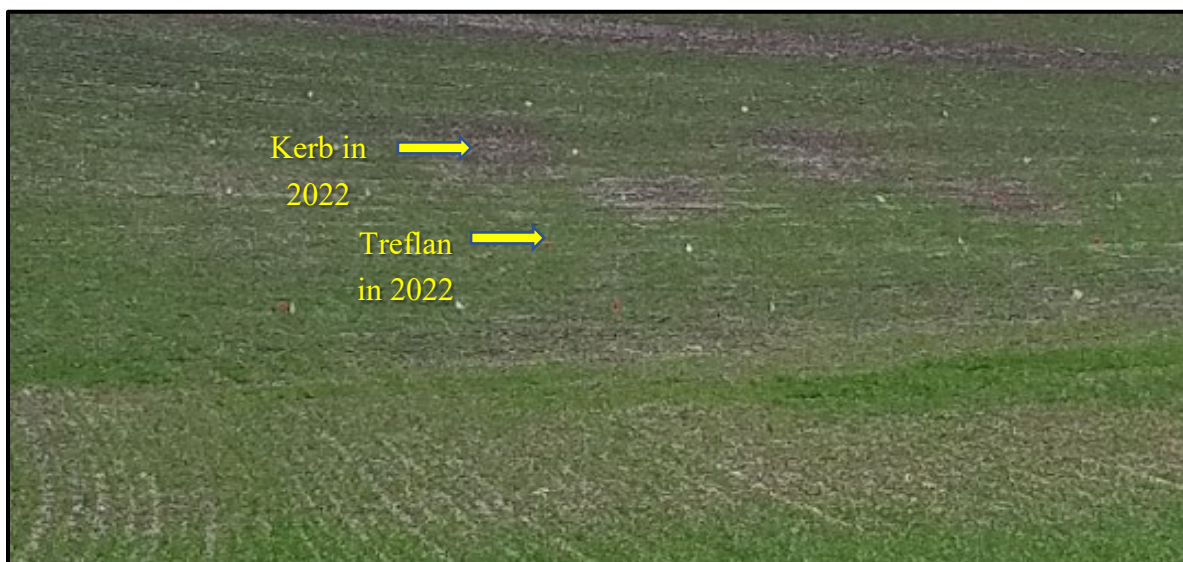
**Table 1.** Winter wheat yield in 2023 following herbicides applied in 2022 for Italian ryegrass control in spring canola.

| Herbicides applied in 2022 spring canola*         | Winter wheat yield in 2023** |
|---|------------------------------|
|   | bu/A                         |
| PowerMax 44 oz/A EPOST                            | 105 a                        |
| PowerMax 22 oz/A EPOST + LPOST                    | 101 ab                       |
| Treflan 24 oz/A PPI                               | 100 ab                       |
| Treflan 24 oz/A PPI + PowerMax 22 oz/A LPOST      | 100 ab                       |
| Treflan 24 oz/A PPI + PowerMax 44 oz/A EPOST      | 99 ab                        |
| Liberty 22 oz/A EPOST + LPOST                     | 98 ab                        |
| Treflan oz/A PPI + PowerMax 22 oz/A EPOST + LPOST | 97 ab                        |
| Treflan 24 oz/A PPI + Liberty 22 oz/A EPOST       | 96 ab                        |
| Nontreated check                                  | 94 b                         |
| PowerMax 22 oz/A LPOST                            | 90 b                         |
| Kerb 20 oz/A PRE + Liberty 22 oz/A EPOST          | 62 c                         |
| Kerb 20 oz/A Pre                                  | 62 c                         |

\*PPI=preplant incorporated; PRE=post-plant preemergence to crop; EPOST=early postemergence; LPOST=late postemergence.

\*\*Means followed by the same letter are not statistically different ( $P \leq 0.05$ ).

We did, however, see reduced yield from the Kerb applied in 2022 (Figure 1). Overall, Treflan applied for Italian ryegrass control in spring canola does not appear to cause yield loss in winter wheat the following year.



**Figure 1.** 2023 winter wheat crop showing injury from Kerb applied in 2022, but no visible injury from Treflan applied in 2022.

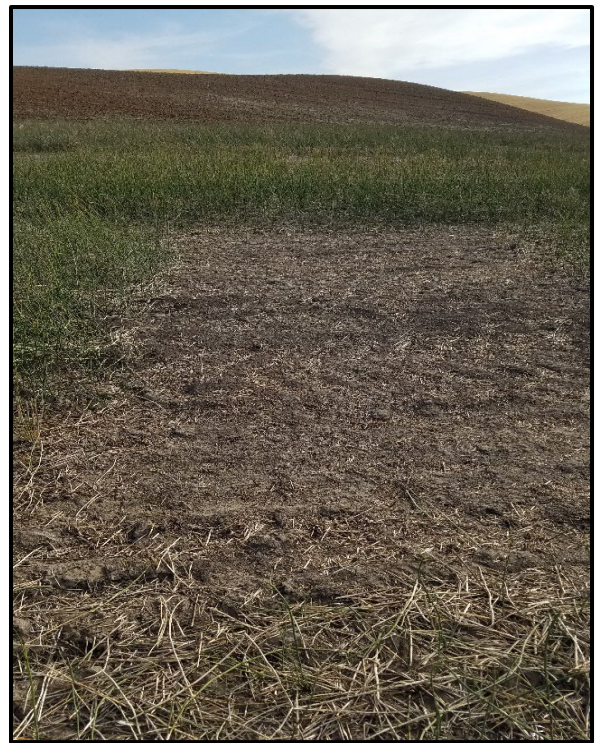


## Finesse® Timing for Smooth Scouringrush Control in Wheat/Fallow Cropping Systems

Mark Thorne, Marija Savic, and Drew Lyon

Finesse herbicide is effective for smooth scouringrush control when applied late spring in fallow; however, applications at other times may fit better in certain management strategies. Finesse is labeled for application anytime in fallow including just before fall seeding, and after one leaf but before the boot stage in wheat and barley. Smooth scouringrush stems usually begin emerging in May and persist until freezing temperatures in the fall. Therefore, it is possible that late fall or early spring applications of Finesse would be applied when smooth scouringrush is not present or not actively growing and the efficacy of these timings is unclear.

We began a study in 2022 at two farms comparing fall and spring applications of Finesse for control of smooth scouringrush. Finesse was applied in the fall to standing stems or bare soil before fall seeding. In the spring, treatments were applied before stem emergence when the winter wheat was tillering and then later when the smooth scouringrush stems were emerging and the wheat had developed a flag leaf. Trials were initiated near Edwall on the Justin Camp farm and near Steptoe on the Mark Hall farm. Each site is in a no-till winter wheat/spring wheat/ fallow rotation. The Edwall site is in a gentle northwest-sloping draw bottom 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 gentle north-facing slope of soil classified as a Palouse-Thatuna silt loam. Soil organic matter and pH measured 2.7% and 5.0, respectively. Both sites average around 16 inches of precipitation per year.



Smooth scouringrush and bare ground plots before fall seeding near Steptoe, WA.

At each site, 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 with a hand-held spray boom with six nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack. Spray output was 15 gpa at 40 psi through TeeJet® AIXR110015 nozzles at 3 mph. Bare ground treatments were applied to plots where all vegetation had been mowed and removed with a rake. Fall treatments were applied on September 14 and 22, and early spring treatments were applied on May 8 and 11 at Steptoe and Edwall, respectively. Late spring treatments were applied on May 18 at both locations; however, smooth scouringrush stems had not yet emerged at Steptoe. This was likely associated with hard dry soil and dry spring conditions observed in 2023.



Treatments were evaluated in July 2023 by counting smooth scouringrush stems in two 1.2-yd<sup>2</sup> quadrats per plot in the winter wheat crop ahead of harvest. At both locations, fall-applied Finesse plus PowerMax resulted in better control when applied to stems rather than to bare soil. This would suggest that foliar uptake is more effective than soil uptake alone. At Edwall, Finesse applied alone was less effective than Finesse plus PowerMax applied to stems in the fall, but no difference was seen at Steptoe as all fall foliar-applied Finesse treatments resulted in zero stem density. At Steptoe, the fall-applied PowerMax alone treatment reduced stem density compared with the nontreated check but was not different from the bare ground treatment or the spring treatments. At Edwall, where greater overall densities were seen, PowerMax alone in the fall was not different from the nontreated check. The spring treatments resulted in lower densities at both locations than the nontreated checks but were not yet as effective as fall-applied foliar Finesse applications. At Steptoe, smooth scouringrush did not emerge until after the late spring treatments were applied, so there was no foliar uptake for these treatments. The spring treatments, so far, are less effective than the fall foliar applications, but they may need more time to be effective. It appears that preplant foliar Finesse applications in the fall can reduce smooth scouringrush density the following year, and it is important to apply to green standing stems. It is too early to determine the efficacy of the spring applications in the crop, but all treatments will be reevaluated in 2024.

**Table 1.** Effect of herbicide timing on smooth scouringrush density.

| Treatments*                     | Timing                  | Target                           | Edwall       | Steptoe |
|---------------------------------|-------------------------|----------------------------------|--------------|---------|
|                                 |                         |                                  | stems/yard** |         |
| Finesse + PowerMax + NIS        | Fall                    | Standing stems                   | 14 e         | 0 c     |
| Finesse + PowerMax + Syl-Coat   | Fall                    | Standing stems                   | 13 e         | 0 c     |
| Finesse + PowerMax + NIS        | Fall                    | Bare ground                      | 34 d         | 21 b    |
| PowerMax + NIS                  | Fall                    | Standing stems                   | 137 a        | 12 b    |
| Finesse + NIS                   | Fall                    | Standing stems                   | 34 d         | 0 c     |
| PowerMax + NIS fb Finesse + NIS | Fall fb<br>early spring | Preemergence<br>to stems in crop | 64 c         | 11 b    |
| PowerMax + NIS fb Finesse + NIS | Fall fb<br>Late spring  | Stems in crop                    | 97 b         | 11 b    |
| Nontreated check                |                         |                                  | 141 a        | 67 a    |

\*Finesse applied at 0.5 oz/A in fall in fallow and 0.4 oz/A in spring in crop; PowerMax was applied at 32 oz/A; NIS and Syl-Coat were applied at 0.5% v/v. All PowerMax applications included NH<sub>4</sub>SO<sub>4</sub> at 17 lb/100 gal. fb=followed by.

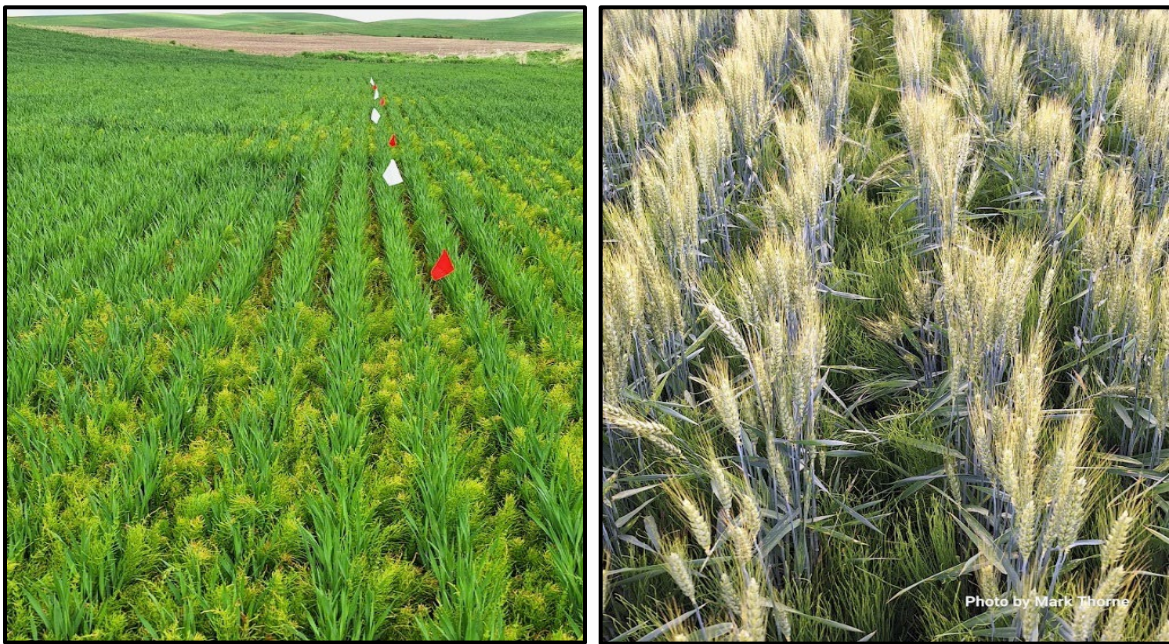
\*\*All stem densities for each site followed by the same letter are not statistically different.

## Horsetail Control in the Palouse Annual Cropping Region

Mark Thorne, Marija Savic, and Drew Lyon

Field horsetail is a member of a prehistoric group of plants in the genus *Equisetum*. *Equisetums* date back about 350 million years and were forage for dinosaurs and then became a major component of the vegetation during the Carboniferous period that developed into coal. Currently, three *Equisetum* species are common in the Pacific Northwest and include field horsetail, smooth scouringrush, and scouringrush. Field horsetail is a perennial rhizomatous species that produces fertile spore-bearing leafless stems early in the spring followed by vegetative stems that resemble Christmas trees that persist through the rest of the year up to freezing temperatures in the fall. Field horsetail can be found on flood plains and along roads where water collects in ditches and barrow pits.

In the high-rainfall Palouse region of eastern Washington and northern Idaho, field horsetail is a problem weed because it is very persistent, hard to control with tillage or herbicides, and is competitive with all crops grown (Figure 1). Herbicides that could be effective do not fit well in the commonly used crop rotations because of long plant-back intervals that would injure sensitive crops like canola or pulses. Chlorsulfuron is an herbicide that is labeled on wheat and is effective on other *Equisetum* species like smooth scouringrush but has up to a 36-month plant-back interval to crops other than wheat. Other herbicides that can control field horsetail, e.g., sulfometuron (Oust) or dichlobenil (Casoron), are not labeled for use in field crops grown in this region also because of long soil residual and potential crop injury.



**Figure 1.** Field horsetail in winter wheat at the flag leaf stage in May (photo on left) and in June when the wheat was headed (photo on right).

In this region, crops are generally grown each year without a fallow year in between. Therefore, herbicides are applied either following crop harvest in the fall, preplant in the spring, or to a growing crop. Finesse® (chlorsulfuron + metsulfuron) is a Group 2 ALS inhibitor herbicide that has been effective on smooth scouringrush when applied during a fallow year, but it has not been well tested on field horsetail. Finesse has a 36-month plantback restriction to peas and a bioassay is recommended for chickpeas or canola. Express XP (tribenuron) is another Group 2 herbicide that has a molecular structure very similar to sulfometuron but has not been tested for field horsetail control; however, Express XP has no plantback restrictions that would affect a crop after 2 months. Widematch (clopyralid + fluroxypyr) is a Group 4 synthetic auxin herbicide that can also be applied to wheat up to the flag leaf stage. It is not known if Widematch has any effect on field horsetail other than to burn down the current year's growth. The plantback interval to canola is 12 months or 18 months to any pulse crop.

Since field horsetail does not emerge early in the spring, foliar applications to field horsetail need to consider the labeled application window of the crop. Finesse, Express XP, and Widematch can all be applied to wheat when it is tillered up to the flag leaf stage, which is typically when field horsetail emerges in the spring. However, if any of these herbicides will control field horsetail, crop rotations may have to be altered to avoid problems with plantback restrictions.

We initiated a field study on the Wayne Jensen Farm for field horsetail control in the high-rainfall (>20" annual precipitation) annual cropping region of the Palouse on September 2022 in a field 500 ft east of the Washington Idaho border near Genesee, ID. The study site was on a floodplain next to a creek and had produced a crop of dry peas in 2022. The soil type is a Latahco silt loam with a pH of 6.0 and 2.8% organic matter. The experimental design was a randomized complete block with four replicates per treatment and 10- by 30-ft plots. The field had been fertilized with a shank-type tillage applicator, therefore, very few of the field horsetail stems were still green. The soil surface was a combination of previous crop residue, withering field horsetail stems, and bare soil. Fall treatments were applied on September 28, 2022. Early spring applications were applied on May 1, 2023, when the wheat was fully tillered and field horsetail reproductive stems were present, but vegetative stems were just beginning to emerge. Late spring applications were on May 17 when the wheat had produced flag leaves and the field horsetail had vegetative stems that averaged 14 inches tall. All herbicide treatments are applied with a hand-held spray boom with six nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack. Spray output was 15 gpa at 40 psi through TeeJet® AIXR110015 nozzles at 3 mph.

Treatment efficacy was evaluated on July 28, 2023, by collecting field horsetail stems between two rows of wheat in each plot. The distance between rows was 10 inches and the length of the sample area was 1.1 yds. Samples were bagged and dried in a plant-drying room and then weighed.

All treatments applied in late spring to field horsetail stems reduced biomass between 40 and 60% of the nontreated check (Table 1). This would indicate that foliar uptake of the herbicides applied in this trial has some effect in controlling field horsetail. Timing is particularly important for Express XP as the late spring application was 50% more effective than when applied in early spring before field horsetail stems emerged, suggesting that the efficacy of Express XP is

dependent on foliar uptake. In contrast, there was no difference in biomass reduction between Finesse + NIS applied in early spring compared with late spring or the fall preplant application. This would indicate that Finesse uptake is both foliar and soil. In addition, there was no benefit of including Syl-Coat<sup>®</sup> organosilicone surfactant compared with a nonionic surfactant to either Finesse or Express XP when applied in late spring to field horsetail stems. Widematch appears to be an effective burndown treatment for field horsetail when applied to the wheat crop up to the flag leaf stage when field horsetail stems are present. These treatments will be reevaluated in 2024.

**Table 1.** Effect of herbicides and timing on field horsetail biomass in winter wheat.

| Herbicides*                   | Timing – crop stage                                      | Target                       | Horsetail biomass**<br>lb dry mass yd <sup>-2</sup> |
|-------------------------------|--|------------------------------|---|
| Express XP + NIS              | Late spring – wheat with flag leaf                       | Horsetail stems              | 0.6 d   |
| Finesse + NIS fb<br>Widematch | Fall – preplant fb<br>late spring – wheat with flag leaf | Ground fb<br>horsetail stems | 0.6 d   |
| Finesse + Syl-Coat            | Late spring – wheat with flag leaf                       | Horsetail stems              | 0.7 d   |
| Finesse + NIS                 | Late spring – wheat with flag leaf                       | Horsetail stems              | 0.8 cd  |
| Express XP + Syl-Coat         | Late spring – wheat with flag leaf                       | Horsetail stems              | 0.8 cd  |
| Finesse + NIS                 | Early spring – wheat tillered                            | Ground                       | 1.0 bc  |
| Finesse                       | Fall – preplant  | Ground                       | 1.0 bc  |
| Express XP + NIS              | Early spring – wheat tillered                            | Ground                       | 1.1 ab  |
| Nontreated check              |  |                              | 1.3 a   |

\*Applications rates: Express = 0.33 oz/A; Finesse in crop = 0.4 oz/A; Finesse in fallow/preplant = 0.5 oz/A; Widematch = 1.33 pt/A; NIS (nonionic surfactant) = 0.5% v/v; Syl-Coat (organosilicone surfactant) = 0.5% v/v.

\*\*Means followed by the same letter are not statistically different ( $P \leq 0.05$ ).

# Yellow Rust Control in Winter Wheat

J.E.R. Kalin & I. C. Burke

## Introduction

In spring of 2023, a field trial was established to evaluate efficacy of three different fungicides to control yellow rust in winter wheat. Yellow rust is a significant disease that can reduce wheat yields and grain quality if not properly managed. The three fungicides used in this trial are Prosaro Pro (Tebuconazole + fluopyram + prothioconazole), Delaro (prothioconazole + trifloxystrobin), and Tilt (propiconazole) - Delaro is not labeled for use in wheat. Yellow rust prevalence varies from year to year but knowing if there is antagonism between the fungicides and business-as-usual herbicide tank mix is important for producers. Therefore, the objective of this study was to determine (1) crop injury, (2) yellow rust control, and (3) weed control using different fungicide tank mixes.

## Methods

The study was established in winter field near Pullman, WA. Treatments were applied when wheat was 3 to 5 tiller and actively growing (Table 1). Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft wide by 30 ft long. Treatments were assessed for crop response and yellow rust control 7, 21, and 29 days after treatment. Plots were harvested with a Wintersteiger small plot combine with a 5-foot header. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 2023).

**Table 1.** Treatment application details.

| Study Application              |               |
|--------------------------------|---------------|
| Date                           | 5/15/2023     |
| Application volume (GPA)       | 15            |
| Timing                         | Postemergence |
| Crop Stage                     | 3 to 5 Tiller |
| Air temperature (°F)           | 67            |
| Wind velocity (mph, direction) | 8, NW         |
| Cloud Cover (%)                | 10            |

## Results

The field that the trial was located did not have any detectable yellow rust in the 2023 growing season, so control ratings are not presented here. However, there was crop injury from the majority of treatments (Table 2). The treatment with Osprey + Huskie + Brox M had the least injury noted (Table 2). The injury noted was slight yellowing and stunting but the observed injury did result in end of season yield loss, which averaged just under 140 bu/A for most treatments (Table 2). However, treatments that included Tilt had slightly higher yield than other treatments. There was no yellow rust to control in the field and weed control was not different among treatments. Yield was slightly higher with Delaro treatments, but not significantly. The application of herbicides and fungicides in mixture is a common practice. Under adverse conditions, such mixtures can result in significant injury. Ideally, applications of fungicides and herbicides should be separated. If a complex mixture is being considered, choosing the least injurious fungicide partner is advised to minimize potential yield loss.





Nontreated plot (left) compared to treatment that included Osprey XTRA + Huskie + BROX-M + Prosaro Pro. There is slight stunting to the entire plot.

**Table 2.** Crop injury of winter wheat in response to fungicide tank mixes. The general injury ratings is the percent of the plot affected by the injury. The discoloration and stunting ratings are the severity of the injury within the injured area. Means with the same letters are not significantly different from each other ( $\alpha = 0.05$ ).

| Treatment <sup>1</sup> |      |      | Discoloration (%) |   | Injury (% of plot) |    | Stunting (%) |    |
|------------------------|------|------|-------------------|---|--------------------|----|--------------|----|
|                        | Rate |      | 5/22/2023         |   | 6/5/2023           |    | 6/5/2023     |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 25                | b | 22                 | b  | 11           | b  |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 63                | a | 57                 | a  | 29           | a  |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Prosaro Pro            | 6.75 | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 100               | a | 65                 | a  | 20           | ab |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Tilt                   | 4    | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 63                | a | 38                 | ab | 10           | b  |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Delaro                 | 7.83 | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 83                | a | 68                 | a  | 25           | ab |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Delaro                 | 6.02 | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 98                | a | 43                 | a  | 15           | ab |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Proline Gold           | 6.84 | oz/A |                   |   |                    |    |              |    |
| Osprey XTRA            | 4.75 | oz/A |                   |   |                    |    |              |    |
| Huskie                 | 13.5 | oz/A | 88                | a | 65                 | a  | 23           | ab |
| BROX-M                 | 16   | oz/A |                   |   |                    |    |              |    |
| Proline Gold           | 5.13 | oz/A |                   |   |                    |    |              |    |

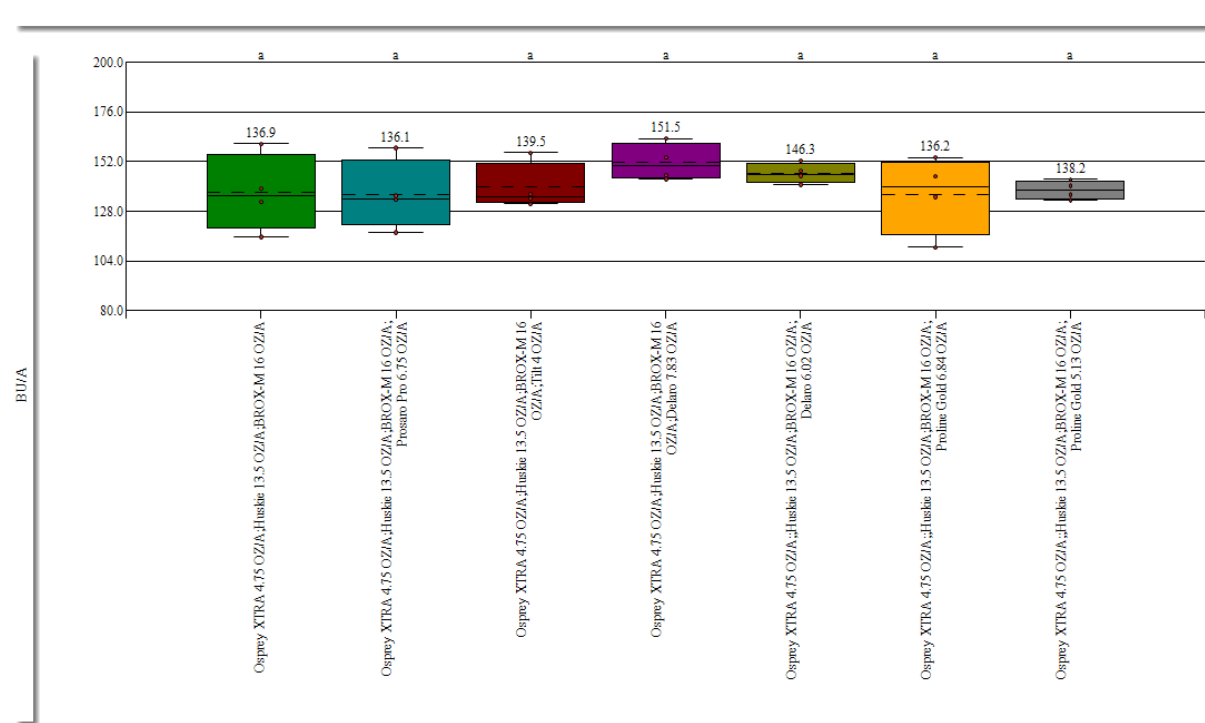
<sup>1</sup>All treatments included NIS (0.25% v/v) and UAN (4 pt/A).



**Table 3.** Crop injury of winter wheat in response to fungicide tank mixes. The general injury ratings is the percent of the plot affected by the injury. The discoloration and stunting ratings are the severity of the injury within the injured area. Means with the same letters are not significantly different from each other (alpha = 0.05).

| Treatment <sup>1</sup> | Rate |      | Injury (% of plot) |   | Stunting (%) |   |
|------------------------|------|------|--------------------|---|--------------|---|
|                        |      |      | 6/13/2023          |   | 6/13/2023    |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 22                 | b | 8            | b |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 57                 | a | 23           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Prosaro Pro            | 6.75 | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 93                 | a | 23           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Tilt                   | 4    | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 60                 | a | 21           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Delaro                 | 7.83 | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 82                 | a | 25           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Delaro                 | 6.02 | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 88                 | a | 28           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Proline Gold           | 6.84 | oz/A |                    |   |              |   |
| Osprey XTRA            | 4.75 | oz/A |                    |   |              |   |
| Huskie                 | 13.5 | oz/A | 85                 | a | 28           | a |
| BROX-M                 | 16   | oz/A |                    |   |              |   |
| Proline Gold           | 5.13 | oz/A |                    |   |              |   |

<sup>1</sup>All treatments included NIS (0.25% v/v) and UAN (4 pt/A).



**Figure 1.** Yield of winter wheat in response to different fungicide tank mixes.

## Safety and Efficacy of Tolpyralate + Bromoxynil Tank Mix on Spring Wheat

J.E.R. Kalin & I.C. Burke

Tolpyralate is a new active ingredient for wheat. An inhibitor of 4-HPPD, tolpyralate is known to control common broadleaf weeds in the PNW. Like Huskie and Talinor, tolpyralate synergizes with bromoxynil, and will be sold in a product with both active ingredients. Tolpyralate may also have annual grass activity. However, little is known about the activity of tolpyralate on weeds unique to the PNW, like mayweed chamomile. Therefore, the study objective was to evaluate tolpyralate + bromoxynil tank mix for crop safety and efficacy in PNW spring wheat.

The study was established in three spring wheat fields near Pullman, WA, one was on Cook Farm and the other two were at the Palouse Conservation Field Station farm. Treatments were applied when wheat was 3 to 5 tiller and actively growing (Table 1). Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft wide by 30 ft long. Treatments were assessed for crop response and weed control 7, 14, and 21 days after treatment. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

**Table 1.** Treatment application details.

| Study Application              |               |               |               |
|--------------------------------|---------------|---------------|---------------|
| Trial                          | A             | B             | C             |
| Date                           | 5/31/2023     | 6/7/2023      | 5/31/2023     |
| Application volume (GPA)       | 15            | 15            | 15            |
| Timing                         | Postemergence | Postemergence | Postemergence |
| Crop Stage                     | 3 to 5 Tiller | 3 to 5 Tiller | 3 to 5 Tiller |
| Air temperature (°F)           | 52            | 85            | 58            |
| Wind velocity (mph, direction) | 7, E          | 5, SE         | 9, E          |
| Cloud Cover (%)                | 10            | 0             | 10            |

### Results

Tolpyralate did not cause injury in spring wheat. Treatments for trials A and C were applied on the same day, with trial B receiving treatments about a week later. Crop injury was negligible for trial A (Table 2), and was not observed in trial C (Table 6). The slight stunting observed in trial B was transient, under 40%, and was higher in the treatments with Huskie and Talinor (Table 4).

Tolpyralate was effective for broadleaf weed control across the three trials (Tables 3, 5, and 6). The treatment that included WideARmatch had consistently high weed control ratings in each trial. Tolpyralate + bromoxynil at 14 oz/A had better weed control than the 11 oz/A rate. Tolpyralate appears to be safe for use in spring wheat and controls common annual broadleaf weeds in the PNW. Additional research is needed to confirm safety to rotational crops, activity on wild oat, and to evaluate a broader range of herbicides to use in mixture. PNW farmers appear to have a new tool for broadleaf weed management in wheat.

**Table 2.** Crop injury for trial A (PCFS1) in response to increasing rates of tolpyralate + bromoxynil. Crop injury was present in 2 treatments 7 days after application but was not present in subsequent rating dates. Means with the same letters are not significantly different from each other (alpha = 0.05). Means with no letters are not significantly different from each other (alpha = 0.05).

| Treatment                | Rate |       | Injury (%) |   | Injury (%) | Injury (%) |
|--------------------------|------|-------|------------|---|------------|------------|
|                          |      |       | 7 DAA      |   | 14 DAA     | 21 DAA     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | a | 0          | 0          |
| MSO                      | 0.5  | % v/v |            |   |            |            |
| Tolpyralate + Bromoxynil | 14.7 | oz/A  | 3          | a | 0          | 0          |
| MSO                      | 0.5  | % v/v |            |   |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | a | 0          | 0          |
| Embed Extra              | 8    | oz/A  |            |   |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | a | 0          | 0          |
| WideARmatch              | 19.4 | oz/A  |            |   |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | a | 0          | 0          |
| Talinor                  | 15   | oz/A  |            |   |            |            |
| CoAct+                   | 2.75 | oz/A  |            |   |            |            |
| COC                      | 1    | % v/v |            |   |            |            |
| Huskie                   | 15   | oz/A  |            |   |            |            |
| NIS                      | 0.5  | % v/v | 8          | b | 0          | 0          |

**Table 3.** Weed control for trial A (PCFS1) in response to increasing rates tolpyralate + bromoxynil. Common lambsquarters control ranged from 70 to 98%. Tolpyralate + bromoxynil treatments that included Embed Extra or Talinor had the highest weed control ratings. Means with the same letters are not significantly different from each other (alpha = 0.05). Means with no letters are not significantly different from each other (alpha = 0.05).

| Treatment                | Rate |       | Common<br>Lambsquarters<br>Control (%) |    | Common<br>Lambsquarters<br>Control (%) |  | Common<br>Lambsquarters<br>Control (%) |  |
|--------------------------|------|-------|--|----|--|--|--|--|
|                          |      |       | 7 DAA                                  |    | 14 DAA                                 |  | 21 DAA                                 |  |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 88                                     | ab | 88                                     |  | 95                                     |  |
| MSO                      | 0.5  | % v/v |  |    |  |  |  |  |
| Tolpyralate + Bromoxynil | 14.7 | oz/A  | 95                                     | a  | 83                                     |  | 93                                     |  |
| MSO                      | 0.5  | % v/v |  |    |  |  |  |  |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 98                                     | a  | 98                                     |  | 90                                     |  |
| Embed Extra              | 8    | oz/A  |  |    |  |  |  |  |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 90                                     | ab | 83                                     |  | 95                                     |  |
| WideARmatch              | 19.4 | oz/A  |  |    |  |  |  |  |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 98                                     | a  | 93                                     |  | 95                                     |  |
| Talinor                  | 15   | oz/A  |  |    |  |  |  |  |
| CoAct+                   | 2.75 | oz/A  |  |    |  |  |  |  |
| COC                      | 1    | % v/v |  |    |  |  |  |  |
| Huskie                   | 15   | oz/A  | 68                                     | b  | 98                                     |  | 88                                     |  |
| NIS                      | 0.5  | % v/v |  |    |  |  |  |  |

**Table 4.** Crop injury for trial B (PCFS2) in response to increasing rates of tolpyralate + bromoxynil. Crop injury was relatively high in this trial compared to the other trials. This could be due to the late treatment application when temperature and relative humidity were higher (table 1). Means with no letters are not significantly different from each other (alpha = 0.05).

| Treatment                |      |       | Injury (%) | Injury (%) | Injury (%) |
|--------------------------|------|-------|------------|------------|------------|
|                          | Rate |       | 7 DAA      | 14 DAA     | 21 DAA     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | 13         | 10         |
| MSO                      | 0.5  | % v/v |            |            |            |
| Tolpyralate + Bromoxynil | 14.7 | oz/A  | 0          | 10         | 10         |
| MSO                      | 0.5  | % v/v |            |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | 13         | 8          |
| Embed Extra              | 8    | oz/A  |            |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | 18         | 15         |
| WideARmatch              | 19.4 | oz/A  |            |            |            |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 0          | 40         | 30         |
| Talinor                  | 15   | oz/A  |            |            |            |
| CoAct+                   | 2.75 | oz/A  |            |            |            |
| COC                      | 1    | % v/v |            |            |            |
| Huskie                   | 15   | oz/A  | 0          | 43         | 78         |
| NIS                      | 0.5  | % v/v |            |            |            |

**Table 5.** Weed control for trial B (PCFS2) in response to increasing rates of tolpyralate + bromoxynil. Mayweed chamomile control was between 65-95%, a wider range compared to the other two trials. Means with no letters are not significantly different from each other ( $\alpha = 0.05$ ).

| Treatment                | Rate |       | Mayweed<br>Chamomile Control<br>(%) | Mayweed<br>Chamomile Control<br>(%) | Mayweed<br>Chamomile Control<br>(%) |
|--------------------------|------|-------|-------------------------------------|-------------------------------------|-------------------------------------|
|                          |      |       | 7 DAA                               | 14 DAA                              | 21 DAA                              |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 70                                  | 63                                  | 73                                  |
| MSO                      | 0.5  | % v/v |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 14.7 | oz/A  | 80                                  | 73                                  | 88                                  |
| MSO                      | 0.5  | % v/v |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 70                                  | 70                                  | 83                                  |
| Embed Extra              | 8    | oz/A  |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 92                                  | 88                                  | 67                                  |
| WideARmatch              | 19.4 | oz/A  |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 90                                  | 85                                  | 95                                  |
| Talinor                  | 15   | oz/A  |                                     |                                     |                                     |
| CoAct+                   | 2.75 | oz/A  |                                     |                                     |                                     |
| COC                      | 1    | % v/v |                                     |                                     |                                     |
| Huskie                   | 15   | oz/A  | 72                                  | 95                                  | 78                                  |
| NIS                      | 0.5  | % v/v |                                     |                                     |                                     |



**Table 6.** Weed control for trial C (Cook) in response to increasing rates of tolpyralate + bromoxynil. Mayweed chamomile control was greater than 85% on any given rating date or treatment. Means with no letters are not significantly different from each other (alpha = 0.05).

| Treatment                | Rate |       | Mayweed<br>Chamomile Control<br>(%) | Mayweed<br>Chamomile Control<br>(%) | Mayweed<br>Chamomile Control<br>(%) |
|--------------------------|------|-------|-------------------------------------|-------------------------------------|-------------------------------------|
|                          |      |       | 7 DAA                               | 14 DAA                              | 21 DAA                              |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 100                                 | 95                                  | 88                                  |
| MSO                      | 0.5  | % v/v |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 14.7 | oz/A  | 100                                 | 98                                  | 95                                  |
| MSO                      | 0.5  | % v/v |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 95                                  | 90                                  | 88                                  |
| Embed Extra              | 8    | oz/A  |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 98                                  | 98                                  | 93                                  |
| WideARmatch              | 19.4 | oz/A  |                                     |                                     |                                     |
| Tolpyralate + Bromoxynil | 11   | oz/A  | 95                                  | 95                                  | 90                                  |
| Talinor                  | 15   | oz/A  |                                     |                                     |                                     |
| CoAct+                   | 2.75 | oz/A  |                                     |                                     |                                     |
| COC                      | 1    | % v/v |                                     |                                     |                                     |
| Huskie                   | 15   | oz/A  | 98                                  | 90                                  | 83                                  |
| NIS                      | 0.5  | % v/v |                                     |                                     |                                     |

## Bixlozone and Clomazone Crop Safety and Efficacy in Pulse Crops

J.E.R. Kalin & I. C. Burke

Bixlozone and clomazone are a selective preemergence herbicides with activity on both grass and broadleaf weeds. Both bixlozone and clomazone are novel herbicides to wheat production and inhibit carotenoid biosynthesis. Carotenoid biosynthesis inhibition causes ‘bleaching’ in weeds and sensitive crops. Pulse crops are an important part of the cropping rotations in the Pacific Northwest, however, weed management in chickpea is challenging because the crop is not competitive. Few options are available for annual grass and broadleaf weed control that are compatible with winter wheat in rotation. Therefore, herbicides that control annual grass and broadleaf weeds in pulse crops and do not carryover to wheat are critical. Bixlozone and clomazone have activity on Italian ryegrass. However, little is known of crop safety when applied to pulses. Therefore, the objective of these trials is to compare chickpea and pea response to bixlozone and clomazone to typical herbicide systems used for weed control.

Two trials were established near Pullman, WA in a newly seeded chickpea (var. Billy Beans) and spring pea. Treatments were applied to the soil as a preemergence tank mix (table 1). Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft by 30 ft long. Treatments were assessed for crop response and weed control 19, 26, and 40 days after treatment. Plots were harvested on September 18, 2023, with a Wintersteiger plot combine with a 5-foot header. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 2023).

| <i>Table 1. Treatment application details.</i> |              |              | Study Application |  |
|--|--------------|--------------|-------------------|--|
| Crop   | Spring Pea   | Chickpea     |                   |  |
| Date   | May 2, 2023  | May 18, 2023 |                   |  |
| Application volume (GPA)                       | 15           | 15           |                   |  |
| Timing   | Preemergence | Preemergence |                   |  |
| Air temperature (°F)                           | 70           | 70           |                   |  |
| Wind velocity (mph, direction)                 | 6, E         | 9, NW        |                   |  |
| Cloud Cover (%)                                | 30           | 70           |                   |  |

### Results

Injury was not evident in the spring pea but there was ample injury in the form of bleaching to the chickpea trial (Table 2). Bleaching was most evident in treatments that included higher rates of Command 3ME and F9600, however, injury was relatively low on any given rating date (5-25%). Injury was not apparent later in the season and did not impact yield. Bixlozone and clomazone appear to be safe on spring pea crops. Even at the highest rates, there was no bleaching found in spring pea. There may be some concern in chickpeas, though. The bleaching did not appear to affect yield of chickpeas (Table 2) but injury was evident in all treatments that included bixlozone and clomazone at rates over 9 oz/A.

Italian ryegrass control in chickpea was comparable among treatments and ranged from 57 to 100% (Table 3), which may be due to the field conditions in which the trial was located. Weed control in spring pea was variable, but generally greater than 70% for all treatments (Table 2). Although on June 6<sup>th</sup>, weed

control was only 57% in the treatment with the novel herbicide, F9600, at 27 oz/A mixed with RoundUp and Spartan Charge.

Yield for both crops were comparable and not significantly different among treatments (Tables 2 and 4). It should be noted that the yield was variable within each treatment for both trials (Figures 1 and 2), which may be due to field conditions rather than a product of the treatments.

Both Command 3ME and the new herbicide bixlozone can cause injury in chickpea and pea. When combined with Spartan Charge, control of Italian ryegrass can be near complete. However, rotation carryover is a concern. Both field sites will be monitored for carryover to winter wheat in 2024. Additional rotational trials evaluating the use of Command and bixlozone are also planned.

**Table 2.** Crop injury (%) and yield (lb/A) in chickpea in response to increasing rates of Command 3ME mixed with RoundUp PowerMax and Spartan Charge. Injury and yield were not different among treatments within each day of assessment ( $\alpha = 0.5$ ).

| Treatment         | Rate |      | Injury (%) | Injury (%) | Yield (lb/A) |
|-------------------|------|------|------------|------------|--------------|
|                   |      |      | 6/13/2023  | 6/27/2023  | 9/18/2023    |
| Command 3ME       | 4.5  | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 0          | 0          | 3500         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| Command 3ME       | 9    | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 0          | 0          | 5480         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| Command 3ME       | 18   | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 10         | 15         | 4900         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| Command 3ME       | 24   | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 26         | 24         | 6400         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| Authority Supreme | 15.4 | oz/A |            |            |              |
| RoundUp PowerMax  | 32   | oz/A | 0          | 0          | 4130         |
| Authority Supreme | 15.4 | oz/A |            |            |              |
| Express           | 0.5  | oz/A | 0          | 0          | 5980         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| F9600             | 12.8 | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 5          | 5          | 7630         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| F9600             | 25.6 | oz/A |            |            |              |
| Spartan Charge    | 8    | oz/A | 5          | 5          | 4170         |
| RoundUp PowerMax  | 32   | oz/A |            |            |              |
| RoundUp Power Max | 32   | oz/A | 5          | 5          | 3850         |
| F9600             | 12.8 | oz/A | 0          | 5          | 4710         |

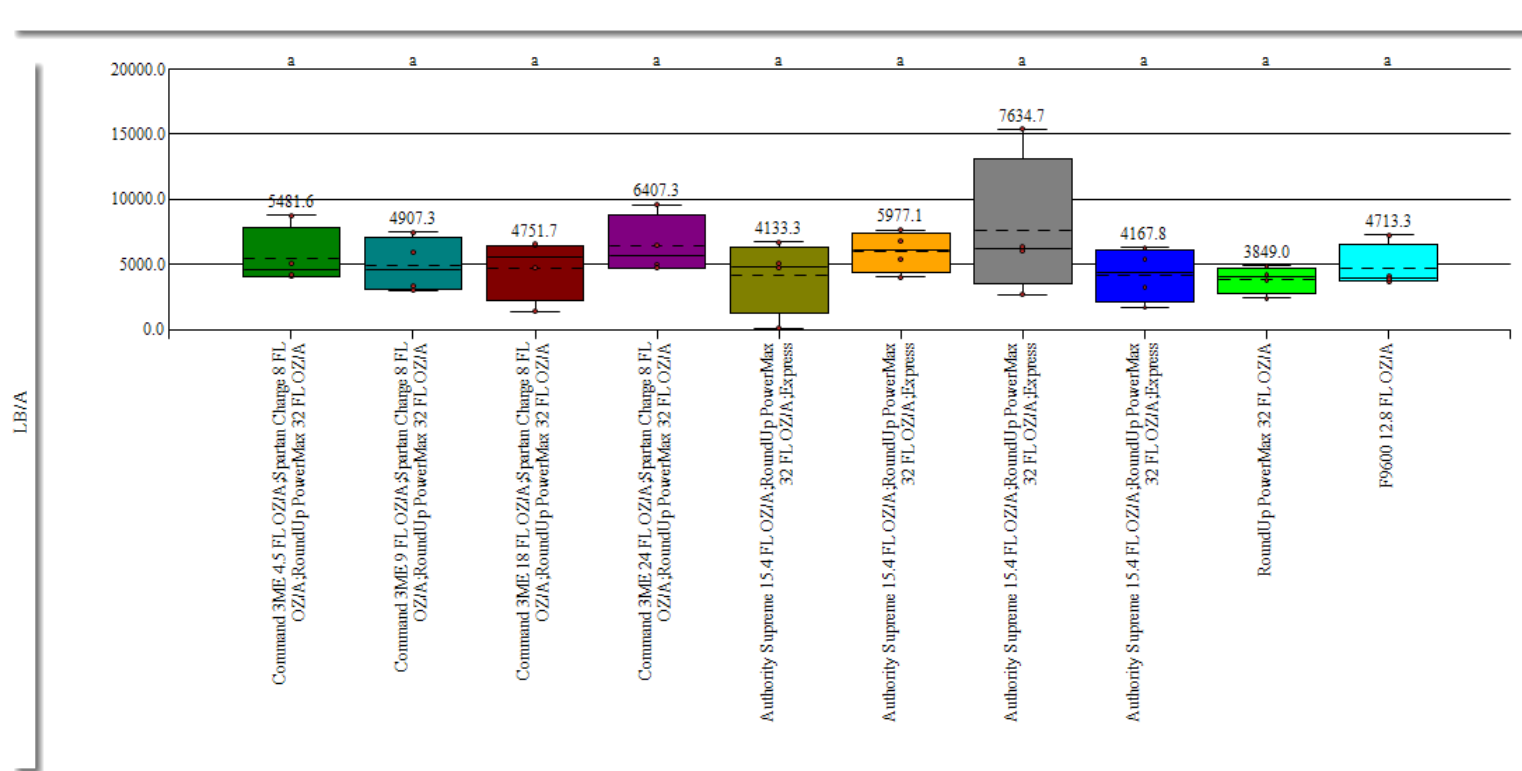
**Table 3.** Italian ryegrass control (%) in chickpea in response to increasing rates of Command 3ME. Control was not different among treatments within each day of assessment ( $\alpha=0.5$ ).

| Treatment         |      |      | Control (%) | Control (%) | Control (%) |
|-------------------|------|------|-------------|-------------|-------------|
|                   | Rate |      | 6/6/2023    | 6/13/2023   | 6/27/2023   |
| Command 3ME       | 4.5  | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 57          | 75          | 65          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| Command 3ME       | 9    | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 85          | 77          | 75          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| Command 3ME       | 18   | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 95          | 75          | 87          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| Command 3ME       | 24   | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 100         | 85          | 95          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| Authority Supreme | 15.4 | oz/A |             |             |             |
| RoundUp PowerMax  | 32   | oz/A | 95          | 90          | 95          |
| Authority Supreme | 15.4 | oz/A |             |             |             |
| Express           | 0.5  | oz/A | 95          | 72          | 87          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| F9600             | 12.8 | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 97          | 92          | 95          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| F9600             | 25.6 | oz/A |             |             |             |
| Spartan Charge    | 8    | oz/A | 97          | 97          | 92          |
| RoundUp PowerMax  | 32   | oz/A |             |             |             |
| RoundUp Power Max | 32   | oz/A | 62          | 90          | 45          |
| F9600             | 12.8 | oz/A | 62          | 95          | 50          |

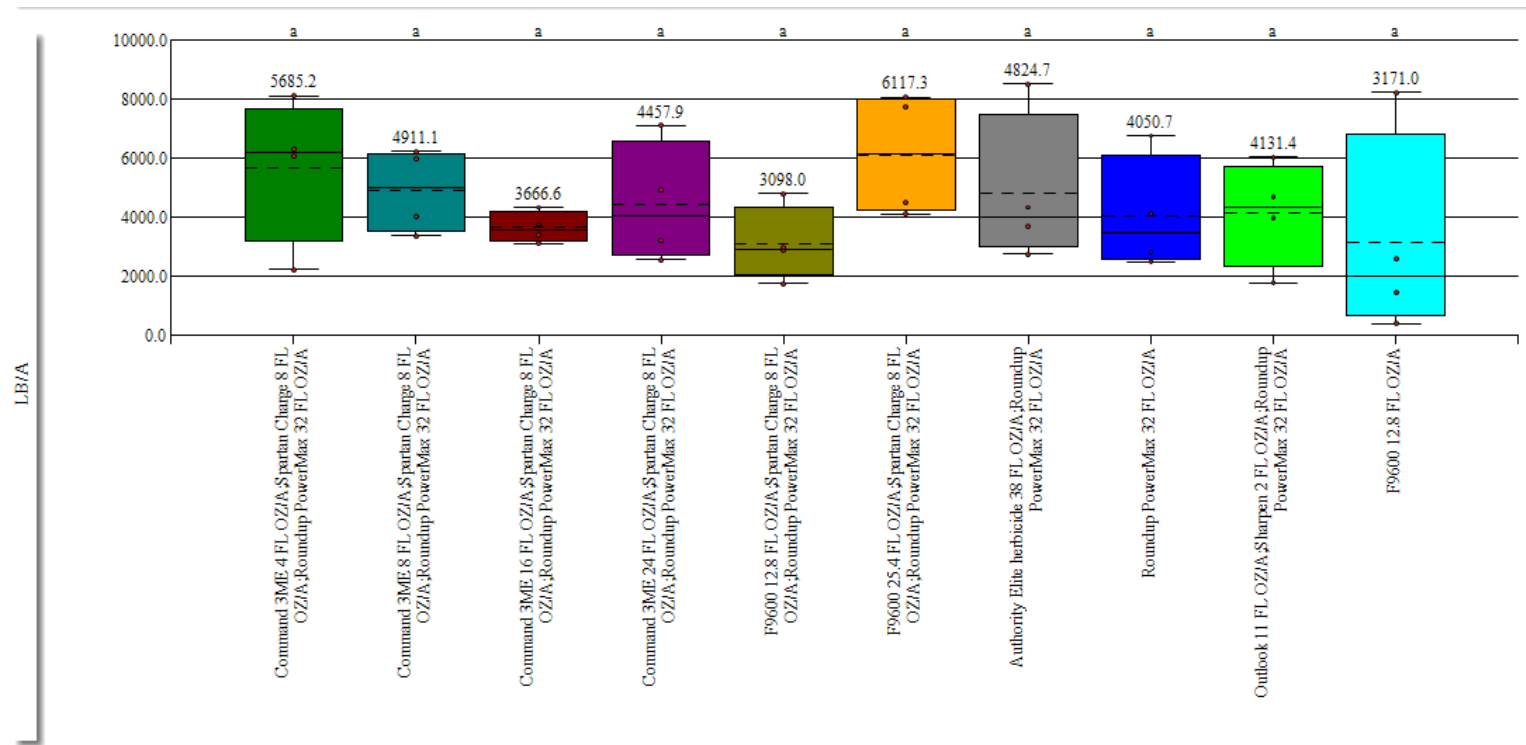
**Table 4.** Italian ryegrass control (%) and yield (bu/A) for spring pea in response to increasing rates of Command 3ME mixed with RoundUp PowerMax and Spartan Charge. Means with different letters are significantly different ( $\alpha = 0.05$ ).

| Treatment         |      |      | Control (%) | Control <sup>1</sup> (%) | Yield <sup>1</sup> (lb/A) |
|-------------------|------|------|-------------|--------------------------|---------------------------|
|                   | Rate |      | 6/6/2023    | 6/27/2023                | 9/18/2023                 |
| Command 3ME       | 4.5  | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 75 ab       | 82                       | 5690                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| Command 3ME       | 9    | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 75 ab       | 67                       | 4910                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| Command 3ME       | 18   | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 90 a        | 92                       | 3660                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| Command 3ME       | 24   | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 95 a        | 85                       | 4460                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| Authority Supreme | 15.4 | oz/A |             |                          |                           |
| RoundUp PowerMax  | 32   | oz/A | 95 a        | 90                       | 3100                      |
| Authority Supreme | 15.4 | oz/A |             |                          |                           |
| Express           | 0.5  | oz/A | 92 a        | 95                       | 6120                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| F9600             | 12.8 | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 97 a        | 92                       | 4820                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| F9600             | 25.6 | oz/A |             |                          |                           |
| Spartan Charge    | 8    | oz/A | 57 b        | 88                       | 4050                      |
| RoundUp PowerMax  | 32   | oz/A |             |                          |                           |
| RoundUp Power Max | 32   | oz/A | 90 a        | 87                       | 4130                      |
| F9600             | 12.8 | oz/A | 85 a        | 95                       | 3170                      |

<sup>1</sup>Weed control and yield were not different among treatments within day of assessment ( $\alpha = 0.05$ ).



**Figure 1.** Chickpea yield (lb/A) in response to increasing rates of Command 3ME in comparison to Spartan Charge and bixlozone (F9600).



**Figure 2.** Spring pea yield (lbs/A) in response to increasing rates of Command 3ME in comparison to Spartan Charge and bixlozone (F9600).



## Tough Efficacy on Common Lambsquarters

J.E.R. Kalin & I. C. Burke

In spring 2023, an herbicide trial was established south of Pullman, WA on Spillman Farm to determine the efficacy of Tough 5EC (pyridate) on common lambsquarters (*Chenopodium album*). Three different rates of Tough were applied with three different carrier volumes – 10, 15, and 20 gallons per acre.

The study was conducted on crop-free ground that was infested with common lambsquarters near Pullman, WA. Treatments were applied when the common lambsquarters was 6-8 inches tall and was actively growing in spring 2023. Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet nozzles (80015VS, 8002VS, 8003VS) with an effective spray pattern of 8 ft and calibrated to deliver 10, 15, or 20 gallons per acre (GPA), respectively. The study was conducted in a randomized complete block design with 3 replications. Plots were 10 ft by 30 ft long. Treatments were assessed for weed control at 7, 10, and 18 days after treatment. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 2023).

**Table 1.** Treatment application details

| Study Application              |                |
|--------------------------------|----------------|
| Date                           | 6/5/2023       |
| Application volume (GPA)       | 10, 15, and 20 |
| Timing                         | Postemergence  |
| Weed Stage                     | 6-8"           |
| Air temperature (°F)           | 63             |
| Wind velocity (mph, direction) | 5, E           |
| Cloud Cover (%)                | 40             |

Figure 1. Weed control examples with Tough 5EC at 24 oz/A, 10 GPA (left) and Tough 5EC at 12 oz/A, 20 GPA (right), taken 6/15/2023.



## Results

Common lambsquarters control with Tough 5EC was variable. Carrier volume appeared to have little effect on weed control, although there was slightly better control in the treatments applied at 10 GPA (Table 2). However, weed control increased with increasing rates of Tough, with 18 and 24 oz/A resulting in the highest weed control among the different carrier volumes. Tough applied at 24 oz/A and 10 GPA provided the most effective common lambsquarters control throughout the rating period, though control ranged between 60 and 80%. The control observed at the lower carrier volume is likely associated with droplet size, where 10 GPA and the 80015VS tip resulted in a fine spray droplet pattern. Higher carrier volumes have larger droplet size patterns. The treatments were applied to larger than recommended common lambsquarters, which was 6-8 inches tall. Applications should be timed to when the common lambsquarters have no more than 4 leaves and are actively growing. Results also confirmed previous research conducted in 2016 ([smallgrains.wsu.edu/uploads/2013/11/Completed-ICB2716-Report.pdf](https://smallgrains.wsu.edu/uploads/2013/11/Completed-ICB2716-Report.pdf)), where lower carrier volume resulted in higher numerical weed control with pyridate. Previous work did not include increasing rates presented here. Continued research with Tough in chickpea is critical to identify the most effective rate, carrier volume and resulting droplet size, and timing of application that results in consistent control of common lambsquarters.

**Table 2.** Weed control ratings in response to increasing doses and application volumes of Tough 5EC near Pullman, WA in 2023. Means with the same letter are not statistically different ( $\alpha=0.5$ ).

| Treatment <sup>1</sup> | GPA | Rate    | Control (%) | Control (%) | Control (%) |
|------------------------|-----|---------|-------------|-------------|-------------|
|                        |     |         | 6/12/2023   | 6/15/2023   | 6/23/2023   |
| Tough 5EC              | 10  | 12 oz/A | 17 bc       | 6 b         | 6 bc        |
| Tough 5EC              | 10  | 18 oz/A | 50 b        | 40 b        | 43 ab       |
| Tough 5EC              | 10  | 24 oz/A | 83 a        | 73 a        | 67 a        |
| Tough 5EC              | 15  | 12 oz/A | 3 bc        | 3 b         | 3 c         |
| Tough 5EC              | 15  | 18 oz/A | 10 bc       | 7 b         | 7 bc        |
| Tough 5EC              | 15  | 24 oz/A | 40 bc       | 30 b        | 43 ab       |
| Tough 5EC              | 20  | 12 oz/A | 30 bc       | 23 b        | 24 bc       |
| Tough 5EC              | 20  | 18 oz/A | 20 bc       | 20 b        | 20 bc       |
| Tough 5EC              | 20  | 24 oz/A | 30 bc       | 23 b        | 23 bc       |

<sup>1</sup> All treatments included MVO at 1% ai/v.

## Italian Ryegrass Control in Spring Canola Using Multiple Herbicide Modes of Action

Mark Thorne, Marija Savic, and Drew Lyon

Italian ryegrass resistance to glyphosate is a potentially serious issue for spring canola growers in the region. Herbicide resistance can develop when a single mode of action is used repeatedly over time, as was the case with Group 1 herbicides like Hoelon for grass weed control in pulse crops. Strategies that incorporate other modes of action can reduce dependence on glyphosate and potentially delay the development of Italian ryegrass resistance to glyphosate. Italian ryegrass in this region has already developed resistance to Group 1 and Group 2 herbicides, but glyphosate (Group 9) resistance, if present, is not yet widespread; therefore, Roundup Ready® canola is still an effective tool for Italian ryegrass control. Non-glyphosate options are limited but soil-active Group 3 herbicides, such as trifluralin (Treflan®) and ethalfluralin (Sonalan®), can be effective if adequately incorporated and activated in the soil by tillage and/or rainfall before ryegrass emergence. Also, glufosinate (Liberty® SC), a Group 10 herbicide, can be applied in LibertyLink® canola but is less effective on grass weeds compared with glyphosate, particularly if the grass weeds are tillered and well developed (Figure 1). Glufosinate is primarily a contact herbicide with only limited translocation in the plant. Finally, Group 13 clomazone (Clomate 3ME) is labeled for canola and may give some control of Italian ryegrass. No other herbicide options, other than the ones mentioned above, are available for selective Italian ryegrass in spring canola.



**Figure 1.** Effect of delayed seeding on Italian ryegrass density in spring canola. Early seeding on the left with no herbicide control, delayed seeding on the right with no herbicide control.



We compared multiple and single mode-of-action herbicide treatments for control of Italian ryegrass in spring canola at a field site on the WSU Cook Agronomy Farm. The field was in chickpeas in 2022 and the residue was left in place. On April 6, 2023, liquid fertilizer, 100-10-0-20 N-P-K-S lb/A, was drop-spread over the plot area. On April 24, 2023, the plot area was cultivated twice at 90° at a depth of 2-3 inches with a field cultivator with an attached tine harrow. Treflan HFP treatments were then applied at 24 fl oz/A and incorporated twice in opposite directions with a field cultivator/harrow. Spring canola, 'InVigor LibertyLink/TruFlex® LR345PC' is resistant to glyphosate and glufosinate and was initially seeded on April 25 with a Great Plains drill with double-disc openers on 10-inch spacing; however, 1.05 inches of rain fell on May 9 and washed out or buried the emerged canola. The trial site was recultivated and reseeded on May 15. The seeding rate was 15 seeds per ft<sup>2</sup> and placed 0.75 to 1.25 inches deep. By May 25, 10 days after seeding, the canola had emerged; however, very little precipitation occurred after emergence resulting in drought conditions and reduced secondary Italian ryegrass emergence. Early postemergence (EPOST) applications of Roundup PowerMax® at 22 and 44 fl oz/A and Liberty SC at 29 oz/A were applied on June 6 when the canola had 3-4 leaves and the Italian ryegrass had 2-4 leaves. Late postemergence (LPOST) treatments of PowerMax at 22 fl oz/A and Liberty at 29 oz/A, were applied on June 15 when the canola had 6 leaves and was beginning to bolt, and the Italian ryegrass plants ranged from 2 leaves to several tillers. All herbicides were applied with a 10-ft hand-held spray boom with six TeeJet® AIXR110015 nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack. Spray output was 15 gpa at 40 psi with a ground speed of 3 mph. All PowerMax and Liberty applications included NH<sub>4</sub>SO<sub>4</sub> at 17 lb/100 gallons of spray mix.

Italian ryegrass control was rated visually as a percent of the nontreated checks on June 15 and 30 in the growing crop, and on September 2, 2023, at harvest. Crop injury from herbicides was visually assessed on June 30 and July 14 compared with the nontreated checks. Canola was harvested on September 2 with a Wintersteiger plot harvester and samples were bagged, cleaned, and weighed to calculate plot yield.

The overall Italian ryegrass density was low this year because the plot area was cultivated and reseeded after the flood event on May 9, which controlled 90% of the Italian ryegrass when comparing the nontreated check plots to an adjacent trial that did not get flooded (Figure 1). However, the flooding did not appear to reduce the efficacy of the PPI Treflan applications as control ratings 44 DAT (days after treatment) were greater than 90% of the nontreated check in all plots (Table 1). Italian ryegrass control with treatments of Treflan followed by PowerMax or Liberty was 100% 9 DAT for the EPOST applications. The EPOST Liberty alone treatment averaged 71% control of the nontreated check on June 15 and 90% by June 30 but was still less effective than all other treatments, which were at or near 100%.

By harvest, Italian ryegrass control was 99-100% with all treatments except the single-mode Liberty treatment, which averaged 80% control. The reduced Italian ryegrass density from the delayed seeding combined with the lack of secondary flushes resulted in good control from all treatments; however, only relying on a single application of Liberty was less effective. All PowerMax applications were so effective in controlling Italian ryegrass that it was difficult to determine if Treflan added control in the multiple-mode treatments; however, Treflan resulted in

fewer plants for the postemergence applications to control and thus reduced the likelihood of selecting for resistance.

**Table 1.** Italian ryegrass control in 2023 spring canola with multiple modes of action.

|     | Apr 24                                | June 6              | June 15                       | June 6                                       | June 15        | June 30         | Sept 2  |
|-----|---------------------------------------|---------------------|-------------------------------|--|----------------|-----------------|---------|
|     | ----- Canola stages* -----            |                     |                               | -----Italian ryegrass control ratings**----- |                |                 |         |
| Trt | PPI                                   | 3-4 leaves<br>EPOST | 6 leaves-<br>bolting<br>LPOST | 44 DAT<br>PPI                                | 9 DAT<br>EPOST | 15 DAT<br>LPOST | Harvest |
|     | ----- Herbicides applied (oz/A) ----- |                     |                               | ----- % of nontreated check-----             |                |                 |         |
| 1   | -                                     | PM (44)             | -                             | -  | 92 cd          | 100 a           | 100 a   |
| 2   | Treflan                               | PM (44)             | -                             | 97 abc                                       | 100 a          | 100 a           | 100 a   |
| 3   | Treflan                               | -                   | -                             | 94 c   | 89 d           | 99 ab           | 99 a    |
| 4   |                                       | -                   | PM (22)                       | -  | 0 f            | 98 b            | 99 a    |
| 5   | Treflan                               | -                   | PM (22)                       | 99 ab  | 97 bc          | 100 a           | 100 a   |
| 6   | -                                     | PM (22)             | PM (22)                       | -  | 87 d           | 100 a           | 100 a   |
| 7   | Treflan                               | PM (22)             | PM (22)                       | 96 bc  | 100 a          | 100 a           | 100 a   |
| 8   | -                                     | Liberty             | -                             | -  | 71 e           | 90 c            | 80 b    |
| 9   | Treflan                               | Liberty             | -                             | 99 a   | 100 ab         | 100 a           | 100 a   |
| 10  |                                       | PM (44)             | Liberty                       | -  | 97 bc          | 100 a           | 100 a   |
| 11  | Treflan                               | Liberty             | Liberty                       | 99 a   | 100 ab         | 100 a           | 100 a   |
| 12  | Nontreated check                      |                     |                               | -  | -              | -               | -       |

\*PPI = preplant incorporated, EPOST = early postemergence, LPOST = late postemergence;  
Treflan (trifluralin) was applied at 24 fl oz/A PPI and incorporated twice with a cultivator at 180°;  
EPOST PowerMax was applied at 44 and 22 fl oz/A, and Liberty was applied at 29 fl oz/A;  
LPOST PowerMax was applied at 22 oz/A; LPOST Liberty was applied at 29 oz/A.

All PowerMax and Liberty applications included NH<sub>4</sub> SO<sub>4</sub> at 17 lb/100 gal

\*\*DAT = days after treatment. Numbers followed by the same letter in each column are not statistically different ( $P \leq 0.05$ ).

The negative outcome of the delayed planting was that flowering occurred later during hotter temperatures, which potentially resulted in greater plant stress and lower yields. This was especially evident for EPOST PowerMax applications at 44 oz/A and the split PowerMax EPOST plus LPOST applications. These PowerMax applications resulted in reduced growth and some yellowing that was observable when the plots were rated on June 30 and July 14 (Table 2). The PowerMax treatments also had lower yields compared with the nontreated check or the single or multiple-mode Liberty treatments. Delayed planting is one tool for controlling Italian ryegrass; however, any physiological stress from glyphosate that delays canola development will be particularly problematic for late-planted canola.

**Table 2.** Spring canola injury and yield.

|     | Apr 25                                | June 2              | June 15                       | June 30                        | July 14             | Sept 2   |
|-----|---------------------------------------|---------------------|-------------------------------|--------------------------------|---------------------|----------|
|     | ----- Canola stages* -----            |                     |                               |                                |                     |          |
| Trt | PPI                                   | 3-4 leaves<br>EPOST | 6 leaves-<br>bolting<br>LPOST | Plants initiating<br>flowering | Plants<br>flowering | Harvest  |
|     | ----- Herbicides applied (oz/A) ----- |                     |                               | Percent crop injury**          |                     | lb/A     |
| 1   | -                                     | PM (44)             | -                             | 23 ab                          | 13 a                | 1365 cde |
| 2   | Treflan                               | PM (44)             | -                             | 17 bc                          | 10 ab               | 1508 bcd |
| 3   | Treflan                               | -                   | -                             | 0 d                            | 0 d                 | 1594 abc |
| 4   |                                       | -                   | PM (22)                       | 1 d                            | 2 cd                | 1332 de  |
| 5   | Treflan                               | -                   | PM (22)                       | 0 d                            | 4 bc                | 1369 cde |
| 6   | -                                     | PM (22)             | PM (22)                       | 13 c                           | 9 ab                | 1289 de  |
| 7   | Treflan                               | PM (22)             | PM (22)                       | 15 bc                          | 10 ab               | 1211 e   |
| 8   | -                                     | Liberty             | -                             | 0 d                            | 1 cd                | 1794 a   |
| 9   | Treflan                               | Liberty             | -                             | 0 d                            | 1 cd                | 1770 a   |
| 10  |                                       | PM (44)             | Liberty                       | 27 a                           | 8 ab                | 1347 de  |
| 11  | Treflan                               | Liberty             | Liberty                       | 1 d                            | 0 d                 | 1734 ab  |
| 12  | Nontreated check                      |                     |                               | 0                              | 0                   | 1793 a   |

\*See Table 1 for application details. PM=Roundup PowerMax herbicide. Numbers followed by the same letter in each column are not statistically different ( $P \leq 0.05$ ).

\*\*Canola injury included stunting and/or yellowing following postemergence applications.

## Italian Ryegrass Control with Liberty® Herbicide in LibertyLink® Spring Canola

Mark Thorne and Drew Lyon

Liberty® 280 SL (glufosinate) is a Group 10 herbicide and is an alternative to glyphosate, Group 9, for the control of Italian ryegrass in spring canola (Figure 1). Liberty functions primarily as a contact herbicide but the mode of action is the inhibition of glutamine synthetase, an enzyme involved in the synthesis of the amino acid, glutamine. Inhibition of glutamine synthetase quickly results in a toxic buildup of ammonia in plant cells that destroys cell membranes. LibertyLink spring canola is resistant to glufosinate because of a gene that codes for an enzyme that converts glufosinate to a non-toxic metabolite in the plant. Glufosinate-resistant canola was first developed in 1995. Glufosinate-resistant canola provides an herbicide option for Italian ryegrass control that can help delay the development of glyphosate-resistant Italian ryegrass.

We compared herbicide treatments for Italian ryegrass control in spring canola at the WSU Cook Agronomy Farm. The field was in chickpeas in 2022 and the residue was left in place. On April 6, 2023, liquid fertilizer, 100-10-0-20 N-P-K-S lb/A, was drop-spread over the plot area. On April 24, the plot area was cultivated twice at 90° at a depth of 2-3 inches with a field cultivator with an attached tine harrow. Treflan HFP, a Group 3 mitosis inhibitor, was applied preplant at 24 fl oz/A and incorporated (PPI) twice in opposite directions with a field cultivator/harrow. Spring canola cultivar ‘InVigor LibertyLink/TruFlex® LR345PC’, resistant to glufosinate and glyphosate, was seeded on April 25 with a Great Plains drill with double-disc openers on 10-inch spacing. The seeding rate was 15 seeds per ft<sup>2</sup> and seed were placed 0.75 to 1.25 inches deep.

By May 5, 10 days after seeding, the canola had emerged. Early postemergence (EPOST) applications of Roundup PowerMax® glyphosate at 22 and 44 fl oz/A and Liberty 280 SL at 29 oz/A were applied on May 20 when the canola had 3-4 leaves and the Italian ryegrass had 1 leaf to 1 tiller. Late postemergence (LPOST) treatments of PowerMax at 22 fl oz/A and Liberty at 29 oz/A, were applied on June 1 when the canola had 6 leaves and was beginning to bolt. The Italian ryegrass plants ranged from 3 leaves to several tillers. All herbicides were applied with a 10-ft hand-held spray boom with six TeeJet® AIXR110015 nozzles on 20-inch spacing and pressurized with a CO<sub>2</sub> backpack. Spray output was 15 gpa at 40 psi with a ground speed of 3 mph. All Liberty applications included AMS at 3



**Figure 1.** Top photo: Liberty following preplant Treflan on Italian ryegrass in canola. Bottom photo: Liberty on Italian ryegrass with no preplant Treflan.

lb dry granules/A, and all PowerMax applications included AMS at 17 lb dry granules/100 gallons of spray mix.

Italian ryegrass control was rated visually 12 days after the EPOST treatments as a percent of the nontreated checks in all treatments on June 1. Control was rated again 15 days after the LPOST treatments on June 16, and again at harvest on August 17. Canola was harvested with a Wintersteiger plot combine and samples were bagged, cleaned, and weighed to calculate plot yield.

**Table 1.** Italian ryegrass control and canola yield.

|     | April 24                          | May 20               | June 1                        | June 1                             | June 16         | August 17  | August 17 |
|-----|-----------------------------------|----------------------|-------------------------------|------------------------------------|-----------------|------------|-----------|
|     | ----- Canola stages* -----        |                      |                               | Italian ryegrass control ratings** |                 | Harvest    |           |
| Trt | PPI                               | 3-4 leaves<br>EPOST  | 6 leaves-<br>bolting<br>LPOST | 12 DAT<br>EPOST                    | 15 DAT<br>LPOST | Harvest    | Yield     |
|     | --- Herbicides applied (oz/A) --- |                      |                               | ---- % of nontreated check ----    |                 | -- lb/A -- |           |
| 1   | Nontreated check                  |                      |                               | -                                  | -               | -          | 1160 b    |
| 2   | Treflan                           | Liberty              | -                             | 96 b                               | 91 c            | 97 b       | 1680 a    |
| 3   | Treflan                           | PM (22)              | -                             | 99 a                               | 99 a            | 99 ab      | 1770 a    |
| 4   | -                                 | Liberty              | Liberty                       | 68 e                               | 79 c            | 90 c       | 1720 a    |
| 5   | -                                 | PM (22)              | PM (22)                       | 92 c                               | 100 a           | 100 a      | 1540 a    |
| 6   | -                                 | PM (44)              | -                             | 96 b                               | 98 a            | 100 a      | 1680 a    |
| 7   | -                                 | Liberty +<br>PM (22) | Liberty +<br>PM (22)          | 88 d                               | 99 a            | 100 a      | 1620 a    |
| 8   | -                                 | Liberty              | PM (22)                       | 72 e                               | 93 b            | 100 a      | 1530 a    |

\* PPI = preplant incorporated, EPOST = early postemergence, LPOST = late postemergence.

Treflan (trifluralin) was applied at 24 fl oz/A PPI and incorporated twice with a cultivator at 180°;

EPOST PowerMax was applied at 44 and 22 fl oz/A and included AMS at 17 lb/100 gal;

All Liberty applications were applied at 29 fl oz/A and included AMS at 3 lb/A.

LPOST PowerMax was applied at 22 oz/A;

\*\*DAT = days after treatment. Means followed by the same letter in each column are not statistically different ( $P \leq 0.05$ ).

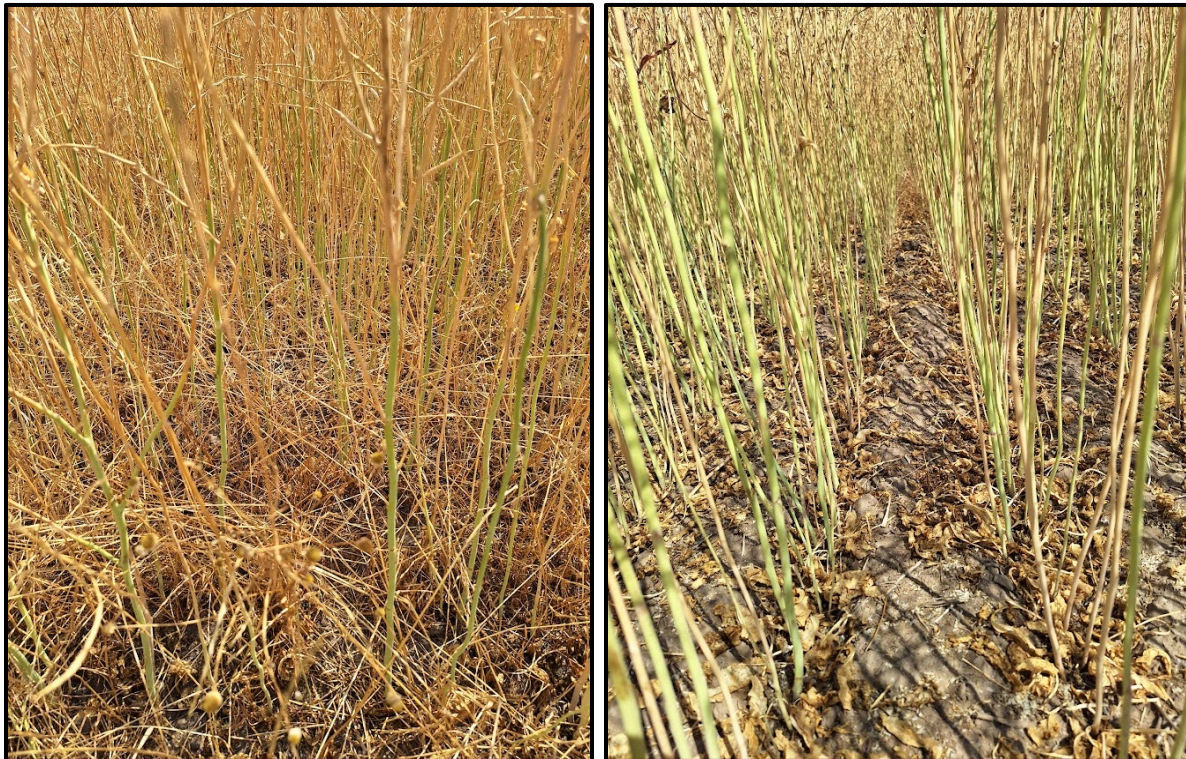
By May 20, when the EPOST treatments were applied, the Treflan applications had resulted in Italian ryegrass density 89% lower compared to the nontreated check (34 vs 299 plants/yd<sup>2</sup>). The reduction in Italian ryegrass density increased the efficacy of the EPOST treatments as Treflan followed by Liberty EPOST controlled Italian ryegrass 96% compared with 68% for only EPOST Liberty (Table 1). Treflan followed by EPOST PowerMax averaged 99% control and was greater than EPOST PowerMax at either 22 or 44 oz/A (Table 1). Two weeks after the



LPOST treatments, Treflan followed by Liberty was not different than Liberty applied both EPOST and LPOST. However, control was greatest with all EPOST PowerMax treatments, and all were not different than 100%. At canola harvest, control with PowerMax was still at or near 100%, and there was no difference between Treflan followed by Liberty or by PowerMax. In plots where control was not 100%, plants that had escaped control had produced some seeds, but the number declined as the control approached 100% (data not shown).

Overall, canola yields were less than in 2022 because of limited precipitation from May through July; however, yield did not differ between any of the herbicide treatments and ranged from 1530 to 1770 lb/A (Table 1). We also did not find obvious antagonism from tank mixing Liberty and PowerMax as is sometimes a concern. The least desirable outcome was from not applying anything, as the canola yield of the nontreated check treatment was only 1160 lb/A, which was lower than all other treatments.

Italian ryegrass is a strong competitor with spring canola and can significantly reduce yield (Figure 2). Liberty, while currently not quite as effective as glyphosate, can provide good control, particularly when applied with another effective mode of action (for example, Treflan HFP or glyphosate) or when applied back-to-back. Incorporating LibertyLink spring canola into the rotation can reduce dependence on glyphosate and help delay the development of glyphosate resistance in Italian ryegrass.



**Figure 2.** Spring canola with no Italian ryegrass control (photo on left) vs. spring canola with good Italian ryegrass control (photo on right).

# Alion Crop Safety and Efficacy in Kentucky Bluegrass

J.E.R. Kalin & I. C. Burke

## Introduction

In fall of 2022, an herbicide trial was established to evaluate Kentucky bluegrass tolerance to Alion (indaziflam). Annual grass weeds are difficult to control in grass seed fields and infestations can reduce stand longevity and productivity. Alion controls annual grass weeds by inhibiting cellulose biosynthesis in newly germinated seedlings.

## Methods

The study was established in a newly seeded Kentucky bluegrass field near Rockford, WA. Treatments were applied when the Kentucky bluegrass was 3 to 5 tiller and actively growing in the fall of 2022. Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft by 25 ft long. Treatments were assessed for crop response and weed control in the spring, 6 months after treatment. Two ½ m<sup>2</sup> subsamples were harvested from each plot. Biomass samples were dried and weighed and yield samples were dried, threshed, and cleaned. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

**Table 1.** Treatment application details.

| Study Application              |               |
|--------------------------------|---------------|
| Date                           | 10/18/2022    |
| Application volume (GPA)       | 15            |
| Timing                         | Postemergence |
| Crop Stage                     | 3 to 5 Tiller |
| Air temperature (°F)           | 57            |
| Wind velocity (mph, direction) | 6, N          |
| Cloud Cover (%)                | 0             |

## Results

The Kentucky bluegrass in this trial did not have injury as a result of the Alion herbicide treatments. Italian ryegrass control was between 90 to 100% and not significantly different between treatments ( $\alpha = 0.05$ , not shown). Again, biomass (Table 2) was not significantly different between treatments ( $\alpha = 0.05$ ). Alion appears to be a safe and effective herbicide on newly seeded Kentucky Bluegrass. Continued research is needed to evaluate newly seeded compared to first year stand response to Alion. Cultivar variation in rhizome production may play an important role in tolerance as well. Overall, Alion appears to be a highly effective annual grass weed control herbicide for Kentucky bluegrass for seed.

**Table 2.** Biomass (g/0.5m<sup>2</sup>) of Kentucky bluegrass (n = 8 per treatment) in response to increasing rates of Alion herbicide treatments.

| Treatment | Biomass (g/0.5m <sup>2</sup> ) |      |          |
|-----------|--------------------------------|------|----------|
|           | Rate                           |      | 6/1/2022 |
| Alion     | 1.5                            | oz/A | 155      |
| Alion     | 2                              | oz/A | 153      |
| Alion     | 3                              | oz/A | 147      |

Biomass was not different among treatments ( $\alpha=0.5$ ).

## Anthem Flex Crop Safety and Efficacy in Kentucky Bluegrass

J.E.R. Kalin & I. C. Burke

Annual grass weeds are difficult to manage in grass seed fields due to similarities in physiology and lifecycles, and infestations can reduce stand longevity and productivity. Preemergence herbicides that control annual grasses selectively in Kentucky bluegrass are critical components of a weed management system. Pyroxasulfone, the active ingredient in Anthem Flex that has soil residual activity, is a new herbicide being considered for use in Kentucky bluegrass. The study objective was to evaluate Anthem Flex (pyroxasulfone + carfentrazone-ethyl) crop safety and efficacy in newly seeded Kentucky bluegrass.

The study was established in a newly seeded Kentucky bluegrass field near Rockford, WA. Treatments were applied when the Kentucky bluegrass was tillering and actively growing in the fall of 2022. Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft by 25 ft long. Treatments were assessed for crop response and weed control in the spring, 6 months after treatment. Two ½ m<sup>2</sup> subsamples were harvested from each plot. Samples were dried, threshed, and cleaned to provide yield data for each treatment. A subset of seeds from each ½ m<sup>2</sup> sample were used to collect data on germination differences between treatments. Biomass, yield, and germination data are still being analyzed. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 2023).

**Table 1.** Treatment application details.

| Study Application              |               |               |
|--------------------------------|---------------|---------------|
| Application Code               | A             | B             |
| Date                           | 10/20/2022    | 5/4/2023      |
| Application volume (GPA)       | 15            | 15            |
| Timing                         | Postemergence | Postemergence |
| Air temperature (°F)           | 62            | 66            |
| Relative humidity (%)          | 47            | 46            |
| Wind velocity (mph, direction) | 7, NE         | 6, NNE        |
| Cloud Cover (%)                | 90            | 30            |



**Figure 1.** Nontreated plot (left) and Anthem Flex 2.75 oz/A in fall plus Anthem Flex 1 oz/A in spring.(right).



## Results

Treatments that included a spring treatment of Anthem Flex or high rates of Anthem Flex (2.75 and 3.76 oz/A) caused significant stunting to the newly seeded Kentucky bluegrass (Figure 1 and Table 2). The injury did become less apparent throughout the growing season but was still visually detectable at time of harvest. The injury ratings presented here are more accurately described as ‘percent of plot area affected’; the magnitude of the stunting injury was 60-80%. Weed control was not significantly different among treatments, but higher rates of Anthem Flex had numerically increased weed control compared to other rates of Anthem Flex, or the Outrider treatment. Anthem Flex does not appear to be a safe herbicide option for newly seeded Kentucky bluegrass at high rates. Applying Anthem Flex at low rates or on older stands of bluegrass is a potential input for control of annual grass weeds in Kentucky bluegrass.

**Table 2.** Crop injury (rated as percent of plot area affected by injury) and weed control for Kentucky bluegrass in response to increasing rates of Anthem Flex herbicide. Means with the same letter are not statistically different ( $\alpha = 0.05$ ).

|    | Treatment   | Timing | Rate      | Injury (%) |    | Injury (%) |   | Control <sup>1</sup> (%) |
|----|-------------|--------|-----------|------------|----|------------|---|--------------------------|
|    |             |        |           | 5/23/2023  |    | 6/5/2023   |   | 6/5/2023                 |
| 1  | Anthem Flex | A      | 2.75 oz/A | 20         | cd | 0          | b | 72                       |
| 2  | Anthem Flex | A      | 3 oz/A    | 10         | cd | 5          | b | 67                       |
| 3  | Anthem Flex | A      | 0.38 oz/A | 100        | a  | 25         | b | 87                       |
|    | Anthem Flex | B      | 2.75 oz/A |            |    |            |   |                          |
| 4  | Anthem Flex | A      | 6 oz/A    | 56         | bc | 25         | b | 87                       |
| 5  | Anthem Flex | A      | 2.75 oz/A | 0          | d  | 12         | b | 77                       |
|    | Prowl H2O   | B      | 64 oz/A   |            |    |            |   |                          |
| 6  | Prowl H2O   | A      | 64 oz/A   | 0          | d  | 0          | b | 70                       |
| 7  | Anthem Flex | A      | 2.75 oz/A | 85         | ab | 95         | a | 90                       |
|    | Anthem Flex | B      | 2.75 oz/A |            |    |            |   |                          |
| 8  | Outrider    | A      | 0.38 oz/A | 0          | d  | 0          | b | 67                       |
| 9  | Outrider    | A      | 0.38 oz/A | 20         | cd | 5          | b | 67                       |
|    | Anthem Flex | A      | 2.75 oz/A |            |    |            |   |                          |
| 10 | Anthem Flex | A      | 3.76 oz/A | 58         | bc | 10         | b | 70                       |

<sup>1</sup>Control was not significantly different among treatments ( $\alpha = 0.05$ ).



## Outrider Crop Safety and Efficacy in Kentucky Bluegrass

J.E.R. Kalin & I. C. Burke

### Introduction

In fall of 2022, an herbicide trial was established to evaluate Kentucky bluegrass tolerance to Outrider (sulfosulfuron). Annual grass weeds are difficult to manage in grass seed fields, and infestations can reduce stand longevity and productivity. Of particular concern is *ventenata*, a winter annual weed closely related to wild oat that has now been classified as a noxious weed in certain western states. *Ventenata* completes its lifecycle well ahead of Kentucky bluegrass and other grass seed crops. Outrider is known to have activity on *ventenata* and other winter annual grass weeds, but crop safety in Kentucky bluegrass in eastern Washington is still unknown. Therefore, the objective of the trial was to evaluate Kentucky bluegrass response to increasing rates of Outrider applied alone and in mixture with another common herbicide and a fungicide.

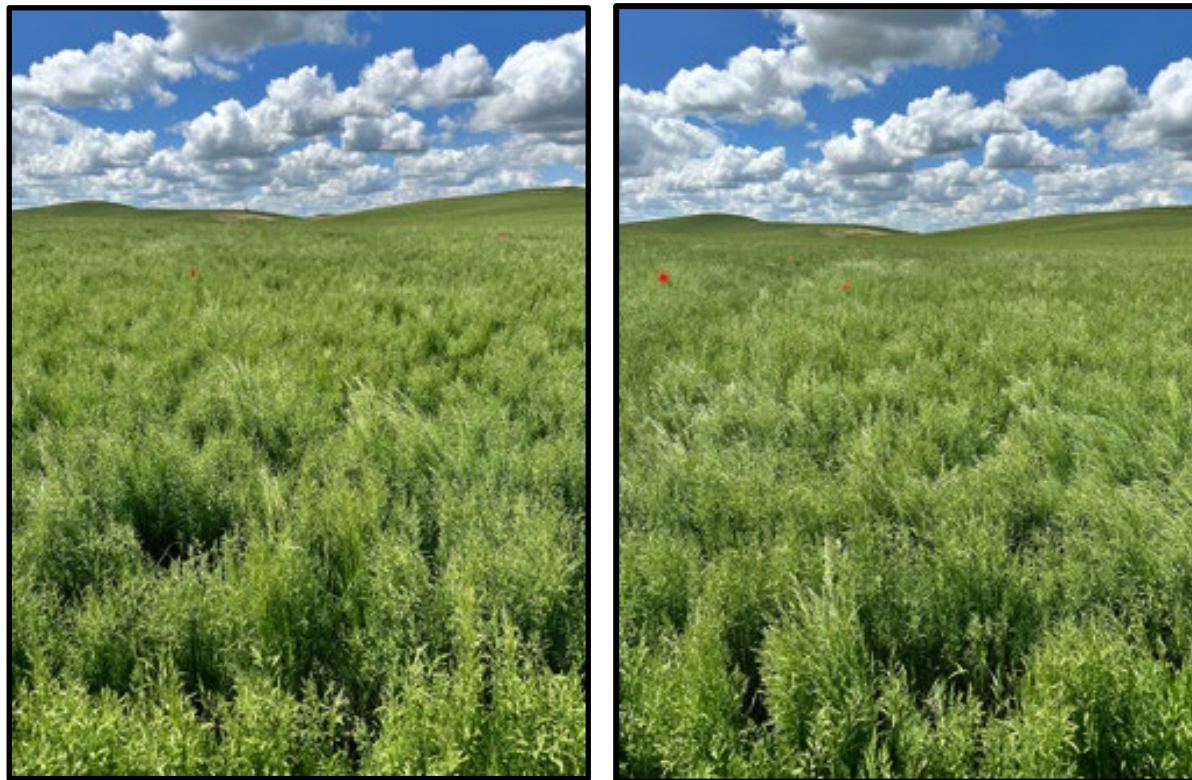
### Methods

The study was established in a newly seeded Kentucky bluegrass field near Rockford, WA. Treatments were applied when the Kentucky bluegrass was 3 to 5 tiller and actively growing in the fall of 2022. Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 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 10 ft by 25 ft long. Treatments were assessed for crop response and weed control in the spring, 6 months after treatment. Two ½ m<sup>2</sup> subsamples were harvested from each plot. Samples were dried, threshed, and cleaned to provide yield data for each treatment. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

**Table 1.** Treatment application details.

| Study Application              |               |
|--------------------------------|---------------|
| Date                           | 10/12/2022    |
| Application volume (GPA)       | 15            |
| Timing                         | Postemergence |
| Crop Stage                     | 3 to 5 Tiller |
| Air temperature (°F)           | 62            |
| Soil temperature (°F)          | 54            |
| Wind velocity (mph, direction) | 7, NE         |
| Cloud Cover (%)                | 90            |

*Figure 1. Nontreated plot (left) and Outrider + Callisto + Trivapro plot (right).*



## **Results**

There was no observable crop injury as a result of any treatments applied to newly seeded Kentucky bluegrass. Grass weed control was variable but ultimately only different between treatments on 6/5/2023 (Figure 1, Table 2). Outrider applied at the highest rate of 0.76 oz/A had the highest control at 90%. The treatment that included both the Trivapro fungicide and Callisto herbicide mixed with the Outrider consistently had lower weed control, suggesting that there is antagonism with that particular tank mix. Yield was not different between herbicide treatments (Table 2). Results from this study indicate that Outrider is safe to use on Kentucky bluegrass while still controlling grass weeds, making it a potentially useful tool for bluegrass grown for seed.

**Table 2.** Weed control and Kentucky bluegrass yield in response to increasing doses of Outrider or Outrider applied with Callisto or Trivapro fungicide in a field trial near Rockford, WA in 2023. Means with the same letter are not statistically different ( $\alpha=0.5$ ).

| Treatment             | Timing | Rate |      | Italian ryegrass control (%) <sup>2</sup> |          | Yield (lbs/A) <sup>2</sup> |
|-----------------------|--------|------|------|---|----------|----------------------------|
|                       |        |      |      | 5/23/2023                                 | 6/5/2023 |                            |
| Outrider <sup>1</sup> | Fall   | 0.25 | oz/A | 97  | 82 ab    | 1024                       |
| Outrider <sup>1</sup> | Fall   | 0.38 | oz/A | 97  | 90 ab    | 1113                       |
| Outrider <sup>1</sup> | Fall   | 0.76 | oz/A | 97  | 95 a     | 1117                       |
| Outrider              | Fall   | 0.38 | oz/A | 95  | 90 ab    | 1039                       |
| Callisto              | Fall   | 3    | oz/A |   |          |                            |
| Outrider              | Fall   | 0.38 | oz/A | 95  | 87 ab    | 1244                       |
| Trivapro              | Fall   | 13.7 | oz/A |   |          |                            |
| Outrider              | Fall   | 0.38 | oz/A | 87  | 70 b     | 1022                       |
| Callisto              | Fall   | 3    | oz/A |   |          |                            |
| Trivapro              | Fall   | 13.7 | oz/A |   |          |                            |

<sup>1</sup>Treatments also had NIS (0.5% v/v) and AMS (3lb/100 gal) added to the tank mix.

<sup>2</sup>Weed control on 5/23/2023 and yield were not different among treatments ( $\alpha=0.5$ ).

## Talinor Crop Safety and Efficacy in Kentucky Bluegrass

J.E.R. Kalin & I. C. Burke

Talinor is a 4-HPPD inhibitor with soil residual activity, and is not currently labeled for use in Kentucky bluegrass grown for seed. Although it does not control annual grass weeds, Talinor does control mayweed chamomile, a listed noxious weed and a serious potential contaminate of Kentucky bluegrass for grown for seed. Talinor may be an important tool for management of mayweed chamomile in Kentucky bluegrass grown for seed. Therefore, in fall of 2022, a herbicide trial was established to evaluate Kentucky bluegrass tolerance to Talinor (bromoxynil octanoate + bicyclopyrone) and mayweed chamomile (*Anthemis cotula*) control.

### Methods

The study was established in a newly seeded Kentucky bluegrass field near Rockford, WA. Treatments were applied when the Kentucky bluegrass was 3 to 5 tiller and actively growing in the fall of 2022. Treatments were applied with a CO<sub>2</sub> powered backpack sprayer and a 5 ft boom with 3 Teejet 11002VS nozzles with an effective spray pattern of 8 ft and calibrated to deliver 15 gallons per acre (GPA). Treatment A was applied in 2022 and treatment B was applied in spring 2023 (table 1). The study was conducted in a randomized complete block design with 4 replications. Plots were 10 ft by 25 ft long. Treatments were assessed for crop response and weed control in the spring, 6 months after treatment. Two ½ m<sup>2</sup> subsamples were harvested from each plot. Samples were dried, threshed, and cleaned to provide yield data for each treatment. A subset of seeds from each ½ m<sup>2</sup> sample were used to collect data on germination differences between treatments. Data were subject to ANOVA using the Agricultural Research Manager software (Ver. 8.5).

**Table 1.** Treatment application details.

| Study Application              |               |               |
|--------------------------------|---------------|---------------|
| Application Code               | A             | B             |
| Date                           | 10/18/2022    | 5/4/2023      |
| Application volume (GPA)       | 15            | 15            |
| Timing                         | Postemergence | Postemergence |
| Crop Stage                     | Newly seeded  | Newly seeded  |
| Air temperature (°F)           | 57            | 66            |
| Relative humidity (%)          | 51            | 46            |
| Wind velocity (mph, direction) | 6, W          | 7, NE         |
| Cloud Cover (%)                | 30            | 30            |

## Results

Overall, there was no injury to the crop from the Talinor applications, regardless of application rate or timing. There was also ubiquitous weed control across the trial, which may be due to poor establishment of the target weed, Mayweed chamomile, at the study site. Yield was also not different among treatments, at around 1,000 lbs/A (Table 2). Talinor appears to be safe on newly-seeded Kentucky bluegrass, but more work needs to be done to determine the efficacy of Talinor on mayweed chamomile in typical Kentucky bluegrass systems and application timings.

**Table 2.** Yield (lbs/A) of Kentucky bluegrass in response to increasing rates of Talinor. There is no significant difference between treatments ( $\alpha = 0.05$ ).

| Treatment   | Timing | Yield (lb/A) |           |
|-------------|--------|--------------|-----------|
|             |        | Rate         | 6/29/2022 |
| Callisto    | A      | 6 oz/A       | 1015      |
| Talinor     | A      | 16 oz/A      | 982       |
| Talinor     | A      | 18.2 oz/A    | 1002      |
| Talinor     | A      | 32 oz/A      | 1007      |
| Talinor     | A      | 16 oz/A      | 945       |
| Callisto    |        | 6 oz/A       |           |
| Talinor     | A      | 32 oz/A      | 1042      |
| Callisto    |        | 12 oz/A      |           |
| Huskie      | A      | 13.5 oz/A    | 986       |
| WideARmatch |        | 14 oz/A      |           |
| Talinor     | B      | 16 oz/A      | 918       |
| Talinor     | B      | 32 oz/A      | 961       |

## Post-harvest Russian Thistle Control in Spring Wheat Stubble

Mark Thorne and Drew Lyon

Post-harvest Russian thistle control in the low and mid-rainfall areas of eastern Washington is critical for preventing soil moisture loss, biomass accumulation, and seed production that will cause problems in future crops. Russian thistle is a warm-season introduced annual forb and is a major weed problem in both winter and spring wheat and will flourish in wheat stubble following harvest if left uncontrolled (Figure 1). Previous research has found that post-harvest late-season Russian thistle root growth can remove as much as 26 gallons of water per plant and deplete most all the available soil moisture to a depth of at least 6 feet. Herbicides effective for post-harvest Russian thistle control are usually contact-type herbicides, e.g., paraquat, that must contact all surfaces of the plants to achieve complete control. Paraquat can be very effective but is also a very toxic chemical and can pose health risks to applicators. Glyphosate, a systemic herbicide, is also applied post-harvest for Russian thistle control but can be less effective if applied at too low of a rate and if the Russian thistle stage of growth is too far advanced. Group 14 protoporphyrinogen oxidase (PPO) inhibitor herbicides have burndown activity and can be tank mixed with glyphosate for increased efficacy.



**Figure 1.** Russian thistle in spring wheat stubble near Lind, WA. Plants actively growing and depleting soil moisture (photo on left), and two weeks after treatment (photo on right).

We compared BAS85101H, an experimental Group 14 PPO herbicide, with and without a glyphosate (PowerMax) tank mix partner for post-harvest Russian thistle control. We also compared Sharpen (saflufenacil) and Reviton (tiafenacil), two other PPO herbicides that are labeled for post-harvest use.

The study location was the WSU Lind Dryland Research Station near Lind, WA, and all treatments were applied on July 28, 2023, a week after the spring wheat was harvested. The wheat stubble height was 8 inches at the time of application and the Russian thistle averaged 12 inches high and 15 inches in diameter with a density of 1.1 plants/yard<sup>2</sup>.

Treatments were applied with a CO<sub>2</sub>-pressurized backpack sprayer and 10-ft hand-held spray boom with six TT11001 TeeJet® nozzles. Spray output was 10 gpa with 48 psi nozzle pressure and 3 mph ground speed. The experimental design was a randomized complete block with four replicates per treatment and 10- by 30-ft plots. All treatments included ammonium sulfate (AMS) at 8.5 lb/100 gal and methylated seed oil (MSO) at 16 oz/A. Treatments were visually evaluated at 1, 2, and 4 weeks after treatment (WAT) and compared as a percent of the nontreated check.

Control 1 WAT was greatest with BAS 8510H tank mixed with PowerMax at either 22 or 32 oz/A and averaged 84 and 81% of the nontreated check (Table 1). BAS 8510H alone resulted in 73% control and was not different than Reviton + PowerMax. Sharpen resulted in the lowest control and did not benefit from PowerMax. At 2 WAT, control was greatest with BAS 8510H tank mixed with PowerMax at 32 oz/A, then with PowerMax at 22 oz/A, and then alone. All Sharpen or Reviton treatments were less effective as the Russian thistle plants exhibited regrowth following the herbicide applications. At 4 WAT, all Russian thistle plants had some degree of regrowth; however, control from BAS 8510H tank mixed with PowerMax was still the most effective treatment with no difference between PowerMax at 22 or 32 oz/A.

BAS 8510H has potential for post-harvest Russian thistle control; however, some further testing may be needed. In this trial, the application rate of 10 gpa may not have been adequate to get good coverage. Furthermore, even though the treatments were applied within two weeks of wheat harvest, Russian thistle regrowth was fast and substantial. Applications closer to harvest may have had greater success. Overall, BAS 8510H resulted in better control than with Sharpen or Reviton when tank-mixed with PowerMax.

**Table 1.** Post-harvest control of Russian thistle.

| Herbicide*           | Rate     | Visual control ratings**                |       |       |
|----------------------|----------|---|-------|-------|
|                      |          | 1 WAT                                   | 2 WAT | 4 WAT |
|                      | oz/A     | ----- percent of nontreated check ----- |       |       |
| Nontreated check     | ---      | ---                                     | ---   | ---   |
| BAS 8510H            | 1.4      | 73 b                                    | 61 c  | 55 bc |
| BAS 8510H + PowerMax | 1.4 + 22 | 84 a                                    | 74 b  | 70 a  |
| BAS 8510H + PowerMax | 1.4 + 32 | 81 a                                    | 80 a  | 76 a  |
| Sharpen              | 1.0      | 68 bc                                   | 55 d  | 47 cd |
| Sharpen              | 2.0      | 61 de                                   | 55 d  | 45 d  |
| Sharpen + PowerMax   | 1.0 + 22 | 64 cd                                   | 54 d  | 54 bc |
| Sharpen + PowerMax   | 2.0 + 22 | 58 e                                    | 55 d  | 58 b  |
| Reviton + PowerMax   | 2.0 + 22 | 73 b                                    | 69 b  | 59 b  |

\*All treatments included ammonium sulfate (AMS) at 8.5 lb/100 gal and methylated seed oil (MSO) at 16 oz/A.

\*\*Visual ratings made 1, 2, and 4 weeks after treatment (WAT). Numbers in each column followed by the same letter are not statistically different.



## Russian Thistle Control in Chemical Fallow

Mark Thorne and Drew Lyon

Russian thistle is a warm-season introduced annual forb and is a major weed problem in the low to mid-rainfall farming regions of eastern Washington. Russian thistle is particularly problematic during the fallow phase of wheat/fallow crop rotations (Figure 1) and if left uncontrolled, will significantly deplete soil moisture, and reduce yield of the following wheat crop. Chemical fallow is used in reduced-tillage or no-till cropping systems to protect soil from erosion; however, control of ongoing flushes of Russian thistle through the summer requires repeat herbicide applications. Glyphosate is a common herbicide for weed control in fallow, but it has no soil residual, and repeat applications are often required. Herbicides with some soil residual could reduce the number of repeat applications, providing the herbicide is effective on Russian thistle.

We compared PowerMax<sup>®</sup> (glyphosate) alone and tank mixed with Sharpen<sup>®</sup>, Valor<sup>®</sup>, Reviton<sup>®</sup>, Huskie<sup>®</sup>, or Talinor<sup>®</sup> herbicides for Russian thistle control in fallow at three locations in eastern Washington.

Treatments were applied on May 2, 2023, near Kahlotus, WA, on the Jeff Yerbich Farm, and near Lind, WA on May 31 on the Traven Smith Farm, and July 3 on the WSU Lind Dryland

Research Station. Sharpen (saflufenacil), Valor (flumioxazin), and Reviton

(tiafenacil) are Group 14 protoporphyrinogen oxidase (PPO) inhibitors that are primarily burndown herbicides with varying degrees of soil activity. Huskie is a product mix of pyrasulfotole and bromoxynil. Talinor is a product mix of bicyclopyrone and bromoxynil. Bicyclopyrone and pyrasulfotole are both Group 27 herbicides that inhibit carotenoid biosynthesis and have some soil activity. Bromoxynil is a Group 6 herbicide that inhibits photosynthesis but is only a contact herbicide with very little soil activity.

Treatments were applied with a CO<sub>2</sub>-pressurized backpack sprayer and 10-ft hand-held spray boom with six AIXR11002 TeeJet<sup>®</sup> nozzles. Spray output was 10 gpa with 21 psi nozzle



**Figure 1.** Russian thistle in fallow in early May near Kahlotus (photo on left), and early July near Lind (photo on right).

pressure and 4 mph ground speed. The experimental design at each location was a randomized complete block with four replicates per treatment and 10- by 30-ft plots.

All treatments included PowerMax at 48 oz/A. PowerMax applied alone included ammonium sulfate (AMS) at 17 lb/100 gal. Sharpen was added at 1 oz/A with AMS at 17 lb/100 gal and methylated seed oil (MSO) at 1% v/v. Valor was added at 2 oz/A with AMS at 2.5 lb/A and MSO at 0.25% v/v. Reviton was added at 2 oz/A with AMS at 17 lb/100 gal and MSO at 1% v/v. Huskie was added at 13.5 oz/A with AMS at 1 lb/A and nonionic surfactant (NIS) at 0.25 v/v. Talinor was added at 16 oz/A with AMS at 1 lb/A and crop oil concentrate (COC) at 1% v/v. CoAct+ was not added. Talinor is not currently labeled in fallow and has a 1-month plant-back restriction interval for wheat and barley.

Soil pH and organic matter (OM) at the Kahlotus site were 5.5 and 2.0%, respectively. At Lind, pH and OM were 5.9 and 1.1% at the May 3 application site, and 6.0 and 2.8% at the July application site. At the time of each application, Russian thistle plants were 3-4 inches tall at Kahlotus, 1-6 inches tall at Lind on May 31, and 3-8 inches tall at Lind on July 3. Treatment efficacy was evaluated visually at 1 week after treatment (WAT), 2 WAT, and 4 WAT as a percentage of nontreated plants.

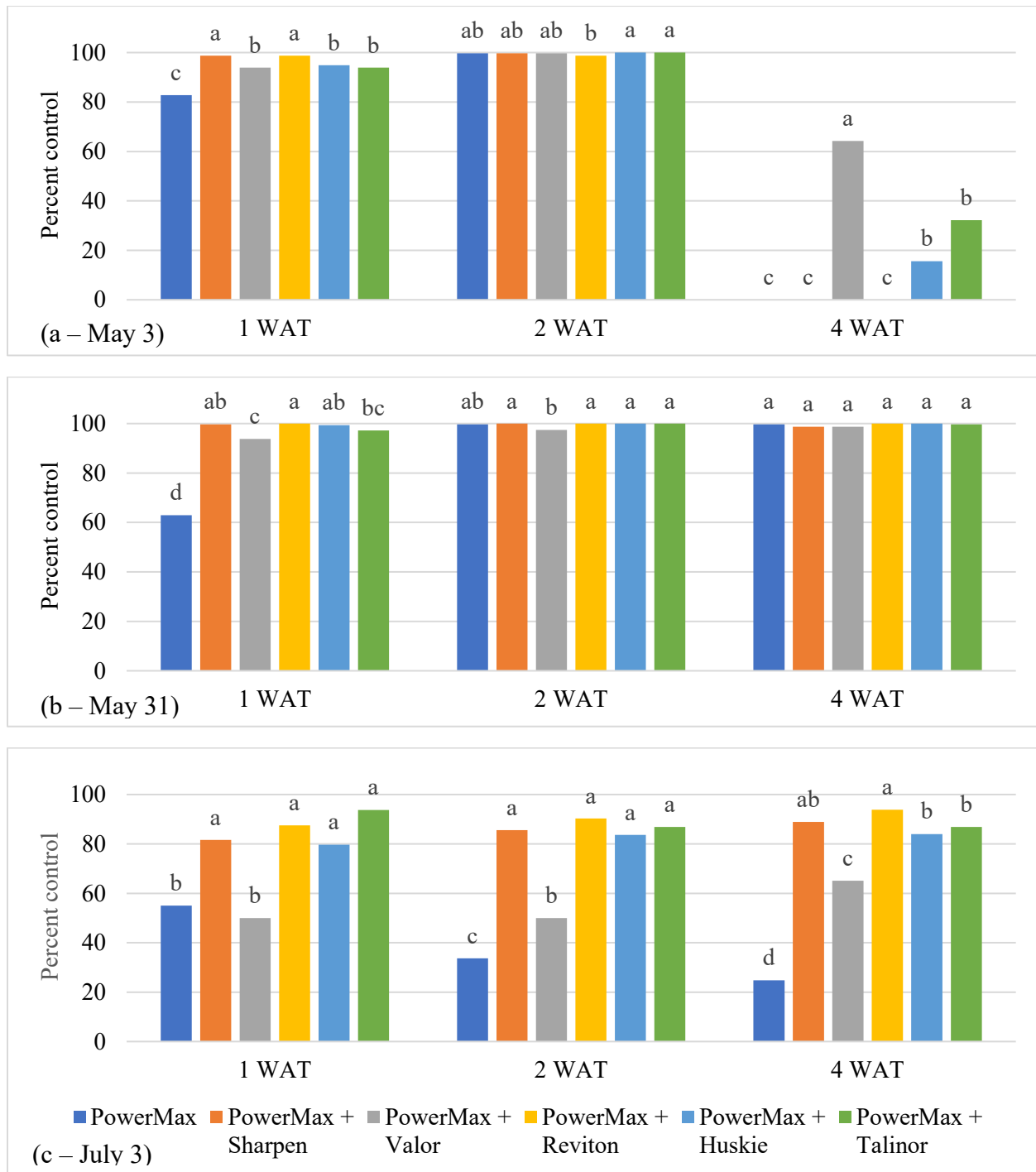
At Kahlotus, Russian thistle control 1 WAT was greater than 90% and was faster acting with all tank-mix treatments than with PowerMax alone at 83% control (Figure 1). At 2 WAT, control had increased to at or near 100% for all treatments. However, by 4 WAT secondary Russian thistle flushes had occurred and PowerMax alone and the tank mixes with Sharpen or Reviton had zero control. Only the PowerMax plus Valor tank mix had maintained control over 50% while tank mixes with Huskie or Talinor still had some residual activity with 16 and 32% control, respectively.

At Lind, the May 31 tank mix applications all resulted in Russian thistle control ranging between 94 and 100% by 1 WAT, and control was maintained through 4 WAT. PowerMax alone only resulted in 63% control by 1 WAT, but its control increased to 100% by 2 and 4 WAT. The high level of control with all treatments was due to good initial efficacy on small plants and a lack of secondary flushes during the evaluation period.

Following the July 3 applications at Lind, Russian thistle control with PowerMax alone declined from 55% at 1 WAT to only 25% control at 4 WAT. This is likely due to the difficulty of controlling larger, more robust, and possibly drought-stressed plants. However, control 1 WAT with the Sharpen, Reviton, Huskie, or Talinor tank mixes resulted in good control between 80 and 94%, and they maintained similar control through 4 WAT. In contrast, control with Valor plus PowerMax was 50% at 1 WAT, similar to PowerMax alone, and only increased to 65% by 4 WAT.

Timing of application and soil activity of the herbicide are important factors in Russian thistle control in chemical fallow. Early applications with herbicides with little or no soil activity will not control subsequent flushes. Later applications may have the potential to be effective if they include tank-mix partners that are effective on larger plants, but larger plants also have had time to deplete soil moisture.

### Russian thistle control in chemical fallow



**Figure 2.** Russian thistle control in chemical fallow as a percent of nontreated check visually rated 1 week after treatment (WAT), 2 WAT, and 4 WAT. Treatments were applied on (a) May 2 near Kahlotus, WA, (b) May 31 at Lind, WA, and (c) July 3 at Lind, WA. Columns within each rating time with the same letter are not significantly different from each other.

**Precipitation data for Pullman, WA - Palouse Conservation Field Station**

| Day           | -----2022-----                    |       |      |      | -----2023----- |       |      |       |      |       |       |       |
|---------------|-----------------------------------|-------|------|------|----------------|-------|------|-------|------|-------|-------|-------|
|               | Sept                              | Oct   | Nov  | Dec  | Jan            | Feb   | Mar  | April | May  | June  | July  | Aug   |
|               | -----precipitation in inches----- |       |      |      |                |       |      |       |      |       |       |       |
| 1             | 0                                 | 0.01  | 0.93 | 0.45 | 0              | 0.01  | 0.11 | 0.23  | 0    | 0     | 0     | 0     |
| 2             | 0                                 | 0     | 0.62 | 0.02 | 0              | 0     | 0.06 | 0.07  | 0    | 0     | 0     | 0     |
| 3             | 0.01                              | 0     | 0.01 | 0    | 0              | 0     | 0.01 | 0.29  | 0.03 | 0     | 0     | 0     |
| 4             | 0                                 | 0     | 0.65 | 0.1  | 0.01           | 0     | 0    | 0.01  | 0    | 0     | 0     | 0     |
| 5             | 0                                 | 0     | 1.53 | 0    | 0              | 0.04  | 0.17 | 0     | 0.2  | 0     | 0     | 0     |
| 6             | 0                                 | 0     | 0.01 | 0.1  | 0              | 0.23  | 0    | 0     | 0.11 | 0     | 0     | 0.01  |
| 7             | 0                                 | 0     | 0.12 | 0    | 0              | 0     | 0    | 0.01  | 0    | 0     | 0     | 0.26  |
| 8             | 0                                 | 0     | 0    | 0    | 0              | 0.13  | 0    | 0.03  | 0    | 0     | 0     | 0.04  |
| 9             | 0                                 | 0     | 0    | 0.06 | 0.17           | 0     | 0.12 | 0     | 0.24 | 0.08  | 0     | 0     |
| 10            | 0                                 | 0     | 0    | 0.19 | 0.11           | 0     | 0.13 | 0.05  | 0    | 0.19  | 0.07  | 0     |
| 11            | 0                                 | 0     | 0    | 0    | 0.05           | 0     | 0.04 | 0.25  | 0    | 0     | 0     | 0     |
| 12            | 0                                 | 0     | 0    | 0    | 0.04           | 0     | 0    | 0.02  | 0    | 0     | 0     | 0     |
| 13            | 0                                 | 0     | 0    | 0    | 0.17           | 0     | 0    | 0     | 0    | 0     | 0     | 0     |
| 14            | 0.02                              | 0     | 0    | 0.08 | 0              | 0     | 0.24 | 0     | 0    | 0     | 0     | 0     |
| 15            | 0                                 | 0     | 0    | 0.02 | 0              | 0     | 0    | 0.01  | 0    | 0     | 0     | 0     |
| 16            | 0                                 | 0     | 0    | 0    | 0.01           | 0     | 0    | 0     | 0.07 | 0     | 0     | 0     |
| 17            | 0                                 | 0     | 0    | 0    | 0              | 0     | 0    | 0.25  | 0    | 0     | 0     | 0     |
| 18            | 0                                 | 0     | 0    | 0    | 0              | 0     | 0    | 0.04  | 0    | 0     | 0     | 0     |
| 19            | 0                                 | 0     | 0    | 0.21 | 0.16           | 0     | 0    | 0.01  | 0    | 0     | 0     | 0     |
| 20            | 0                                 | 0     | 0    | 0.3  | 0              | 0.02  | 0.01 | 0     | 0    | 0     | 0     | 0     |
| 21            | 0                                 | 0     | 0    | 0.11 | 0              | 0.01  | 0.08 | 0.22  | 0    | 0     | 0     | 0     |
| 22            | 0.57                              | 0.48  | 0    | 0    | 0.04           | 0.11  | 0    | 0     | 0    | 0     | 0     | 0.22  |
| 23            | 0.02                              | 0.29  | 0.31 | 0.16 | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0.43  |
| 24            | 0                                 | 0.03  | 0    | 0.27 | 0              | 0.01  | 0.09 | 0.03  | 0    | 0     | 0     | 0     |
| 25            | 0                                 | 0.34  | 0    | 0    | 0              | 0     | 0.07 | 0     | 0    | 0     | 0.06  | 0     |
| 26            | 0                                 | 0.14  | 0.01 | 0.13 | 0              | 0.05  | 0    | 0     | 0    | 0     | 0     | 0.07  |
| 27            | 0                                 | 0.01  | 0    | 0.6  | 0.19           | 0     | 0    | 0     | 0    | 0.01  | 0     | 0     |
| 28            | 0                                 | 0     | 0.02 | 0.57 | 0              | 0.13  | 0    | 0     | 0.15 | 0     | 0     | 0     |
| 29            | 0.57                              | 0     | 0.09 | 0    | 0              |       | 0    | 0     | 0    | 0     | 0     | 0     |
| 30            | 0.38                              | 0     | 0.16 | 0.29 | 0              |       | 0.11 | 0     | 0    | 0     | 0     | 0.06  |
| 31            |                                   | 0.08  |      | 0.07 | 0              |       | 0    |       | 0    |       | 0     | 0     |
| <b>Total</b>  | 1.57                              | 1.38  | 4.46 | 3.73 | 0.95           | 0.74  | 1.24 | 1.52  | 0.8  | 0.28  | 0.13  | 1.09  |
| <b>Normal</b> | 2.67                              | 1.94  | 2.05 | 1.96 | 1.81           | 1.22  | 0.44 | 0.48  | 0.65 | 1.8   | 2.62  | 2.77  |
| <b>Depart</b> | -1.1                              | -0.56 | 2.41 | 1.77 | -0.86          | -0.48 | 0.8  | 1.04  | 0.15 | -1.52 | -2.49 | -1.68 |

Sept 22 – Aug 23 total = 17.89 inches; Normal average = 20.41 inches.

Normal precipitation based on 1991-2020 data; Depart = departure from normal.

**Precipitation data for Davenport, WA – Davenport Airport**

| Day           | -----2022-----                    |      |       |      | -----2023----- |       |      |       |      |       |       |      |
|---------------|-----------------------------------|------|-------|------|----------------|-------|------|-------|------|-------|-------|------|
|               | Sept                              | Oct  | Nov   | Dec  | Jan            | Feb   | Mar  | April | May  | June  | July  | Aug  |
|               | -----precipitation in inches----- |      |       |      |                |       |      |       |      |       |       |      |
| 1             | 0                                 | 0    | 0.09  | 0    | 0              | 0     | 0    | 0.32  | 0    | 0     | 0     | 0    |
| 2             | 0                                 | 0    | 0.43  | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 3             | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 4             | 0                                 | 0    | 0.26  | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 5             | 0                                 | 0    | 0.08  | 0    | 0              | 0     | 0    | 0     | 0.22 | 0     | 0     | 0    |
| 6             | 0                                 | 0    | 0     | 0    | 0              | 0.1   | 0    | 0     | 0.06 | 0     | 0     | 0.03 |
| 7             | 0                                 | 0    | 0.16  | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 8             | 0                                 | 0    | 0     | 0    | 0.02           | 0.02  | 0    | 0.51  | 0    | 0     | 0     | 0    |
| 9             | 0                                 | 0    | 0     | 0.41 | 0.17           | 0     | 0.11 | 0     | 0    | 0.27  | 0     | 0    |
| 10            | 0                                 | 0    | 0     | 0.26 | 0.11           | 0     | 0    | 0.11  | 0.08 | 0.32  | 0.14  | 0    |
| 11            | 0                                 | 0    | 0     | 0.15 | 0              | 0     | 0.22 | 0.57  | 0    | 0.07  | 0.11  | 0    |
| 12            | 0                                 | 0    | 0     | 0    | 0.03           | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 13            | 0                                 | 0    | 0     | 0    | 0.57           | 0     | 0.03 | 0     | 0    | 0     | 0     | 0    |
| 14            | 0.02                              | 0    | 0     | 0    | 0.13           | 0     | 0.21 | 0     | 0    | 0     | 0     | 0    |
| 15            | 0                                 | 0    | 0     | 0    | 0.02           | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 16            | 0                                 | 0    | 0     | 0    | 0.09           | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 17            | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0.03  | 0.45 | 0     | 0     | 0    |
| 18            | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 19            | 0                                 | 0    | 0     | 0    | 0.16           | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 20            | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0    |
| 21            | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0.22  | 0    | 0.12  | 0     | 0    |
| 22            | 0                                 | 0.27 | 0     | 0    | 0.06           | 0.07  | 0    | 0     | 0    | 0     | 0     | 0.03 |
| 23            | 0                                 | 0    | 0.25  | 0    | 0              | 0     | 0    | 0     | 0    | 0     | 0     | 0.06 |
| 24            | 0                                 | 0    | 0     | 0    | 0              | 0     | 0    | 0.25  | 0    | 0     | 0     | 0    |
| 25            | 0                                 | 0.02 | 0     | 0.42 | 0              | 0     | 0    | 0.09  | 0    | 0     | 0     | 0    |
| 26            | 0                                 | 0    | 0     | 0.06 | 0              | 0.04  | 0    | 0     | 0    | 0     | 0     | 0    |
| 27            | 0                                 | 0    | 0     | 0.76 | 0              | 0.02  | 0    | 0     | 0    | 0     | 0     | 0    |
| 28            | 0                                 | 0    | 0     | 0.04 | 0              | 0.32  | 0    | 0     | 0.28 | 0.16  | 0     | 0    |
| 29            | 0.16                              | 0    | 0     | 0    | 0              |       | 0    | 0     | 0    | 0     | 0     | 0    |
| 30            | 0.06                              | 0    | 0.17  | 0.26 | 0              |       | 0    | 0     | 0    | 0     | 0     | 0.05 |
| 31            |                                   | 0    |       | 0    | 0              |       | 0    |       | 0    |       | 0     | 0.13 |
| <b>Total</b>  | 0.24                              | 0.29 | 1.44  | 2.36 | 1.36           | 0.57  | 0.57 | 2.1   | 1.09 | 0.94  | 0.25  | 0.3  |
| <b>Normal</b> | 1.73                              | 0.99 | 1.53  | 1.11 | 1.37           | 1.15  | 0.42 | 0.3   | 0.49 | 1.26  | 1.72  | 1.9  |
| <b>Depart</b> | -1.49                             | -0.7 | -0.09 | 1.25 | -0.01          | -0.58 | 0.15 | 1.8   | 0.6  | -0.32 | -1.47 | -1.6 |

Sept 22 – Aug 23 total = 11.51 inches; Normal annual = 13.97 inches

Normal precipitation based on 1991-2020 data; Depart = departure from normal.