2018 Annual Report

for the

Saskatchewan Barley Development Commission

Project Title: Control of Japanese brome (*Bromus japonicus* L.) in barley

(#Skbly20160401)

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Project Identification

1. **Project Title:** Control of Japanese brome (*Bromus japonicus* L.) in barley
2. **Project Number:** (#Skbly20160401)
3. **Producer Group Sponsoring the Project:** Saskatchewan Barley Development Commission
4. **Project Location(s):** Scott, Saskatchewan, Lethbridge, Alberta
5. **Project start and end dates (month & year):** May 1, 2016 to December 30, 2018
6. **Project contact person & contact details:**

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Objectives and Rationale

7. **Project objectives:**

There are three main objectives of this study:

1) To determine crop tolerance to various herbicide combinations and application timing
2) To determine the best herbicide combination and application timing to control Japanese brome
3) Pursue a potential Minor Use Registration for control of Japanese brome in barley

Project Rationale:

Japanese brome (*Bromus japonicus L.*) is usually regarded as a noxious weed on rangelands and prairies because it competes with native perennials for water and nutrients (Gartner et al. 1976; Andersen et al. 1990). In North America, it is commonly seen in northern mixed-grass prairies (Ogle et al. 2003). In Canada, Japanese brome has been reported in all provinces except Prince Edward Island and Newfoundland and Labrador (Brouillet et al. 2016). There are reports indicating that Japanese brome is expanding its range (Darbyshire 2003). In Ontario, there is an early record of this species from 1912 and additional scattered records until 1948, after which records increased rapidly (Dore and McNeill 1980). By 1980, Japanese brome was widely established in the southwestern counties and "threatening to spread throughout southern Ontario" (Dore and McNeill 1980). In western Canada, it was found in a few districts of Alberta but was not yet common in the 1960s (Budd and Best 1964); by 1980, it was described as "abundant in the dry lands of southern Alberta and adjacent British Columbia" (Dore and McNeill 1980). Now Japanese brome often occurs in mixed infestations with *Bromus tectorum* in the southern interior of British Columbia (Gayton and Miller 2012), southwestern and central Saskatchewan and Alberta (Kirkland and Brenzil 2007).

For weed control in established locations, chemical control can be an effective management strategy. Atrazine is most commonly used (Currie et al. 1987; Hulbert 1955). A variety of products are registered for use on Japanese brome in Canada (Health Canada 2015). Examples include imazamox (in product combination with bentazon or imazapyr) and pyroxsulam (Alberta Invasive Species Council 2014b), though resistance of Japanese brome to several Group 2 herbicides (imazamox, propoxycarbazone-sodium, pyroxsulam and sulfosulfuron) was reported in winter wheat in 2007 in Kansas (Heap 2015). Furthermore, much of the registered products to control Japanese brome are not registered for barley production. Contamination of Japanese brome seed in seed grain reduces the value and/or intended use of seed lots. It is also a common contaminant in Canadian wheat grain (western and eastern), and to a lesser extent, in rye, canola, flax, lentils, and peas (Canadian Grain Commission data). Therefore, this study was initiated to establish the control options for Japanese brome in barley.

Methodology and Results

8. Methodology:

This study was conducted at the AAFC Scott Research Farm in Saskatchewan and Lethbridge, Alberta in 2017. The experiment set up was a randomized complete block design (RCBD) with four replications. Barley cultivar AC Metcalfe was seeded at a rate of 250 seeds m^{-2}. Japanese brome was seeded at a rate of 200-250 seeds m^{-2} at Lethbridge but no broadcasting was done at Scott in 2017 as a natural population is present. The trial was sown on canola stubble using an R-tech drill with 10-inch row spacing at Scott at Lethbridge plots were seeded with a pillar laser seeder. There were seventeen treatments assigned to individual plots (Table 1). Fertilizer was applied according to soil test recommendations. Pesticides were also applied as and when required. Plant density was assessed by counting two one-meter rows in the front and back of the plot for a total of four rows per plot. The average of the four rows was converted to plants m^{-2} based on 10-inch spacing. Crop phytotoxicity was measured on a visual scale rate of 0 (no injury) to 100 (severe) relative to the control treatment. Ratings were done 7 and 21 days after application (DAA) of post-emergence pinoxaden. Weed control was also measured on a visual scale rate of 0 (Check plots) to 100 (control) relative to the control treatment.

Ratings were done 7 and 21 DAA. Plant biomass was assessed for the crop and the weed. Two 0.5 m^2 quadrats were used per plot at the front and back samples inside the quadrats were weighed. Grain yield was determined from cleaned harvested grain samples and corrected to 14% moisture content. Quality parameters measured were thousand kernel weight (TKW) and bushel weight (BW).

Table 1. Treatment list, products, rates and herbicide application timings.

	Application timing and rate (g a.i. ha^{-1})		
Treatment number	**Fall Application Timing**	**Spring Application Timing**	**Post-emergence**
1			
2	Glyphosate (900)		
3		Glyphosate (900)	
4	Flumioxazin (70) Glyphosate (900)		
5	Flumioxazin (105) Glyphosate (900)		
6		Flumioxazin (70) Glyphosate (900)	
7		Flumioxazin (105) Glyphosate (900)	
8			Pinoxaden (60)
9	Flumioxazin (70) Glyphosate (900)		Pinoxaden (60)
10	Flumioxazin (105) Glyphosate (900)		Pinoxaden (60)
11		Flumioxazin (70) Glyphosate (900)	Pinoxaden (60)
12		Flumioxazin (105) Glyphosate (900)	Pinoxaden (60)
13	Triallate (1400)		
14	Triallate (1400) Flumioxazin (70) Glyphosate (900)		
15	Triallate (1400) Flumioxazin (105) Glyphosate (900)		
16		Triallate (1400) Flumioxazin (70) Glyphosate (900)	
17		Triallate (1400) Flumioxazin (105) Glyphosate (900)	

9. Results:

Growing Season Weather

Scott

The 2017 growing season started with great soil moisture in April and May with 30.9 mm and 69 mm of precipitation, respectively. Midseason growing conditions in June and July were very dry with less than half precipitation compared to the long-term average. Throughout the growing season, the temperature was very similar to the long-term average. Growing degree days were higher than the long-term average for the months of May to July and lower for August and September (Table 2).

Table 2. Mean monthly temperature, precipitation and growing degree day accumulated from April to October in 2016 and 2017 at Scott, SK.

Year	April	May	June	July	August	Sept.	Oct.	Average /Total
---------*Temperature (°C)*---------								
2016	5.9	12.4	15.8	17.8	16.2	10.9	1.6	11.5
2017	3.0	11.5	15.1	18.3	16.6	11.5	3.8	11.4
Long-term[z]	3.8	10.8	14.8	17.3	16.3	11.2	3.4	11.1
---------*Precipitation (mm)*---------								
2016	1.9	64.8	20.8	88.1	98.2	22.2	33.1	329.1
2017	30.9	69.0	34.3	22.4	53.0	18.9	20.9	228.5
Long-term[z]	24.4	38.9	69.7	69.4	48.7	26.5	13.0	290.6
---------*Growing Degree Days*---------								
2016	58.9	224.9	303	398.7	343.8	176.2	12.5	1518.0
2017	16.6	202.7	283.3	399.1	348.4	194.8	33.8	1478.7
Long-term[z]	44	170.6	294.5	380.7	350.3	192.3	42.5	1474.9

[z]Long-term average (1985 - 2014)

Lethbridge

The growing season started with slightly less precipitation than the long-term average, June got drier and for the rest of the growing season conditions were very dry. The temperature was very similar to the long-term average throughout the growing season. For all the months of the growing season the growing degree days were below the long-term average (Table 3).

Table 3. Mean monthly temperature, precipitation and growing degree day accumulated from April to October in 2016 and 2017 at Lethbridge, AB.

Year	April	May	June	July	August	Sept.	Oct.	Average /Total
Temperature (°C)								
2016	8	10.8	16.4	18.3	17.6	13.5	6.1	13.2
2017	11.1	12.7	16.1	20.4	18.7	13.8	6.2	14.1
Long-term^{z}	5.9	11.4	15	18.1	17.5	12.9	6.6	12.5
Precipitation (mm)								
2016	13.8	65.5	12.8	32.4	30.1	19.4	14.2	188.2
2017	26.8	41.1	28.3	7.3	10.8	0	38.7	153.0
Long-term^{z}	35.1	49.5	83.6	38.4	37.8	39.8	23.1	307.3
Growing Degree Days								
2016	87.2	168.5	261.3	265.9	265.2	211.8	45.9	1305.8
2017	33.1	193.6	289.8	369.2	355.8	183.8	64.8	1490.1
Long-term^{z}	78.6	198	295.5	397.7	384.8	236.6	94.7	1658.9

^{z}Long-term average (1985 - 2014)

Results

Plant density

Scott

Plant density results did not have any differences (P= 0.2318) and no trends were observed indicating that a consistent stand was established.

Lethbridge

Plant emergence at Lethbridge was not homogeneous resulting in differences among the treatments (P= 0.0444) (Fig 1). These results were not expected and may influence the other variables assessed.

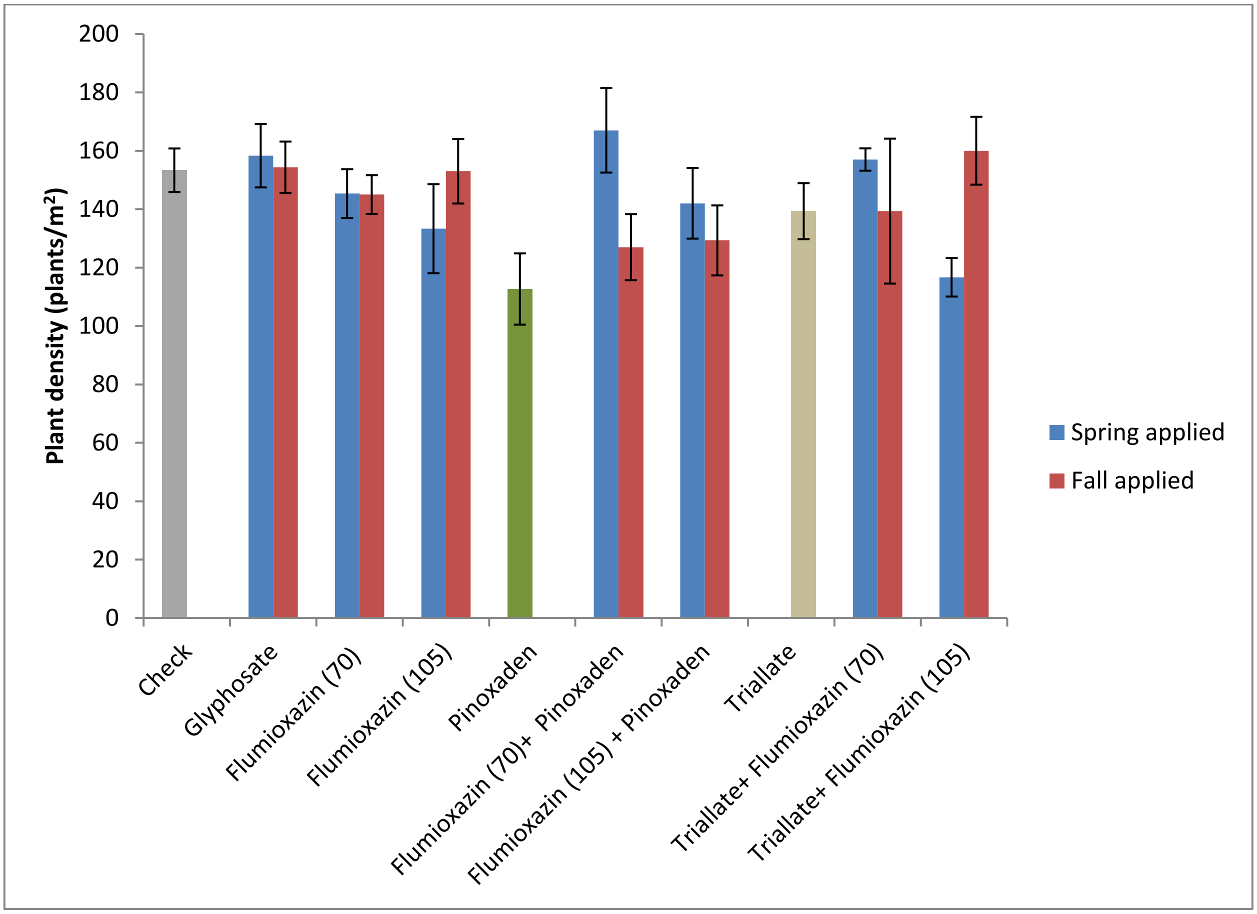

Figure 1. Plant density for all treatments at Lethbridge, AB in 2017. All treatments with flumioxazin included glyphosate.

Crop phytotoxicity

Scott

Phytotoxicity ratings done 7 DAA indicated that some treatments had a slight difference with the unsprayed check (P= 0.0009). No differences were detected with the check treatments with glyphosate applied in the fall and spring and a trend indicated also that the treatments with flumioxazin at a low rate applied in the fall and spring had a lower crop injury. All the treatments that included triallate had crop injury and the treatments with pinoxaden and flumioxazin applied in the fall at a high rate and spring at both rates affected the crop.

Ratings done 21 DAA had a slight reduction for all the treatments; however, some differences were detected (P= 0.0320). The highest crop injury corresponded to the treatments with triallate and flumioxazin at a high rate applied in the fall and spring.

Lethbridge

Crop phytotoxicity data was not reported for this site in 2017.

Herbicide efficacy ratings

Scott

Herbicide efficacy ratings conducted at 7 DAA indicated that all the herbicide treatments were different from the untreated check (P< 0.0001). Herbicide efficacy ratings of 67% indicated that control was not acceptable for the post-emergence application of pinoxaden with. Flumioxazin at a low rate applied in the fall with pinoxaden had a good weed control with 83% and it was the most effective treatment. A general trend indicated that flumioxazin at a high rate had the greatest weed suppression in the fall. When flumioxazin was applied at low rates in the spring had greater or equal suppression than fall applications.

Results from the efficacy ratings conducted at 21 DAA had similar results to the 7 DAA ratings but indicated a slight increase in efficacy. The untreated check was different from all the herbicide treatments (P< 0.0001). The most effective treatment was still flumioxazin at a low rate applied in the fall with pinoxaden with a good weed control of 88%. At 21 DAA, the lowest efficacy ratings were of triallate applied alone. In general, a trend indicated that flumioxazin applications at a high rate in the fall had acceptable weed control. Flumioxazin applied at low rates had greater or equal suppression than fall applications.

Lethbridge

Herbicide efficacy ratings done 7 DAA had differences among the treatments (P <0.0001). Five treatments had very good to excellent weed control with 97 to 100%. These treatments included glyphosate applied in the spring and flumioxazin applied in spring with high and low rates. An exception was flumioxazin applied in the spring at low and high rates with triallate. The other treatments had a poor weed control. Those treatments included glyphosate alone applied in the fall; flumioxazin at low and high rates applied in the fall; and triallate and pinoxaden both applied alone.

Herbicide efficacy ratings at 21 DAA also had differences among the treatments (P <0.0001). Herbicide efficacy had a slight improvement. Five treatments had excellent weed control with 100%. These treatments consisted of glyphosate applied in the spring and flumioxazin applied in the spring with low and high rates. Flumioxazin at a high rate applied in the fall with triallate had a weed suppression of 73%. Three treatments had not acceptable weed control; these were flumioxazin at a low rate applied in the fall with triallate, flumioxazin at a high rate applied in the fall with pinoxaden and pinoxaden alone. Seven treatments had a poor weed control these included glyphosate applied in the fall; flumioxazin applied in the fall at high and low rates except when it was applied at a high rate with triallate and triallate alone. The treatments that consisted of flumioxazin applied in the spring at low and high rates with triallate inexplicable had poor weed control at both weed ratings.

Biomass

Scott

Herbicide treatments had an effect on Japanese brome biomass (P= 0.049). The untreated checks had the lowest weed biomass (27 g.). No differences were detected between the untreated check and flumioxazin with a low rate applied in the fall (22 g.) and pinoxaden (16 g.) alone.

The lowest Japanese brome biomass resulted from the treatments that had a combination with triallate; however, a trend indicated that when triallate was the only product applied biomass tended to be greater than when a combination was used (Fig. 2).

No treatment effects were observed for crop biomass (P= 0.0923). A trend indicated that the untreated check had the lowest crop biomass.

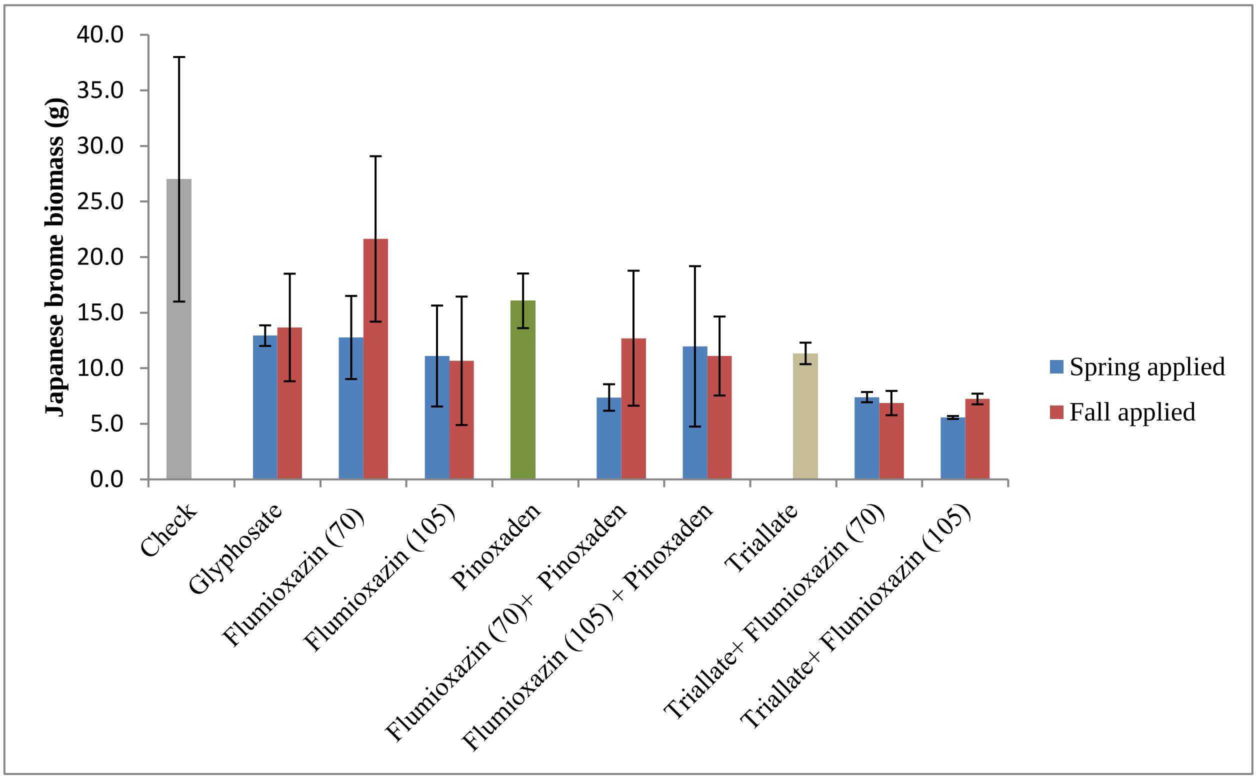

Figure 2. Herbicide effect on Japanese brome biomass at Scott, SK in 2017. All treatments with flumioxazin included glyphosate.

Lethbridge

No differences in crop biomass were observed at this location (P= 0.2067). The untreated checks had one of the lowest crop biomass values; this result is not unexpected as weed-crop competition is higher. No trends were observed. Weed biomass was not collected for the majority of the treatments. This was attributed to a lack of Japanese brome present, even though efficacy ratings were conducted.

Grain yield

Scott

A treatment effect was observed on grain yield (P= 0.0453). The lowest yield was for the untreated checks with 41.3 bu ac^{-1}. All the other treatments had a significantly higher yield but no differences were detected among them. A trend indicated that five treatments had a yield above 65 bu ac^{-1}. The highest yield was achieved when flumioxazin was applied at a high rate in the fall with pinoxaden (68 bu ac^{-1}). Generally, treatments with flumioxazin and pinoxaden resulted in the highest yields. The lowest yield corresponded to pinoxaden alone (58 bu ac^{-1}) (Fig. 3).

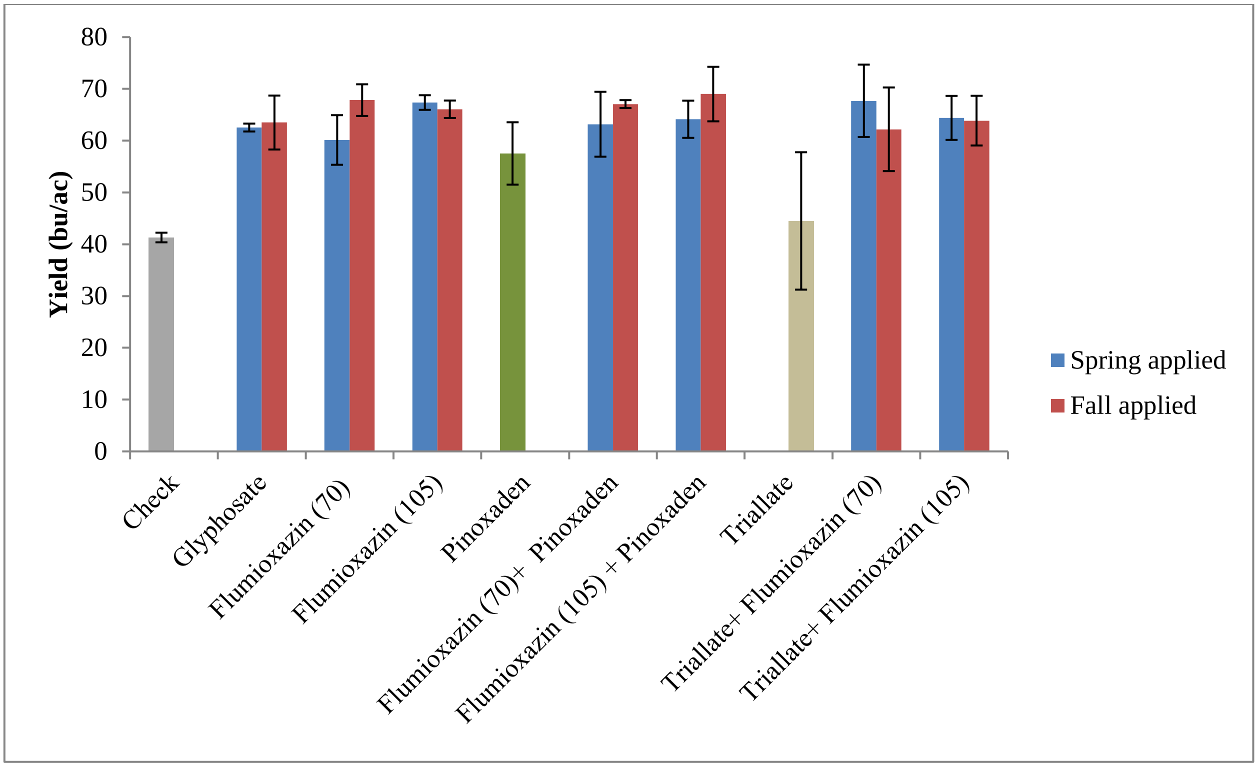

Figure 3. Herbicide effect on barley yield at Scott, SK in 2017. All treatments with flumioxazin included glyphosate.

Lethbridge

No treatment effect on yield was detected at this location (P= 0.5221). Yields were very low ranging from 11 to 18 bu ac^{-1} for all the treatments and no trends were observed.

Quality

Scott

No differences were detected for BW (P= 0.6551) and TKW (P= 0.5503). Differences among all the treatments for these variables were minimal. The only trend observed indicated that the untreated checks had a slight quality decrease.

Lethbridge

No differences were detected for BW (P= 0.3465) or TKW (P= 0.1264) at this location. Both quality parameters at this location had very low values and no trends were observed among the treatments.

Discussion

Results from Lethbridge were not as expected, plant emergence had differences among the treatments and at this point of the study no effects were expected. Another problem that caused issues at this location was the lower than normal precipitation levels after May. Furthermore, crop tolerance ratings along with weed biomass data were not collected. For these reasons, the data from Lethbridge site will be excluded from our discussion and ultimately the conclusions of this report.

Glyphosate applied alone resulted in a poor weed control regardless of the application timing. When a residual product such as flumioxazin was applied, control tended to increase. Flumioxazin applied in the fall with a low rate had poor weed control. Initially, suppression was good but Japanese brome outgrew control. High rates of flumioxazin were more effective with an average reduction of 81% when compared to the untreated control. Spring applied flumioxazin had similar results and suppression was better for the spring applications than fall.

Control of Japanese brome was further enhanced when flumioxazin and the post-emergence pinoxaden was applied resulting in an herbicide layering application. Herbicide layering is effective as weed growth is initially suppressed and the in-crop product provides additional control of non-target weeds. A reduction in overall crop-weed competition resulted in the highest yields. In contrast, spring applied flumioxazin at the high rate applied with the in-crop pinoxaden resulted in a slight yield decline. These results are likely because the crop was slightly damaged by the flumioxazin application and then the post-emergence application under stress conditions resulted in further plant damage.

Triallate provided better control than the non-residual glyphosate application, but weed suppression was poor. These results were reflected in yield that significantly declined due to the high population of Japanese brome in one of the replications. Triallate with flumioxazin were very effective reducing Japanese brome biomass. However, high rates of flumioxazin applied in the spring had greater crop damage compared to the same rate applied in the fall. Fall applications were effective and less likely to result in crop damage. More data with different environmental conditions are required to determine a consistent trend.

Agronomic and field operations

Table 4: Detailed agronomic and field operations

	Location and date	
Activity	***Scott***	***Lethbridge***
Pre-seed burn-off	September 16, 2016 Buctril M @ 400ml/ac	October 01, 2016
Broadcasting *J. brome*	N/A	October 06, 2016
Plot Staking	September 26, 2016	October 04, 2016
Fall application **(glyphosate + flumioxazin)**	October 21, 2016	October 22, 2016
Fall application **(triallate)**	October 22, 2016	October 22, 2016
Seeding date	May 10, 2017	May 10, 2017
Spring application (**glyphosate + flumioxazin**)	May 9, 2017	April 19, 2017
Post-emergence application (**pinoxaden**)	June 15, 2017	June 6, 2017
Fungicide application (**metconazole**)	July 14, 2017	N/A
Harvest date	August 28, 2017	August 17, 2017

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Extension

This demonstration was a formal stop during the Farmer Writers of Saskatchewan Tour at Scott Saskatchewan. The tour was well attended and signs were in place to acknowledge the support of Saskatchewan Barley Development Commission. A poster presentation was also conducted at Soils and Crops, 2018. The poster was also highlighted at the WARC annual conference, Crop Opportunity on March 13th, 2018. There was approximately 120 producers and agronomists in attendance. The results in the form of a factsheet will also be made available on the WARC website.

10. Conclusions and Recommendations

Our preliminary results demonstrated that a single product application did not effectively control Japanese brome control. A combination of products and application timings were more effective to control and at the same time minimized the risks of generating herbicide resistant Japanese brome. Our preliminary results demonstrated that a combination of flumioxazin applied at 105 g a.i. per ha with glyphosate applied in the fall followed by pinoxaden was the most effective treatment to control Japanese brome and to achieve a high yield. Treatments that included flumioxazin and triallate were also very effective in reducing Japanese brome biomass. However, some of the combinations when flumioxazin was applied at a high rate resulted in crop injury and this had a detrimental effect on yield. Our second field season will give us more in-depth information to establish safe rates and application timings to control effectively Japanese brome without affecting the crop.

Abstract

11. Abstract/Summary:

Trials were established at Scott and Lethbridge in fall of 2016 with the objective of determining the best herbicide combination and application timing to control Japanese brome on barley. The second objective to assess crop tolerance to herbicides and application timings. And a third objective to pursue a potential minor use registration for control of Japanese brome in barley. The study was setup as an RCBD with four replicates. Barley cultivar AC Metcalfe was seeded at a rate of 250 seeds m^{-2}, and 17 herbicide treatments were applied. Four herbicides were used glyphosate (900 g a.i per ha), flumioxazin at a low (70 g a.i per) and high rate (105 g a.i per ha), pinoxaden (60 g a.i per ha) and triallate (1400 g a.i per ha). The treatment list included an unsprayed check, glyphosate applied in the fall and spring, flumioxazin at a low and high rate applied in the fall and spring, pinoxaden alone and with flumioxazin, triallate alone and with flumioxazin. All flumioxazin treatments included glyphosate. A combination of flumioxazin and glyphosate applied in the fall with a post-emergence application of pinoxaden had a good Japanese brome control (86%) and yielded 65% more than the unsprayed check. Treatments that included a combination of flumioxazin, glyphosate and triallate had a mean weed suppression of 70% and yield increase of 58% compared to the check. However, crop injury was detected when flumioxazin was applied at a high rate. Therefore, an herbicide combination of glyphosate and flumioxazin applied in the fall and pinoxaden are recommended for the control of Japanese brome in barley without yield penalty.