Herbicide Screening for Use in Annual Ryegrass for Seed Production

For: Saskatchewan Forage Seed Development Commission

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Objective/Rationale: To evaluate crop tolerance and weed control efficacy of potential new herbicides for use in Annual Ryegrass for seed production in support of registration under the Minor Use Program.

Methodology: This small plot research trial was conducted in a randomized complete block design with 4 replicates. Each plot was 2m by 7m with borders on each replicate end. There were 11 treatments consisting of 5 different herbicide products applied at either a 1X or 2X of the recommended label rate (Table 1). There was one untreated control for comparison in which no herbicide was applied.

Table 1: Treatments used in Herbicide Screening for Seedling Annual Ryegrass for Seed Production in Melfort, SK 2019.

TRT #	Product	Rate
1	Untreated	
2	Prestige XL 1x	0.85 L/ac
3	Prestige XL 2x	1.7 L/ac
4	Pixxaro A + Pixxaro B 1x	125 ml/ac + 235 ml/ac
5	Pixxaro A + Pixxaro B 2x	250 ml/ac + 470 ml/ac
6	Paradigm + Merge 1x	10 g/ac + 0.5 L/100L Solution
7	Paradigm + Merge 2x	20 g/ac + 1.0L/100L Solution
8	Cipreme 1x	See note[y] + Agral 90 (250 mL/ac)
9	Cipreme 2x	See note[z] + Agral 90 (250 mL/ac)
10	Puma Advance 1x	413 mL/ac
11	Puma Advance 2x	826 mL/ac

[y]Cipreme 1X was a tank-mix of Paradigm (10g/ac), Lontrel 360 (85mL/ac), and MCPA Ester 600 (280mL/ac)
[z]Cipreme 2X was a tank-mix of Paradigm (20g/ac), Lontrel 360 (170mL/ac), and MCPA Ester 600 (560mL/ac)

On May 28th, 2019 Annual Ryegrass (tetraploid – var. unknown) was seeded at a 0.75-inch depth into canola stubble. All plots were seeded using a 6-row Fabro plot seeder on 12-inch row spacing. The target seeding rate was 18 lbs/ac and was adjusted for a 90% germination and a 2.6g thousand kernel weight. No seed treatments were applied. The site was soil sampled prior to seeding to determine residual nutrient levels (Table 2). The soil test recommended that 18 lbs/ac of P_2O_5 and 111 lbs/ac of nitrogen be applied. Nitrogen was side-band as 46-0-0 and phosphorus was seed-placed as 11-52-0. No potassium or sulphur fertilization was required.

Table 2: Residual soil nutrient levels (0-12") found in Herbicide Screening for Seedling Annual Ryegrass for Seed Production in Melfort, SK 2019.

Residual Soil Levels			
Nitrogen (lb/ac)	*Phosphorus (ppm)*	*Potassium (ppm)*	*Sulphur (lb/ac)*
37	10	514	52

The trial area received crop protection products as needed, outside of the herbicide treatments. An application of glyphosate 540 (0.51L/ac) was applied on May 30th, to all plots for pre-emergent weed control. All in-crop herbicide treatments were applied July 5th, at the rates listed in Table 1, using a CO_2 propelled sprayer mounted on an ATV. On July 10th, Assert (670 mL/ac) was used for additional grassy

weed control. No fungicides, insecticides, or desiccants were applied to this trial. All plots were harvest on October 4th, with 5 full crop rows collected by a Wintersteiger plot combine.

Data collection consisted of baseline weed species, crop tolerance, weed control, yield and quality. Baseline weeds were accounted for by noting the weed species present in the test area prior to herbicide application. Crop tolerance was noted 4-7 days and 28-35 days after herbicide application on a 0-100% scale. Weed control was rated by noting the major weed species present and the percentage of broadleaf control 4-7 days and 28-35 days after herbicide application. Yield was determined by cleaning and weighing each harvested sample, correcting for 11% moisture, and converted into lb/ac equivalents. Quality was analyzed by sending away composite samples for each of the 11 treatments for purity and germination determination. Lastly, statistical analysis was completed using One-way ANOVA (with the control) and a factorial analysis (without the control) in Statistix 10.

Results:

Environmental Conditions: May through August were cooler than normal, while September was warmer (Table 3). Both May and August were 1.9°C cooler, while June, July, and September were within 0.4 to 0.6°C of the long-term climate normal for each respective month. May, July, and August received less precipitation than normal, while June and September had more than normal (Table 3). However, both July and September were within 4 mm of the long-term climate normal, while May, June, and August were within 21 to 33 mm of their normal. Due to the cool, dry conditions in May, seedling germination was slow and sporadic. The wet conditions in June, assisted in plant establishment, but also resulted in more seedling germination. This caused for multiple growth stages within a small area, ultimately leading to increased variability within and between plots. This inevitably led to delays in maturity and harvesting. Overall, the growing season was slightly cooler and drier than the long-term climate normal.

Table 3: Mean temperatures and precipitation collect from the Environment Canada Weather Station at Melfort SK., from May to September 2019.

	May	June	July	August	September	Average/Total
			--- Mean Temperature (°C) ---			
2019	8.8	15.3	16.9	14.9	11.2	13.4
Long-Term[x]	10.7	15.9	17.5	16.8	10.8	14.3
			--- Total Precipitation (mm) ---			
2019	18.8	87.4	72.7	30.7	43.0	252.6
Long-Term[x]	42.9	54.3	76.7	52.4	38.7	265.0

[x] Long-term climate normal from Environment Canada Weather Station located at Melfort SK., from 1981-2010

Baseline: Prior to herbicide application, the major weed species noted in the trial area were volunteer canola, volunteer wheat, Canada thistle, cleavers, and lamb's quarter.

Crop tolerance: At 4 to 7 days post herbicide application, there were no significant differences between the level of crop damage caused by the treatments and the untreated control (Table 4). However, between the applied treatments, there was a significant difference in the level of crop damage. On average, applying 2x the recommended rate resulted in 2% more damage than the 1x rate. Although this is statistically significant, the overall level of damage is well above the industry allowance of 15%, and was relatively unnoticeable. At 28 to 35 days post application, crop tolerance was significantly different

between the 11 treatments (Table 4). One month after, there was still evidence of crop damage caused by Paradigm application, while the other 4 products no longer displayed any negative effects. Damaged caused by Paradigm was similar at both 7 days and 28 days POST application, averaging 98%. However, despite some negative effects, any damage continued to be above the industry standard.

Weed Control: To facilitate weed control ratings, a one-meter square in each plot was hand weeded, so that ratings could be compared directly within the plot. At 4 to 7 and 28 to 35 days after application, as expected, there were significant differences in the level of weed control between the treatments (Table 4). At both time periods, there were significant differences between the herbicide products used, while the difference in rates was not significant (Table 4). One week after application, as expected, the broadleaf herbicides Prestige XL, Pixxaro, Paradigm, and Cipreme provided 43 to 53% control. As there were little grassy weeds present, Puma Advance resulted in only 6% weed control. One month after application, as expected, overall herbicide control increased as plants were visibly dying. Puma Advance continued to have low weed control overall, yet had slightly increased from the previous rating. Of the four broadleaf products, Cipreme provided the best broadleaf weed control (98%) and was significantly greater than Paradigm which provided the least (90%). These two products also provided similar levels of control to Pixxaro and Prestige XL. Overall, as expected, all five herbicide products provided adequate levels of weed control. Lastly, there was no significant difference in the level of weed control provided by the two application rates.

Yield: Due to the wet and windy period prior to harvest, significant seed losses occurred and they varied from plot to plot. Thus, seed yield is presented on actual combined yields and yields adjusted based on the percentage of seed on the ground for that plot. The was no significant difference between the seed yield of each treatment and the untreated control (Table 4). However, when the control treatment was removed, there was a significant difference between the yield of each treatment due herbicide product choice (Table 4). Prestige XL had the highest yields, although not statistically different from Cipreme and Pixxaro. However, Prestige XL did have significantly higher yields than Paradigm and Puma Advance, with an average increase of 240 to 370 lb/ac. This suggests that the decrease in herbicide efficacy provided by Paradigm was large enough to result in yield losses. However, this is still surprising as efficacy was still roughly 90%. It is interesting to note that despite significant different in herbicide efficacy between the four broadleaf products and Puma Advance, the yield of the Puma Advance treatment was numerically greater than Paradigm, albeit statistically similar.

Table 4: Statistical analysis of treatment factors for Herbicide Screening for Seedling Annual Ryegrass for Seed Production in Melfort, SK 2019. *** highly significant p<0.0001; * significant at p<0.05; [z] letters signify values that are significantly different at p<0.05

	Tolerance				Weed Control				Yield			
	4-7 days		28-35 days		4-7 days		28-35 days		lb/ac		adj. lb/ac	
One-Way (with control) ANOVA (control removed)	0.1834		0.0256	*	<0.0001	***	<0.0001	***	0.1604		0.1537	
Herbicide Product (HP)	0.4532		0.0699		<0.0001	***	<0.0001	***	0.0397	*	0.0454	*
Herbicide Rate (HR)	0.0473	*	0.1288		1.0000		0.6014		0.2474		0.2354	
HR * HP	0.4532		0.0699		0.8779		0.5402		0.9689		0.9996	
Grand Mean	99.0		99.6		38.8		74.9		1534.2		1699.5	
CV	3.1		1.5		29.6		8.0		12.8		13.8	
Prestige XL	98.8	a	100.0	a	43.8	a	91.9	ab	1711.2	a	1902.1	a
Pixxaro	100.0	a	100.0	a	43.8	a	91.9	ab	1512.2	ab	1667.2	ab
Paradigm	98.8	a	98.1	b	46.9	a	89.8	b	1384.8	b	1523.3	b
Cipreme	97.5	a	100.0	a	53.1	a	97.9	a	1565.7	ab	1744.2	ab
Puma Advance	100.0	a	100.0	a	6.3	b	3.1	c	1497.3	b	1660.8	b
1X	100.0	a	100.0	a	38.8	a	94.4	a	1571.0	a	1744.4	a
2X	98.0	b	99.3	a	38.8	a	95.4	a	1497.5	a	1654.7	a
Control	100.0		100.0		0.0		0.0		1679.8		1904.9	
Prestige XL 1X	100.0	a	100.0	a	43.8	a	93.8	ab	1760.0	a	1952.9	a
Prestige XL 2X	97.5	ab	100.0	a	43.8	a	90.0	b	1662.3	ab	1851.2	ab
Pixxaro 1X	100.0	a	100.0	a	43.8	a	88.8	b	1582.6	abc	1717.4	abc
Pixxaro 2X	100.0	a	100.0	a	43.8	a	95.0	ab	1441.9	bc	1617.1	abc
Paradigm 1X	100.0	a	100.0	a	50.0	a	88.8	b	1393.2	bc	1569.2	bc
Paradigm 2X	97.5	ab	96.3	b	43.8	a	90.8	ab	1376.5	c	1477.4	c
Cipreme 1X	100.0	a	100.0	a	50.0	a	97.0	ab	1607.1	abc	1794.0	abc
Cipreme 2X	95.0	b	100.0	a	56.3	a	98.8	a	1524.4	abc	1694.4	abc
Puma Advance 1X	100.0	a	100.0	a	6.3	b	3.8	c	1512.3	abc	1688.3	abc
Puma Advance 2X	100.0	a	100.0	a	6.3	b	2.5	c	1482.3	abc	1633.4	abc

Quality: As samples were sent away as a composite representation of the 4 plots per treatment, there was only one sample per treatment reported. Thus, statistically analysis was not completed and any suggested effects are based on numerical differences. Purity of the submitted samples were high overall and similar across treatments. This suggests that any weed seeds collected during harvesting, were easily separated out of the sample. However, it does appear that there may have been slightly more weeds in the Paradigm 2x plots, which would be expected with the reduce weed herbicide efficacy found in that treatment. The germination of the harvested seed samples was much more variable across treatments. Across all herbicide treatments, germination was equal to or better than the control, suggesting that none of the herbicide products tested have negative effects on harvested seed germination. Additionally, it does appear that at the 2x application rate of Paradigm, Cipreme, and Puma Advance decreased germination occurred compared to the 1x rate. However, the opposite effect is found with Prestige and Pixxaro. Thus, no definitive conclusions can be made.

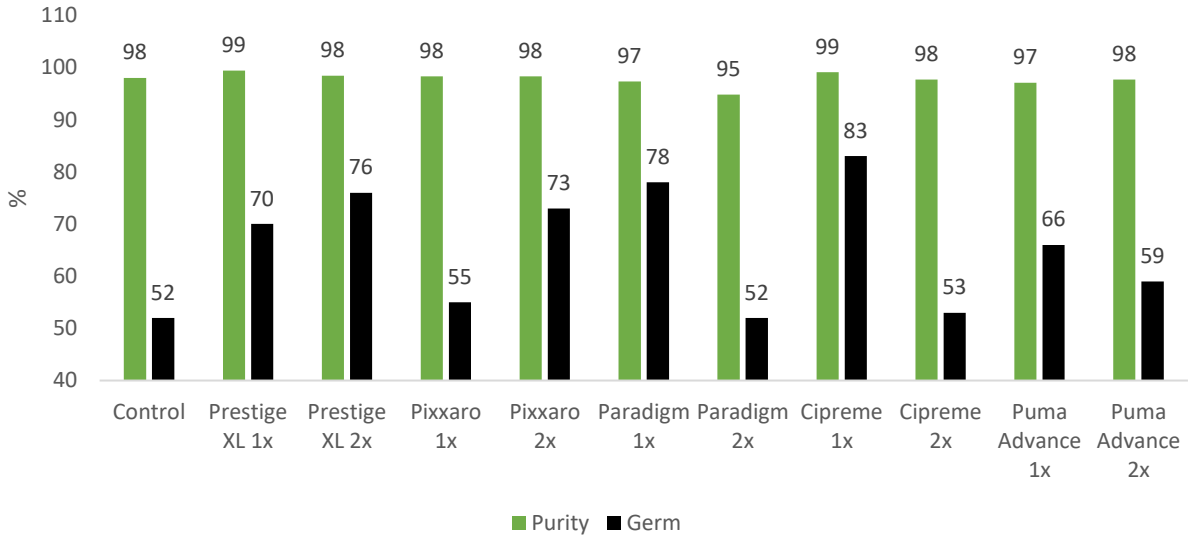

Figure 1: Germination and Purity (%) found in Herbicide Screening for Seedling Annual Ryegrass for Seed Production in Melfort, SK 2019.

Conclusions: Overall, the crop tolerance, herbicide efficacy, and subsequent effects on yield and quality responses of Annual ryegrass to the 10 applied herbicide treatments varied depending on the product and/or rate used. Crop tolerance was equal to or greater than 95% regardless of time after application, herbicide product, and application rate. As expected, herbicide efficacy was high for all products tested. Prestige XL, Pixxaro, Paradigm, and Cipreme provided 90% or more broadleaf weed control; while Puma Advance caused negligible broadleaf weed control. Although overall yields were not significantly different between treatments, there were some notable trends in the data. Paradigm application did result in some yield losses, while Prestige XL was the best product for yield retention. Although, initially applying 2x the recommended rate caused more crop damage than the 1x rate, later in the growing season these effects were diminished. Results also suggest that one product does not provide better weed control or crop tolerance at a specific rate. Overall, this data set can be used to support the minor use registration of these 5 herbicide products for use in Annual ryegrass for seed production.