Herbicide Screening for Winter Annual Weed Control in Established Red Clover

For: Saskatchewan Forage Seed Development Commissions

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Objective/Rationale: To evaluate crop tolerance and weed control efficacy of potential spring applied herbicides for use in established red clover, 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 end. There were 11 treatments consisting of 5 different herbicides: Authority, Embutox, MCPA Amine 600, Buctril M, and Valterra (Table 1). Each herbicide was applied at a 1X and 2X rate. An untreated control (0x herbicide applied) was also used.

Table 1: Treatments used in Winter Annual Weed Control in Established Red Clover in Melfort, SK 2019.

Treatment #	Product	Rate
1	Control	0x
2	Authority	1x (0.118 L/ac)
3	Authority	2x (0.236 L/ac)
4	Embutox	1x (0.91 L/ac)
5	Embutox	2x (1.82 L/ac)
6	MCPA Amine 600	1x (0.19 L/ac)
7	MCPA Amine 600	2x (0.38 L/ac)
8	Buctril M	1x (0.4 L/ac)
9	Buctril M	2x (0.8 L/ac)
10	Valterra	1x (113 g/ac)
13	Valterra	2x (227 g/ac)

On June 13, 2018 Belle red clover was seeded at a 0.5-inch depth into wheat stubble. All plots were seeded using a ConservaPak airseeder on 9-inch row spacing. The target seeding rate was 3.7lbs/ac. The only fertilizer applied in this trial was seed-placed phosphorus at 40 kg/ha of 11-52-0.

This trial received crop protection as needed, exclusive of the herbicide treatments. Weeds were controlled in 2018 by an in-crop herbicide application of Odyssey for broadleaved weeds and Assure II for grassy weeds. Late in the 2018 growing season, weeds were controlled by mowing above the crop canopy. No seed treatments or inoculants were applied. In 2019, the in-crop herbicide treatments were applied on May 9th, at the rates indicated in Table 1. All plots were desiccated with Reglone at 1.06 L/ac on September 6th, and later harvested on October 11th with a small plot combine.

Data collection consisted of weed species, crop tolerance, weed control, flowering, yield, and quality. Weed species were noted prior to herbicide applications, to establish initial weed pressure and develop a base line for herbicide efficacy. Crop tolerance was rated on a 0-100 scale, 4 to 5 weeks after treatment application. Weed control was noted by recording the number of grassy and broadleaved weeds when annual weeds were at the 1-3 leaf stage and after flowering. Start of flowering was determined by recording the date when each individual plot began to flower. Yield was determined by cleaning and weighing each harvested plot, while correcting for a 11% moisture. All weights were converted into kg/ha and lbs/ac equivalents. Lastly, quality was determined by sending composite samples of each treatment away for purity and % germination determination. Statistical analysis was completed using a one-way ANOVA and factorial analysis without the control in Statistix 10.

Results:

2019 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 2). 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 2: 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

Weed species: Prior to treatment application, only a few larger Perennial Sow Thistles were found sporadically throughout the trial area. In Melfort 2019, spring conditions were very dry, resulting in minimal initial weed populations. This was notably marked by no field horsetail and volunteer canola being found, which were the primary weeds of concern during the year of establishment.

Crop Tolerance: Red clover's tolerance to the applied treatments was significantly different between the treatments and the untreated control (Table 3). Application of Valterra did not result in any crop damage during 2019, which made it similar to the untreated control (Figure 1). Application of MCPA Amine 600, caused the greatest level of crop damage, with levels exceeding 30%. Buctril M, Embutox, and Authority also cause crop damage, but levels were statistically more similar to Valterra and the untreated control. Furthermore, crop tolerance was statistically similar between the 1x and 2x rates, despite the trend for the 2x rate to cause slightly more crop damage (Table 4).

Table 3: One-way ANOVA and means for Winter Annual Weed Control in Established Red Clover in Melfort, SK 2019.

Source	Crop Tolerance (%)[z]	Broadleaved Weeds (avg/m^2)[z]	Grassy Weeds (avg/m^2)[z]	Flowering[z]	Yield (kg/ha)[z]	Yield (lb/ac)[z]
Treatment	0.0116*	0.2595	0.4635	NA	0.6842	0.6842
Grand Mean	89.643	0.2955	0.0227	NA	801.17	714.15
CV	15.52	206.22	663.3	NA	11.21	11.21
Control	100.0a	0.5ab	0.0b	24-Jun	795.8a	709.3a
Authority 1X	100.0a	0.0b	0.0b	24-Jun	823.8a	734.3a
Authority 2X	87.5ab	1.0a	0.0b	24-Jun	748.6a	667.3a
Embutox 1X	83.8ab	0.8ab	0.0b	24-Jun	755.7a	673.6a
Embutox 2X	86.3ab	0.0b	0.0b	26-Jun	764.3a	681.3a
MCPA Amine 1X	70.0b	0.0b	0.0b	24-Jun	840.3a	749.0a
MCPA Amine 2X	68.8b	0.0b	0.3a	24-Jun	782.3a	697.3a
Buctril M 1X	100.0a	0.0b	0.0b	24-Jun	876.1a	781.0a
Buctril M 2X	93.3a	0.3ab	0.0b	24-Jun	779.2a	694.6a
Valterra 1X	100.0a	0.5ab	0.0b	24-Jun	832.8a	742.4a
Valterra 2X	100.0a	0.3ab	0.0b	24-Jun	827.3a	737.4a

*** highly significant ($p<0.0001$); * significant at $p<0.05$

[z] letters signify values that are significantly different at $p<0.05$

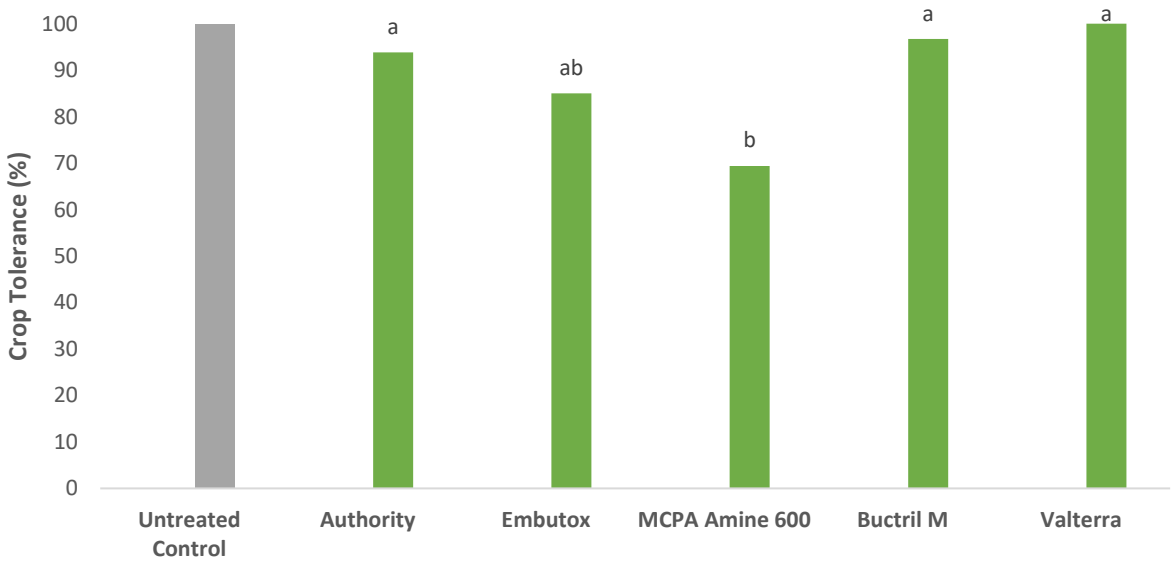

Figure 1: Established red clover crop tolerance to Authority, Embutox, MCPA Amine 600, Buctril M, and Valterra spring applied herbicides.

Table 4: Factorial analysis without the control and treatment means for Winter Annual Weed Control in Established Red Clover in Melfort, SK 2019.

Source	Crop Tolerance[z]	Yield (kg/ha)[z]	Yield(lb/ac)[z]
Product	0.0022**	0.5581	0.5581
Rate	0.4597	0.1507	0.1507
Product*Rate	0.8548	0.7908	0.7908
Grand Mean	89.0	803.04	715.82
CV	16.45	11.72	11.72
Authority	93.8a	786.2a	700.8a
Embutox	85.0ab	760.0a	677.4a
MCPA Amine	69.4b	811.3a	723.2a
Buctril M	96.7a	827.7a	737.8a
Valterra	100.0a	830.0a	739.9a
1x	90.8a	825.7a	736.1a
2x	87.2a	780.3a	695.6a
Authority 1x	100.0a	823.8a	734.3a
Authority 2x	87.5a	748.6a	667.3a
Embutox 1x	83.8a	755.7a	673.6a
Embutox 2x	86.3a	764.3a	681.3a
MCPA Amine 1x	70.0a	840.3a	749.0a
MCPA Amine 2x	68.8a	782.3a	697.3a
Buctril M 1x	100a	876.1a	781.0a
Buctril M 2x	93.3a	779.2a	694.6a
Valterra 1x	100.0a	832.8a	742.4a
Valterra 2x	100.0a	827.3a	737.4a

*** highly significant at p<0.0001; * significant at p<0.05

[z] letters signify values that are significantly different at p<0.05

Weed Control: Due to the very dry conditions in 2019 and very minimal initial weed pressure, weed control for both broadleaved and grassy weeds were not significantly different amongst the treatments (Table 3). Weed species present after in-crop herbicide applications included volunteer wheat, Canada thistle, Sweet clover, Alsike clover, and alfalfa. All weeds present were in very low densities with less than 2 individual weeds/m^2 in any given plot.

Flowering: Due to the minor variations in flowering date amongst the plots, statistical analysis could not be completed. However, there was a trend for the 2x rate of Embutox to cause a delay in flowering by 2 days (Table 3).

Yield: Despite significant differences in the level of crop damage produced by the herbicides, red clover seed yield was not significantly different between the treatments (Table 3). All yields were similar to the untreated control. This is not surprising as weed pressure was minimal and any crop damage appeared to be contained to the lower leaves that would have been in contact with the herbicides. When the untreated control was removed, there was also no significant difference between the herbicide products and their application rates (Table 4). However, for most herbicide products there was a general trend for yield to decrease when the 2X rate was applied (Figure 2). It is interesting to note that despite 30% or more crop damage cause by MCPA Amine 600, seed yields within this treatment were similar to or greater than the untreated control. This also suggests that damage was transient and contained to the lower leaves. Also, despite the 2 day delay in flowering caused by Embutox 2x, yields appear to be similar to any other treatment. Suggesting that the delay is not agronomically significant.

Figure 2: Red clover seed yield by applied herbicide treatment and compared to the untreated control in Melfort 2019.

Purity and Germ: Purity and germination analyses were conducted on composite samples from each treatment, thus statistical analysis was not preformed. Purity analysis confirmed that weed pressure was low in 2019, with less than 1% of the analyzed sample containing any weed seeds. Canada thistle and Perennial Sow thistle were the primary weed seeds found in the samples. Otherwise, pure seed counts of each treatment were excellent and above 97%. As well, total germination of each treatment was above 92% which is considered excellent. Furthermore, there was no discernable negative effects in regards to germination caused by MCPA Amine 600 and/or the 2x rates, which had caused some negative effects towards crop tolerance and yield.

Table 5: Purity and Germination (%) for treatments used in Winter Annual Weed Control in Established Red Clover in Melfort, SK 2019.

Treatment	Purity (%)		Germination (%)
	Pure Seed	Weed Seeds	Total
Untreated Control	98.5	0.1	95
Authority 1x	98.7	0.0	92
Authority 2x	98.7	0.0	93
Embutox 1x	98.2	0.0	96
Embutox 2x	98.7	0.0	92
MCPA Amine 600 1x	97.9	0.1	95
MCPA Amine 600 2x	98.9	0.0	92
Buctril M 1x	97.5	0.1	92
Buctril M 2x	97.0	0.0	96
Valterra 1x	97.2	0.0	96
Vlaterra 2x	97.9	0.1	96

Conclusion: Due to the low initial weed pressure in 2019, it was hard to determine the efficacy of the 5 herbicide products tested. Herbicide application did not significantly reduce broadleaved or grassy weed populations compared to those in the untreated control, as expected. This effect likely contributed to the high amounts of pure seed found within the analyzed samples. Thus, all five herbicide products were equally effective in providing weed control during 2019. However, the products tested did provide differing levels of crop damage. Application of MCPA Amine 600 at either rate caused 30% or more crop damage; while Authority, Embutox, and Buctril M only caused up to 16% crop damage. Valterra was the only product applied that did not cause any significant crop damage, and crop health was similar to that of the untreated control. Despite some significant initial crop damage, effects appeared to be transient and were less visual at the time of harvest. Red clover yields and germination values were similar between the five applied products and the untreated control. This illustrates that the crop damage sustained between the products was contained to the lower leaves, and did not contribute to negatively to yield and germination of red clover seed. Overall, in 2019, the red clover exhibited acceptable levels of crop tolerance to the five herbicide products tested. However, the use of MCPA Amine 600 should be cautioned due to its higher rate of crop damage.