Renz Weed Science
COLLEGE OF AGRICULTURAL & LIFE SCIENCES
UNIVERSITY OF WISCONSIN-MADISON

Extension
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UW – Madison Weed Science Renz Lab

Native Forb Herbicide Tolerance to ProClova and GF-4574

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Objective:

Determine the tolerance of established native forb species that are commonly planted in prairie restorations to spring and fall applications of ProClova (florpyrauxifen + 2,4-D amine) and GF-4574 (florpyrauxifen + 2,4-D choline salt).

Summary:

Forbs demonstrated a species-specific response to spring applications of ProClova and GF-4574. By 3 months after spring treatment (MAT), several species demonstrated tolerance (low injury) to both herbicides and application rates, including: purple coneflower, smooth blue aster, and smooth penstemon. Canada goldenrod and common milkweed had moderate injury, while golden alexanders, yellow coneflower and wild bergamot were severely impacted (high injury).

One year after initial applications, however only two of eight common forbs (yellow coneflower and wild bergamot) continued to be reduced in cover by herbicides. All treatments and timings reduced yellow coneflower cover and survivorship by June of 2021 (20-30% reduction in cover). Wild bergamot cover and survivorship was also reduced by all herbicide treatments except ProClova at 24 fl oz/A in fall, while GF-4574 at 28 fl oz/A in the fall had similar survivorship to non-treated areas. All other forbs (golden alexander, smooth penstemon, purple coneflower, smooth blue aster, and goldenrod) had similar cover and survivorship to non-treated controls.

Response of forbs to the timing of application was highly variable depending on the species and herbicide treatment. Wild bergamot and yellow coneflower appeared more sensitive to spring treatments with cover about ½ that of fall treatments. In contrast, smooth blue aster may be more sensitive to fall treatments. Impact of treatments in the fall may have been influenced by

dry conditions during the fall treatment timing which resulted in stressed forbs at the time of application.

The 2nd year following applications of ProClova or GF-4574 few native forb species were reduced in cover, yellow coneflower and wild bergamot showed the most sensitivity when herbicide was applied in the spring. Purple coneflower, smooth blue aster, smooth penstemon and golden alexander were seen as generally tolerant to each treatment with the higher rates of both herbicides showing minor, but not significant, cover reductions. Rarely were differences in formulations (ProcClova vs GF-4574) detected in this trial. Additional effort is needed to evaluate the benefits of these applications in heavily infested prairies and on additional native species.

Notes

- A significant drought occurred during August 2020 between 2 MAT and 3 MAT ratings in southern Wisconsin, resulting in significant injury to all forbs, including in untreated plots
- Cover was estimated using 40 points along fixed transects to evaluate each plot for forb presence and injury at 0 DAT and 3 MAT and just forb presence at 1 and 2 YAT

Herbicide Treatments

Treatment Number	Treatment	Rate	Application Timing
1	ProClova	24 fluid ounces/acre (fl oz/A)	spring
2	GF-4574	28 fl oz/A	spring
3	ProClova	32 fl oz/A	spring
4	GF-4574	37.4 fl oz/A	spring
5	Nontreated Control (NTC)	-	-
6	ProClova	24 fl oz/A	fall
7	GF-4574	28 fl oz/A	fall
8	ProClova	32 fl oz/A	fall
9	GF-4574	37.4 fl oz/A	fall

Note: All treatments contain 1% methylated seed oil (MSO) at 1% volume by volume

Herbicide Application

Application Timing	spring	fall
Date	June 15th, 2020, 10:00-11:00am	September 29th, 2020, 9:15-10:15am
Equipment	CO_2 pressurized 10-foot boom sprayer (20 GPA)	
Nozzles & spacing	8 TeeJet 11002VS flat fan nozzles with 15-inch spacing	
Regulator PSI	38	42

Research Plot Information	
Plot Dimensions	20 foot by 20 foot
Design	Randomized Complete Block, 3 blocks
Soil Type	Plano silt loam
Soil Characteristics	21% clay, 0.9% organic matter, 7.1 pH, 4% slope

Weather Data		
Weather Station	KWIARLIN2	
Application Timing	spring	fall
Temperature	64°F - 68°F	48°F - 50°F
Wind Speed and Direction	8 mph – 9 mph	4 mph – 6 mph
Relative Humidity	49% - 53%	86% - 93%
Cloud Cover	10%	95%
Previous Rain Event Within 48 Hours	None	September 27, 2020, 3:30pm – 0.41 inches
When ≥ 0.25 inches of precipitation occurred after treatment	June 20th, 2020, 4:15pm – 0.85 inches	October 20th, 2020, 10:30pm – 0.25 inches

Common Bergamot at 3 MAT in GF-4574 High Rate Plot: Note Living Leaf Tissue

Common Bergamot at 3 MAT in GF-4574 High Rate Plot: Note 100% Injury. Injury Variability Existed Within Plots

Overall response of forbs 1 YAT with Fall ProClova at 24 fl oz/A application. Note that while many didn't flower, cover was not impacted from many forbs.

Plants Present at Spring Application – Developmental Stage			
common name	***scientific name***	**Average Height (in)**	**Phenological Stage**
Canada goldenrod	*Solidago canadensis*	22	vegetative
common milkweed	*Asclepias syriaca*	28	flower buds present
golden Alexanders	*Zizea aurea*	32	flowering
purple coneflower	*Echinacea purpurea*	16	vegetative
smooth blue aster	*Symphyotrichum lavae*	14	vegetative
smooth penstemon	*Penstemon digitalis*	32	flowering
wild bergamot	*Monarda fistulosa*	20	vegetative
yellow coneflower	*Ratibida pinnata*	22	vegetative
Plants Present at Fall Application – Developmental Stage			
common name	***scientific name***	**Average Height (in)**	**Phenological Stage**
Canada goldenrod	*Solidago canadensis*	41	100% flowering
common milkweed	*Asclepias syriaca*	41	75% seed present, 25% senesced
fleabane species	*Erigeron sp.*	42	100% senesced
golden Alexanders	*Zizea aurea*	36	10% seed present, 90% senesced
heath aster	*Symphyotrichum ericoides*	33	100% flowering
purple coneflower	*Echinacea purpurea*	38	10% flowering, 90% seed present
smooth blue aster	*Symphyotrichum lavae*	24	75% flowering, 25% seed present
smooth penstemon	*Penstemon digitalis*	35	100% seed present
common bergamot	*Monarda fistulosa*	40	30% vegetative, 70% seed present
yellow coneflower	*Ratibida pinnata*	48	100% seed present

Index of Ratings and Results

Key to Injury Ratings:				
Tolerant (0-15% injury/mortality)	Moderately Tolerant (16-50% injury/mortality)	Moderately Susceptible (51-75% injury/mortality)	Susceptible (76-100% injury/mortality)	No Data

Treatment 1 – ProClova Low Rate (spring)		% Injury				# Plants Present in Point-Intercept Transects
		Visual estimation of whole plot			From point-intercept[1]	
Common Name	*Scientific Name*	2 WAT	1 MAT	2 MAT	3 MAT	Pre-Application
Canada goldenrod	*Solidago canadensis*	40*	50*	20	N/A	0
common milkweed	*Asclepias syriaca*	10	15	8*	64	9
fleabane species	*Erigeron sp.*	26*	53*	97*	100	23
golden Alexanders	*Zizea aurea*	8*	9	4	57	20
purple coneflower	*Echinacea purpurea*	22	6*	20	21	63
smooth blue aster	*Symphyotrichum lavae*	12*	10	4	13	33
smooth penstemon	*Penstemon digitalis*	8*	6*	3	7	7
wild bergamot	*Monarda fistulosa*	78*	92*	93*	86*	65
yellow coneflower	*Ratibida pinnata*	22*	19	40*	74	16

In the application year smooth blue aster and smooth penstemon showed good tolerance and purple coneflower showed moderate tolerance, while all other common forbs species were moderately susceptible to susceptible to ProClova (24 fl oz/A) when applied in the spring.

[1] 40 points along fixed transects were evaluated for forb presence and injury at 0 DAT and 3 MAT and presence at 1 and 2 YAT
[2] (*) indicates significant difference from Nontreated control at P=0.05, LSD

Treatment 2 – GF-4574 Low Rate (spring)		% Injury				# Plants Present in Point-Intercept Transects
		Visual estimation of whole plot			From point-intercept	
Common Name	*Scientific Name*	2 WAT	1 MAT	2 MAT	3 MAT	Pre-Application
Canada goldenrod	*Solidago canadensis*	60*	50*	62	52	14
common milkweed	*Asclepias syriaca*	9	8	12*	30	4
fleabane species	*Erigeron sp.*	25*	53*	86*	100	19
golden Alexanders	*Zizea aurea*	10*	8	2	58	21
purple coneflower	*Echinacea purpurea*	16	6*	23	20	57
smooth blue aster	*Symphyotrichum lavae*	3	5	5	9	25
smooth penstemon	*Penstemon digitalis*	4*	5*	2	8	11
wild bergamot	*Monarda fistulosa*	86*	62*	88*	91*	48
yellow coneflower	*Ratibida pinnata*	26*	43	90*	100	13

In the application year smooth blue aster and smooth penstemon showed good tolerance, common milkweed and purple coneflower showed moderate tolerance, while all other common forbs species were moderately susceptible to susceptible to GF-4574 (28 fl oz/A) when applied in the spring.

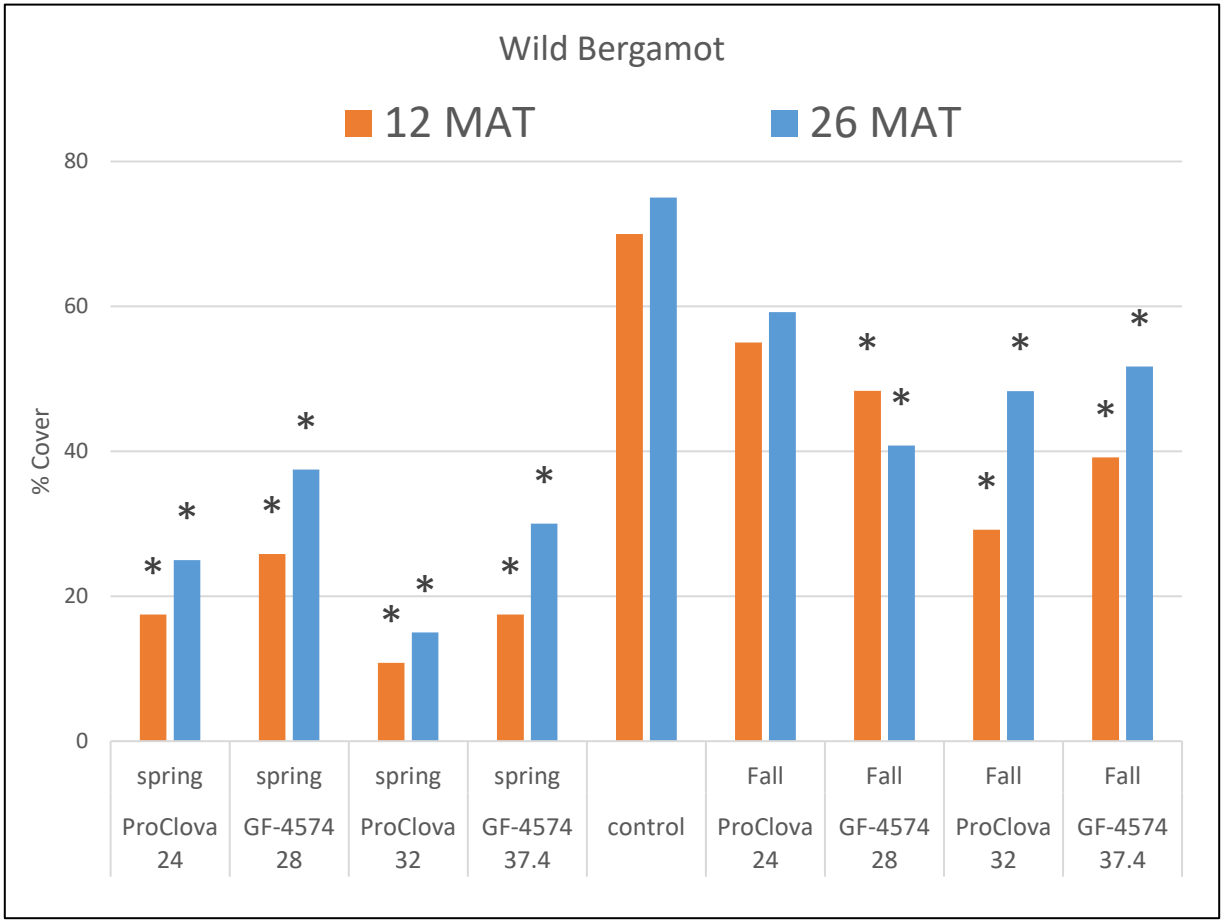
Treatment 3 – ProClova High Rate (spring)		% Injury				# Plants Present in Point-Intercept Transects
		Visual estimation of whole plot			From point-intercept	
Common Name	*Scientific Name*	2 WAT	1 MAT	2 MAT	3 MAT	Pre-Application
Canada goldenrod	*Solidago canadensis*	58*	60*	48	64	9
common milkweed	*Asclepias syriaca*	8	8	10*	33	7
fleabane species	*Erigeron sp.*	30*	45*	99*	100	12
golden Alexanders	*Zizea aurea*	10*	8	2	16	20
purple coneflower	*Echinacea purpurea*	23	13*	23	20	20
smooth blue aster	*Symphyotrichum lavae*	6*	16	3	14	23
smooth penstemon	*Penstemon digitalis*	5*	4*	2	12	17
wild bergamot	*Monarda fistulosa*	86*	83*	86*	91*	54
yellow coneflower	*Ratibida pinnata*	32*	22	100*	100	16

In the application year smooth blue aster and smooth penstemon showed good tolerance and purple coneflower showed moderate tolerance, while all other common forbs species were moderately susceptible to susceptible to ProClova (32 fl oz/A) when applied in the spring.

Treatment 4 – GF-4574 High Rate (spring)		% Injury				# Plants Present in Point-Intercept Transects
		Visual estimation of whole plot			From point-intercept	
Common Name	*Scientific Name*	2 WAT	1 MAT	2 MAT	3 MAT	Pre-Application
Canada goldenrod	*Solidago canadensis*	56*	68*	62	61	13
common milkweed	*Asclepias syriaca*	6	8	8*	34	8
fleabane species	*Erigeron sp.*	25*	60*	90*	100	23
golden Alexanders	*Zizea aurea*	10*	5	3	41	14
purple coneflower	*Echinacea purpurea*	23	8*	18	30	26
smooth blue aster	*Symphyotrichum lavae*	2	6	5	14	14
smooth penstemon	*Penstemon digitalis*	5*	5*	4	22	27
wild bergamot	*Monarda fistulosa*	75*	90*	93*	90*	66
yellow coneflower	*Ratibida pinnata*	16*	35	35*	72	10

In the application year smooth blue aster showed good tolerance; common milkweed, purple coneflower, golden alexander, and smooth penstemon showed moderate tolerance, while all other common forbs species were moderately susceptible to susceptible to GF-4574 (37.4 fl oz/A) when applied in the spring.

Change in cover of wild bergamot 1 and 2 years following treatments



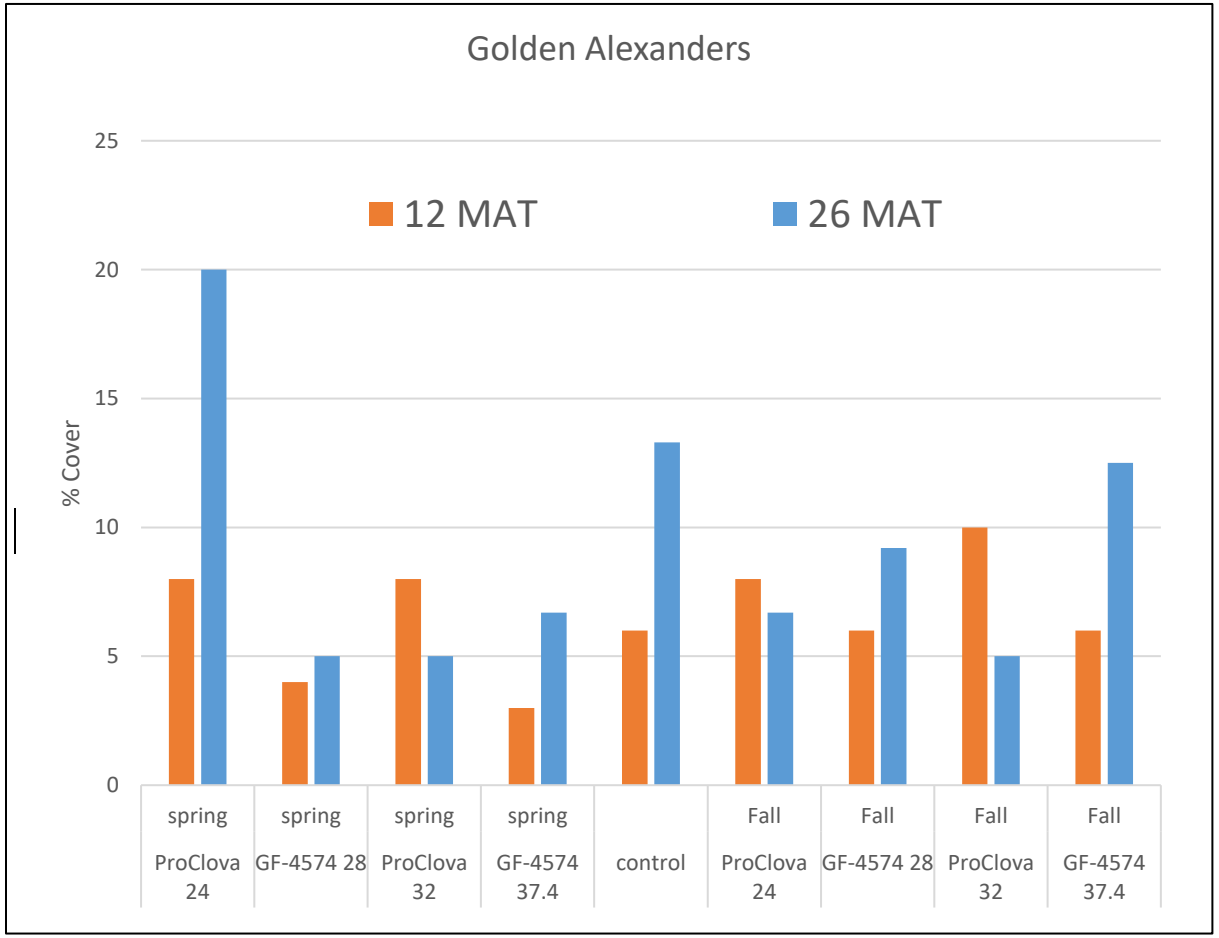
Cover: Spring applications reduced cover >50% 1 YAT; cover remained reduced by 30-60% 2 YAT.
Fall applications were less injurious.
ProClova at 24 fl oz/A in fall was not different than control 1 and 2 YAT.
Other treatments had high cover (>40%) 2 YAT.

Application timing: The fall appeared to be safer than spring treatments

Herbicide: ProClova and GF-4574 response was similar

* Indicates difference from control (P<0.05)

Change in cover of golden alexanders 1 and 2 years following treatments



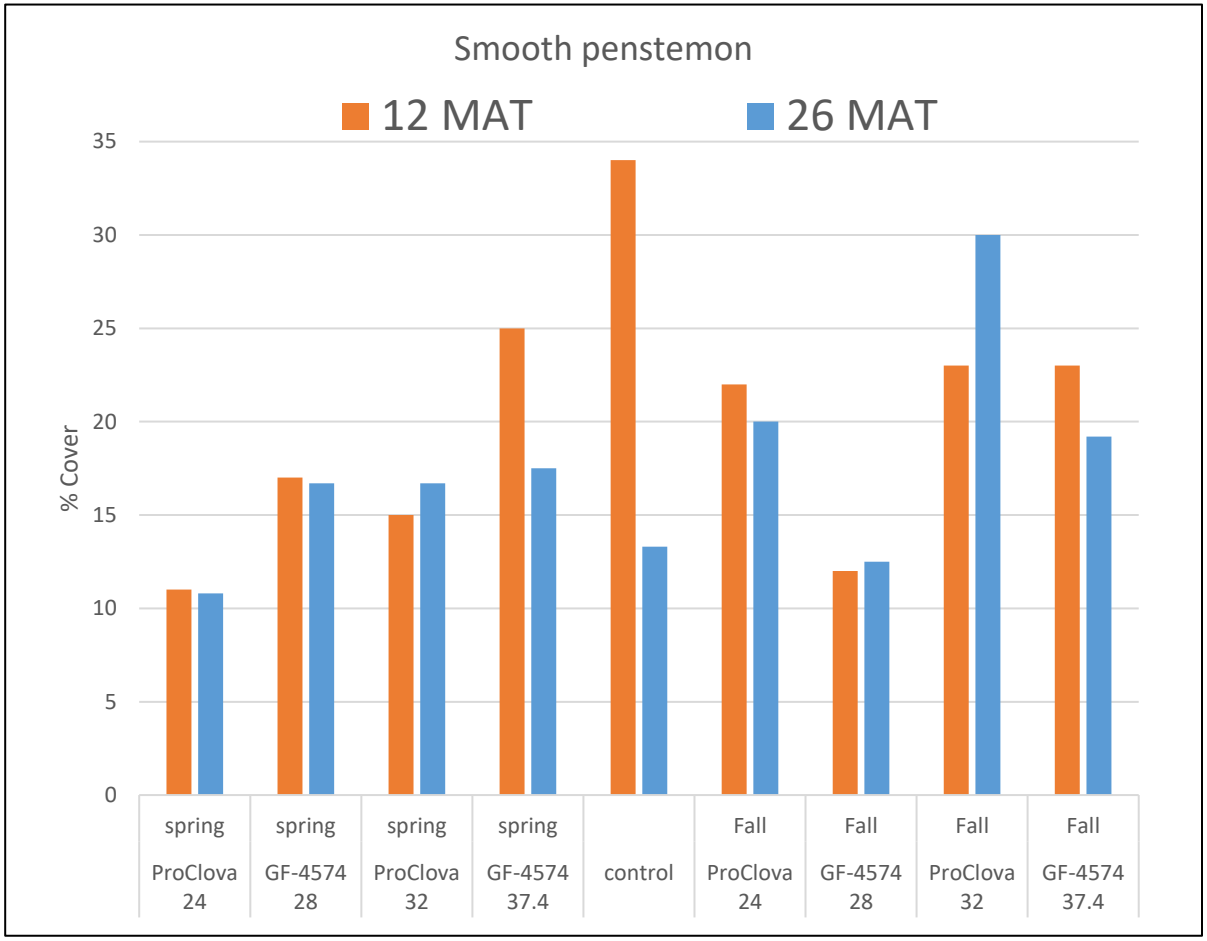
No differences in cover among treatments (P>0.05)

Cover: herbicide treatments were similar in cover compared to the non-treated control for both spring and fall applications

Application timing: No differences between timings were observed

Herbicide: While no differences existed, ProClova trended to be more tolerant than GF-4574

Change in cover of smooth penstemon the 1 and 2 years following treatments



No differences in cover among treatments (P>0.05)

Cover: May see some cover reduction 1 YAT (not significant) but populations all had abundant cover (with 2 % cover of control) 2 YAT

Application timing: No differences between timings were observed

Herbicide: While not differences existed, ProClova trended to be more tolerant than GF-4574

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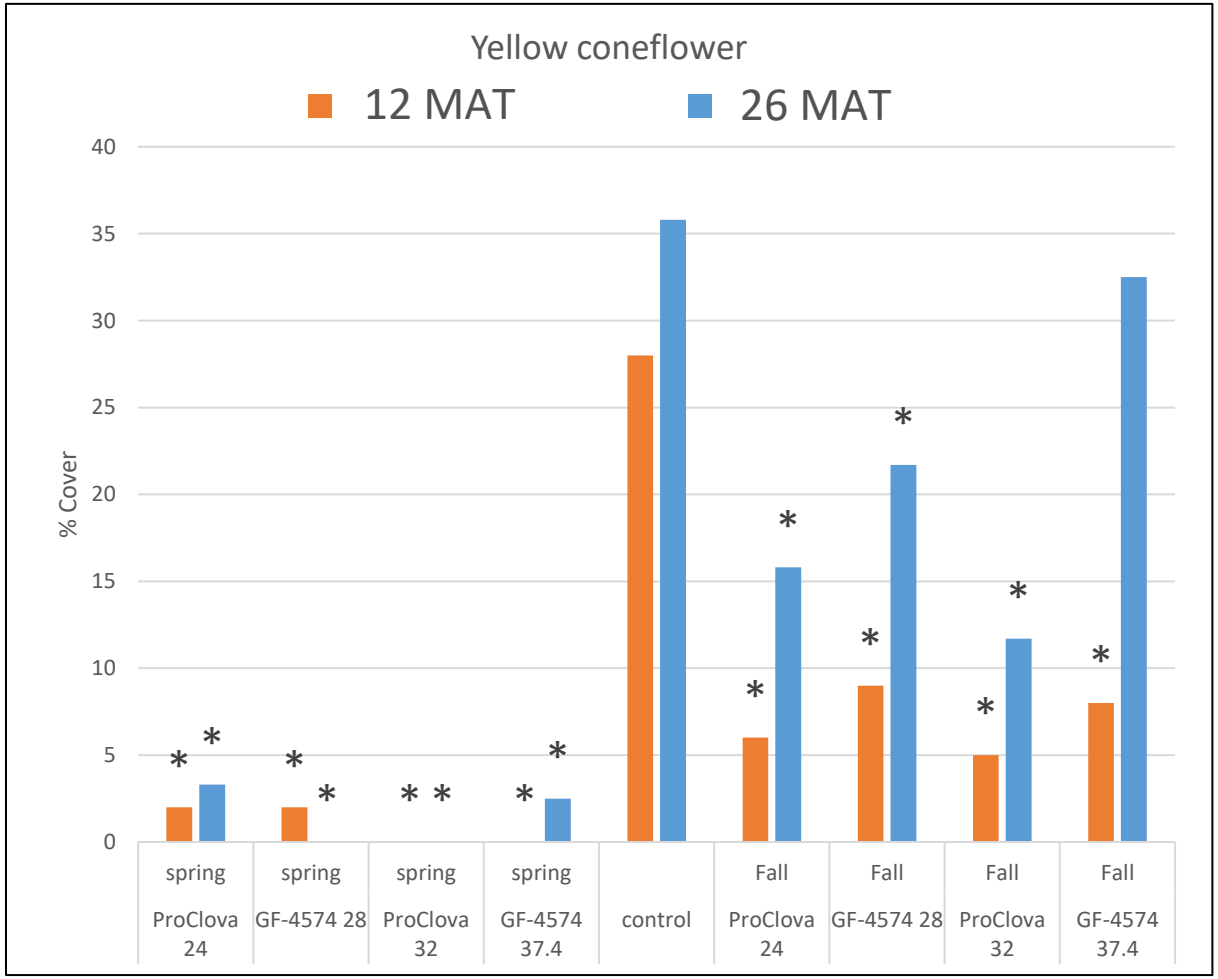
Change in cover of yellow coneflower 1 and 2 years following treatments



Cover: Spring applications nearly eliminated populations (<5% cover 1 and 2 YAT).

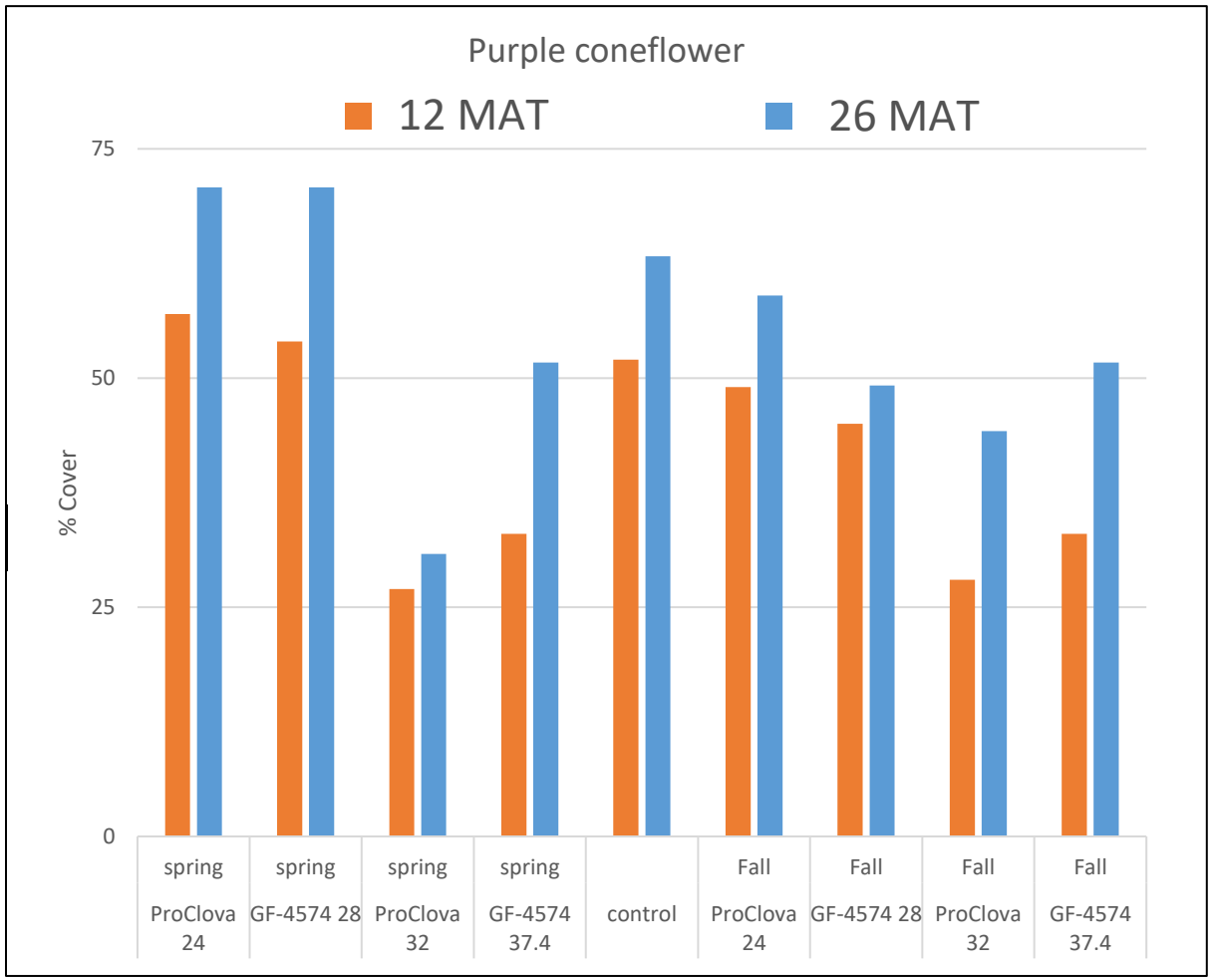
Fall applications were less injurious. All treatments reduced cover by > 2/3rd 1 YAT. Recovery occurred 2 YAT, with cover ½ of control except for the high rate of GF-4574 which was similar.

Application timing: Fall timing appears to be safer with fall applications

Herbicide: ProClova and GF-4574 response was similar

* Indicates difference from control (P<0.05)

Change in cover of purple coneflower 1 and 2 years following treatments



No differences in cover among treatments (P>0.05)

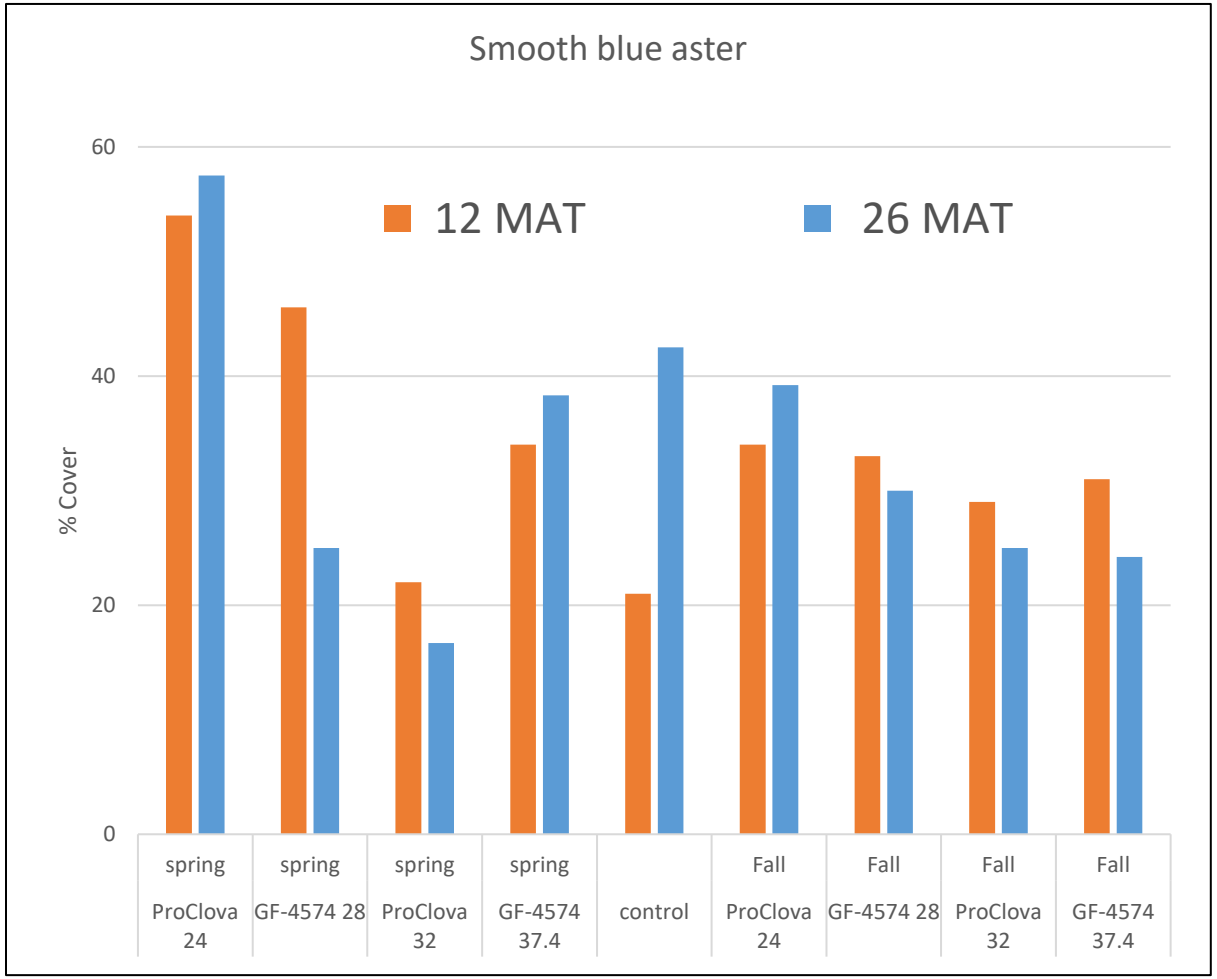
Cover: Spring and fall applications did not significantly reduce cover 1 and 2 YAT

High rates of GF-4574 1 YAT or ProClova 1 and 2 YAT may cause reduced cover (not significant)

Application timing: No differences between timings were observed

Herbicide: ProClova and GF-4574 response was similar

Change in cover of smooth blue aster 1 and 2 years following treatments



Cover: Spring and fall applications did not significantly reduce cover 1 and 2 YAT

High rates of ProClova and GF-4574 applied in fall may cause reduced cover (not significant)

Application timing: No differences between timings were observed

Herbicide: ProClova and GF-4574 response was similar

No differences in cover among treatments (P>0.05)

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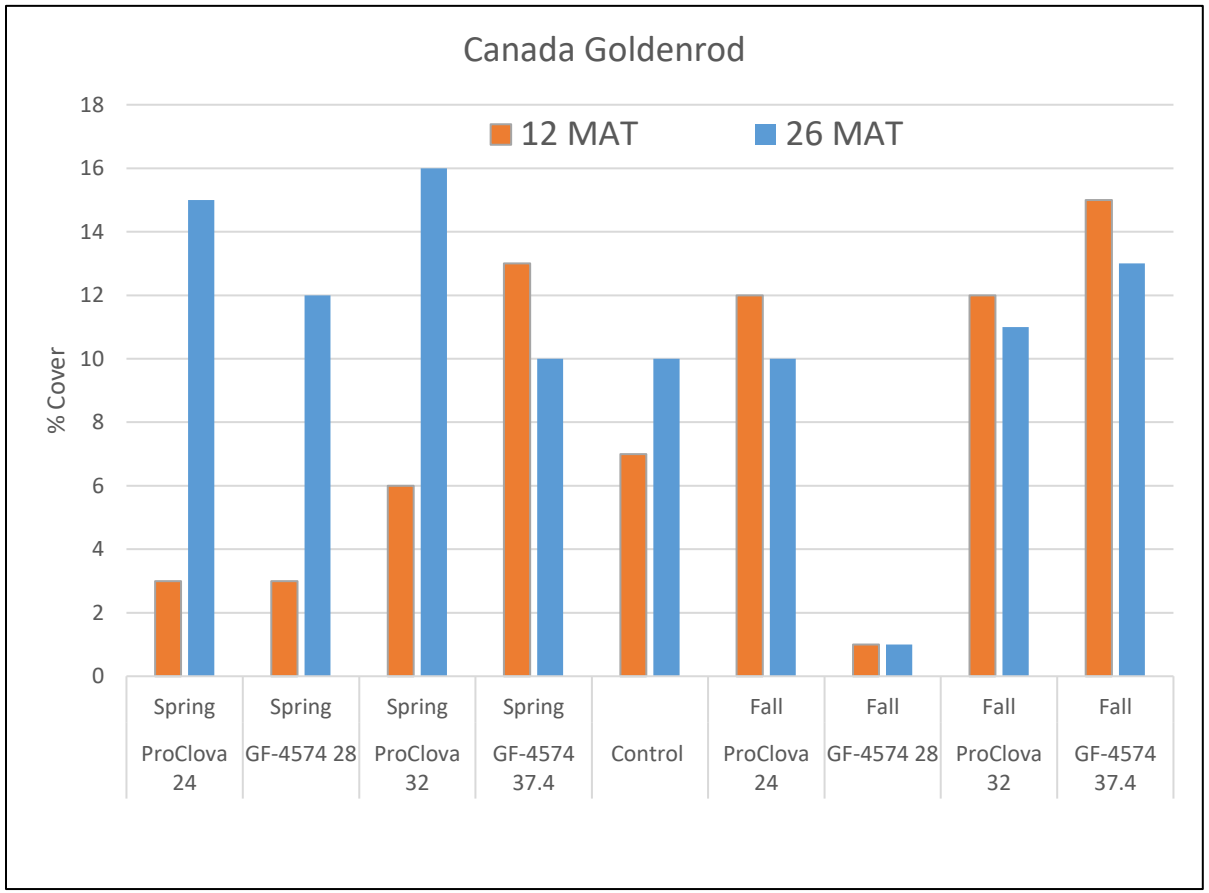
Change in cover of Canada goldenrod 1 and 2 years following treatments



Cover: herbicide treatments were similar in cover compared to the non-treated control both 1 and 2 YAT

Application timing: No differences between timings were observed

Herbicide: ProClova and GF-4574 response was similar

No differences in cover among treatments (P>0.05)

% Species Mortality 1 YAT						
Treatment	wild bergamot	golden Alexanders	smooth penstemon	yellow coneflower	purple coneflower	smooth blue aster
ProClova low rate (spring)	79 a	80 -	92 -	100 a	33 -	28 -
GF-4574 low rate (spring)	62 abc	67 -	61 -	93 ab	40 -	32 -
ProClova high rate (spring)	83 a	76 -	69 -	100 a	44 -	58 -
GF-4574 high rate (spring)	77 ab	94 -	57 -	100 a	36 -	66 -
Nontreated control	29 d	93 -	49 -	60 c	36 -	67 -
ProClova low rate (fall)	39 cd	80 -	30 -	81 ab	29 -	53 -
GF-4574 low rate (fall)	38 cd	83 -	88 -	76 bc	37 -	56 -
ProClova high rate (fall)	72 ab	60 -	58 -	85 ab	49 -	85 -
GF-4574 high rate (fall)	49 bcd	85 -	60 -	93 ab	42 -	59 -
P value	0.0051	0.7148	0.4577	0.0110	0.9958	0.1381

% Species Cover 1 YAT – June 16th, 2021						
Treatment	wild bergamot	golden Alexanders	smooth penstemon	yellow coneflower	purple coneflower	smooth blue aster
ProClova 24 fl oz/A (spring)	18 d	8 -	11 -	2 b	57 -	54 -
GF-4574 28 fl oz/A (spring)	26 cd	4 -	17 -	2 b	54 -	46 -
ProClova 32 fl oz/a (spring)	11 d	8 -	15 -	0 b	27 -	22 -
GF-4574 37.4 fl oz/A (spring)	18 d	3 -	25 -	0 b	33 -	34 -
Nontreated control	70 a	6 -	34 -	28 a	52 -	21 -
ProClova 24 fl oz/A (fall)	55 ab	8 -	22 -	6 b	49 -	34 -
GF-4574 28 fl oz/A (fall)	48 abc	6 -	12 -	9 b	45 -	33 -
ProClova 32 fl oz/A (fall)	29 bcd	10 -	23 -	5 b	28 -	29 -
GF-4574 37.4 fl oz/A (fall)	39 bcd	6 -	23 -	8 b	33 -	31 -
P value	0.0001	0.4465	0.5884	0.0001	0.3653	0.1522

Note: Means followed by same letter or symbol do not significantly differ (P=.05, LSD).

% Species Cover 2 YAT – August 11th, 2022						
Treatment	wild bergamot	golden Alexanders	smooth penstemon	yellow coneflower	purple coneflower	smooth blue aster
ProClova 24 fl oz/A (spring)	25 bc	20 -	11 -	3 c	71 -	58 -
GF-4574 28 fl oz/A (spring)	38 bc	5 -	17 -	0 c	71 -	25 -
ProClova 32 fl oz/a (spring)	15 c	5 -	17 -	0 c	31 -	17 -
GF-4574 37.4 fl oz/A (spring)	30 bc	7 -	18 -	2 c	52 -	38 -
Nontreated control	75 a	13 -	13 -	39 a	63 -	43 -
ProClova 24 fl oz/A (fall)	59 ab	7 -	20 -	16 bc	59 -	39 -
GF-4574 28 fl oz/A (fall)	41 bc	9 -	13 -	22 ab	49 -	30 -
ProClova 32 fl oz/A (fall)	48 abc	5 -	30 -	12 bc	44 -	25 -
GF-4574 37.4 fl oz/A (fall)	52 abc	13 -	19 -	33 a	52 -	24 -
P value	0.0017	0.1423	0.6041	0.0001	0.4115	0.1881

Note: Means followed by same letter or symbol do not significantly differ (P=.05, LSD).