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Native Forb Herbicide Tolerance to Milestone, TerraVue, and DuraCor

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Objective:

Compare the tolerance of common established native prairie forbs to summer applications of Milestone (aminopyralid) versus TerraVue (aminopyralid + florpyrauxifen) or DuraCor (aminopyralid + florpyrauxifen).

Summary:

Forbs demonstrated a species-specific response to summer applications of TerraVue and DuraCor. While injury was observed on all forbs, at three months after treatment (MAT), only pale Indian plantain and smooth penstemon appeared to have moderate tolerance (<50% injury) to both herbicides. This contrasts with the low rate of Milestone, which had 7 forb species with good to moderate tolerance, and the high rate of Milestone, which had 6 good to moderately tolerant species.

In 2021 (12 MAT), forb tolerance was similar among Milestone treatments 3 MAT, but improved with TerraVue and DuraCor. Milestone had six to eight forb species that were moderately tolerant or better depending on rate. TerraVue and DuraCor tolerance was better than 2020 but ranged between five and seven species and was less than Milestone at 5 fl oz/A. Differences were most evident with rosinweed as it was more tolerant to Milestone (minor stand reductions) versus products that contain florpyrauxifen (DuraCor, Terravue) which eliminated populations. Other differences were minor and variable depending on the treatment and forb species.

These resulted in minor differences in cover 18 MAT of common species. While Canada goldenrod cover increased by more than 10% from applications of Milestone (5 fl oz/A only significant), ox-eye sunflower, Pale Indian plantain, and smooth penstemon cover did not differ among all treatments. Minor reductions in bergamot cover and other broadleaf species were also observed with products that contain florpyrauxifen (DuraCor, TerraVue) which resulted in higher cover of grass species with these treatments.

Results 24 MAT continued to demonstrate forb specific responses. Penstemon, bergamot, and pale plantain all showed high tolerance to all herbicide treatments. In contrast rosinweed was sensitive to all treatments while New England aster populations were severely reduced at this time, making it difficult to assess tolerance.

Overall results suggest that differences in tolerance of established native prairie forbs exist between Milestone, TerraVue, and DuraCor. Most of the results are visible one year after treatment, and overall changes in plant populations two years after treatment made it difficult to assess long-term impact of several forbs. The higher rates of products (especially those that contain aminopyralid) seems to reduce cover and increase mortality in most species, therefore we recommend utilizing lower rates when feasible to achieve desired results.

Notes

- A significant drought occurred during August 2020 between 2 MAT and 3 MAT ratings
  - resulted in significant injury to all forbs, including in Nontreated control plots
- Ratings in summer of 2021 (July) and 2022 (July) only counted presence/absence and did not estimate % injury or cover reduction

Herbicide Treatments

Treatment Number	Treatment	Rate
1	Milestone	5 fluid ounces per acre (fl oz/A)
2	Milestone	7 fl oz/A
3	TerraVue	2.85 ounces of dry weight per acre (oz wt/A)
4	TerraVue	2.85 oz wt/A
5	DuraCor	20 fl oz/A
6	Nontreated Control (NTC)	-

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

Herbicide Application

Date	June 18th, 2020, 8:45-9:30am
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

Weather Data related to application	
Weather Station	KWIMCFAR9
Temperature	74°F - 78°F
Wind Speed and Direction	1 mph – 2 mph
Relative Humidity	62% - 67%
Cloud Cover	0%
Previous Rain Event Within 48 Hours	None
When ≥ 0.25 inches of precipitation occurred after treatment	June 24th, 2020, 9pm, 0.35 inches

Research Plot Information	
Plot Dimensions	20 foot by 50 foot with 3 fixed 0.50m^2 quadrats per plot
Design	Randomized Complete Block, 3 blocks
Soil Type	St. Charles silt loam
Soil Characteristics	18.6% clay, 1% organic matter, 6.7 pH, 1% slope

Plants Present at Application – Developmental Stage			
common name	***scientific name***	**Average Height (in)**	**Phenological Stage**
Canada goldenrod	*Solidago canadensis*	6	vegetative
cup plant	*Silphium perfoliatum*	27	vegetative
New England aster	*Symphyotrichum novae-angliae*	23	vegetative
ox-eye sunflower	*Heliopsis helianthoides*	24	vegetative/flower buds present
pale Indian plantain	*Arnoglossum atriplicifolium*	20	vegetative
rosinweed	*Silphium integrifolium*	32	vegetative
smooth penstemon	*Penstemon digitalis*	32	flowering
wild bergamot	*Monarda fistulosa*	25	vegetative
yellow coneflower	*Ratibida pinnata*	22	vegetative

Treated (at right) versus nontreated (at left) areas at 3 MAT. Note height reductions and lack of flowering plants in treated areas.

Close-up of DuraCor quadrat at 3 MAT. Note pale Indian plantain is relatively uninjured and flowering.

Closeup of plants treated with Milestone (5fl oz/a) at 12 MAT.

Closeup of plants treated with TerraVue at 12 MAT. Higher grass cover was observed with treatments of TerraVue or DuraCor.

Index of Ratings and Results

Results:

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

Treatment 1 – Milestone (5 fl oz/A)	% Visual Injury			Treatment 2 – Milestone (7 fl oz/A)	% Visual Injury		
	whole plot	whole plot	quadrats[1]		whole plot	whole plot	quadrats
Common Name	1 MAT	2 MAT	3 MAT	Common Name	1 MAT	2 MAT	3 MAT
Canada goldenrod	20*	28*	38*	Canada goldenrod	26*	32*	45*
cup plant	45	51	75	cup plant	30	55	100
New England aster	85*	50	38	New England aster	90*	28	38
ox-eye sunflower	23*	8	40	ox-eye sunflower	38*	30*	36
pale Indian plantain	15	8	20	pale Indian plantain	16	15	25
rosinweed	68*	96*	100	rosinweed	75*	98*	88
smooth penstemon	0	2	5	smooth penstemon	3	2	6
wild bergamot	25*	51*	46	wild bergamot	35*	76*	48
yellow coneflower	40	43	22	yellow coneflower	no data	42	100

Results after 3 MAT suggest that most common forb species were either moderately tolerant or generally tolerant to injury from Milestone at a rate of 5 fl oz/A, while cup plant and rosinweed were moderately susceptible or susceptible to injury.

When using Milestone at a rate of 7 fl oz/A after 3 MAT most common forb species were moderately or generally tolerant to injuries, while cup plant, rosinweed and yellow coneflower showed to be susceptible to injury.

[1] 3 fixed 0.50m^2 quadrats were evaluated for forb presence and injury at 0 DAT and 3 MAT and just presence 1 and 2 YAT
[2] (*) indicates significant difference from Nontreated control at P=0.05, LSD

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

Treatment 3 – TerraVue (2.85 oz/A)	% Visual Injury		
	whole plot	whole plot	quadrats[3]
Common Name	1 MAT	2 MAT	3 MAT
Canada goldenrod	32*	35*	55*
cup plant	60	72*	98
New England aster	85*	60	70
ox-eye sunflower	45*	45*	68
pale Indian plantain	23	13	28
Rosinweed	no data	98*	100
smooth penstemon	0	6	8
wild bergamot	63*	84*	90*
yellow coneflower	43	40	100

Treatment 4 – TerraVue (2.85 oz/A)	% Visual Injury		
	whole plot	whole plot	quadrats
Common Name	1 MAT	2 MAT	3 MAT
Canada goldenrod	32*	43*	78*
cup plant	58	80*	96
New England aster	100*	45	no data
ox-eye sunflower	36*	33*	42
pale Indian plantain	22	12	19
Rosinweed	62*	90*	100
smooth penstemon	2	2	8
wild bergamot	42*	80*	83
yellow coneflower	35	38	100

Results suggest that at 3 MAT most common forb species were either moderately susceptible or susceptible to TerraVue at a rate of 2.85 oz/A with only pale Indian plantain and smooth penstemon showing any tolerance in treatment 3 or 4.

[3] 3 fixed 0.50m^2 quadrats were evaluated for forb presence and injury at 0 DAT and 3 MAT and just presence 1 and 2 YAT
[4] (*) indicates significant difference from Nontreated control at P=0.05, LSD

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

Treatment 5– DuraCor (20 fl oz/A)	% Visual Injury		
	whole plot	whole plot	quadrats[5]
Common Name	1 MAT	2 MAT	3 MAT
Canada goldenrod	35*	32*	68*
cup plant	62	88*	100
New England aster	86*	50	65
ox-eye sunflower	36*	35*	56
pale Indian plantain	18	8	21
Rosinweed	62*	90*	100
smooth penstemon	2	6	6
wild bergamot	43*	86*	79
yellow coneflower	10	58	90

Results suggest that at 3 MAT most common forb species were either moderately susceptible or susceptible to DuraCor at a rate of 20 fl oz/A with only pale Indian plantain and smooth penstemon showing any tolerance.

[5] 3 fixed 0.50m^2 quadrats were evaluated for forb presence and injury at 0 DAT and 3 MAT and just presence 1 and 2 YAT
[6] (*) indicates significant difference from Nontreated control at P=0.05, LSD

Number of Quadrats with Species Present Pre-treatment – June 16, 2020

		Species Common Name								
Treatment No.	Herbicide	Canada goldenrod	cup plant	New England aster	ox-eye sunflower	Pale Indian Plantain	rosinweed	smooth penstemon	wild bergamot	yellow coneflower
1	Milestone 5 fl oz/A	9	1	2	7	5	2	4	5	5
2	Milestone 7 fl oz/A	9	2	2	6	3	2	3	7	2
3	TerraVue 2.85 oz/A	9	3	4	9	3	3	2	6	3
4	TerraVue 2.85 oz/A	9	4	0	8	4	1	2	4	6
5	DuraCor 20 fl oz/A	9	1	2	8	3	2	5	7	8
6	NTC	7	4	5	6	1	3	6	8	7

Table shows the number of quadrats (3 fixed 0.50m^2) that each species is present in for each treatment before herbicides were applied. Total number of quadrat measurements taken for each treatment was 9.

% Mortality of species 1 and 2 YAT*

		Species Common Name							
		Rosinweed		Smooth penstemon		Wild bergamot		yellow coneflower	
Treatment No.	Herbicide	1 YAT	2 YAT	1 YAT	2 YAT	1 YAT	2 YAT	1 YAT	2 YAT
1	Milestone 5 fl oz/A	50	100	0	100	0	33	100 a	100
2	Milestone 7 fl oz/A	50	0	50	100	0	17	100 a	100
3	TerraVue 2.85 oz/A	100	100	0	100	28	11	100 a	100
4	TerraVue 2.85 oz/A	100	100	0	0	67	100	100 a	100
5	DuraCor 20 fl oz/A	100	50	17	33	39	39	100 a	100
6	NTC	33	67	0	67	0	11	0 b	100
P value		0.6326	0.2625	0.3680	0.0946	0.0986	0.0750	Not analyzed	1.0000

% Mortality of species 1 and 2 YAT*

		Species Common Name									
		Canada goldenrod		cup plant		New England aster		ox-eye sunflower		Pale Indian Plantain	
Treatment No.	Herbicide	1 YAT	2 YAT	1 YAT	2 YAT	1 YAT	2 YAT	1 YAT	2 YAT	1 YAT	2 YAT
1	Milestone 5 fl oz/A	11	0	0	0	0	100	44	61	17	33
2	Milestone 7 fl oz/A	0	0	0	50	50	100	72	89	0	50
3	TerraVue 2.85 oz/A	0	0	0	25	50	83	22	55	25	25
4	TerraVue 2.85 oz/A	0	0	50	100	.	.	75	61	67	67
5	DuraCor 20 fl oz/A	0	0	0	100	50	100	13	50	0	0
6	NTC	0	0	33	22	33	100	17	17	0	0
P value		0.4651	1.0000	0.6173	0.1478	0.8351	0.7407	0.0856	0.1624	0.3304	0.7252

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

* Results should be interpreted carefully as these were created from three permanent 0.25 m^2 quadrats in each plot and may not reflect plot level trends.

1 YAT -Sept. 28, 2021		% Cover (whole plot)							
		Species Common Name							
Treatment No.	Herbicide	Canada goldenrod	Smooth penstemon	Wild bergamot	Ox-eye sunflower	Pale Indian Plantain	Grasses	Other Broadleaf Weeds	Bareground/ Litter
1	Milestone 5 fl oz/A	47 a	3 -	10 a	3 -	11 -	6 b	13 ab	7 -
2	Milestone 7 fl oz/A	43 ab	7 -	6 ab	3 -	7 -	21 b	8 bc	5 -
3	TerraVue 2.85 oz/A	40 abc	6 -	4 ab	2 -	12 -	17 b	8 bc	12 -
4	TerraVue 2.85 oz/A	32 c	3 -	1 b	0 -	4 -	45 a	7 c	8 -
5	DuraCor 20 fl oz/A	30 c	8 -	2 ab	1 -	8 -	37 a	7 c	8 -
6	NTC	33 bc	2 -	7 ab	4 -	7 -	19 b	15 a	13 -
P value		0.0324	0.1295	0.0436	0.2273	0.2167	0.0005	0.0467	0.4052

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

2 YAT - July 11,2022		% Cover (whole plot)				
		Species Common Name				
Treatment No.	Herbicide	Canada goldenrod	Smooth penstemon	Wild bergamot	Smooth blue aster	Grasses
1	Milestone 5 fl oz/A	36 -	6 -	7 -	12 -	31 -
2	Milestone 7 fl oz/A	38 -	8 -	7 -	10 -	22 -
3	TerraVue 2.85 oz/A	37 -	12 -	7 -	11 -	24 -
4	TerraVue 2.85 oz/A	28 -	6 -	4 -	4 -	36 -
5	DuraCor 20 fl oz/A	27 -	9 -	10 -	12 -	33 -
6	NTC	23 -	7 -	12 -	12 -	19 -
P value		0.5443	0.5547	0.2719	0.4231	0.0646