

Characterization of dicamba- and fluroxypyr-resistant kochia [*Bassia scoparia* (L.) A.J.Scott] in Alberta

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Introduction

A 2017 survey confirmed dicamba resistance in an estimated 18% of kochia populations in Alberta, while 10% were triple-resistant to tribenuron/thifensulfuron (group 2; acetolactate synthase inhibitors), glyphosate (group 9; inhibitor of 5-enolpyruvylshikimate-3-phosphate synthase) and dicamba (group 4; synthetic auxin)¹. This followed the first confirmation of auxinic herbicide-resistant kochia in western Canada found in a spring wheat field in Saskatchewan (in 2015)²; however, observations of dicamba- or fluroxypyr-resistant kochia in the United States date back to as early as 1994³⁻⁶. While the initial auxin-resistant kochia population in Canada exhibited resistance to both dicamba and fluroxypyr, the Alberta populations were tested with dicamba only.

The problem:

Auxinic herbicide cross-resistance in kochia populations would leave growers with limited herbicide options, especially for use in small-grain cereal crops.

Our objective:

Characterize resistance to the synthetic auxin herbicides dicamba and fluroxypyr in Alberta kochia populations collected in 2017 and 2018.

Materials & Methods

- Greenhouse dose-response experiments:
 - Dicamba** (*Xtendimax*TM with *VaporGrip*TM Technology, Bayer CropScience)
 - 0, 35, 70, 140, 280, 560, and 1120 g ae ha⁻¹
 - Fluroxypyr** (*Prestige*TM XCA; Corteva Agriscience)
 - 0, 17.5, 35, 70, 140, 280, and 560 g ae ha⁻¹
- Randomized complete block design:
 - 17 kochia populations**
 - 12 putative resistant populations identified using single-dose screening (Fig. 1)^{1,7}
 - 4 susceptible controls
 - 1 dicamba- plus fluroxypyr-resistant control
 - 3 replications, 2 experimental runs**
- Experimental procedures:
 - 6 kochia plants per pot
 - Herbicide applied at 5 to 8 cm height
 - 275 kPa; 200 L ha⁻¹ water carrier

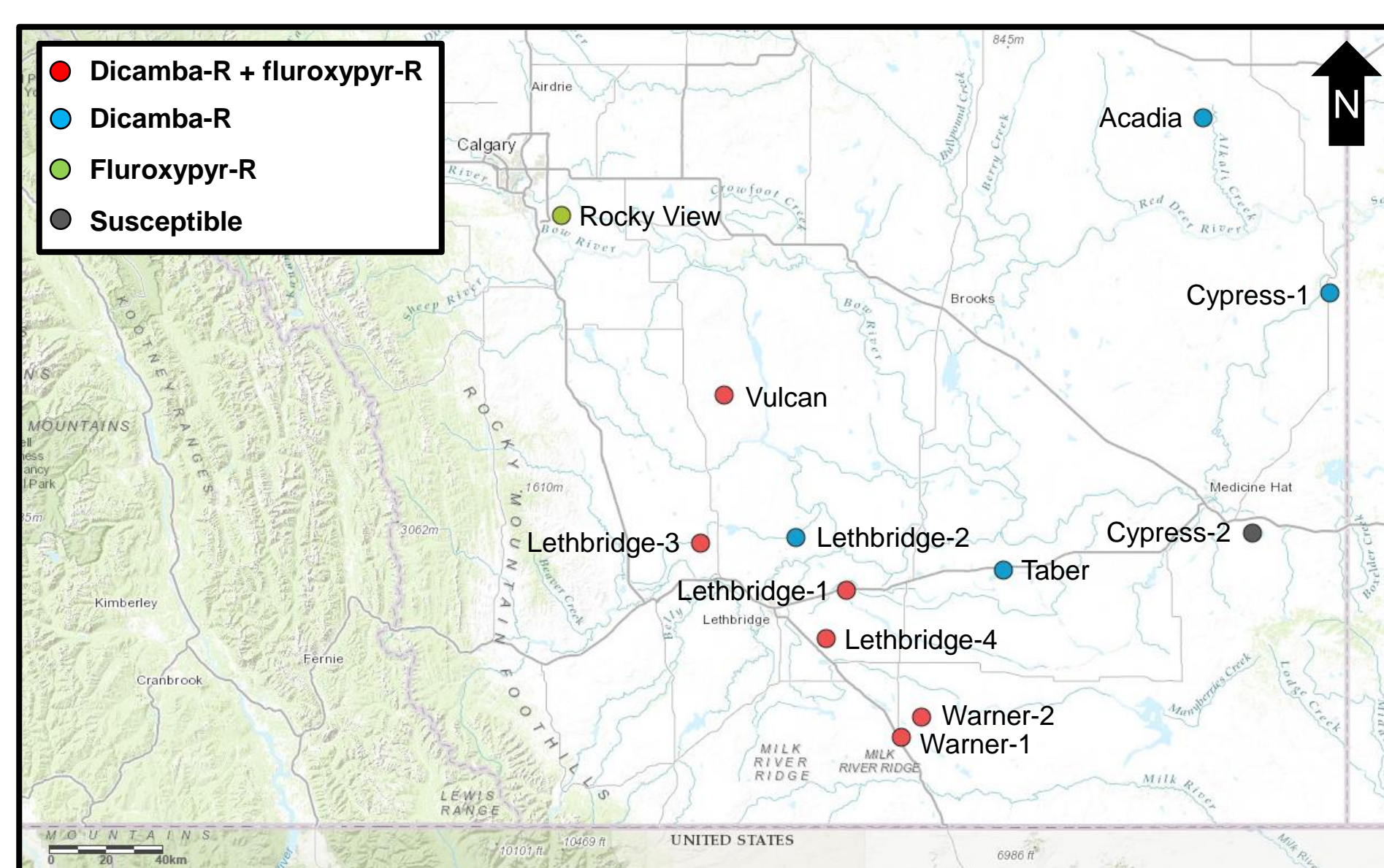


Figure 1. Collection locations for the 12 kochia populations tested from Alberta, excluding control populations.

- Statistical analysis:
 - Nonlinear regression using the 'drc' package in R v.3.6.0
 - Models selected based on parsimony, AIC & lack of fit test
 - Main response variable was shoot biomass fresh weight

Summary

The herbicide dose required to reduce shoot biomass fresh weight by 50% relative to the untreated control (GR50) ranged among kochia populations from 36 to 314 g ae ha⁻¹ for dicamba, and 3 to 916 g ae ha⁻¹ for fluroxypyr (Fig. 2; Table 1). Excluding the controls, ten of the twelve kochia populations were confirmed dicamba-resistant; three with high-level resistance [resistant to susceptible ratio (R/S) of 4.0 to 5.3], and seven with low-level resistance (R/S of 2.0 to 2.8). Seven populations were fluroxypyr-resistant; five with high-level resistance (R/S of 13.2 to 29.8) and two with low-level resistance (R/S of 3.8 to 4.0). Six populations were cross-resistant to dicamba and fluroxypyr, four were resistant to dicamba only, and one was resistant to fluroxypyr only (Figs. 1-3; Table 1).

In conclusion, kochia populations in Alberta can be resistant to one or more synthetic auxin active ingredients.

Further research is required to determine whether resistance to dicamba and/or fluroxypyr is conferred by one or more resistance mechanisms, and to determine population responses to other synthetic auxin herbicides.

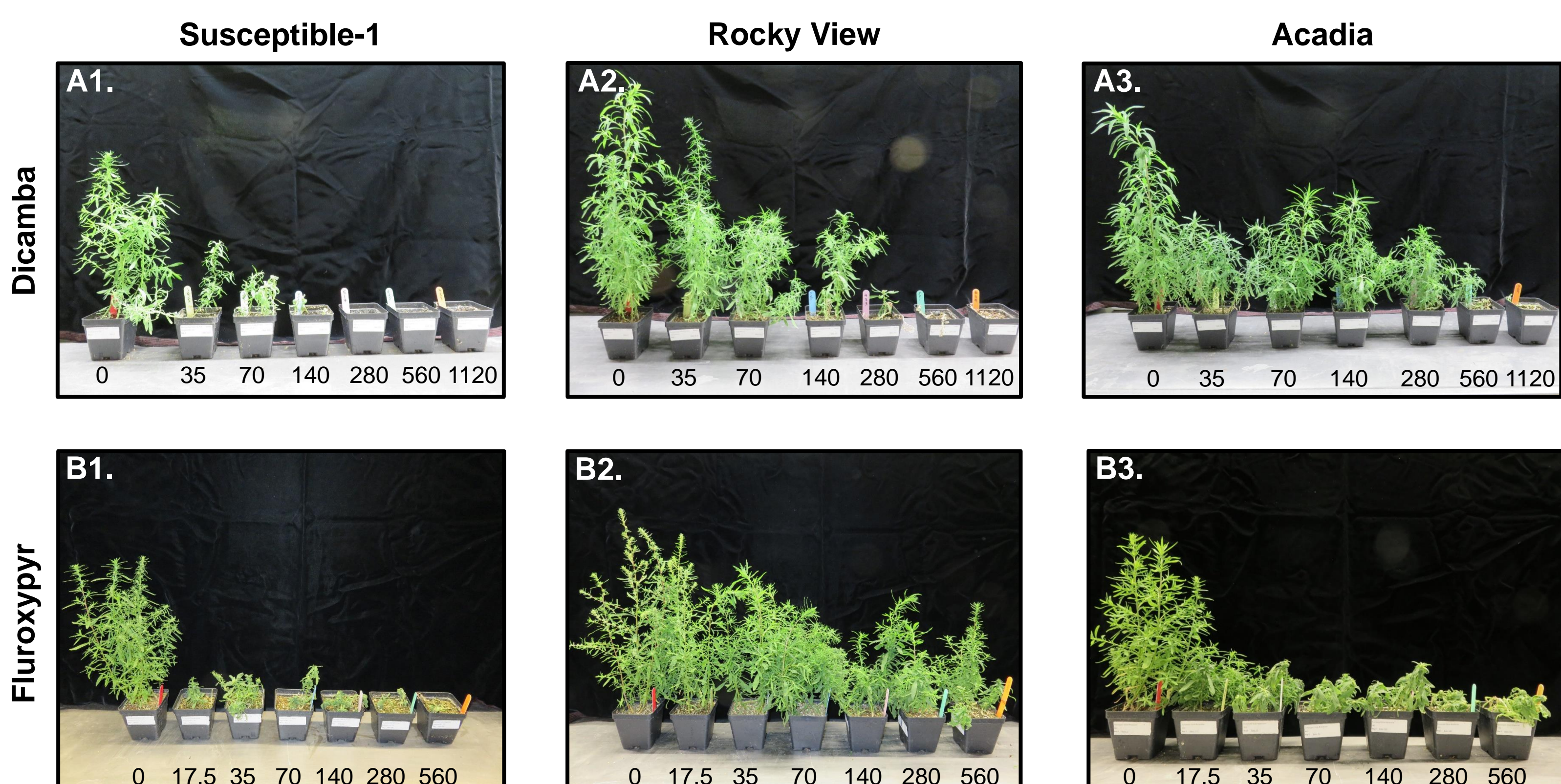


Figure 3. The response of kochia populations Susceptible-1 (A1 & B1), Rocky View (A2 & B2), and Acadia (A3 & B3) to rate titrations of dicamba (A1-3; top) and fluroxypyr (B1-3; bottom). Herbicide rates in g ae ha⁻¹ are designated below each pot.

Results

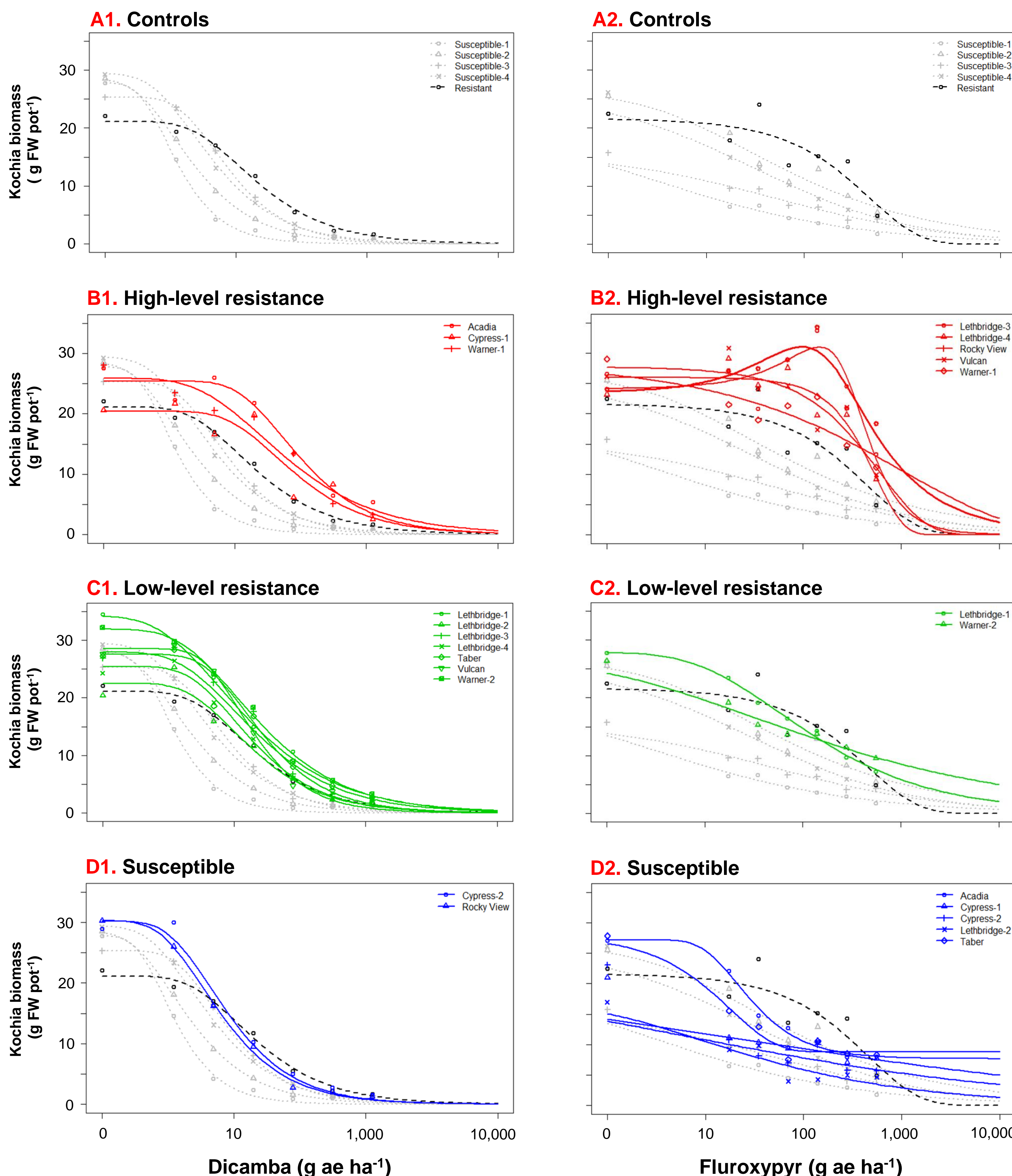


Figure 2. Kochia shoot biomass fresh weight (FW) response to dicamba (A1-D1) and fluroxypyr (A2-D2) rate titrations. Sub-figures show (A) resistant and susceptible controls, with populations exhibiting (B) high-level resistance, (C) low-level resistance, and (D) susceptibility.

Table 1. Dicamba and fluroxypyr doses required to decrease shoot biomass fresh weight by 50% relative to the untreated control (GR50) for each kochia population and the corresponding resistant to susceptible (R/S) ratios.

Population	Dicamba		Fluroxypyr	
	GR50 (g ae ha ⁻¹)	R/S ratio ^{†‡}	GR50 (g ae ha ⁻¹)	R/S ratio
Acadia	314 ± 39.3	5.3	29 ± 4.0	0.9
Cypress-1	286 ± 46.2	4.8	4 ± 1.0	0.1
Cypress-2	90 ± 9.5	1.5	6 ± 6.0	0.2
Lethbridge-1	119 ± 15.2	2.0	118 ± 27.6	3.8
Lethbridge-2	136 ± 20.0	2.3	26 ± 18.8	0.8
Lethbridge-3	164 ± 18.3	2.8	574 ± 77.0	18.7
Lethbridge-4	136 ± 16.7	2.3	440 ± 54.7	14.3
Rocky View	79 ± 8.9	1.3	916 ± 246.5	29.8
Taber	147 ± 20.1	2.5	12 ± 2.6	0.4
Vulcan	138 ± 12.8	2.3	416 ± 103.3	13.5
Warner-1	239 ± 54.6	4.0	407 ± 184.6	13.2
Warner-2	152 ± 19.5	2.6	122 ± 49.0	4.0
Resistant control	147 ± 26.5	2.5	302 ± 82.8	9.8
Susceptible-1	36 ± 3.5	0.6	3 ± 0.2	0.1
Susceptible-2	46 ± 5.6	0.8	65 ± 21.4	2.1
Susceptible-3	90 ± 11.1	1.5	52 ± 30.2	1.7
Susceptible-4	65 ± 7.4	1.1	3 ± 0.2	0.1
Susceptible mean[§]	59	1.0	31	1.0

[†] Resistant to susceptible ratios were determined using the means of all four susceptible controls

[‡] R/S ratios in black indicate herbicide-susceptibility, while ratios in red and green indicate high- and low-level resistance, respectively

[§] Means of all four susceptible controls

References

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