Does crop competition impact the expression of a herbicide-resistant weed phenotype?

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Introduction and Objective

Canada is home to the third-largest number of unique herbicide-resistant weed biotypes surpassed only by the United States and Australia[1]. About half of these biotypes are present in the Canadian prairies, and result in increased weed control measures which cost prairie farmers an estimated $530 Million annually[2]. Dose-response experiments remain the standard method for documenting and characterizing herbicide-resistant weeds because they allow researchers to identify resistance even when the mechanism remains unknown[3,4]. While dose-response experiments are useful for identifying herbicide resistance, results do not apply directly to field crop scenarios because these experiments fail to account for interspecific plant competition. Could crop competition ameliorate the phenotypic expression of herbicide resistance in a weed population confirmed resistant during a typical dose-response experiment? The objective of this research was to determine the impact of wheat (*Triticum aestivum* L.) density on the expression of a fluroxypyr-resistant kochia [*Bassia scoparia* (L.) A.J. Scott] phenotype under controlled-environment.

Materials and Methods

Greenhouse dose-response experiment

- 7 fluroxypyr doses (*Prestige™ XCA*; Corteva Agriscience)
  - 0, 17.5, 35, 70, 140, 280, and 560 g ae ha^{-1}
- 3 kochia populations[5] (**Figures 1 & 2**)
  - RockyView18 <- resistant
  - Vulcan17
  - Lethbridge18(S) <- susceptible
- 4 wheat densities
  - Equivalent to 0, 200, 400, and 600 plants m^{-2}
- 3 replications, 2 experimental runs

Figure 1. Kochia in a wheat field in southwestern Saskatchewan.

Experimental procedures

- 5 kochia plants pot^{-1} (eq. to 500 plants m^{-2})
- Herbicide applied at 5 to 8 cm kochia height
  - Moving-nozzle cabinet sprayer
  - TeeJet® 8002VS flat fan nozzles
  - 275 kPa; 200 L ha^{-1} solution
- Response variables (4 wk after application)
  - Plant survival, visible control, shoot biomass fresh weight (FW), and dry weight (DW)

Statistical analysis

- Nonlinear regression using the 'drc' package in R v. 3.6.0 (R Core Team 2019).
- Three-parameter Weibull type 1 model:

$$y = (d)\exp\left(-\exp\left(b(\log(x) - \log(e))\right)\right)$$

d = upper asymptote
b = slope at dose e
e = dose at the inflection point
y = response variable
x = fluroxypyr dose

Results

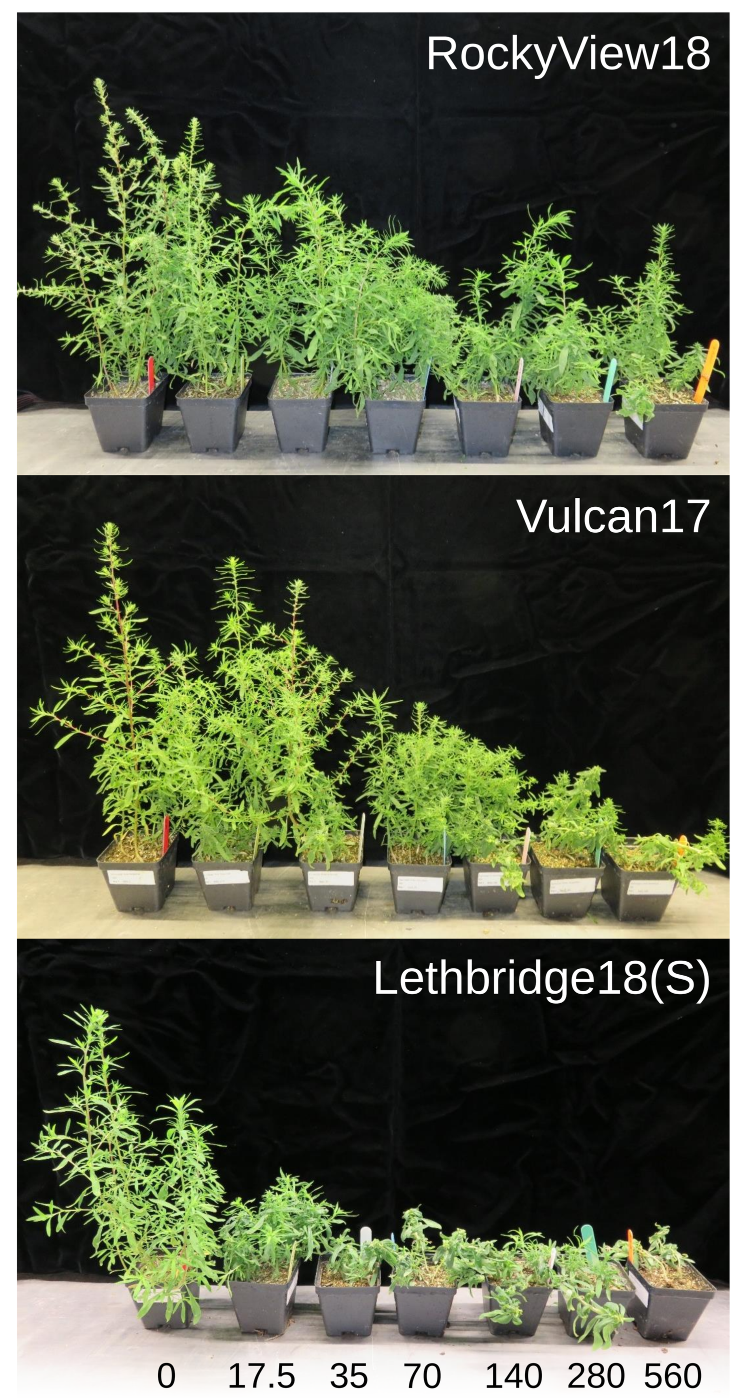

Figure 2. The response of kochia populations RockyView18, Vulcan17, and Lethbridge18(S) to fluroxypyr rate titrations absent of wheat. Fluroxypyr dose (g ae ha^{-1}) designated below each pot.

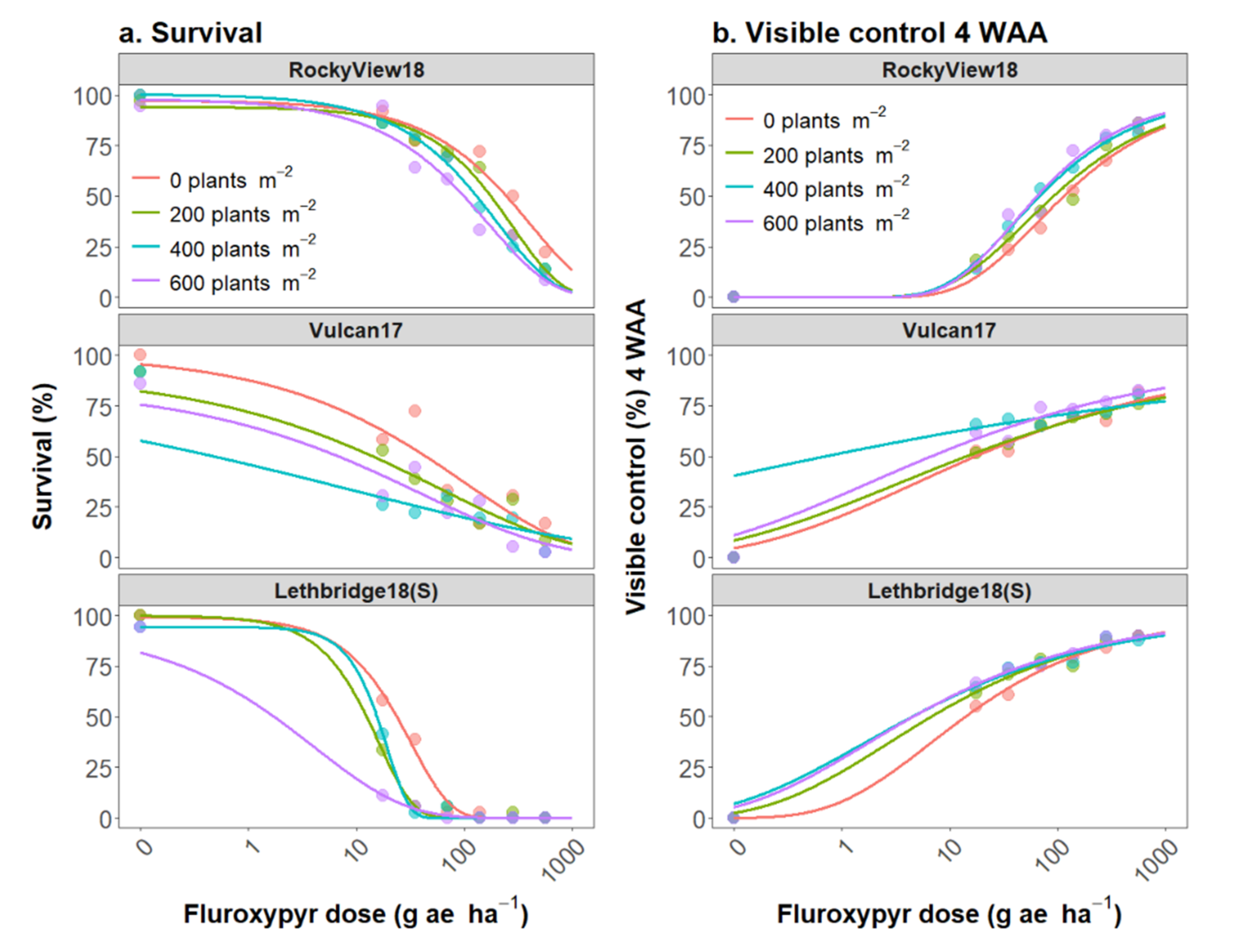

Figure 3. (a) Plant survival, and (b) visible control four weeks after application (WAA) for three kochia populations (RockyView18, Vulcan17, and Lethbridge18(S)) with four wheat densities (0, 200, 400, and 600 plants m^{-2}).

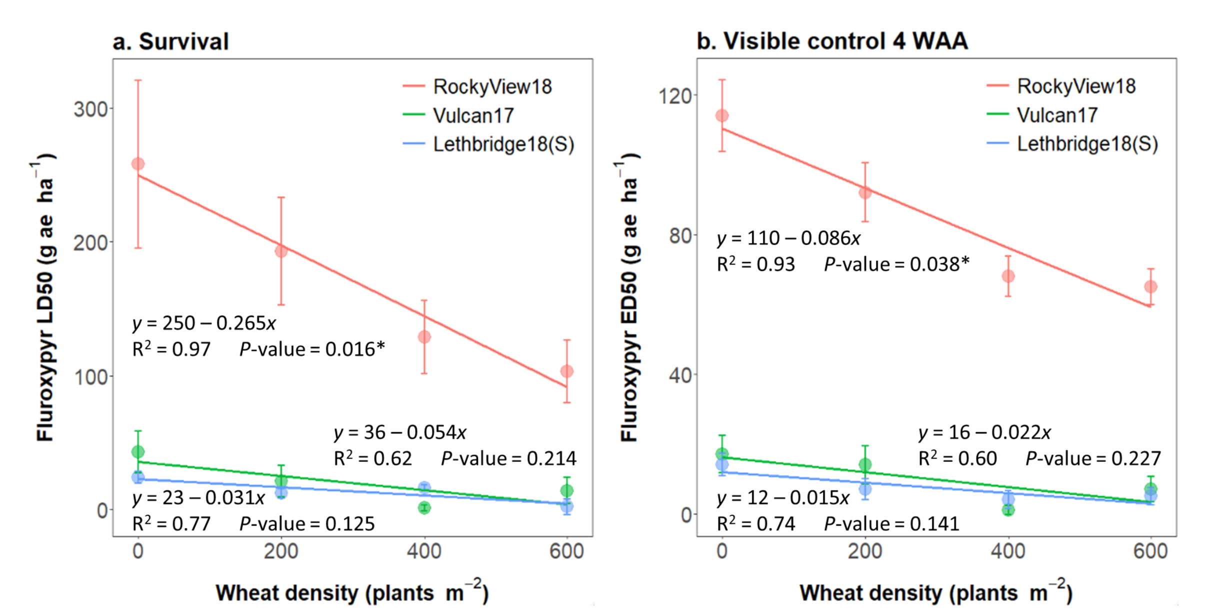

Figure 4. The fluroxypyr dose resulting in (a) 50% plant survival (LD50), and (b) 50% visible control (ED50) four weeks after application (WAA) to three kochia populations (RockyView18, Vulcan 17, and Lethbridge18(S)) with four wheat plant densities (0, 200, 400, and 600 plants m^{-2}). Bars indicate ± SE.

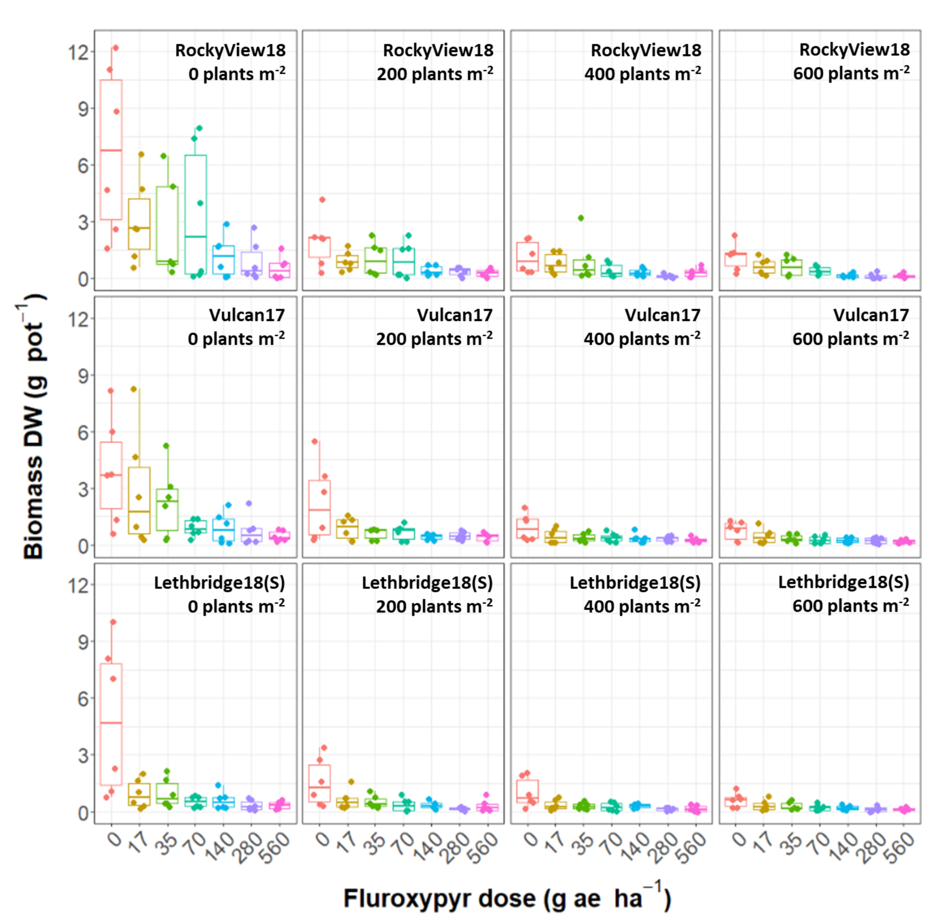

Figure 5. Shoot biomass dry weight (DW) of three kochia populations (RockyView18, Vulcan17, and Lethbridge18(S)) in response to four wheat densities (0, 200, 400, and 600 plants m^{-2}) and seven fluroxypyr doses.

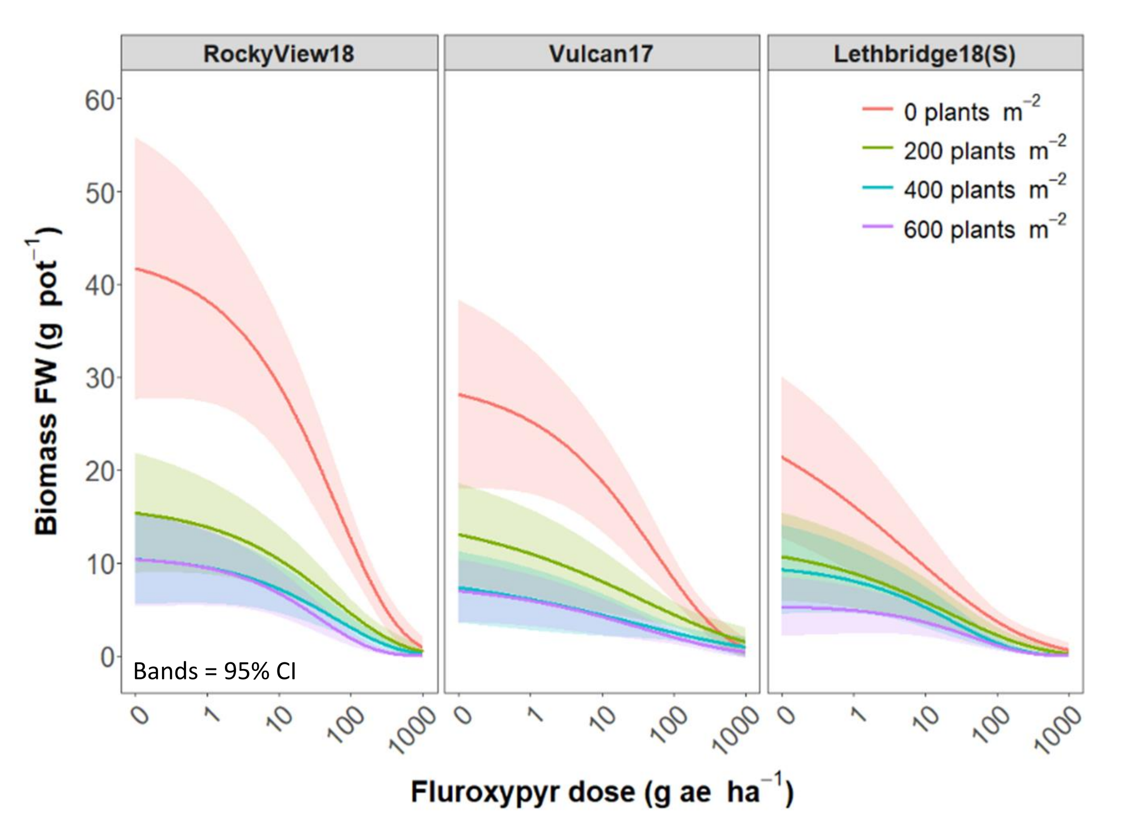

Figure 6. Shoot biomass fresh weight (FW) of three kochia populations (RockyView18, Vulcan 17, and Lethbridge18(S)) in response to four wheat densities (0, 200, 400, and 600 plants m^{-2}) and seven fluroxypyr doses.

Results and Discussion

- **RockyView18 was considered resistant** in the absence of wheat interference based on plant survival [resistant/susceptible (R/S) ratio of 10.8**] and visible control (R/S ratio of 8.1***) four weeks after application (**Figures 2 & 3**).
- **The fluroxypyr dose required to decrease RockyView18 plant survival by 50% (LD50) decreased linearly from 258 to 103 g ae ha^{-1} as wheat density increased from 0 to 600 plants m^{-2}** (**Figure 4a**). A similar response was observed for visible control four weeks after application (ED50 decreased from 114 to 65 g ae ha^{-1}) (**Figure 4b**). When compared with the susceptible kochia control absent of wheat, increasing wheat density reduced the LD50 R/S ratio from 10.8** to 4.3** and the ED50 R/S ratio from 8.1*** to 4.6**.
- **Greater wheat density decreased variability in kochia shoot biomass DW** in response to fluroxypyr regardless of the kochia population (**Figure 5**).
- **Wheat interference reduced kochia biomass FW regardless of the fluroxypyr dose**, and greater wheat density resulted in lower kochia biomass among populations and most flyroxypyr doses (**Figure 6**). This agrees with previous work which showed a similar impact of lentil (*Lens culinaris* Medik.) seeding density on the dose-response of herbicide-susceptible Indian mustard [*Brassica juncea* (L.) Czern.] to fluthiacet-methyl[6].
- Together, results suggest that greater implementation of cultural weed management will help mitigate the spread of auxinic herbicide-resistant kochia in western Canada[5,7], and potentially also other herbicide-resistant weed biotypes.

In conclusion, greater interspecific competition as a result of increased wheat plant density can partially revert the expression of a fluroxypyr-resistant kochia phenotype.

Further research is warranted to determine whether these effects transfer over to a field scenario, and whether a similar response may be observed with other herbicide-resistant weed biotypes exposed to other cultural weed management tools.

Main Findings

- Interspecific competition altered, but did not repress, the expression of a fluroxypyr-resistant kochia phenotype.
- Greater wheat density reduced the herbicide dose required for plant mortality and visible control of the herbicide-resistant weed population.
- Cultural weed management tools, like increased crop densities, can mitigate the spread of herbicide-resistant weeds and reduce risk of herbicide failure.

References

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