The economic threshold for glyphosate-resistant kochia (*Bassia scoparia*) in canola

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Introduction

Kochia [*Bassia scoparia* (L.) A.J. Scott] is a troublesome tumbleweed that is capable of causing substantial crop yield losses[1]. Glyphosate-resistant kochia has increased rapidly throughout the southern Canadian prairies in the past decade[2,3]. Glyphosate-resistant kochia can be problematic particularly in glyphosate-resistant crops such as canola, soybean or corn, and in conservation tillage systems. New canola cultivars with stacked resistance to glyphosate and glufosinate may offer growers an opportunity to manage kochia plants that survive glyphosate by following up with a rescue application of glufosinate. However, rapid growth of kochia requires these decisions to be made quickly. Understanding when this approach is economically viable could help growers make these decisions efficiently so that glufosinate may be applied before kochia plants are beyond the window for effective management.

Many growers chase net returns by finding ways to reduce input costs without sacrificing productivity, and canola is no exception. As a result, recommended canola plant densities have declined in recent decades due to the higher cost of patented seed technologies[4,5]. A recent producer survey suggested that current canola crops are seeded at lower rates (4.5–5.5 kg ha^{-1}) than those in the early 1990s (5.6–7.8 kg ha^{-1})[6,7]. In addition, new hybrid cultivars typically have larger seed[8] resulting in fewer seeds kg^{-1}. It is therefore not surprising that a recent field survey commonly found lower canola plant densities (< 43 plants m^{-2}) than the economic optimum under weed-free conditions (62–73 plants m^{-2})[7]. Low canola densities could result in greater vulnerability to weed interference, and lower economic thresholds for management.

Objectives:

a. Determine the economic and action thresholds for glyphosate-resistant kochia in canola.
b. Determine how these thresholds are affected by canola target plant density.

Materials & Methods

Economic threshold: kochia density at which the cost of crop yield loss becomes greater than the cost of an additional weed control pass[9]

- High = \$60 ha^{-1}, glufosinate (Liberty® 150 SN, BASF Canada) @ 600 g ai ha^{-1} with custom application
- Low = \$45 ha^{-1}, glufosinate @ 400 g ai ha^{-1} with equipment depreciation, fuel, and repairs

Action threshold: the kochia density at which crop yield loss reaches a predetermined threshold (e.g., 5% yield loss)[9]

Small-plot field experiment

- Randomized complete block design
  - **3 locations** (**Fig. 1**)
    - Lethbridge, AB dryland
    - Lethbridge, AB irrigated
    - Scott, SK dryland
  - **1 year:** 2022
  - **4 replications**
- 2-way factorial treatment structure
  - **2 canola target densities**
    - 50 vs. 100 plants m^{-2}
    - Glyphosate/glufosinate-resistant 'LR344PC' (BASF Canada)
  - **8 kochia densities**
    - 0, 10, 30, 90, 270, 810, 2,430 & 7,290 viable seeds m^{-2}
    - Glyphosate-resistant kochia broadcast before canola seeding
- Herbicides
  - Pre-seed burnoff: glyphosate + topramezone + bromoxynil
    - 445 + 5.8 + 141 g ae/ai ha^{-1}
    - *Roundup WeatherMax*® (Bayer CropScience)
    - *Certitude*® (BASF Canada)
    - *Merge*® *Adjuvant* @ 0.2% v/v (BASF Canada)
  - Postemergence: glyphosate @ 445 g ae ha^{-1}
- Main measurements: plant densities, biomass & grain yield
- Statistical analyses
  - Nonlinear regression using proc NLIN in SAS Studio 3.81
  - Yield loss modelled using a rectangular hyperbola function (**Eq. 1**)[10]
  - Economic (\$45 and \$60 ha^{-1}) and action (5% yield loss) thresholds determined by solving **Eq. 2** using the I and A values from **Eq. 1**[9]

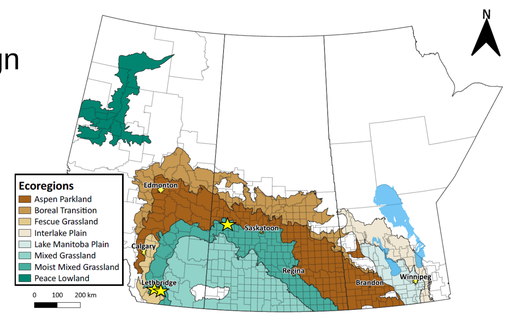

Figure 1. Experiment locations.

$$(1)\ Y = \frac{I \times d}{1 + (I \times d)(A)^{-1}} \qquad (2)\ \text{Action threshold (plants m}^{-2}) = \frac{Y \times A}{I \times (A - Y)}$$

Y = Canola yield loss (%)
d = Kochia density (plants m^{-2})
A = Maximum canola yield loss as d approaches infinity
I = Canola yield loss as d approaches zero

Results

Table 1. Statistical significance (α = 0.05) of the main and interaction effects of canola target plant density and kochia seeding rate on canola yield loss in a preliminary analysis of variance for each location of the experiment.

Factor	Lethbridge, AB dryland	Lethbridge, AB irrigated	Scott, SK dryland
	P-values		
Canola target density (CDens)	0.4709	**0.0036**	0.4066
Kochia seeding rate (KRate)	0.5947	**< 0.0001**	**< 0.0001**
CDens × KRate	0.9037	0.2360	0.0734

Panel 1. One replicate of the Lethbridge, AB irrigated experiment showing increasing densities of glyphosate-resistant kochia in canola seeded at two densities targeting 50 and 100 canola plants m^{-2}.

Table 2. Canola weed-free yields, canola yield loss model parameter estimates, and economic and action thresholds for glyphosate-resistant kochia in canola planted at two different target densities in the Lethbridge, AB irrigated and Scott, SK dryland experiments.

Location	Canola target plant density	Weed-free yield	Yield loss parameter		5% Action threshold	Economic threshold	
			I	*A*		\$45 ha^{-1}	\$60 ha^{-1}
	plants m^{-2}	kg ha^{-1}	%		plants m^{-2}		
Lethbridge, AB	50	1,251	0.66	29.8	9.1	6.2	8.7
irrigated	100	1,222	0.02	30.2	327.5	229.0	320.5
Scott, SK	50	1,051	0.10	98.4	50.2	42.7	57.7
dryland	100	1,142	0.18	95.3	29.4	22.9	30.9

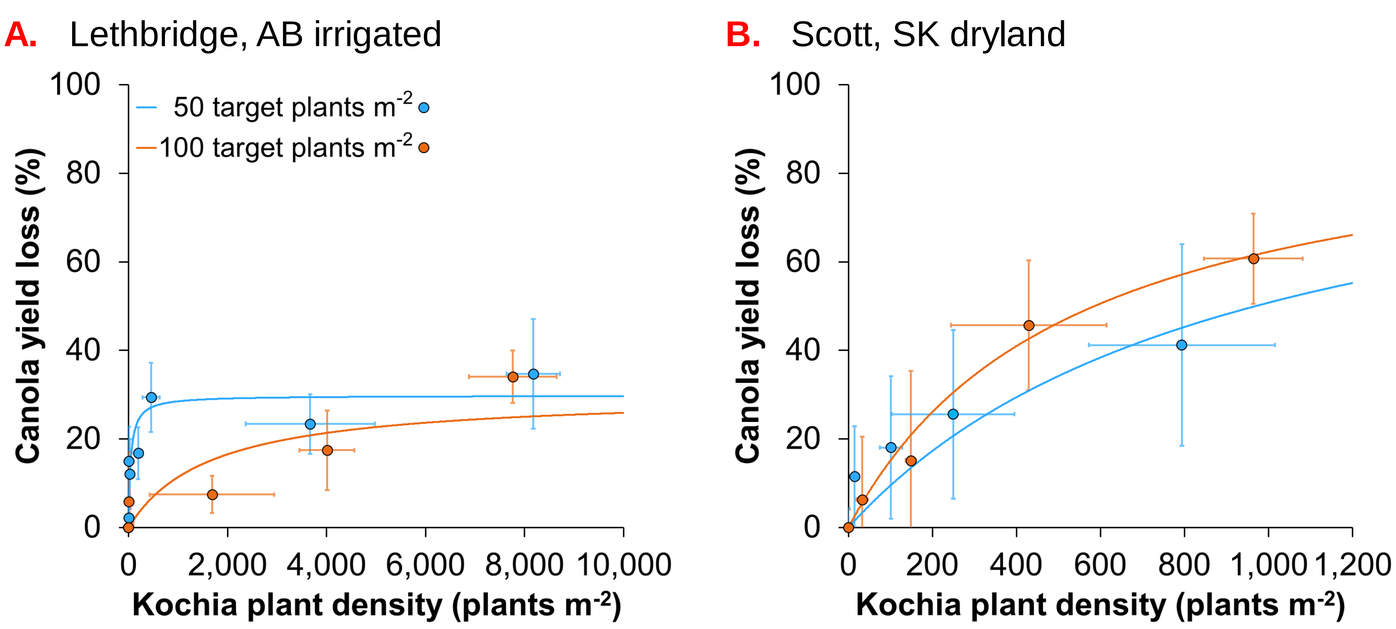

Figure 2. The effect of kochia plant density on canola yield loss when canola was seeded at two different rates targeting 50 (blue) and 100 (orange) canola plants m^{-2} in the (**A**) Lethbridge, AB irrigated (P = 0.0002), and (**B**) Scott, SK dryland (P < 0.0001) experiments. Dots indicate kochia density and canola yield loss means for each canola target density, while bars indicate ± SE. Model parameters are provided in **Table 2**.

Main Findings

- No differences in canola yield loss were observed in the Lethbridge, AB dryland experiment (**Table 1**) due to large variability in emergence caused by delayed spring precipitation.
- Targeting a canola density of 100 plants m^{-2} increased yield by 14% compared with 50 plants m^{-2} among kochia density treatments in the Lethbridge, AB irrigated experiment, but not Scott, SK dryland (data not shown).
- Canola target density influenced yield loss due to kochia interference in the Lethbridge, AB irrigated experiment, but not Lethbridge, AB dryland or Scott, SK dryland (**Table 1; Panel 1**). The low and high economic thresholds for glyphosate-resistant kochia in canola, defined as the density of kochia resulting yield losses equivalent to \$45 and \$60 ha^{-1}, ranged from 6–9 and 229–321 kochia plants m^{-2} when canola was seeded at target densities of 50 and 100 plants m^{-2}, respectively, in the Lethbridge, AB irrigated experiment (**Table 2; Fig. 2**).

In conclusion, the economic and action thresholds for glyphosate-resistant kochia in canola were substantially lower at target canola densities of 50 compared with 100 plants m^{-2} at one site, but not the other, while yield differences were absent at a third site.

Furture research aims to repeat this experiment in four locations in 2023 to help elucidate the economic impact of glyphosate-resistant kochia in canola, and whether low canola densities could result in greater vulnerability to weed interference.

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