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SHORT COMMUNICATION

Control of glyphosate resistant Canada fleabane in soybean with preplant herbicides

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Abstract: Thirteen herbicide tankmixes were evaluated during 2013-2015 for control of glyphosate resistant (GR) Canada fleabane in soybean. Glyphosate+saflufenacil+s-metolachlor/metribuzin, glyphosate+amitrole and glyphosate+metribuzin were the most efficacious and controlled GR Canada fleabane 86 to 92%, reduced density 98 to 99% and reduced aboveground biomass 96 to 97%.

Key words: Canada fleabane, glyphosate resistance, preplant herbicides, soybean

Ontario farmers produce approximately 70% of Canadian soybean production. Effective weed control is the greatest challenge that faces Ontario soybean producers, particularly glyphosate resistant (GR) weeds. Canada fleabane (*Conyza canadensis* (L.) Cronq.) was the first broadleaf

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Abbreviations: GR, glyphosate resistant; PP, preplant; WAT, weeks after treatment

weed to evolve resistance to glyphosate in a continuous Roundup Ready cropping system in Delaware, USA (VanGessel 2001). Previously, glyphosate provided excellent control of Canada fleabane. Recent weed surveys conducted in Ontario have identified GR Canada fleabane in 30 counties from Essex County in the southwest to Glengarry County adjacent to the Quebec border. In addition, there are 22 counties in Ontario with multiple resistant Canada fleabane (Group 2 and 9) (Byker et al. 2013c). GR Canada fleabane populations have been identified as a weed of economic significance in Ontario. Efficacious, cost-effective control of these yield-robbing resistant biotypes are crucial for Ontario soybean producers to be competitive in the global market.

Canada fleabane, a member of the Asteraceae family, is a prolific winter or summer annual capable of producing up to one million seeds per plant (Frankton and Mulligan 1987; Weaver 2001; Kruger et al. 2010). The seeds of Canada fleabane are small, 1 to 2 mm long, with an attached pappus that aids in wind dispersal of up to 550 km from the parent plant (Frankton and Mulligan 1987; Royer and Dickenson 1999; Shields et al. 2006). Canada fleabane can germinate in the spring, summer or fall (Weaver 2001). If no weed management tactics are used, GR Canada fleabane can caused as much as 93% reduction in yield of soybean (Byker et al. 2013b).

Due to the long emergence pattern of Canada fleabane, a preplant (PP) herbicide application with residual activity is a desirable strategy for the control this troublesome weed (Loux et al. 2006). Saflufenacil alone has been documented to provide effective control (> 90%) of GR Canada fleabane (Byker et al. 2013a). However, some studies have shown, and experience by Ontario soybean producers, that weed control with saflufenacil applied PP can be variable under Ontario environmental conditions (Budd et al. 2016). Therefore, the objective of this research

was to evaluate the efficacy of thirteen glyphosate tankmixes to determine if any of these tankmixes provide more consistent control of GR Canada fleabane in soybean.

Eight field trials were conducted over a three-year period (2013, 2014 and 2015) in commercial soybean fields located near Blenheim, Harrow, Morpeth, Mull, Ridgetown and Windsor, Ontario with confirmed GR Canada fleabane. Field trials were established as a randomized complete block design with four replications. Soybean was seeded to a depth of 5 cm at the rate of approximately 400,000 seeds ha⁻¹. Each plot was 2.25 m wide (3 rows spaced 75 cm apart) and 8.0 m long. All herbicide treatments were applied preplant (PP) and are listed in Table 1. The weed free control was maintained weed free by applying glyphosate (1800 g ae ha⁻¹) plus amitrole (2000 g ai ha⁻¹) followed by hand hoeing as required throughout the growing season. Herbicide treatments were applied with a CO₂-pressurized back-pack sprayer equipped with Hypro ULD120-02 nozzle tips (Hypro, New Brighton, MN) calibrated to deliver 200 L ha⁻¹ of water at 200 kPa. Herbicide applications were made with a 1.5 m boom with four nozzles spaced 50 cm apart.

Crop injury was estimated on a scale of 0 (no injury) to 100% (complete plant death) at 2 and 4 weeks after treatment (WAT). Control of GR Canada fleabane was estimated on a scale of 0 (no control) to 100% (complete control) at 4 and 8 WAT. GR Canada fleabane density and aboveground biomass were determined at 4 WAT by counting and then cutting the Canada fleabane at the soil surface from 1 square meter in each plot. Plants were dried at 60 C to a constant moisture and then weighed.

Data were analyzed as an RCBD using PROC MIXED in SAS 9.2 (Statistical Analysis Systems, Cary, NC, USA). Herbicide treatment was considered a fixed effect, while environment (year-location combinations), the interaction between environment and herbicide

treatment, and replicate nested within environment were considered random effects.

Significance of the fixed effect was tested using a F-test and random effects were tested using a Z-test of the variance estimate. The UNIVARIATE procedure was used to test data for normality and homogeneity of variance. The untreated control (for control ratings) and the weed-free control (for density and aboveground biomass) were excluded from the analysis. However, all values were compared independently to zero to evaluate treatment differences with the untreated control. To satisfy the assumptions of the variance analyses, weed control was arcsine square root transformed, and density and aboveground biomass were log transformed. Treatment comparisons were made using Fisher's Protected LSD at a level of $P < 0.05$. Data compared on the transformed scale were converted back to the original scale for presentation of results.

There was no injury at 2 and 4 WAT in soybean with any of the herbicides evaluated in this study (data not shown). Glyphosate controlled GR Canada fleabane 8 to 15%, reduced aboveground biomass 22% but did not reduce density (Table 1). The tankmixes of glyphosate plus saflufenacil, saflufenacil/dimethenamid or saflufenacil/imazethapyr controlled GR Canada fleabane 68 to 79%, reduced density 92 to 95% and reduced aboveground biomass 87 to 93% (Table 1). Variable control of GR Canada fleabane with glyphosate plus saflufenacil, is consistent with results from Ikley (2012) which indicated only 37 and 57% control of GR Canada fleabane with glyphosate (900 g ae ha^{-1}) plus saflufenacil (25 g ai ha^{-1}) in soybean; but in contrast to Byker et al. (2013a) who reported 90 to 100% and 88 to 100% at 2 and 4 WAT, respectively. Budd et al. (2016) also found that glyphosate plus saflufenacil controlled Canada fleabane 88-99%, reduced density 96% and aboveground biomass 89% in soybean.

The tankmixes of glyphosate plus amitrole, glyphosate plus metribuzin and glyphosate plus s-metolachlor/metribuzin plus saflufenacil controlled GR Canada fleabane 86 to 92%, reduced

density 98 to 99% and reduced aboveground biomass 96 to 97% (Table 1). The tankmixes of glyphosate plus 2,4-D, cloransulam-methyl, chlorimuron plus metribuzin, s-metolachlor/metribuzin or imazethapyr plus metribuzin controlled GR Canada fleabane 45 to 68%, reduced density 71 to 92% and reduced aboveground biomass 72 to 84% (Table 1). In other studies, Eubank et al. (2008) reported that with glyphosate (900 g a.e. ha⁻¹) plus 2,4-D (840 g a.i. ha⁻¹) reduced GR Canada fleabane density 99% and glyphosate (900 g a.e. ha⁻¹) plus metribuzin (420 g a.i. ha⁻¹) reduced GR Canada fleabane density 66%. In other studies Budd et al. (2016) found that glyphosate plus saflufenacil plus metribuzin controlled Canada fleabane 96-99%, reduced density 98% and aboveground biomass 92% in soybean.

Overall, among the glyphosate tankmixes evaluated, the tankmix of glyphosate (900 g a.e. ha⁻¹) plus metribuzin (1120 g a.i. ha⁻¹), amitrole (2000 g a.i. ha⁻¹) or s-metolachlor/metribuzin plus saflufenacil (1943 + 25 g a.i. ha⁻¹) provide the most consistent control of GR Canada fleabane in soybean under Ontario environmental conditions.

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Table 1. Percent control 4 and 8 WAT, density and aboveground biomass 4 WAT for glyphosate resistant Canada fleabane in glyphosate-resistant soybean treated with glyphosate plus various PP herbicides at various ON locations (2013-2015). Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at $P < 0.05$.^a

Treatment ^b	Rate (g ai ha ⁻¹)	Control (%)		Density (# m ⁻²)	Aboveground biomass (g m ⁻²)
		4 WAT	8 WAT		
Weedy check		0 h	0 g	269 g	58.6 g
Weed-free check		100 a	100 a	0 a	0.0 a
Glyphosate	900	15 g	7 f	283 g	45.7 g
Saflufenacil	25	74 cde	70 cde	18 cde	5.5 cde
Saflufenacil/dimethenamid-p	245	79 bcd	77 bcd	13 bcd	3.9 bcd
Saflufenacil/imazethapyr	100	74 cde	68 cde	21 de	7.4 def
Amitrole	2000	90 bc	88 bc	6 abc	1.5 ab
2, 4-D ester	500	68 def	61 de	46 ef	9.2 def
Cloransulam-methyl	35	53 ef	50 e	72 f	16.7 f
Flumetsulam	70	50 f	45 e	77 f	15.9 f
Metribuzin	1120	92 b	91 b	2 a	1.5 ab
Chlorimuron-ethyl + metribuzin	9 + 412.5	67 def	62 de	21 de	9.4 def
S-metolachlor/metribuzin	1943	61 def	58 de	29 def	12.4 ef
Imazethapyr + metribuzin	100 + 400	62 def	59 de	25 def	9.6 def
S-metolachlor/metribuzin + saflufenacil	1943 + 25	88 bc	86 bc	4 ab	2.1 abc

^a Abbreviations: PP, preplant; WAT, weeks after herbicide treatment.

^b All treatments included glyphosate (900 g ae ha⁻¹).