Weed Technology

www.cambridge.org/wet

Control of glyphosate-resistant horseweed (*Conyza canadensis*) with tiafenacil mixes in corn

Nader Soltani[1], Christy Shropshire[2] and Peter H. Sikkema[3]

[1]Adjunct Professor, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada; [2]Research Technician, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada and [3]Professor, University of Guelph Ridgetown Campus, Ridgetown, ON, Canada

Research Article

Cite this article: Soltani N, Shropshire C, Sikkema PH (2021) Control of glyphosate-resistant horseweed (*Conyza canadensis*) with tiafenacil mixes in corn. Weed Technol. **35**: 908–911. doi: 10.1017/wet.2021.44

Received: 26 March 2021
Revised: 21 May 2021
Accepted: 27 May 2021
First published online: 21 June 2021

Associate Editor:
David Johnson, Corteva Agriscience

Nomenclature:
Atrazine; bromoxynil; dicamba; dimethenamid-p; glyphosate; saflufenacil; tiafenacil; tolpyralate; horseweed; *Conyza canadensis* (L.) Cronquist; corn; *Zea mays* L.

Keywords:
Canada fleabane; crop injury; density; dry biomass; glyphosate resistance; preplant application; visible control

Author for correspondence:
Nader Soltani, Department of Plant Agriculture, University of Guelph Ridgetown Campus, 120 Main Street East, Ridgetown, ON N0P 2C0, Canada. (Email: soltanin@uoguelph.ca)

Abstract

Four field experiments were completed in commercial corn fields during 2019 and 2020 to determine glyphosate-resistant (GR) horseweed control in corn with tiafenacil alone or in combination with bromoxynil, dicamba, or tolpyralate applied preplant (PP). Corn planted 1 to 10 d after herbicide application was not injured with any of the herbicides tested. GR horseweed interference reduced corn grain yield 32% when left uncontrolled. Herbicides reduced GR horseweed interference and resulted in corn grain yield that was similar to the weed-free control. Glyphosate (900 g ae ha^{-1}) + tiafenacil at 12.5, 25, and 37.5 g ha^{-1} controlled GR horseweed 63%, 68%, and 72% at 4 wk after treatment (WAT) and decreased GR horseweed density 64%, 43%, and 83% and dry biomass 69%, 55%, and 83%, respectively. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ha^{-1} plus bromoxynil (280 g ai ha^{-1}) controlled GR horseweed 81%, 88%, and 87% at 4 WAT and reduced GR horseweed density 82%, 94%, and 93% and dry biomass 93%, 93%, and 98%, respectively. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ha^{-1} plus dicamba (300 g ai ha^{-1}) controlled GR horseweed 86%, 88%, and 88% at 4 WAT and decreased GR horseweed density 76%, 89%, and 86% and dry biomass 94%, 98%, and 98%, respectively. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ha^{-1} plus tolpyralate (30 g ai ha^{-1}) controlled GR horseweed 90%, 90%, and 91% at 4 WAT and decreased GR horseweed density 93%, 91%, and 95% and dry biomass 98%, 97%, and 97%, respectively. The industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p controlled GR horseweed 95% and 100% at 4, 8, and 12 WAT and caused 99% and 100% density or biomass reduction, respectively.

Introduction

Corn is an important crop for agriculture and the economy of Canada and more specifically in the province of Ontario, where more than 60% of Canadian corn is produced (OMAFRA 2017). On average, growers in Ontario seed nearly 900,000 ha of corn and produce approximately 9 billion kg of grain corn valued to be approximately Can$1.54 billion (OMAFRA 2017). Weed management is an important component of profitable corn production. A study conducted by the yield loss committee of the Weed Science Society of America has estimated 50% yield loss in corn if weeds are not controlled (Soltani et al. 2016). Early control of weeds is of particular importance, as early-season competition can substantially reduce corn yield (Hall et al. 1992).

Glyphosate-resistant (GR) horseweed is a highly competitive winter or summer annual weed that has rapidly spread throughout Ontario after its discovery in 2010 (Byker et al. 2013; Mahoney et al. 2017; Metzger et al. 2019; Weaver 2001). GR horseweed has now been identified in more than 30 Ontario counties (Budd et al. 2016). GR horseweed can interfere with corn growth and has been shown to cause as much as 69% corn yield reduction if not adequately controlled (Ford et al. 2014; Metzger et al. 2019). Early-season GR horseweed control is important to decrease early-season weed competition, prevent corn yield loss, reduce weed escapes, and increase net returns. GR horseweed needs to be controlled before seeding with preplant (PP) herbicides that have burndown/residual activity to minimize weed interference and maximize corn yield and farm profitability (Brown et al. 2016; Budd 2016; Davis and Johnson 2008; Ford et al. 2014; Mahoney et al. 2017).

Tiafenacil is a new nonselective contact herbicide from the pyrimidinedione chemical family, developed by FarmHannong Co., Ltd., Korea for registration in corn, soybean [*Glycine max* (L.) Merr.], wheat (*Triticum aestivum* L.), cotton (*Gossypium hirsutum* L.), and other crops to control emerged grass and broadleaf weeds before crop emergence (Anonymous 2020; Park et al. 2018; Westerveld 2021). Tiafenacil inhibits the activity of protoporphyrinogen IX oxidase enzyme in susceptible weeds, including velvetleaf (*Abutilon* *theophrasti* Medik.), *Amaranthus* spp., common purslane (*Portulaca oleracea* L.), and barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.] (Haring and Hanson 2020; Park et al. 2018). Tiafenacil is registered as a useful herbicide for herbicide-resistant (HR) weed management, as it provides an alternative for the control/suppression of GR weeds, including GR Palmer amaranth (*Amaranthus palmeri* S. Watson), GR horseweed, and GR waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer var. *rudis*] in corn and soybean (EPA 2020; Haring and Hanson 2020). HR weeds such as GR horseweed have created a challenge for farmers in terms of pest management, crop yield, and profitability of their farm enterprises (Haring and Hanson 2020). Tiafenacil is proposed for PP and PRE burndown use before crop emergence (EPA 2020). Tiafenacil degrades rapidly in the soil and has shown to have a low risk to non-target organisms (EPA 2020).

Currently, tiafenacil is being considered for registration at rates of 25 to 75 g ai ha^{-1} for PP burndown in corn. Herbicides that are currently registered in corn can be applied as a partner with tiafenacil to extend and broaden the spectrum of weeds controlled (Anonymous 2020). Current registered herbicides with biological activity against GR horseweed in Ontario include bromoxynil, dicamba, and tolpyralate (Budd 2016; Ford et al. 2014; Metzger et al. 2019). Mixing tiafenacil with these herbicides can increase the spectrum of weeds controlled and improve the consistency of control of GR horseweed and other troublesome weeds.

Published data on the effectiveness of tiafenacil applied alone or in mixture with other herbicides for GR horseweed control in corn are scarce. The objective of this research was to assess GR horseweed control in corn with tiafenacil alone or in combination with bromoxynil, dicamba, and tolpyralate and compare their efficacy with the industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p.

Materials and Methods

Four field experiments (randomized complete block design with four replications) were conducted in Ontario over 2 yr (2019 and 2020) in commercial fields near Ridgetown, ON, with confirmed GR horseweed populations. Treatments evaluated are listed in Table 1. Glyphosate (900 g ae ha^{-1}) was included in all treatments, including weed-free and non-treated controls, to eliminate all other weed species and non-GR horseweed plants. Tiafenacil herbicide treatments included methylated seed oil (0.5% v/v). Plots were 2.25 wide (3 rows spaced 75 cm apart) by 8 m in length with a 2-m walkway between replicates. Corn was seeded with a no-till planter at approximately 80,000 seeds ha^{-1} to a depth of 4 cm.

Herbicides were sprayed 1 to 10 d before planting, when horseweed was up to 10 cm in height, with a CO_2-pressurized backpack sprayer (1.5-m spray boom with 4 ULD-120-02 nozzles [Pentair, New Brighton, MN, USA] spaced 50 cm apart) calibrated to deliver 200 L ha^{-1} water volume at 240 kPa, producing a spray width of 2.0 m. Glyphosate (450 g ha^{-1}) was applied POST to all trials to eliminate all other weed species, including glyphosate-susceptible horseweed.

Visible corn injury (0 to 100 = no injury to complete death) was estimated at 2 and 4 wk after emergence (WAE). GR horseweed control (0 to 100 = no to complete horseweed control) was estimated at 4, 8, and 12 wk after treatment (WAT). GR horseweed density and aboveground dry biomass were determined at 8 WAT by counting GR horseweed plants within two 0.25-m^2 quadrats per plot, dried to a constant moisture and weighed. Corn grain yield was collected upon harvest maturity by combining the center two rows of each plot. Corn grain moisture was transformed to 15.5%.

Data were analyzed in SAS (Ver. 9.4, SAS Institute Inc., Cary, NC, USA). The generalized linear mixed model included treatment as the fixed effect and location-year (environment), replicate within environment, and treatment by environment interaction as random effects. Percent visible GR horseweed control and relative corn yield were analyzed utilizing a gaussian distribution, and relative GR horseweed density and dry biomass were analyzed utilizing a lognormal distribution in the GLIMMIX procedure. The distributions chosen were the ones that best met the assumptions of the analysis; studentized residual plots were used to assess homogeneity of variance, normality was checked using a normal probability plot, and the Shapiro-Wilk statistic and the Pearson chi-square/df ratio were checked to ensure there was no overdispersion. If a treatment was assigned a fixed value, as was the case for the non-treated and weed-free control for visible control and relative density and dry weight, those treatments were not included in the analysis. However, the remaining treatments could still be compared with the value zero using the P-value from the LSMEANS table produced by the GLIMMIX procedure. Treatment pairwise comparisons were subjected to Tukey's adjustment, and a significance level of 0.05 was used for all comparisons. Data analyzed using the lognormal distribution were back-transformed for presentation of results.

Results and Discussion

Corn Injury and Yield

Corn was not injured at 2 and 4 WAE by any of the herbicides tested (data not shown). GR horseweed interference caused a 32% reduction in the grain yield of corn (Table 1). Metzger et al. (2019) reported 47% yield loss in corn when multiple herbicide–resistant horseweed was not controlled. Ford et al. (2014) reported a 69% corn yield loss due to GR horseweed interference. Westerveld (2021) reported 69% soybean yield loss due to GR horseweed interference. Glyphosate (900 g ha^{-1}) + tiafenacil at 12.5, 25, and 37.5 g ha^{-1} applied PP alone or in combination with bromoxynil (280 g ai ha^{-1}), dicamba (300 g ai ha^{-1}), or tolpyralate (30 g ai ha^{-1}) resulted in corn yield that was statistically similar to the weed-free control and the industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p (Table 1). Similarly, Metzger et al. (2019) reported corn grain yield comparable to the weed-free control with glyphosate + dicamba, bromoxynil, and tolpyralate applied PP in corn. Westerveld (2021) reported yield comparable to the non-weedy plots with tiafenacil applied PP at 25 and 50 g ai ha^{-1} alone and in mixes with other herbicides in soybean.

Horseweed Control

All herbicide treatments evaluated provided at least 63% GR horseweed control relative to the non-treated control (Table 1). Adding an additional mix herbicide improved control in most cases. At 4 WAT, glyphosate (900 g ae ha^{-1}) + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} controlled GR horseweed 63%, 68%, and 72%, respectively (Table 1). Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} plus bromoxynil (280 g ai ha^{-1}) improved GR horseweed control to 81%, 88%, and 87%, respectively. Similarly, glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} plus dicamba (300 g ai ha^{-1}) improved GR horseweed control to 86%, 88%, and 88%, respectively. Glyphosate + tiafenacil at 12.5,

Table 1. Visible glyphosate-resistant (GR) horseweed percent control at 4, 8 and 12 wk after herbicide application (WAT), GR horseweed density and dry biomass at 8 WAT relative to the non-treated control, and corn grain yield at four sites in 2019–2020 near Ridgetown, Ontario.[a]

Herbicide treatment[b]	Rate	GR horseweed control			Relative GR horseweed density	Relative GR horseweed dry biomass	Relative corn yield
		4 WAT	8 WAT	12 WAT			
	g ai ha^{-1}	%					
Weed-free control		100	100	100	0 a	0 a	100
Non-treated control		0 f	0 f	0 f	100	100	68 b
Tiafenacil	12.5	63 e	55 e	48 e	36 e	31 e	97 a
Tiafenacil	25	68 e	60 e	51 e	57 e	45 e	93 a
Tiafenacil	37.5	72 de	67 de	63 de	17 cde	17 de	101 a
Tiafenacil + bromoxynil	12.5 + 280	81 cd	76 cd	72 cd	18 cde	7 cd	103 a
Tiafenacil + bromoxynil	25 + 280	88 bc	85 abc	83 abc	6 bcd	7 cd	104 a
Tiafenacil + bromoxynil	37.5 + 280	87 bc	84 abc	82 abcd	7 bcd	2 bc	99 a
Tiafenacil + dicamba	12.5 + 300	86 bc	81 bcd	79 bcd	24 de	6 cd	102 a
Tiafenacil + dicamba	25 + 300	88 bc	85 abc	84 abc	11 cd	2 bc	103 a
Tiafenacil + dicamba	37.5 + 300	88 bc	85 abc	83 abc	14 cd	2 bc	100 a
Tiafenacil + tolpyralate	12.5 + 30	90 abc	88 abc	86 abc	7 bcd	2 bc	101 a
Tiafenacil + tolpyralate	25 + 30	90 abc	86 abc	83 abc	9 cd	3 bc	106 a
Tiafenacil + tolpyralate	37.5 + 30	91 abc	89 abc	86 abc	5 bc	3 bc	108 a
Dicamba/atrazine	1800	95 ab	95 ab	95 ab	1 ab	1 ab	101 a
Saflufenacil/dimethenamid-p[c]	745	100 a	100 a	100 a	0 a	0 a	103 a

[a] Means within a column followed by the same lowercase letter do not differ significantly according to Tukey's HSD at $P < 0.05$.

[b] All treatments included glyphosate at 900 g ae ha^{-1}. Tiafenacil herbicide treatments included methylated seed oil (0.5% v/v).

[c] With oil-surfactant blend (Merge®, BASF Canada Inc., Mississauga, ON, Canada) at 1 L ha^{-1}

25, and 37.5 g ai ha^{-1} plus tolpyralate (30 g ai ha^{-1}) improved GR horseweed control to 90%, 90%, and 91%, respectively. There was no difference in GR horseweed control among the tiafenacil mixes evaluated, nor was there a significant tiafenacil rate response. However, although not significant, treatments with 12.5 g ai ha^{-1} of tiafenacil tended to give slightly lower control compared with the higher tiafenacil rates. The industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p, controlled GR horseweed 95% and 100%, respectively.

At 8 WAT, the control of GR horseweed with glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} decreased to 55%, 60%, and 67%, respectively (Table 1). As at 4 WAT, additional mix herbicides improved control in most cases. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} plus bromoxynil (280 g ai ha^{-1}) controlled GR horseweed 76%, 85%, and 84%, respectively. Glyphosate + tiafenacil at 12.5, 25 and 37.5 g ha^{-1} plus dicamba (300 g ai ha^{-1}) controlled GR horseweed 81%, 85%, and 85%, respectively. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} plus tolpyralate (30 g ai ha^{-1}) controlled GR horseweed 88%, 86%, and 89%, respectively. Glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p controlled GR horseweed 95% and 100%, respectively.

At 12 WAT, there was a further trend to reduced GR horseweed control with tiafenacil (Table 1). Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} controlled GR horseweed 48%, 51%, and 63%, respectively (Table 1). Glyphosate + tiafenacil plus bromoxynil (280 g ai ha^{-1}), dicamba (300 g ai ha^{-1}), or tolpyralate (30 g ai ha^{-1}) controlled GR horseweed 72% to 83%, 79% to 84%, and 83% to 86%, respectively. The industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p, controlled GR horseweed 95% and 100%, respectively.

Results are consistent with other studies that have shown 75% to 84% horseweed control at 3 d after treatment (DAT) and 71% to 73% horseweed control at 7 DAT with tiafenacil applied PP at 25, 50, and 75 g ai ha^{-1} (Haring and Hanson 2020). Mahoney et al. (2017) reported GR horseweed control of 93% to 96% with bromoxynil + atrazine and dicamba/atrazine applied POST at 8 WAT in corn. However, in their study, glyphosate mixtures with 2,4-D, mesotrione, and topramezone provided only 65% to 76% control of GR horseweed, while atrazine, tembotrione/thiencarbazone-methyl, glufosinate, and halosulfuron mixtures provided minimal control (36% to 57%) of GR horseweed in corn (Mahoney et al. 2017). In soybean, Westerveld (2021) found up to 66% control of GR horseweed at 2 and 4 WAT with tiafenacil applied PP at 25 and 50 g ai ha^{-1}. Their study also showed that when metribuzin was added to tiafenacil, GR horseweed control increased to 93% (Westerveld 2021). Other pyrimidinedione herbicides such as saflufenacil in combination with metribuzin or glyphosate/dicamba were shown to provide excellent (98% to 100%) GR horseweed control in soybean (Westerveld 2021).

All herbicide treatments evaluated caused a decrease in GR horseweed dry biomass and density. Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} reduced density of GR horseweed 64%, 43%, and 83% and dry biomass of GR horseweed 69%, 55%, and 83%, respectively (Table 1). Glyphosate + tiafenacil at 12.5, 25, and 37.5 g ai ha^{-1} plus bromoxynil (280 g ai ha^{-1}), dicamba (300 g ai ha^{-1}), or tolpyralate (30 g ai ha^{-1}) reduced GR horseweed density 82% to 94%, 76% to 89%, and 91% to 95%, respectively, and reduced GR horseweed biomass 93% to 98%, 94% to 98%, and 97% to 98%, respectively. The industry standards in Ontario, glyphosate + dicamba/atrazine and glyphosate + saflufenacil/dimethenamid-p, reduced density and dry biomass of GR horseweed 99% and 100%, respectively. Mixture responses are similar to other studies that have shown that tiafenacil (25 and 50 g ai ha^{-1}) mixed with other herbicides such as metribuzin can reduce GR horseweed density as much as 94% and biomass 73% in soybean (Westerveld 2021). Metzger et al. (2019) found 98% to 100% reduction in density and dry biomass of GR horseweed with tolpyralate, dicamba/atrazine, tolpyralate + atrazine, and bromoxyil + atrazine in corn. Mahoney et al. (2017) reported 99% to 100% reduction in density and dry biomass of GR horseweed with bromoxynil + atrazine and dicamba/atrazine applied POST in corn.

In the same study, glyphosate mixtures with 2,4-D ester, mesotrione + atrazine, and topramezone + atrazine reduced density 89% to 96% and dry biomass 97% to 99% in corn (Mahoney et al. 2017).

In conclusion, glyphosate plus tiafenacil applied PP at 12.5, 25, and 37.5 g ai ha^{-1} alone or mixed with bromoxynil, dicamba, or tolpyralate caused no injury in corn. Reduced GR horseweed interference with all the herbicide treatments tested resulted in corn grain yield that was similar to the weed-free control. This research also suggests that tiafenacil applied alone is not as efficacious as the industry standards for the control of GR horseweed. However, the mixes of glyphosate + tiafenacil (25 or 37.5 g ai ha^{-1}) + bromoxynil, dicamba, or tolpyralate have the potential to provide acceptable GR horseweed control in corn, although in many cases not quite up to the levels of the industry standards, dicamba/atrazine or saflufenacil/dimethenamid-p. Mixing herbicides with different modes of action may help reduce the evolution of herbicide-resistant weeds.

Acknowledgments. The authors would like to thank the Grain Farmers of Ontario (GFO) for funding this research. No other conflicts of interest have been declared.

References

Anonymous (2020) Tiafenacil 339SC herbicide label. Concord, OH: ISK Biosciences Corporation. EPA Registration No. 71512. 18 p

Brown LR, Shropshire C, Sikkema PH (2016) Control of glyphosate-resistant Canada fleabane in corn with preplant herbicides. Can J Plant Sci 96:932–934

Budd CM (2016) Improving the Consistency of Glyphosate-resistant Canada fleabane (*Conyza canadensis*) Control with Saflufenacil: Distribution and Control in Soybean (*Glycine max*). M.Sc thesis. Guelph, ON: University of Guelph. 51 p

Budd CM, Soltani N, Robinson DE, Hooker DC, Miller RT, Sikkema PH (2016) Control of glyphosate resistant Canada fleabane with saflufenacil plus tankmix partners in soybean. Can J Plant Sci 96:989–994

Byker HP, Soltani N, Robinson DE, Tardif FJ, Lawton MB, Sikkema PH (2013) Control of glyphosate-resistant horseweed (*Conyza canadensis*) with dicamba applied preplant and postemergence in dicamba-resistant soybean. Weed Technol 27:492–496

Davis VM, Johnson WG (2008) Glyphosate-resistant horseweed (*Conyza canadensis*) emergence, survival, and fecundity in no-till soybean. Weed Sci 56:231–236

[EPA] Environmental Protection Agency (2020) EPA Proposes Registration of New Herbicide to Aid in Resistance Management. https://content.govdelivery.com/accounts/USAEPAOPPT/bulletins/298347a. Accessed: March 10, 2021

Ford L, Soltani N, Robinson DE, Nurse RE, McFadden A, Sikkema PH (2014) Canada fleabane (*Conyza canadensis*) control with preplant applied residual herbicides followed by 2,4-D choline/glyphosate DMA applied postemergence in corn. Can J Plant Sci 94:1231–1237

Hall MR, Swanton CJ, Anderson GW (1992) The critical period of weed control in grain corn (*Zea mays*). Weed Sci 40:441–447

Haring B, Hanson B (2020) Glufosinate and Tiafenacil Burndown Trial. University of California, Davis. https://ucanr.edu/repository/fileaccess.cfm?article=178644&p=NFLFGK. Accessed: March 19, 2020

Mahoney KJ, Shropshire C, Sikkema PH (2017) Post-emergence herbicides for control of glyphosate-resistant Canada fleabane in corn. Can J Plant Sci 97:206–209

Metzger BA, Soltani N, Raeder AJ, Hooker DC, Robinson DE, Sikkema PH (2019) Multiple herbicide-resistant horseweed (*Conyza canadensis*) dose response to tolpyralate and tolpyralate plus atrazine and comparison to industry standard herbicides in corn. Weed Technol 33:366–373

[OMAFRA] Ontario Ministry of Food and Rural Affairs (2017) Area, Yield, Production and Farm Value of Specified Field Crops, Ontario, 2012–2017 (Imperial and Metric Units). http://www.omafra.gov.on.ca/english/stats/crops/estimate_new.htm#metric. Accessed: March 19, 2020

Park J, Young OA, Jeong-Won N, Myoung KH, Namsook S, Taejoon K, Gyung-Hee Y, Soon-Kee S (2018) Biochemical and physiological mode of action of tiafenacil, a new protoporphyrinogen IX oxidase-inhibiting herbicide. Pestic Biochem Physiol 152:38–44

Soltani F, Dille JA, Burke IC, Everman WJ, VanGessel MJ, Davis VM, Sikkema PH (2016) Potential corn yield losses from weeds in North America. Weed Technol 30:979–984

Weaver SE (2001) The biology of Canadian weeds. 115. *Conyza canadensis*. Can J Plant Sci 81:867–875

Westerveld D (2021) Evaluation of Bromoxynil, Pyraflufen-ethyl/2,4-D, and Tiafenacil for the Control of Glyphosate-resistant Canada Fleabane (*Conzya canadensis*) in Soybean (*Glycine max*) and Metribuzin for the Control of Waterhemp (*Amaranthus tuberculatus*) with Two Mechanisms of Resistance to Photosystem II-inhibiting herbicides. M.Sc thesis. Guelph, ON: University of Guelph. 191 p. Westerveld_David_202103_MSc.pdf (uoguelph.ca). Accessed: March 24, 2020