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Canada fleabane (*Conyza Canadensis* L. Cronq.) in Ontario**

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SHORT COMMUNICATION

Distribution of glyphosate and cloransulam-methyl resistant Canada fleabane (*Conyza canadensis* L. Cronq.) in Ontario

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Abstract: From 2013-2015 a survey was conducted to document the distribution of GR and multiple-resistant Canada fleabane with resistance to glyphosate and cloransulam-methyl across Ontario. This survey shows that GR Canada fleabane is present throughout southern Ontario from Essex county in the southwest to Glengarry county adjacent to the Quebec border.

Key words: Canada fleabane, cloransulam-methyl resistant, distribution, glyphosate resistance, soybean, survey

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Abbreviations: GR, glyphosate resistant; PBL, Planetary Boundary Layer; WAA, weeks after application

Introduction

GR Canada fleabane was first reported in Delaware USA in 2001 (Shields et al. 2006). In Canada, it was first reported in Essex county Ontario in 2010 (Byker et al. 2013). Two years later, GR Canada fleabane was reported in Elgin, Essex, Haldimand, Huron, Kent, Lambton, Middlesex and Niagara counties and multiple-resistant Canada fleabane biotypes have been reported in Elgin, Essex, Kent, Lambton and Middlesex counties, these biotypes are resistant to glyphosate and cloransulam-methyl (Byker et al. 2013).

Canada fleabane is a member of the *Asteraceae* family, and can germinate in the fall or spring (Weaver 2001). With fall-germinated Canada fleabane the basal rosette formed in the fall, bolts in the spring (Frankton and Mulligan 1987). The first leaves of Canada fleabane are spatula-shaped and have many hairs on the upper leaf surface; mature leaves are also hairy but have an oblong to lance shape (Weaver 2001). The stem of Canada fleabane is unbranched at the base, covered in short bristly hairs (Loux et al. 2006), and can grow up to 180-cm in height in Canada (Frankton and Mulligan 1987). Towards the top of the stem, several short leafless branches form that contain small flower heads (3-to-5-mm in diameter) (Frankton and Mulligan 1987). The flowers are primarily self-pollinated and self-compatible (Weaver 2001).

For no-tillage crop production systems, herbicides are used to control GR Canada fleabane (Bruce and Kells 1990). Control of GR Canada fleabane with POST herbicides in soybean are not effective, or have limited control (Loux et al. 2006). Therefore it is desirable to use a PP herbicide with residual activity for GR Canada fleabane control in soybean (Loux et al. 2006). At 8 weeks after application (WAA), the most consistent control of multiple-resistant Canada fleabane in glyphosate-resistant soybean in Ontario was with a combination of glyphosate (900 g

a.i. ha⁻¹) plus saflufenacil (25 g a.i. ha⁻¹), plus the addition of either metribuzin (400 g a.i. ha⁻¹) or 2,4-D (500 g a.i. ha⁻¹) that provided 96 and 95% control, respectively (Budd et al. 2016).

Interference from GR Canada fleabane can reduce crop yields. Where no weed control strategies were implemented, grain corn yield can be reduced up to 69% from GR Canada fleabane interference (Ford et al. 2014). Soybean yield is most sensitive to GR Canada fleabane interference where yield loss can be up to 93% (Byker et al. 2013).

Several morphological features of GR Canada fleabane contribute to its rapid spread. A GR Canada fleabane plant can produce up to 230,000 seeds (Weaver 2001). Each of these seeds has a pappus, which is a structure that aids in wind-dispersal (Weaver 2001). Air movement is complex and can affect the movement of GR Canada fleabane seed with gusts and updrafts and most of the seeds (99%) were deposited within 100 m of the mother plant (Shields et al. 2006). Shields et al. (2006) also mentioned that the viable Canada fleabane seed was found in the Planetary Boundary Layer (PBL) and estimated that Canada fleabane seeds can travel 550 km.

Undisturbed soils in cropped and non-cropped areas are ideal for Canada fleabane establishment; the increased use of no-tillage crop production, especially for soybean, provides a large area for the spread of Canada fleabane (Nandula et al. 2006). The first reported survey for GR Canada fleabane in Ontario focused on the far southwest counties in the province (Byker et al. 2013). This study focused on all Ontario counties where soybean is grown that were not confirmed in the previous survey. Ontario farmers want to know the geographical distribution of resistant biotypes in the province so they may use this information when planning. The objective of this survey was to provide an update on the distribution of glyphosate and cloransulam-methyl-resistant Canada fleabane in the soybean growing regions of Ontario.

Materials and Methods

Seed Collection

Canada fleabane seed was collected from 27 sites in 2013, 54 sites in 2014, and 129 sites in 2015. This survey focused on counties where GR Canada fleabane was not confirmed from a survey in southwestern Ontario in 2011-2012 (Byker et al. 2013). The seed collection sites were identified by roadside surveying of fields with Canada fleabane escapes, or from agronomists and farmers who reported poor Canada fleabane control; following the methodology described in several surveys conducted in past (Byker et al. 2013).

Seed collection was completed in September and October of each year. The seed collection sites were primarily soybean fields, however some seed was collected from drybean, and harvested winter wheat and canola fields. The sites contained single to dense patches of Canada fleabane plants. Seeds were collected as a composite sample from approximately 20 plants (where possible) per site throughout the field. The field locations were recorded using a global positioning system (Garmin GPSMAP 76CSx).

Resistance Screening

Canada fleabane seed can readily germinate upon maturity, due to having no/low seed dormancy (Weaver 2001). Germination trays were filled with Sunshine Professional Growing Mix and then watered. Canada fleabane seed was spread over then covered with 0.5 mm of the soilless mixture to improve seed contact but allow light for germination (Nandula et al. 2006). The greenhouse was set to provide a 16 hour photoperiod and day/night temperature of 25 and 18°C, respectively. The trays were watered daily as needed.

Canada fleabane seedlings were transplanted at the three to four leaf stage into 10 cm diameter pots, one seedling per pot, filled with soilless potting mixture. For each sample, 35 plants were transplanted of which the 28 most uniform were selected and 12 were sprayed with glyphosate, 12 were sprayed with cloransulam-methyl and four were left untreated. Resistance screening examined if the Canada fleabane seedlings were resistant to glyphosate, or cloransulam-methyl; if the sample had at least one plant survive the glyphosate and one plant survive the cloransulam-methyl application, that site was classified as multiple-resistant (Byker et al. 2013). Herbicide applications were made when the Canada fleabane plants were at the rosette stage, 10 cm in diameter (Byker et al. 2013). Glyphosate was sprayed at $900 \text{ g a.e. ha}^{-1}$ and cloransulam-methyl was sprayed at $17.5 \text{ g a.i. ha}^{-1}$ + Agral 90 + UAN 28% in a spray chamber with a flat fan even nozzle calibrated to deliver 200 L ha^{-1} at 2.54 km hr^{-1} and 276 kPa. Herbicide dose was selected based on previous resistance screening work that was based on previous dose response work (Byker et al. 2013).

Previously determined susceptible populations of Canada fleabane from Middlesex county and a non-cropped area at the University of Guelph Ridgetown Campus were used as susceptible controls and sprayed at the same time as the sampled populations. Control ratings were recorded on a scale of 0 (no herbicide injury) to 100 (complete necrosis) at 4 and 5 weeks after application (WAA), plants were classified as dead (growing point was necrotic) or alive (Byker et al. 2013).

Results and Discussion

GR Canada fleabane was confirmed in 22 additional counties since the previous survey. After the application of glyphosate, the total number of sites with at least one plant surviving at 5 WAA was 27, 47, and 82 in 2013, 2014, and 2015 respectively (Table 1). In all years the

susceptible populations did not survive the herbicide applications (Data not shown). In 2013, four additional counties confirmed with GR Canada fleabane, Brant, Durham, Norfolk and Oxford (Figure 4). In 2014, 16 additional counties were confirmed with GR Canada fleabane: Hamilton, Perth, Waterloo, Wellington, Bruce, Dufferin, Peel, Halton, York, Peterborough, Northumberland, Hastings, Lennox Addington, Prince Edward, Ottawa, Stormont Dundas & Glengarry. (Figure 5). In 2015, two additional counties were identified with GR Canada fleabane, Simcoe and Frontenac (Figure 6). At the end of the 2015 growing season there were 30 counties in Ontario with GR Canada fleabane (Figure 6).

In 2013, 2014, and 2015 there were 4, 9, and 32 additional sites confirmed with multiple-resistant Canada fleabane with resistance to glyphosate and cloransulam-methyl (Table 1). Huron county was confirmed in 2013 with multiple-resistant Canada fleabane (Figure 4). In 2014, multiple-resistant Canada fleabane was confirmed in Northumberland, Perth, Peterborough, Waterloo and Wellington counties (Figure 5). In 2015, 11 counties were identified with multiple-resistant Canada fleabane including: Oxford, Norfolk, Brant, Haldimand, Niagara, Hamilton, Halton, Peel, York, Lennox Addington, Stormont Dundas & Glengarry. There are now 22 counties in Ontario with multiple-resistant Canada fleabane (Figure 6).

The geographic spread of GR Canada fleabane in Ontario since 2010-2012 (Byker et al. 2013) has been very rapid. Several factors such as the morphology of Canada fleabane, crop rotation, and weed control tactics contribute to the dispersal of GR Canada fleabane (Weaver 2000; Loux et al. 2006; Shields et al. 2006). Some morphological features include Canada fleabane being primarily self-pollinated and its ability to produce over 200,000 seeds (Weaver 2001), which can travel by wind due to an attached pappus on the seed and spread up to 500 km (Shields et al. 2006). Diverse crop rotations involve several factors that can help manage GR Canada fleabane;

such factors include intensive tillage, heavy crop residues, and use of competitive crops such as corn (*Zea mays* L.) or wheat (*Triticum spp.*) (Loux et al. 2006). Weed control tactics have become more simplified with the repeated use of glyphosate for weed control, which has created strong selection pressure for glyphosate resistance. The best herbicide option for managing GR Canada fleabane in soybean is a tankmix of saflufenacil with metribuzin, paraquat or dicamba (for dicamba-tolerant soybean only) as this provides consistent control and multiple modes of effective action (Budd et al. 2016). The best herbicide options for GR Canada fleabane control in corn in Ontario are the dicamba based herbicides while in wheat, pyrasulfotole plus bromoxynil is the most efficacious and safest option (Peter Sikkema, personal communication).

This survey provides updated information on the distribution of GR Canada fleabane throughout Ontario since 2012. This survey does not provide information on the frequency of GR Canada fleabane in Ontario since the methodology involved non-random site selection procedures. This survey was setup to investigate a very large geography, being all soybean-growing regions of Ontario not confirmed from the previous survey to provide an update for all Ontario soybean farmers. Investigating the frequency of GR Canada fleabane would have limited the geography of the survey due to our resources. With sites confirmed with GR Canada fleabane in Stormont, Dundas and Glengarry county, this means GR Canada fleabane is present up to 750 km away from where it was originally confirmed in Essex county in 2010 (Byker et al. 2013). Knowledge of GR Canada fleabane being present across the province of Ontario is important to farmers so that they can implement weed control tactics to manage resistant populations. The identification of Ontario counties with multiple-resistant Canada fleabane is also important for farmers as POST use of cloransulam-methyl in soybean was an option for control that should not be relied on now. Diversifying crop rotations or mixing herbicides with alternative modes of action is encouraged to manage resistant populations of Canada fleabane.

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Table 1. Number of sites per county with at least one plant surviving five weeks after application of glyphosate or cloransulam-methyl from greenhouse screening from a 2013-2015 survey of Canada fleabane in Ontario, Canada.

County	2013		2014		2015	
	G Res. ^{a,b}	G + C Res. ^b	G Res. ^b	G + C Res. ^b	G Res. ^b	G + C ^b Res.
Brant	4	0	-	-	8	3
Bruce	-	-	1	0	2	0
Dufferin	-	-	1	0	0	0
Durham	1	0	2	0	1	0
Elgin	6	1	-	-	-	-
Frontenac	-	-	-	-	1	0
Grey	-	-	0	0	0	0
Haldimand	-	-	-	-	10	3
Halton	-	-	1	0	4	1
Hamilton	-	-	5	0	5	2
Hastings	-	-	2	0	2	0
Huron	1	1	-	-	7	4
Kawartha Lakes	-	-	-	-	0	0
Leeds & Grenville	-	-	-	-	0	0
Lennox & Addington	-	-	2	0	4	1
Middlesex	4	2	-	-	-	-
Niagra	-	-	-	-	3	1
Norfolk	7	0	-	-	5	2
Northumberland	-	-	6	1	4	3
Ottawa	-	-	2	0	1	0

Oxford	4	0	1	0	5	4
Prince Edward	-	-	2	0	1	0
Peel	-	-	2	0	3	1
Perth	-	-	4	2	3	2
Peterborough	-	-	1	1	2	0
Prescott & Russell	-	-	-	-	0	0
Simcoe	-	-	0	0	2	0
Stormont, Dundas & Glengarry	-	-	1	0	1	1
Waterloo	-	-	4	3	3	3
Wellington	-	-	9	2	4	0
York	-	-	1	0	1	1
Total	27	4	47	9	82	32

^a G= Glyphosate (900 g a.i. ha⁻¹), C= Cloransulam-methyl (17.5 g a.i. ha⁻¹) applied with Agral 90 and UAN 28%.

^b A dash indicates that no samples were taken from that county in that year.

Figure Legends

Figure 1. Distribution of Multiple-resistant Canada fleabane in Ontario, Canada in 2013.

Figure 2. Distribution of Multiple-resistant Canada fleabane in Ontario, Canada in 2014.

Figure 3. Distribution of Multiple-resistant Canada fleabane in Ontario, Canada in 2015.

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Glyphosate (Group 9) Resistant

Glyphosate (Group 9) and Group 2 (e.g. FirstRate) Resistant