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Control of Canada fleabane (*Conyza canadensis*) with glyphosate DMA/2,4-D choline applications in corn (*Zea mays*)

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ABSTRACT

Glyphosate resistant (GR) Canada fleabane (horseweed) has quickly spread across southwestern Ontario and is a difficult weed to control in GR crops. Glyphosate dimethylamine (DMA)/2,4-D choline (Enlist Duo®™ Dow AgroSciences LLC), a new herbicide premix developed by Dow Agro Sciences, provides control of GR and other problematic weeds. The objective of this study was to compare single and sequential applications of glyphosate DMA/2,4-D choline for the control of GR Canada fleabane in GR corn. Three single applications of glyphosate (DMA)/2,4-D choline (1720 g·ae·ha^{-1}) were evaluated: 1) preplant (PP) applied to Canada fleabane up to 10 cm diameter/height, 2) postplant 1 (POST 1) applied when Canada fleabane was up to 20 cm tall and 3) postplant 2 (POST 2) applied up to 30 cm tall Canada fleabane. Four sequential applications were also examined:1) PP followed by (fb) POST 1, 2) PP fb POST 2, 3) POST 1 fb POST 2 and 4) PP fb POST 1 fb POST 2. The single applications provided 69% - 86% control of the GR Canada fleabane while the sequential applications increased control to 92% - 100%. Three applications did not provide an increase in control over a sequential two-pass application at 8 weeks after the application (WAA). Results from this research indicate that a sequential 2-pass application of glyphosate DMA/2,4-D choline provided acceptable control of GR Canada fleabane in corn.

KEYWORDS

Enlist; Glyphosate Resistant; Height; Injury; Seed Moisture; Yield

1. INTRODUCTION

Conyza canadensis, commonly known as Canada fleabane, horseweed or mare's tail, is a facultative winter annual weed meaning it is capable of germinating in the spring or autumn and over wintering as a rosette [1-3]. However, Canada fleabane is not limited in autumn and spring germination, as it has been reported to germinate year round as long as the environmental conditions are adequate for germination and emergence [1,3-5]. This weed is difficult to control with one herbicide application due to its year round germination. Canada fleabane was originally found in undisturbed soil such as roadsides and railways; a shift towards no-tillage farming operations has provided an excellent additional infield environment for this species [6].

The introduction of glyphosate resistant (GR) soybean in 1996 and GR corn in 1998 enabled post-emergence application of glyphosate on these crops [7-9]. GR crops supported the adoption of no-tillage practices, especially in soybean, allowing glyphosate to be the primary method of weed control replacing single and multiple tillage passes [10]. Glyphosate is the most widely used herbicide in agriculture because of its broad-spectrum weed control, low cost and wide margin of crop safety in GR crops [9,11]. However, the overuse of glyphosate has increased the selection for the resistant weed biotypes which has led to GR populations [12].

Glyphosate resistant Canada fleabane was first found in Delaware in 2000 [13]. It was first confirmed in Canada in the fall of 2010 making it the second confirmed GR weed in Canada following giant ragweed in 2008 [14,15]. Canada fleabane has quickly spread across southwestern Ontario, which has been related to its seed production (1 million seeds/plant) as well as its high long distance wind dispersal mechanisms [3,16]. The seed has been reported to travel hundreds of kilometers away from the parent plant due to the long pappus attached to the seed [17]. Canada fleabane's seed is non-dormant therefore it germinates shortly after seed release [1]. The rapid spread of GR Canada fleabane can be attributed to its high seed production, long distance dispersal and flexible germination requirements.

Alternative herbicides, including 2,4-D, are being investigated for the control of GR weeds, including Canada fleabane. 2,4-D is a systemic herbicide moving through both the phloem and xylem of the plant [18]. This herbicide acts upon the plant as a plant growth regulator hormone causing the sprayed susceptible plants to undergo uncontrolled plant growth, which results in a twisted appearance of the stem and petiole, and abnormal leaf development referred to as epinasty [18]. 2,4-D ester and amine formulations have been previously tested for the control of GR Canada fleabane. Kruger *et al*. [19] found that both 2,4-D amine and ester (560 g·ae·ha^{-1}) provided 90% or greater control of GR Canada fleabane. Byker *et al*. [20] determined that a tank mix of 2,4-D ester with glyphosate (500 + 900 g·ae·ha^{-1}) provided 78% - 92% control of GR Canada fleabane as a preplant application in soybean. Because Canada fleabane can germinate year round, the application timing of 2,4-D is essential for the control of this weed as 2,4-D does not provide extended residual control [21].

Glyphosate dimethylamine (**DMA**) salt/2,4-D choline salt (Enlist Duo®™ Dow Agro Sciences LLC) (894/826 g·ae·ha^{-1}) is a new product developed by Dow AgroSciences [18]. This herbicide premix solution allowing for the easy application of two different modes of action, has reduced odors and greater stability at lower storage temperatures compared to the 2,4-D amine and ester formulations [18]. Glyphosate DMA/2,4-D choline contains Colex-D technology which is the combination of the new choline salt formulation of 2,4-D[22]. This technology has been found to reduce drift (up to 90%) and volatility (92% less vapor loss) compared to 2,4-D ester[22]. Dow Agro Sciences is also developing glyphosate/2,4-D tolerant corn, soybean and cotton hybrids/cultivars which can rapidly metabolize the herbicide [18]. The effectiveness of glyphosate tank mixes with 2,4-D ester and amine to control GR Canada fleabane has been established [19,20], but there remains a paucity of information on the application of glyphosate DMA /2,4-D choline salt in the literature. The objective of this research is to determine the most effective application program of glyphosate DMA/2, 4-D choline for the control of GR Canada fleabane in corn (*Zea mays* L.) comparing single preplant and post plant applications as well as sequential applications.

2. MATERIALS AND METHODS

Six field trials were conducted over two consecutive years; 2012 and 2013. Canada fleabane seeds from these sites were confirmed to be glyphosate resistant through greenhouse experiments in 2011 and 2012 [14]. Two trials were near Windsor (L1 and L6), one near Ridgetown (L4) and three were near Harrow (L2, L3 and L5), Ontario, Canada. Weed control in five of the six field trials were included in the analysis as L6 (Windsor) was removed, due to very poor Canada fleabane population. Roundup Ready®™ (Monsanto) corn was no-tilled at all the six sites (L1 - L6). The planting information and soil characteristics for each site are summarized in **Table 1**.

The trials were set up in a randomized complete block design with four replications. Each plot was 2.5 meters wide and 8 meters long. Weedy and weed-free controls were included in each replication. The weed-free controls were maintained weed-free using a preplant application of glyphosate dimethylamine (DMA) (900 g·ae·ha^{-1}) plus flumetsulam (50 g·ae·ha^{-1}) and s-metolachlor/atrazine (1800 g·ae·ha^{-1}) followed by hand weeding as required. Glyphosate DMA/2,4-D choline (1720 g·ae·ha^{-1}) was investigated in this experiment, looking at different application timings and combinations for the control of GR Canada fleabane. Three single applications of glyphosate DMA/2,4-D choline (1720 g·ae·ha^{-1}) were examined as well as four sequential applications. The single applications included three timings: 1) preplant (PP), 2) postplant 1 (POST 1) and 3) postplant 2 (POST 2). The timing of these applications was dependent on GR Canada fleabane size and not corn leaf stage. The PP treatment was applied when the Canada fleabane averaged 10 cm in diameter. The POST 1 and POST 2 treatments were applied when the Canada fleabane in the weedy check was up to 20 cm and 30 cm in height, respectively. The diameter size was used to determine when the PP should be applied, but the plant bolted before it reached 20 cm in diameter so the height of Canada fleabane was utilized to determine when the POST applications were applied. The four sequential herbicide applications included: 1) PP application followed by (fb) POST 1, 2) PP fb POST 2, 3) POST 1 fb POST 2 and; 4) PP fb POST 1 fb POST 2. The date of the applications and the developmental corn stage at the time of the treatments is summarized in **Table 2**. Herbicide applications were applied with a CO_2 pressurized backpack sprayer calibrated to apply 200 L·ha^{-1} at 200 kPa. The boom width was 1.5 m with four

Table 1. Location information, soil characteristics, crop description and planting date for single versus sequential application of glyphosate DMA/2,4-D choline on Canada fleabane.

Location	Year	Nearest Town	Soil Texture	Soil % OM	Soil pH	Corn Hybrid	Planting Date	Planting Population (Seeds ha^{-1})	Row Spacing (cm)
L1	2012	Windsor	Sandy Loam	2.5	6.7	P0118AR	18-May-12	46930	76.2
L2	2012	Harrow	Loam	3.3	7.2	P0245	04-May-12	83900	76.2
L3	2012	Harrow	Loam	3.3	7.2	P0245	04-May-12	83900	76.2
L4	2013	Ridgetown	Loam	2.2	5.7	P 35F50	15-May-13	79781	96.5
L5	2013	Harrow	Sandy Loam	1.4	7.5	DK 49-94 RIB	22-May-13	79040	76.2
L6	2013	Windsor	Clay Loam	2.6	7.2	DK 49-94 RIB	07-Jun-13	79040	76.2

Table 2. Glyphosate DMA/2,4-D choline application dates and stage of corn at the time of the applications for the single and sequential program conducted in Ontario, Canada in 2012 and 2013.

Location	Year	Nearest Town	PP Date[a]	PO 1 Date[b]	PO 2 Date[c]	Corn Stage at PO 1 (leaf #)	Corn Stage at PO 2 (leaf #)	Canada fleabane density (m^{-2})
L1	2012	Windsor	14-May-12	30-May-12	08-May-12	3	5	262
L2	2012	Harrow	18-Apr-12	01-May-12	17-May-12	Preplant	2	24
L3	2012	Harrow	18-Apr-12	08-May-12	23-May-12	Preemerge	3	24
L4	2013	Ridgetown	09-May-13	29-May-13	17-Jun-13	3	7	309
L5	2013	Harrow	30-Apr-13	14-May-13	30-May-13	Preplant	Spike stage	241
L6	2013	Windsor	04-Jun-13	26-Jun-13	03-Jul-13	4	6	3

[a]PP stands for preplant application of glyphosate/2,4-D (1720 $g{\cdot}ae{\cdot}ha^{-1}$) applied on Canada fleabane up to 10 cm in diameter/height; [b]PO 1 stands for postplant application of glyphosate/2,4-D (1720 $g{\cdot}ae{\cdot}ha^{-1}$) applied on Canada fleabane up to 20 cm in height; [c]PO 2 stands for postplant application of glyphosate/2,4-D (1720 $g{\cdot}ae{\cdot}ha^{-1}$) applied on Canada fleabane up to 30 cm in height.

120-02 flat fan nozzles spaced 50 cm apart.

Control of GR Canada fleabane was assessed visually 1, 2, 4 and 8 weeks after the POST 2 application (WAA) and corn injury was assessed 1, 2 and 4 WAA. Canada fleabane control and corn injury was assessed using a 0 - 100% scale (0 representing no control or injury and100 representing complete Canada fleabane control or crop death). Corn injury was assessed to determine whether the glyphosate/2,4-D premix injures non-glyphosate/2,4-D tolerant corn, therefore making the tolerant corn necessary with this herbicide. Weed counts and weed dry weights were completed 8 WAA. Canada fleabane in two 0.25 m^2 quadratsper plot were counted and then cut at the soil surface. Weed dry matter for each treatment was determined by drying these samples for 2 weeks in a 60˚C dryer to a constant moisture and then weighed. Corn yields were taken when the crop was at physiological maturity by removing the cobs from 2 m row sections of both the weedy and weed free controls. Corn yields were not taken from the two Harrow locations (L2 and L3), as the plots were harvested by the farmer before they could be obtained. The corn was threshed in a stationary thresher, weighed and the moisture was recorded. Corn yields were adjusted to 15.5% moisture.

These data were subjected to an ANOVA using the SAS PROC MIXED procedure in SAS 9.1 program (SAS Institute Inc., Cary, NC). A Type I error of 0.05 was used for all statistical tests. The dependent variables (Canada fleabane control, density and dry weight, corn injury ratings and yield) were partitioned into random effects; environment, replication within the environment and the treatment by environment interaction and fixed effect, the glyphosate DMA/2,4-D choline treatment. F-tests and Z-tests were used to test the significance of the fixed and random effects, respectively. The significance of the environment by treatment interaction was used to determine whether the sites data could be combined. The residuals were plotted to determine if the ANOVA assumptions (errors are random, homogenous, and independent of effects and normally distributed) were met. Three transformations (natural log, square root and arcsine square root) were performed on all dependent variables if necessary to meet the ANOVA assumptions. Contrasts were preformed on these data to compare: (a) sequential applications to the single applications, and (b) the three pass program to the two pass program.

Glyphosate resistant Canada fleabane control data 1 WAA for sites L1, L2, L3 and L5 were transformed using

the arcsine square root transformation. The square root transformation was applied to L4 at 1 WAA. At 2 WAA the arcsine square root transformation was used for all the locations. The control ratings 4 WAA used the arcsine square root transformation for L1, L2, L3 and L5. Transformations were not necessary for L4 at 4 WAA. At 8 WAA the arcsine square root transformation was appropriate for all the sites. Density and dry weight data was transformed using the log transformation at L1, L2 and L3 and the square root transformation at L4 and L5. For the corn injury ratings at 1WAA sites L1 and L4 were transformed using the square root and no transformation was required for L6 injury. At 2 WAA the arcsine square root transformation was used for L1 and L4 and the square root transformation was required for L6 analysis. At 4 WAA, the arcsine square root transformation was used for L1 and L6. No transformations were necessary for corn yield data.

3. RESULTS AND DISCUSSION

All the single and sequential applications of glyphosate DMA/2,4-D choline (1720 g·ae·ha^{-1}) provided an improvement in control of GR Canada fleabane over the untreated control. The single preplant (PP) application-provided effective early control of the GR Canada fleabane 1 and 2 WAA, 74% - 91% and 79% - 84%, respectively (**Table 3**). These levels of control are similar to Eubank *et al*. [23] who determined that a preplant application of glyphosate plus 2,4-D ester (860 + 840 g·ae·ha^{-1}) provided 80-88% control of GR Canada fleabane 2 WAA. The sequential programs with a preplant treatment followed by (fb) a POST application provided 85% - 100% control 1 WAA and 99% - 100% 2 WAA (**Table 3**). These results are slightly higher than a sequential application of dicamba + glyphosate (300 + 900 g·ae·ha^{-1}) that provided 75% - 88% 1 WAA and 87% - 95% control 2 WAA [24]. The herbicide programs that did not include a PP application had delayed control of GR Canada fleabane. The corn in the treatments was stunted due to early GR Canada fleabane interference (Ford, Personal observation). Similar findings in soybeans reported a yield loss with a POST application of glufosinate + 2,4-D amine [25]. Symptoms observed on the GR Canada fleabane due to the glyphosate DMA/2,4-D choline application included epinasty of the growing point, overall yellowing and stunting compared to the weedy control.

At 4 WAA the PP, POST 1 and POST2 application of glyphosate/2,4-D provided 64% - 80%, 76% - 79% and 68% - 86% control of GR Canada fleabane, respectively. The two- and three-pass programs provided 97% - 100% and 100% control, respectively (**Table 4**). At 8 WAA the PP application of glyphosate/2,4-D provided 79% control, the POST 1 provided 77% - 84% and the POST 2 provided 71% - 93% control of the GR Canada fleabane (**Table 4**). In cases where the POST applications provided higher control than the PP application it was due to new emerging Canada fleabane after the PP application. These results indicate that the application of glyphosate/2,4-D to GR Canada fleabane at 10 cm in diameter and 20 or 30 cm in height results in similar control. Gly-

Table 3. Mean visual estimates and results of means contrasts of glyphosate resistant Canada fleabane control 1, 2 and 4weeks after single and sequential applications of glyphosate/2,4-D choline (1720 g·ae·ha^{-1}) in Ontario, Canada in 2012 and 2013.

Treatment[h]	Control 1 WAA[g]			Control 2 WAA		Control 4 WAA	
Glyphosate/2,4-D choline	L1, L2 and L3	L4	L5	L2, L3 and L5	L1 and L4	L1, L2, L3 and L5	L4
		(%)		(%)		(%)	
Untreated control	0 e	0 f	0 f	0e	0 e	0 e	0 d
Weed free control	100 a	100 a	100 a	100 a	100 a	100 a	100 a
Single applications: 1720 g·ae·ha^{-1}							
Preplant	91 b	74 d	88 c	84 b	79 c	80 d	64 c
POST 1	67 c	76 cd	75 d	73 c	80 c	79 d	76 b
POST 2	43 d	61 e	61 c	52 d	56 d	86 c	68 c
Sequential applications: 1720 g·ae·ha^{-1} fb 1720 g·ae·ha^{-1}							
Preplantfb POST 1	99 a	100 a	99 b	99 a	99 ab	97 b	100 a
Preplantfb POST 2	99 a	85 b	99 b	100 a	99 ab	100 a	100 a
POST 1 fb POST 2	72 c	82 bc	89 c	81 bc	98 b	100 a	98 a
Preplantfb POST 1 fb POST 2	100 a	100 a	100 a	100 a	100 a	100 a	100 a
Contrasts							
Single vs. sequential	69 vs. 97*	70 vs. 92*	76 vs. 99*	70 vs. 98*	72 vs. 99*	82 vs. 100*	69 vs. 99*
Two pass vs. three pass	94 vs. 100*	89 vs. 100*	97 vs. 100*	96 vs. 100*	99 vs. 100	99 vs. 100*	99 vs. 100

[a-f]Means followed by the same letter within the same column do not differ statistically according to Fisher's Protected LSD $P < 0.05$; [g]Abbreviations: L1, Windsor; L2, L3 and L5 Harrow; L4, Ridgetown; WAA, Week after application; [h]Preplant applied to Canada fleabane 10 cm height/diameter; POST 2 applied to Canada fleabane 20 cm in height; POST 2 applied to Canada fleabane 30 cm in height. *Denotes statistical significance $P < 0.05$.

Table 4. Means and results of means contrasts of glyphosate resistant Canada fleabane control 8 weeks after single and sequential glyphosate/2, 4-D choline (1720 g·ae·ha^{-1}) applications examined in Ontario Canada in 2012 and 2013.

Treatment[h]	Control 8 WAA[g]		Density		Dry Weight	
Glyphosate/2,4-D choline	L1, L2 and L3	L4 and L5	L1, L2 and L3	L4 and L5	L1, L2 and L3	L4 and L5
	(%)		(no. m^{-2})		(g·m^{-2})	
Untreated control	0 f	0 c	53.1 e	67.6 d	274 c	574 d
Weed free control	100 a	100 a	0 a	0 a	0 a	0 a
Single applications: 1720 g·ae·ha^{-1}						
Preplant	79 e	79 b	6.2 d	12.3 bc	7.4 b	19.7 bc
POST 1	84 e	77 b	4.9 cd	14.6 c	3.9 b	17.3 bc
POST 2	93 d	71 b	1.2 abc	57.0 d	0.5 a	28.6 c
Sequential applications 1720 g·ae·ha^{-1} fb 1720 g·ae·ha^{-1}						
Preplantfb POST 1	98 c	99 a	1.9 bcd	1.2 ab	0.66 a	1.54 abc
Preplantfb POST 2	99 bc	100 a	0.98 ab	0 a	0.18 a	0 ab
POST 1 fb POST 2	99 abc	100 a	0.29 ab	0.3 a	0.07 a	0.14 ab
Preplantfb POST 1 fb POST 2	100 ab	100 a	0.51 ab	0 a	0.08 a	0 ab
Contrasts						
Single vs. sequential	86 vs. 99*	76 vs. 100*	3.59 vs. 0.83*	24.6 vs. 0.34*	3.02 vs. 0.22*	21.5 vs. 0.33*
Two pass vs.three pass	99 vs. 100	100 vs. 100	0.96 vs. 0.5	0.47 vs. 0	0.28 vs. 0.08	0.46 vs. 0.0

[a-f]Means followed by the same letter within the same column do not differ statistically according to Fisher's Protected LSD P < 0.05; [g]Abbreviations: L1, Windsor; L2, L3 and L5 Harrow; L4, Ridgetown; WAA, Week after application; [h]Preplant applied to Canada fleabane 10 cm height/diameter; POST 2 applied to Canada fleabane 20 cm in height; POST 2 applied to Canada fleabane 30 cm in height. *Denotes statistical significance P < 0.05.

phosate DMA/2,4-D choline applied PP, POST1 or POST2 reduced GR Canada fleabane dry weight by 97%, 99% and 100% at L1,L2 and L3 and 97%, 97% and 95% at L4 and L5, respectively (**Table 4**). The two-pass and three-pass programs all reduced GR Canada fleabane dry weight greater than 99%. These findings are comparable to Kruger *et al*. [19] who found the control of GR Canada fleabane with 2,4-D ester was the same for plants ranging from 0 - 30 cm in height. The density of Canada fleabane, similar to the dry weight results, was greatly reduced with the two-pass program compared to the single applications. The sequential applications 4 and 8 WAA were 97% - 100% and 98% - 100%, respectively (**Table 4**). This study concludes that a sequential application of glyphosate DMA/2,4-D choline provides excellent control of GR Canada fleabane.

The single applications of glyphosate DMA/2,4-D choline (1720 g·ae·ha^{-1}) provided between 69% - 86% while the sequential programs provided 92% - 100% control of GR Canada fleabane 1 - 8 WAA (**Tables 3** and **4**). The sequential program improved control of GR Canada fleabane over a single application at all evaluation timings. The results from this study are consistent with those reported by Craigmyle *et al*. [25] who found two passes of glufosinate plus 2,4-D amine provided better control of problematic weeds over a single post plant application of these two herbicides. The three-pass program of glyphosate DMA/2,4-D choline provided better control of GR Canada fleabane than the two-pass program 1 and 2 WAA, but there was no benefit 4 and 8 WAA. Because Canada fleabane can germinate year round and 2,4-D does not provide extended residual activity, it is beneficial to apply two applications of this herbicide over a single application. Applying a PP fb either an early or late POST application would be most effective with Canada fleabane as it can be extremely competitive with the crop early in the season and can result in a yield loss.

There was no corn injury observed at sites L2, L3 and L5. Corn injury 1 WAA at L1 and L4 ranged from 0% - 6% while at L6 the injury was more severe and ranged from 0% - 64% (**Table 5**). Corn injury was observed when glyphosate DMA/2,4-D choline was applied to corn at the 4-leaf stage or later (**Table 2**). This is consistent with current recommendations in the Ontario Publication 75 [26], that states that 2,4-D amine can be applied on corn as an overall spray until the corn is 15 cm (leaf extended), which is equivalent to approximately the 4 leaf corn stage [27]. Injury included brittle stems (cases where it lodged), fused brace roots and some leaf tissue twisting making it difficult for new leaves to emerge. This injury was similar to the description from Wright *et al*. [28] of auxin-induced symptoms on other monocot crops. No corn injury was found at L2, L3 and L5 as the corn was below the 4-leaf stage at the time of the applications (**Table 2**). At L1 and L4, injury was observed on the treatments that received a POST 2 treatment because the corn was at the 5 and 7 leaf stage, respectively, at time of application (**Table 2**). More severe injury was found at L6 because the corn was at or past the 4-leaf stage at POST 1 and POST 2. Also, at this site the stems became very brittle after the POST 2 treatment increasing the corn's susceptibility to wind damage. The injury was

Table 5. Means of corn injury1, 2 and 4 weeks after application of glyphosate/2,4-D choline and corn yield investigated in Ontario, Canada in 2012 and 2013.

Treatment[d]	Injury 1 WAA[c]			Injury 2 WAA			Injury 4 WAA		Corn Yield
Glyphosate/2,4-D choline	L2, L3 and L5	L1 and L4	L6	L2, L3 and L5	L1 and L4	L6	L2, L3, L4 and L5	L1 and L6	L1
		(%)			(%)		(%)		(t ha^{-1})
Untreated control	N/S	0 a	0 a	N/S	0 a	0 a	N/S	0 a	0.66 b
Weed free control	N/S	0a	0 a	N/S	0 a	0 a	N/S	0 a	8.1 a
Single application: 1720 g·ae·ha^{-1}									
Preplant	N/S	0 a	0 a	N/S	0 a	0 a	N/S	0 a	-
POST 1	N/S	0 a	0 a	N/S	0 a	0 a	N/S	0 a	-
POST 2	N/S	6 b	63 b	N/S	4 b	29 b	N/S	0 a	-
Sequential applications: 1720 g·ae·ha^{-1} fb 1720 g·ae·ha^{-1}									
Preplantfb POST 1	N/S	0 a	0 a	N/S	0 a	0 a	N/S	0 a	-
Preplantfb POST 2	N/S	6 b	60 b	N/S	1 ab	27 b	N/S	3 a	-
POST 1 fb POST 2	N/S	6 b	64 b	N/S	2 ab	29 b	N/S	2 a	-
Preplantfb POST 1 fb POST 2	N/S	6 b	61 b	N/S	2 ab	28 b	N/S	6 a	-

[a-b]Means followed by the same letter within the same column do not differ according to Fisher's protected LSD $P < 0.05$; [c]Abbreviations: L1 and L6 Windsor; L2, L3 and L5 Harrow; L4, Ridgetown; N/S, Non significant; WAA, Weeks after application; [d]Preplant applied to Canada fleabane 10cm in diameter/height; POST 1 applied to Canada fleabane 20cm in height; POST 2 applied to Canada fleabane 30 cm in height.

transient with reduced injury observed at 2 and 4 WAA. There was 0% - 64%, 0% - 29% and 0% - 6% injury 1, 2 and 4 WAA, respectively (**Table 5**). 4 WAA, there was no longer corn injury observed at L4. Corn injury for L1 and L6 at 4 WAA ranged from 2% - 9% (**Table 5**) with the prominent injury being fused brace roots.

Canada fleabane interference with corn caused a 7.44 ton·ha^{-1} (92%) decrease in yield when comparing the weedy and the weed-free controls (**Table 5**). Similarly, Byker *et al*. [24] found an average soybean yield reduction of 80% - 92% from Canada fleabane competition. These are economically devastating yield losses and control strategies such as the glyphosate DMA/2,4-D choline system must be incorporated to control GR Canada fleabane.

4. CONCLUSION

A sequential application of glyphosate DMA/2,4-D choline was required for commercially acceptable control of GR Canada fleabane. Three applications of glyphosate DMA/2,4-D choline while it does provide excellent control of the Canada fleabane did not differ from the two applications 8 WAA. Starting with a PP application in a sequential program allows the crop to grow in a weed free environment. The second application in this program should be applied when the later flush of GR Canada fleabane reaches 10 cm in diameter to minimize weed interference. Early herbicide applications could result in late emerging weeds, as 2,4-D does not provide extended residual weed control, degrading within 18 - 38 days [29] (Bolan and Baskaran, 1996). Sequential applications of glyphosate DMA/2,4-D choline should not be the only weed management strategy used year after year to reduce the possibility of selecting for resistant biotypes. Some Canada fleabane populations have already shown tolerance to 2,4-D and proper herbicide rotation should be utilized [6]. To prevent corn injury from 2,4-D choline after the 4-leaf stage, corn seed with the glyphosate/2,4-D trait should be used with the glyphosate DMA/2,4-D mixture.

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Abbreviations

GR: Glyphosate Resistant;
POST: Postemergence;
PP: Preplant;
PRE: Preemergence;
WAA: Week After herbicide Application

