

# Effect of Class Act NG Adjuvant on Glyphosate Efficacy in Corn

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Received: August 9, 2023

Accepted: September 5, 2023

Online Published: October 15, 2023

doi:10.5539/jas.v15n11p1

URL: <https://doi.org/10.5539/jas.v15n11p1>

## Abstract

There is little information on the effect of the co-application of glyphosate with Class Act NG adjuvant on weed control efficacy and corn yield under Ontario environmental conditions. This study consisted of 6 field experiments that were conducted in Ontario during 2021 and 2022 to determine if the addition of Class Act NG (2.5% v/v) to glyphosate at 450, 900 and 1350 g ae ha<sup>-1</sup> would improve weed control and result in a concomitant increase in corn yield. The co-application of glyphosate with Class Act NG resulted in no visible corn injury at 1 and 4 weeks after herbicide application (WAA). The addition of Class Act NG to glyphosate at 450 g ae ha<sup>-1</sup> improved control of common lambsquarters, velvetleaf, Powell amaranth, common ragweed, and barnyardgrass as much as 20, 14, 9, 8, and 7%, respectively but there was no improvement in control of giant foxtail, or green foxtail and there was no increase in corn yield. The addition of Class Act NG to glyphosate at 900 g ae ha<sup>-1</sup> improved common lambsquarters control 6 and 5% at 4 and 8 WAA, respectively and improved barnyardgrass control 4% at 4 WAA. The addition of Class Act NG to glyphosate at 1350 g ae ha<sup>-1</sup> provided no improvement in control of velvetleaf, Powell amaranth, common ragweed, common lambsquarters, barnyardgrass, giant foxtail, or green foxtail and there was no increase in corn yield. Based on this data the co-application of glyphosate with Class Act NG results in improved control of some annual broadleaf and grass weeds (common lambsquarters, velvetleaf, Powell amaranth, common ragweed and barnyardgrass) when glyphosate is applied at 450 or 900 g ae ha<sup>-1</sup>; however, when glyphosate is applied at 1350 g ae ha<sup>-1</sup> there was no improvement in weed control. The addition of Class Act NG to glyphosate at 450, 900 and 1350 g ae ha<sup>-1</sup> did not result in an increase in corn yield.

**Keywords:** barnyardgrass, common lambsquarters, common ragweed, giant foxtail, green foxtails, Powell amaranth, velvetleaf

## 1. Introduction

Corn (*Zea mays* L.) is one of the most valuable and dominant grain crops in the world that is grown for human and animal food, biofuel, and other industrial uses (Baker, 2018). Ontario is the main corn-producing province in Canada. Most of the corn produced in Ontario is used for animal feed (60%) and the remainder is used for various industrial uses (40%) (OMAFRA, 2023a).

Ontario farmers seed approximately 820,000 hectares of grain corn with a farm-gate value of approximately \$1.6 billion annually (OMAFRA, 2023b; Soltani et al., 2022). Weed interference can reduce corn yield dramatically; consequently, effective weed management programs are essential for profitable corn production. A meta-analysis by the Weed Science Society of America (WSSA) determined that corn producers in North America would lose 50% of their production (148 million tonnes) with a value of US\$26.7 billion if no weed management tactics are implemented (Soltani et al., 2016a). Despite the rapid evolution of glyphosate-resistant (GR) weeds from the repeated use of glyphosate in GR crops, many crop producers continue to depend on glyphosate as a major component of their weed management programs due to its excellent weed control efficacy, wide margin of crop safety, no residues affecting future crops in the rotation, low environmental impact, and low cost (Beckie et al., 2014; Sikkema & Soltani, 2007). Currently, more than 95% of the corn in Ontario is seeded GR hybrids (Beckie et al., 2014).

Glyphosate provides effective, broad-spectrum control of annual, biennial, and perennial grass and broadleaf weeds. However, there has been variable weed control; one reason for the variable control is attributed to the quality of water used for the herbicide carrier (Pratt et al., 2003; Thelen et al., 1995). Some studies have concluded that the inclusion of additives such as ammonium sulfate (AMS) could help improve the weed control

efficacy with glyphosate for the control of some weed species especially when glyphosate is applied at low rates (Nurse et al., 2008; Soltani et al., 2011, 2016b). It has been suggested that the negatively charged sulfate ion ( $\text{SO}_4^{--}$ ) from water conditioners that include AMS can bind to the positively charged cations in water including calcium, iron, magnesium, potassium, and sodium present in water thus preventing them from binding to the negatively charged glyphosate which results in increased herbicide absorption and subsequent greater weed control efficacy (Thelen et al., 1995; Winfield United, 2023). Hall et al. (2000) reported that the addition of AMS to glyphosate is necessary to adequately control weeds such as velvetleaf regardless of water hardness.

Class Act NG is a new adjuvant marketed by Winfield Solutions, LLC (Winfield Solutions, LLC, St. Paul, MN, USA) as a water conditioner and surfactant spreader sticker for use with some herbicides including glyphosate (Winfield United, 2023). According to the label, Class Act NG contains 50.5% ammonium sulfate, corn syrup, alkyl polyglucoside, and 45.5% constituents that are ineffective as spray adjuvants (Winfield Solutions, 2023). In addition to AMS, Class Act NG includes a nonionic surfactant (CornSorb<sup>®</sup> Technology, Winfield Solutions, LLC, St. Paul, MN, USA) and antifoaming agent in a liquid premix (Winfield Solutions, 2023). Class Act NG as a hard water conditioner is designed to help the movement of the herbicide across the non-living leaf cuticle into living plant cells (Winfield Solutions, 2023). There is little information on the effect of Class Act NG on weed control efficacy with glyphosate for the control of common, wide-spread, annual grass and broadleaf weeds in corn under Ontario environmental conditions. This data is imperative so Ontario corn producers can make science-based decisions to maximize weed control efficacy and corn yield while minimizing weed management costs.

The objective of this study was to ascertain if the addition of Class Act NG to glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> would improve the control of common weeds in Ontario including velvetleaf, Powell amaranth, common ragweed, common lambsquarters, barnyardgrass, giant foxtail, and green foxtail.

## 2. Materials and Methods

Six field experiments (3 in 2021 and 3 in 2022) were conducted at Huron Research Station, Exeter, ON, and the University of Guelph, Ridgetown Campus, Ridgetown, Ontario. Detailed information including soil characteristics, corn seeding and emergence dates, herbicide application dates, and weather conditions at herbicide application for each site are listed in Table 1. Seedbed preparation included fall mouldboard plowing followed by two passes with a field cultivator with rolling basket harrows in the spring.

Table 1. Year, location, soil characteristics, corn seeding and emergence dates, herbicide application dates, and weather conditions at application for six experiments conducted in Ontario, Canada in 2021 and 2022

Year	Location	Texture	Soil characteristics <sup>a</sup>					Seeding date	Emergence date	Application date	Application weather conditions			
			Sand	Silt	Clay	Organic matter	pH				Air temperature	Relative humidity	Wind speed	
												-----	%	-----
E1	2021	Ridgetown A	Loam	33	31	36	4.1	7.3	May 14	May 21	June 11	24.7	69.7	4.3
E2	2021	Ridgetown B	Clay loam	27	38	35	4.2	7.4	May 18	May 23	June 16	24.0	43.1	1.2
E3	2021	Exeter	Clay loam	29	44	27	4.4	7.9	April 27	May 17	June 2	20.4	59.1	1.5
E4	2022	Ridgetown A	Clay loam	30	31	39	4.7	7.2	May 12	May 19	June 15	26.6	81.0	7.8
E5	2022	Ridgetown B	Loam	26	36	38	4.1	7.3	May 13	May 20	June 17	24.2	57.1	6.9
E6	2022	Ridgetown C	Sandy loam	74	15	11	3.1	6.4	May 12	May 19	June 15	29.5	78.1	2.9

Note. <sup>a</sup> Soil cores were extracted to a depth of 15 cm and analyzed by A&L Canada Laboratories Inc. (2136 Jetstream Road, London, ON) to determine soil characteristics.

Experiments were established as a randomized complete block design with four replications. Treatments included a weedy control and glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> applied alone or with Class Act NG adjuvant at 2.5% v/v (Tables 2-4). Each plot was 3 m wide and 8 or 10 m long and consisted of four rows spaced 0.75 m apart of GR 'DKC39-97 RIB'/'DKC 42-04RIB' corn. Corn was planted at a rate of approximately 85,000 seeds ha<sup>-1</sup>.

Herbicide treatments were applied postemergence when weeds were approximately 10 cm in height (V2-4 corn growth stage) using a CO<sub>2</sub>-pressurized backpack sprayer calibrated to deliver 200 L ha<sup>-1</sup> aqueous solution at 240

kPa. The boom was 1.5 m wide with four ULD120-02 nozzles (Hypro, New Brighton, MN, USA) spaced 0.5 m apart producing a spray width of 2.0 m.

Corn injury was visually evaluated 1 and 4 weeks after herbicide application (WAA) and weed control was visually evaluated 4 and 8 WAA on a scale of 0 (no injury/control) to 100% (complete necrosis/control). Corn was combined at harvest maturity with a small plot combine; weight and seed moisture content were recorded. Corn yield was adjusted to 15.5% seed moisture content prior to analysis.

Data analyses were conducted using the GLIMMIX procedure in SAS Studio v9.4, OnDemand for Academics (SAS Institute, Cary, NC) with a significance level of 0.05. Data were pooled across environments. The fixed effect of herbicide treatment and the random effects of environment (location-year combinations), block nested within environment, and the environment-by-treatment interaction accounted for model variance. Treatments with zero variance were excluded from analyses. Visual estimates of weed control at 4 and 8 WAA were analyzed for each species using a Gaussian (identity link), beta (logit link), or binomial (complementary log-link or probit link) distribution. When required, data were arcsine square-root transformed prior to analysis. Corn yield was analyzed using a Gaussian distribution (identity link). Pearson chi-square/degrees of freedom ratio and Shapiro-wilk statistic were used to evaluate model fitness and identify potential overdispersion of residuals, respectively. Plots of normal probability and studentized residuals were generated to verify assumptions of normality and homogeneity of variance, respectively. Non-orthogonal contrasts were used to evaluate the effect of Class Act NG on glyphosate efficacy. All treatments were independently compared to zero using a t-test. Tukey-Kramer multiple range test was used to separate least square means. Data transformed using the arcsine square root function were back-transformed post-analysis.

### 3. Results and Discussion

Data were pooled and averaged over years and locations when there was no statistically significant interaction between year, location, and treatments (Tables 2-4). Weeds were included when present in 2 or more sites.

#### 3.1 Corn Injury

At 1 and 4 WAA, there was no visible corn injury with any of the herbicide treatments evaluated (data not presented). This is consistent with other studies showing no/minimal corn injury from glyphosate applied alone or co-applied with AMS (Nurse et al., 2008; Soltani et al., 2011, 2016b).

#### 3.2 Velvetleaf (*ABUTH*)

Glyphosate (450 g ae ha<sup>-1</sup>) controlled velvetleaf 78% at 4 WAA and 81% at 8 WAA; the addition of Class Act NG improved control 14% at 8 WAA (Table 2). Glyphosate (900 g ae ha<sup>-1</sup>) controlled velvetleaf 91% and 4 WAA and 97% at 8 WAA; the addition of Class Act NG did not significantly improve control (Table 2). Glyphosate (1350 g ae ha<sup>-1</sup>) controlled velvetleaf 97% at 4 WAA and 99% at 8 WAA; the addition of Class Act NG adjuvant did not significantly improve control (Table 2). Based on non-orthogonal contrasts, averaged across all glyphosate rates, the addition of Class Act NG to glyphosate improved velvetleaf control 7% at 4 WAA and 3% at 8 WAA (Table 2). In other studies, the addition of AMS to glyphosate applied at 450, 675, or 900 g ae ha<sup>-1</sup> provided little or no improvement in velvetleaf control (Soltani et al., 2016b). Soltani et al. (2011) observed no benefit from the addition of AMS to glyphosate (900 g ae ha<sup>-1</sup>) for the control of velvetleaf in corn. However, Pratt et al. (2003) reported that velvetleaf control can be improved up to 70% when added to 280 g ae ha<sup>-1</sup> of glyphosate; however, this is 31% of the lowest registered rate in Ontario. Nurse et al. (2008) and Young et al. (2003) also reported that the addition of AMS to glyphosate, at doses of < 450 g ae ha<sup>-1</sup> (half the label rate) can improve velvetleaf control. Hall et al. (2000) reported that the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate at 125, 250, 500 or 1000 g ae ha<sup>-1</sup> can improve velvetleaf control regardless of water hardness.

Table 2. Visible control and non-orthogonal contrasts for velvetleaf (ABUTH), Powell amaranth (AMAPO), and common ragweed (AMBEL) 4 and 8 weeks after application (WAA) of glyphosate and glyphosate plus Class Act NG adjuvant applied postemergence in corn in field trials across Ontario, Canada in 2021 and 2022

Herbicide treatment	Rate	Control					
		ABUTH		AMAPO		AMBEL	
		4 WAA	8 WAA	4 WAA	8 WAA	4 WAA	8 WAA
	g ae ha <sup>-1</sup>	%					
Untreated control	-	0 c	0 c	0 c	0 c	0 d	0 c
Glyphosate	450	78 b	81 b	89 b	91 b	81 c	80 b
Glyphosate + Class Act NG <sup>b</sup>	450	90 ab	95 a	98 a	98 a	88 bc	88 ab
Glyphosate	900	91 ab	97 a	99 a	98 a	90 ab	90 a
Glyphosate + Class Act NG	900	98 a	99 a	99 a	99 a	93 ab	93 a
Glyphosate	1350	97 ab	99 a	99 a	99 a	95 ab	95 a
Glyphosate + Class Act NG	1350	98 a	99 a	99 a	99 a	95 a	94 a
<i>Contrasts</i>							
Glyphosate vs. glyphosate + Class Act NG	450	78 vs. 90 NS	81 vs. 95**	89 vs. 98**	91 vs. 98 **	81 vs. 88*	80 vs. 88*
Glyphosate vs. glyphosate + Class Act NG	900	91 vs. 98 NS	97 vs. 99 NS	99 vs. 99 NS	98 vs. 99 NS	90 vs. 93 NS	90 vs. 93 NS
Glyphosate vs. glyphosate + Class Act NG	1350	97 vs. 98 NS	99 vs. 99 NS	99 vs. 99 NS	99 vs. 99 NS	95 vs. 95 NS	95 vs. 94 NS
Glyphosate vs. glyphosate + Class Act NG <sup>d</sup>		90 vs. 97*	95 vs. 98**	97 vs. 99*	97 vs. 99*	89 vs. 93 *	89 vs. 92 NS

Note. Abbreviations: WAA; weeks after application.

<sup>a</sup> The nontreated control was excluded from visible control analyses; herbicide tank-mixtures were compared to the nontreated control using p-values generated from Least Square Means comparisons.

<sup>b</sup> Class Act NG was included at 2.5% v/v (Winfield Solutions, LLC, St. Paul, MN, USA).

<sup>c</sup> Means followed by the same letter within a column are not significantly different according to Tukey-Kramer multiple range test ( $P > 0.05$ ).

<sup>d</sup> Averaged across all treatment levels.

\* significant at  $P < 0.05$ , \*\* significant at  $P < 0.01$ .

### 3.3 Powell Amaranth (AMPO)

Glyphosate (450 g ae ha<sup>-1</sup>) controlled Powell amaranth 89% at 4 WAA and 91% at 8 WAA; the addition of Class Act NG improved control 9% at 4 WAA and 7% at 8 WAA (Table 2). Glyphosate at 900 g ae ha<sup>-1</sup> or 1350 g ae ha<sup>-1</sup> controlled Powell amaranth 98-99% at 4 and 8 WAA; non-orthogonal contrasts indicated that the addition of Class Act NG to glyphosate at 900 g ae ha<sup>-1</sup> or 1350 g ae ha<sup>-1</sup> provided no improvement of Powell amaranth at 4 or 8 WAA (Table 2). Averaged across all glyphosate rates, the addition of Class Act NG to glyphosate improved Powell amaranth control 2% at 4 and 8 WAA (Table 2). These results are similar to other studies in which redroot pigweed was controlled 95-100% when glyphosate was applied with or without 2% AMS at rates of at least 450 g ae ha<sup>-1</sup> (Guza et al., 2002; Krausz et al., 1996). In other studies, the addition of AMS to glyphosate applied at 450, 675, or 900 g ae ha<sup>-1</sup> did not improve redroot pigweed control in corn (Soltani et al., 2016b). Another study also found no benefit from the addition AMS (2.5 L ha<sup>-1</sup>) to glyphosate (900 g ae ha<sup>-1</sup>) for the control of pigweed in corn (Soltani et al., 2011). Mahoney et al. (2014) reported that the addition of AMS to glyphosate applied at 900 g ae ha<sup>-1</sup> regardless of the carrier water hardness provided negligible effects on pigweed control in corn. Nurse et al. (2008) reported improvement in the control of redroot pigweed at 2 WAA when AMS was added to glyphosate at 225 g ae ha<sup>-1</sup> (25% of the lowest label rate in Ontario).

### 3.4 Common Ragweed (AMBEL)

Glyphosate (450 g ae ha<sup>-1</sup>) controlled common ragweed 81% at 4 WAA and 80% at 8 WAA; based on non-orthogonal contrasts the addition of Class Act NG improved common ragweed control 7 and 8% at 4 and 8 WAA, respectively (Table 2). Glyphosate at 900 and 1350 g ae ha<sup>-1</sup> controlled common ragweed 90 and 95%, respectively at 4 and 8 WAA; the addition of Class Act NG provided no improvement in common ragweed control at 4 or 8 WAA (Table 2). Based on non-orthogonal contrasts, averaged across all glyphosate rates, the addition of Class Act NG to glyphosate improved common ragweed control 4% at 4 WAA but provided no improvement of common ragweed control at 8 WAA (Table 2). Results are similar to other studies where glyphosate applied at 450, 675, and 900 g ae ha<sup>-1</sup> controlled common ragweed 80-97%, 85-99%, and 86-99%, respectively; the addition of AMS (2.5 L ha<sup>-1</sup>) provided little to no added benefit for the control of common

ragweed in corn (Soltani et al., 2016b). Another study also found no benefit from the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate (900 g ae ha<sup>-1</sup>) for the control of common ragweed in corn (Soltani et al., 2011).

### 3.5 Common Lambsquarters (CHEAL)

Glyphosate (450 g ae ha<sup>-1</sup>) controlled common lambsquarters 77% at 4 WAA and 70% at 8 WAA; the addition of Class Act NG improved control 14% at 4 WAA and 20% at 8 WAA (Table 3). Non-orthogonal contrasts indicated that the addition of Class Act NG to glyphosate (900 g ae ha<sup>-1</sup>) improved common lambsquarters control 6% at 4 WAA and 5% at 8 WAA (Table 3). The addition of Class Act NG to glyphosate (1350 g ae ha<sup>-1</sup>) did not improve common lambsquarters control at 4 or 8 WAA (Table 3). Averaged across all glyphosate rates, the addition of Class Act NG to glyphosate improved common lambsquarters control 6% at 4 WAA and 7% at 8 WAA (Table 3). Results are similar to other studies where glyphosate applied at 450, 675, and 900 g ae ha<sup>-1</sup> controlled common lambsquarters 91-99%, 93-100%, and 94-100%, respectively and the addition of AMS (2.5 L ha<sup>-1</sup>) did not result in improved control of common lambsquarters with glyphosate at high rates in corn (Soltani et al., 2016b). Another study has also shown no benefit with the addition AMS (2.5 L ha<sup>-1</sup>) to glyphosate at 900 g ae ha<sup>-1</sup> (label rate) for the control of common lambsquarters in corn (Soltani et al., 2011). Nurse et al. (2008) reported that the addition of 2% AMS to glyphosate at rates below 450 g ae ha<sup>-1</sup> can improve common lambsquarters control but there is no improvement in the control when glyphosate is applied at rates above 450 g ae ha<sup>-1</sup>.

Table 3. Visible control and non-orthogonal contrasts for common lambsquarters (CHEAL), barnyardgrass (ECHCG), and giant foxtail (SETFA) 4 and 8 weeks after application (WAA) of glyphosate and glyphosate plus class act NG applied postemergence in corn in field trials across Ontario, Canada in 2021 and 2022

Herbicide treatment	Rate	Control					
		CHEAL		ECHCG		SETFA	
		4 WAA	8 WAA	4 WAA	8 WAA	4 WAA	8 WAA
	g ae ha <sup>-1</sup>	%					
Untreated control	-	0 d	0 d	0 c	0 b	0 b	0 b
Glyphosate	450	77 c	70 c	85 b	82 a	85 a	98 a
Glyphosate + Class Act NG <sup>b</sup>	450	91 b	90 b	92 ab	90 a	99 a	99 a
Glyphosate	900	91 b	91 ab	91 ab	89 a	100 a	99 a
Glyphosate + Class Act NG	900	97 ab	96 ab	95 a	93 a	100 a	100 a
Glyphosate	1350	97 ab	96 ab	95 a	93 a	100 a	100 a
Glyphosate + Class Act NG	1350	98 a	97 a	95 a	93 a	100 a	100 a
<i>Contrasts</i>							
Glyphosate vs. glyphosate + Class Act NG	450	77 vs. 91**	70 vs. 90**	85 vs. 92*	82 vs. 90 NS	85 vs. 99 NS	98 vs. 99 NS
Glyphosate vs. glyphosate + Class Act NG	900	91 vs. 97*	91 vs. 96*	91 vs. 95*	89 vs. 93 NS	100 vs. 100 NS	99 vs. 100 NS
Glyphosate vs. glyphosate + Class Act NG	1350	97 vs. 98 NS	96 vs. 97 NS	95 vs. 95 NS	93 vs. 93 NS	100 vs. 100 NS	100 vs. 100 NS
Glyphosate vs. glyphosate + Class Act NG <sup>d</sup>		90 vs. 96**	88 vs. 95**	91 vs. 94**	88 vs. 92 NS	95 vs. 99 NS	99 vs. 100 NS

Note. Abbreviations: WAA; weeks after application.

<sup>a</sup> The nontreated control was excluded from visible control analyses; herbicide tank-mixtures were compared to the nontreated control using p-values generated from Least Square Means comparisons.

<sup>b</sup> Class Act NG was included at 2.5% v/v (Winfield Solutions, LLC, St. Paul, MN, USA).

<sup>c</sup> Means followed by the same letter within a column are not significantly different according to Tukey-Kramer multiple range test ( $P > 0.05$ ).

<sup>d</sup> Averaged across all treatment levels.

\* significant at  $P < 0.05$ , \*\* significant at  $P < 0.01$ .

### 3.6 Barnyardgrass (ECHCG)

Glyphosate (450 g ae ha<sup>-1</sup>) controlled barnyardgrass 85% at 4 WAA and 82% at 8 WAA; based on non-orthogonal contrasts the addition of Class Act NG adjuvant improved barnyardgrass control 7% at 4 WAA (Table 3). Glyphosate (900 g ae ha<sup>-1</sup>) controlled barnyardgrass 91% at 4 WAA and 89% at 8 WAA; based on non-orthogonal contrasts the addition of Class Act NG adjuvant improved barnyardgrass control 4% at 4 WAA (Table 3). Glyphosate at 1350 g ae ha<sup>-1</sup> controlled barnyardgrass 95 and 93% at 4 and 8 WAA, respectively; the addition of Class Act NG adjuvant provided no improvement in control of barnyardgrass at 4 or 8 WAA (Table

3). Non-orthogonal contrasts indicated that the addition of Class Act NG adjuvant to glyphosate (averaged across all rates) improved barnyardgrass control 3% at 4 WAA but provided improved control at 8 WAA (Table 3). Results are similar to another study where glyphosate applied at 450, 675, and 900 g ae ha<sup>-1</sup> controlled barnyardgrass 90-98%, 95-100%, and 97-100%, respectively (Soltani et al., 2016b); the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate did not improve barnyardgrass control in corn (Soltani et al., 2016b). Another study also found no benefit in the control of annual grasses including barnyardgrass with the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate applied at 900 g ae ha<sup>-1</sup> in corn (Soltani et al., 2011).

### 3.7 Giant Foxtail (*SETFA*)

Glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> controlled giant foxtail 85, 100, and 100%, respectively at 4 WAA; the addition of Class Act NG did not improve giant foxtail control (Table 3). Glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> controlled giant foxtail 98, 99, and 100%, respectively at 8 WAA; the addition of Class Act NG did not improve giant foxtail control (Table 3). Based on non-orthogonal contrasts, averaged across all glyphosate rates, the addition of Class Act NG to glyphosate provided no improvement in giant foxtail control at 4 and 8 WAA (Table 3). Nurse et al. (2008) reported that the addition of 2% AMS to glyphosate at rates above 225 g ae ha<sup>-1</sup> provides no improvement in the control of annual grasses (including foxtails) in corn. In another study, orthogonal contrasts indicated that there was no improvement in the percent control of annual grasses such as foxtails when AMS (2.5 L ha<sup>-1</sup>) was added to glyphosate (900 g ae ha<sup>-1</sup>) using water sources with various hardness 2, 4, and 8 WAA (Soltani et al., 2011).

### 3.8 Green Foxtail (*SETVI*)

Glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> controlled green foxtail 88, 96, and 98%, respectively at 4 WAA; the addition of Class Act NG did not improve green foxtail control (Table 4). Glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> controlled green foxtail 92, 96, and 97%, respectively at 8 WAA; the addition of Class Act NG did not improve green foxtail control (Table 4). Based on non-orthogonal contrasts, averaged across all glyphosate rates, the addition of Class Act NG to glyphosate provided no improvement in green foxtail control at 4 and 8 WAA (Table 4). Results are similar to other studies where glyphosate applied at 450, 675, and 900 g ae ha<sup>-1</sup> controlled green foxtail 91-100%, 96-100%, and 97-100%, respectively and the addition of AMS (2.5 L ha<sup>-1</sup>) provided no improvement in the control of green foxtail in corn (Soltani et al., 2016b). Another study also found no benefit in the control of green foxtail in corn with the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate (900 g ae ha<sup>-1</sup>) (Soltani et al., 2011).

Table 4. Visible control of green foxtail (SINAR) 4 and 8 weeks after application (WAA), corn grain yield, and non-orthogonal contrasts from glyphosate and glyphosate plus Class Act NG applied postemergence in corn in field trials across Ontario, Canada in 2021 and 2022

Herbicide treatment	Rate	Control		Yield
		SETVI		
		4 WAA	8 WAA	
	g ae ha <sup>-1</sup>	-----	% -----	kg ha <sup>-1</sup>
Untreated control	-	0 b	0 b	3,550 b
Glyphosate	450	88 a	92 a	9,290 a
Glyphosate + Class Act NG <sup>b</sup>	450	96 a	96 a	10,210 a
Glyphosate	900	96 a	96 a	10,490 a
Glyphosate + Class Act NG	900	97 a	97 a	10,440 a
Glyphosate	1350	98 a	97 a	10,480 a
Glyphosate + Class Act NG	1350	98 a	97 a	10,320 a
<i>Contrasts</i>				
Glyphosate vs. glyphosate + Class Act NG	450	88 vs. 96 NS	92 vs. 96 NS	9,290 vs. 10,210 NS
Glyphosate vs. glyphosate + Class Act NG	900	96 vs. 97 NS	96 vs. 97 NS	10,490 vs. 10,440 NS
Glyphosate vs. glyphosate + Class Act NG	1350	98 vs. 98 NS	97 vs. 97 NS	10,480 vs. 10,320 NS
Glyphosate vs. glyphosate + Class Act NG <sup>d</sup>		94 vs. 97 NS	95 vs. 97 NS	10,080 vs. 10,330 NS

Note. Abbreviations: WAA; weeks after application.

<sup>a</sup> The nontreated control was excluded from visible control analyses; herbicide tank-mixtures were compared to the nontreated control using p-values generated from Least Square Means comparisons.

<sup>b</sup> Class Act NG was included at 2.5% v/v (Winfield Solutions, LLC, St. Paul, MN, USA).

<sup>c</sup> Means followed by the same letter within a column are not significantly different according to Tukey-Kramer multiple range test ( $P > 0.05$ ).

<sup>d</sup> Averaged across all treatment levels.

\* significant at  $P < 0.05$ , \*\* significant at  $P < 0.01$ .

### 3.9 Corn Yield

Weed inference reduced corn yield up to 66% (highest yielding treatment compared to the weedy control) in this study. Reduced weed interference with glyphosate increased corn yield 162 to 195% compared to the untreated (weedy) control. There was no improvement in corn yield from the addition of Class Act NG to glyphosate at 450, 900, and 1350 g ae ha<sup>-1</sup> (Table 4).

Results are similar to other studies where glyphosate at 450, 675, or 900 g ae ha<sup>-1</sup> applied with and without AMS (2.5 L ha<sup>-1</sup>) resulted in similar corn yield (Soltani et al., 2016b). Another study also found no yield benefit when AMS (2.5 L ha<sup>-1</sup>) was added to glyphosate at 900 g ae ha<sup>-1</sup> in corn (Soltani et al., 2011). Nurse et al. (2008) also reported that the addition of AMS (2.5 L ha<sup>-1</sup>) to glyphosate at 225, 450, 675, and 900 g ae ha<sup>-1</sup> provided no improvement in con yield.

## 4. Conclusions

This research shows that the addition of Class Act NG (2.5% v/v) to glyphosate at 450 g ae ha<sup>-1</sup> can provide improved control of common lambsquarters, velvetleaf, Powell amaranth, common ragweed and barnyardgrass but does not provide any improvement in control of giant foxtail or green foxtail or corn yield. The addition of Class Act NG (2.5% v/v) to glyphosate at 900 g ae ha<sup>-1</sup> provides improved control of common lambsquarters and barnyardgrass but does not provide improved control of velvetleaf, Powell amaranth, common ragweed, giant foxtail, and green foxtail or corn yield. The addition of Class Act NG (2.5% v/v) to glyphosate at 1350 g ae ha<sup>-1</sup> does not provide any improvement in control of velvetleaf, Powell amaranth, common ragweed, common lambsquarters, barnyardgrass, giant foxtail, and green foxtail or corn yield. Based on this data the effect of Class Act NG (2.5% v/v) on weed control efficacy with glyphosate in corn is most frequent at the low rate of 450 g ae ha<sup>-1</sup> and is weed species-specific.

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## Acknowledgments

The authors would like to thank the Grain Farmers of Ontario, and the OMAFRA Alliance program for funding this research. No other conflicts of interest have been declared.

## Authors Contributions

Drs. Peter Sikkema and Nader Soltani were responsible for the study design and writing of this manuscript. Christian Willemse conducted the statistical analysis of the data collected.

**Funding**

This research was funded in part by Winfield Solutions, LLC (Winfield Solutions, LLC, St. Paul, MN, USA), Grain Farmers of Ontario (GFO), and the Ontario Agri-Food Innovation Alliance.

**Competing Interests**

No other competing interests have been declared.

**Informed Consent**

Obtained.

**Ethics Approval**

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

**Provenance and Peer Review**

Not commissioned; externally double-blind peer-reviewed.

**Data Availability Statement**

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

**Data Sharing Statement**

No additional data are available.

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