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Control of wild carrot (*Daucus carota* L.) in corn, soybean, and winter wheat

Nader Soltani, Christy Shropshire and Peter H. Sikkema

Abstract: Herbicide options are limited for the control of wild carrot in field crops in Ontario. This study which comprised 25 field trials, 9 in corn (4 PRE and 5 POST herbicides trials), 8 in soybean (3 PP and 5 POST herbicides trials) and 8 in winter wheat (8 POST herbicides trials) was completed to determine the most efficacious herbicides for the control of wild carrot in these crops. There was no significant visible injury in corn, soybean and winter wheat with herbicides evaluated. Atrazine, dicamba, dicamba/atrazine, isoxaflutole + atrazine, mesotrione + atrazine, saflufenacil, and saflufenacil/dimethenamid-p applied PRE provided inadequate (39 to 75%) control of wild carrot in corn. Prosulfuron + dicamba applied POST at 10 + 140 g ai ha⁻¹ controlled wild carrot 93 to 97% with density and biomass similar to the weed-free control in corn. Among PP herbicides evaluated in soybean, only glyphosate (2700 g ai ha⁻¹) and glyphosate + imazethapyr (900 + 100 g ai ha⁻¹) controlled wild carrot >80%. None of the POST herbicides evaluated in soybean provided adequate control of wild carrot. In winter wheat, prosulfuron + bromoxynil (10 + 140 g ai ha⁻¹) controlled wild carrot 83 to 86% compared to other herbicides which controlled wild carrot 21 to 73%.

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N. Soltani, C. Shropshire, and P.H. Sikkema. University of Guelph Ridgetown Campus, Ridgetown, ON N0P 2C0, Canada.

Corresponding author: Nader Soltani (e-mail: soltanin@uoguelph.ca).

Abbreviations: WAA, weeks after herbicide application; PP, preplant; PRE, preemergence; POST, postemergence

Keywords: Corn, efficacy, preemergence herbicide, preplant herbicide, postemergence herbicide, soybean, wild carrot, winter wheat, weed control

Introduction

Wild carrot (*Daucus carota* L.) is a deep-rooted biennial weed from the carrot/parsley (*Umbelliferae*) family that reproduces only by seed (Cowbrough 2005). Wild carrot has hairy stems and finely divided leaves (Stachler and Kells 1995; Cowbrough 2005). Wild carrot odour is similar to cultivated carrot when crushed. During the first year, wild carrot emerges as early as April with thin cotyledons and eventually forms a rosette which overwinters and resumes growth in March of the second year and bolts as early as June to form mostly white but sometimes pink compound umbel flowers which eventually closes to form a “bird’s-nest” shape (Anonymous 2005; Cowbrough 2005). Wild carrot can grow up to 1.0 m in height with stems that are branching, grooved and bristly (OMAFRA 2000). Each umbel can produce as much as 1000 seeds that are primarily dispersed by wind although dispersal by spines which attached to animal fur or human clothing can also occur (Cowbrough 2005). Wild carrot seeds can persist in the soil up to seven years but most of the seeds germinate within two years of dispersal (Cowbrough 2005).

In Ontario, historically wild carrot has generally been a problem in old pastures, roadsides, meadows, and occasionally in flower bed gardens (Cowbrough 2005). However, in recent years, with the adoption of reduced- and no-till, wild carrot has become a problem weed in field crops such as corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merrill] and winter wheat (*Triticum aestivum* L.). Corn, soybean and winter wheat are the three primary field crops grown in rotation with each other in Ontario (Kulasekera 2016).

The efficacy of corn herbicides in Ontario including atrazine, dicamba, dicamba/atrazine, isoxaflutole + atrazine, mesotrione + atrazine, saflufenacil, saflufenacil/dimethenamid-p applied preemergence (PRE) and atrazine dicamba, dicamba/diflufenzopyr, dicamba/atrazine, bromoxynil + atrazine, prosulfuron + dicamba, mesotrione + atrazine, topramezone + atrazine, bentazon/atrazine and glyphosate applied postemergence (POST) was unknown when this research was initiated (Shaner 2014; OMAFRA 2016).

Among registered soybean herbicides in Ontario, glyphosate alone or in combination with linuron, metribuzin, cloransulam-methyl, flufenacet/metribuzin, s-metolachlor + metribuzin, flumetsulam/s-metolachlor, imazethapyr and imazethapyr + metribuzin applied preplant (PP) and acifluorfen, fomesafen, bentazon, thifensulfuron-methyl, chlorimuron-ethyl, chlorimuron-ethyl/thifensulfuron, cloransulam-methyl, imazethapyr, imazethapyr + bentazon, imazamox + bentazon and glyphosate applied POST may have potential to control wild carrot in glyphosate-resistant soybean (OMAFRA 2016). Similarly, among registered winter wheat herbicides in Ontario, 2,4-D ester, MCPA ester, dicamba/MCPA/mecoprop, dichlorprop-p/2,4-D, clopyralid, bromoxynil/MCP, thifensulfuron/tribenuron + MCPA ester, fluroxypyr + MCPA ester, pyrasulfotole/bromoxynil and prosulfuron + bromoxynil applied POST may have potential to control wild carrot in winter wheat (OMAFRA 2016).

There has been little research on emerging problematic weeds such as wild carrot in field crops. Based on Ian Heap website (<http://weedscience.org/Summary/Species.aspx?WeedID=76>), there are three documented cases of herbicide resistant (all 2,4-D in Ontario, Michigan and Ohio) in wild carrot. Research is needed to identify herbicides that provide consistent control of wild carrot including herbicide resistant biotypes in corn, soybean and winter wheat under Ontario environmental conditions. In the absence of clear recommendations based on sound science for

wild carrot control, growers and ag-retailers rely on their “best guess” to address this emerging weed problem which can result in the application of ineffective herbicides and reduced crop yield and profitability and unnecessary application of pesticides in the environment that do not provide any benefit at all. Efficacy of these herbicides for the control of wild carrot is not known under Ontario environmental conditions. Therefore, the objective of this study was to determine the effectiveness of various herbicides available (highest registered label rate) for use in corn, soybean and winter wheat to control wild carrot in Ontario.

Materials and Methods

A total of 25 field experiments were conducted in corn [4 PRE herbicides trials (2 in 2010 and 2 in 2011) and 5 POST herbicides trials (1 in 2002; 2 in 2010 and 2 in 2011)], soybean [3 PP herbicides trials (2 in 2002 and 1 in 2004) and 5 POST herbicides trial (2 in 2002, 1 in 2004 and 2 in 2007)] and winter wheat [8 POST herbicides trials (1 in 2003, 2 in 2009, 4 in 2010 and 1 in 2011)] on Ontario farms with heavy infestations of wild carrot.

The experiments were arranged in a randomized complete block design (RCBD) with four replications. Herbicide treatments for corn (PRE and POST), soybean (PP and POST) and winter wheat (POST) studies including adjuvants used are listed in Tables 1, 2, 3, 4 and 5, respectively. The herbicide rates selected are the highest registered label rate in eastern Canada. In addition, each experiment included a weedy and weed-free control. Weed-free control plots were maintained with hand hoeing as required.

Corn and soybean plots were 2.25 m wide and 8 m long with three rows seeded 0.75 m apart. Similarly, winter wheat plots were 2 m wide and 8 m long with rows spaced 19 cm apart. Glyphosate-resistant corn was seeded at the rate of approximately 75,000 seeds ha⁻¹ and

glyphosate-resistant soybean was seeded at the rate of approximately 400,000 seeds ha⁻¹ in early May to early June of each year. Winter wheat was seeded at the rate of approximately 3.75 million seeds ha⁻¹ in early to late October of each year.

A CO₂-pressurized back-pack sprayer calibrated to deliver 200 L ha⁻¹ of water at 200 kPa was used to apply the herbicide treatments. The boom was 1.5 m long with four nozzles (Hypro ULD120-02 nozzle tips, Hypro, New Brighton, MN) spaced 0.5 m apart resulting in a 2.0 m spray width. PP herbicides were applied 1-2 days before seeding soybean to the soil surface and were not incorporated. PRE herbicides were applied 1 to 2 d after seeding corn to the soil surface. POST herbicides were applied to 4-7 leaf corn, 1-2 tri-foliolate soybean and Z 30 in winter wheat when wild carrot was up to 40 cm in height.

Crop injury was visually estimated on a scale of 0 (no injury) to 100% (complete plant death) at 1 and 4 weeks after herbicide application (WAA). Control of wild carrot was visually estimated on a scale of 0 (no control) to 100% (complete control) at 4 and 8 weeks after herbicide application (WAA). Wild carrot density and dry weight for PRE and POST corn studies and POST soybean studies were evaluated 8 WAA by counting and cutting plants at the soil surface for two randomly selected 0.5 square meter in each plot. Plants were dried at 60 C to constant moisture and then weighed.

Data were analyzed as an RCBD using PROC MIXED in SAS 9.4 (SAS 2015). Herbicide treatment was considered a fixed effect, while environment (year-location combinations), the interaction between environment and herbicide treatment, and replicate nested within environment were considered random effects. Significance of the fixed effect was tested using a F-test and random effects were tested using a Z-test of the variance estimate. The UNIVARIATE procedure was used to test data for normality and homogeneity of variance. The untreated

control (for control ratings) and the weed-free control (for density and dry weight) were excluded from the analysis. However, all values were compared independently to zero to evaluate treatment differences with the untreated control. To satisfy the assumptions of the variance analyses, weed control 4 and 8 WAA were untransformed and density and biomass were log transformed. Treatment comparisons were made using Fisher's Protected LSD at a level of $P < 0.05$. Data compared on the transformed scale were converted back to the original scale for presentation of results.

Results and Discussion

For all studies in corn, soybean and winter wheat, there was no significant interaction between environment and treatments for the variables evaluated, therefore data were pooled and averaged over environments for each study (Tables 1-5).

Corn

Preemergence Herbicides

There was no corn injury from the PRE herbicides evaluated (Table 1). Atrazine (1500 g ai ha⁻¹), dicamba (600 g ai ha⁻¹), dicamba/atrazine (1800 g ai ha⁻¹), isoxaflutole + atrazine (105 + 1063 g ai ha⁻¹), mesotrione + atrazine (140 + 1000 g ai ha⁻¹), saflufenacil (75 g ai ha⁻¹), saflufenacil/dimethenamid-p (735 g ai ha⁻¹), saflufenacil/dimethenamid-p + saflufenacil (735 + 25 g ai ha⁻¹), saflufenacil/dimethenamid-p + dicamba/atrazine (735 + 1000 g ai ha⁻¹) applied PRE provided poor control of wild carrot in corn at 4 and 8 WAA (Table 1). At 8 WAA, wild carrot control was as low as 39% with atrazine and as high as 75% with saflufenacil/dimethenamid-p + saflufenacil or saflufenacil/dimethenamid-p + dicamba/atrazine (Table 1). Wild carrot density

was reduced with PRE application of mesotrione + atrazine ($140 + 1000 \text{ g ai ha}^{-1}$) and saflufenacil/dimethenamid-p + dicamba/atrazine ($735 + 1000 \text{ g ai ha}^{-1}$). Wild carrot dry weight was similar to the weedy control with the herbicides evaluated (Table 1). Results are similar to Stachler and Kells (1997) who found less than 69% control of wild carrot with PRE application of glyphosate + pendimethalin at $840 + 1121 \text{ g ai ae ha}^{-1}$ in no-tillage corn. In the same study, herbicides such as atrazine, flumetsulam and paraquat in combination with other herbicides applied PRE controlled wild carrot 32 to 70%. However, halosulfuron-methyl and cyanazine + pendimethalin + paraquat controlled wild carrot as much as 85% (Stachler and Kells 1997).

Postemergence Herbicides

There was no corn injury from the POST herbicides evaluated (Table 2). Prosulfuron + dicamba ($10 + 140 \text{ g ai ha}^{-1}$) applied POST was the best treatment among treatments evaluated by providing 93 to 97% visual control of wild carrot with similar density and biomass as weed-free control (Table 2). Glyphosate ($1800 \text{ g ai ha}^{-1}$) applied POST provided good (81%) control of wild carrot and reduced density and biomass comparable to control (Table 2). Results were more variable with other treatments. Atrazine ($1500 \text{ g ai ha}^{-1}$), dicamba (600 g ai ha^{-1}), dicamba/diflufenzopyr (200 g ai ha^{-1}), dicamba/atrazine ($1800 \text{ g ai ha}^{-1}$), bromoxynil + atrazine ($280 + 1500 \text{ g ai ha}^{-1}$), mesotrione + atrazine ($100 + 280 \text{ g ai ha}^{-1}$), topramezone + atrazine ($12.5 + 500 \text{ g ai ha}^{-1}$), bentazon/atrazine ($1600 \text{ g ai ha}^{-1}$) and glyphosate (900 g ai ha^{-1}) applied POST provided 34 to 70% control of wild carrot and reduced density 0 to 56% and dry weight 0 to 88% compared to the weedy control (Table 2). In other studies, Stachler and Kells (1997) found greater than 78% control of wild carrot with herbicides such as atrazine, halosulfuron-methyl, nicosulfuron, flumetsulam + clopyralid + 2,4-D and primisulfuron applied POST in no-tillage

corn. However, other POST herbicides such as 2,4-D, clopyralid, cyanazine and dicamba provided 35 to 79% control of wild carrot (Stachler and Kells 1997).

Soybean

Preplant Herbicides

There was no soybean injury from the PP herbicides evaluated (data not shown). Among preplant herbicide treatments evaluated in soybean, only glyphosate (2700 g ai ha⁻¹) and glyphosate + imazethapyr (900 + 100 g ai ha⁻¹) applied PP provided greater than 80% control of wild carrot (Table 3). Glyphosate applied at 900, 1800 and 2700 g ai ha⁻¹ controlled wild carrot 59, 77 and 86%, respectively at 8 WAA.

Wild carrot was least controlled (41%) with glyphosate + linuron (900 + 2250 g ai ha⁻¹) and best controlled (83%) with glyphosate + imazethapyr (900 + 100 g ai ha⁻¹) and at 4 or 8 WAA (Table 3). Results are similar to Stachler and Kells (1997) who found 7 to 72% wild carrot control with early PP application of 2,4-D ester applied at 1120 g ae ha⁻¹ in no-tillage soybean in Michigan. Stachler and Kells (1997) also found 24 to 95% control of wild carrot with early PP application of glyphosate at 840 g ae ha⁻¹ in soybean. Similarly, glyphosate, imazethapyr, linuron and metribuzin applied PRE provided 7 to 68% control of wild carrot in soybean (Stachler and Kells 1997).

Postemergence Herbicides

There was 3% or less soybean injury with the POST herbicides evaluated (Table 4). All of the POST herbicide treatments evaluated in soybean provided less than acceptable (80%) wild carrot control with density and dry weight similar to the weedy control (Table 4). Acifluorfen

(600 g ai ha⁻¹), fomesafen (240 g ai ha⁻¹), bentazon (1080 g ai ha⁻¹), thifensulfuron-methyl (6 g ai ha⁻¹), imazamox + bentazon (25+600 g ai ha⁻¹) and glyphosate (900 g ai ha⁻¹) controlled wild carrot 2-31%. Chlorimuron-ethyl (9 g ai ha⁻¹), chlorimuron-ethyl/thifensulfurone (14.1 g ai ha⁻¹), cloransulam-methyl (17.5 g ai ha⁻¹), imazethapyr (100 g ai ha⁻¹), imazethapyr + bentazon (75+840 g ai ha⁻¹), and glyphosate (1800 g ai ha⁻¹) controlled wild carrot 35 to 78%. All herbicides treatments provided poor wild carrot control that resulted in similar wild carrot density and biomass as the weed-free control (Table 4). Inconsistent results in this study are similar to that of Stachler and Kells (1997) which showed a maximum control of 25, 32, 71, 34 and 72% wild carrot control in no-tillage soybean with POST application of acifluorfen, bentazon, imazethapyr, thifensulfuron + tribenuron, respectively. However, in the same study chlorimuron applied POST controlled wild carrot 72 to 84% (Stachler and Kells 1997).

Winter wheat

Postemergence Herbicides

Among herbicides evaluated in winter wheat, prosulfuron + bromoxynil (10 + 140 g ai ha⁻¹) applied POST provided the greatest wild carrot control at 83 to 86% (Table 5). The other herbicides evaluated in winter wheat did not provide adequate control of wild carrot. Wild carrot was controlled up to 23% with 2,4-D ester (528-850 g ai ha⁻¹), 40% with MCPA ester (630-850 g ai ha⁻¹), 35% with dicamba/MCPA/mecoprop (600 g ai ha⁻¹), 47% with dichlorprop-p/2,4-D (1017 g ai ha⁻¹), 71% with clopyralid (200 g ai ha⁻¹), 25% with bromoxynil/MCP (560 g ai ha⁻¹), 73% with thifensulfuron/tribenuron + MCPA ester (15 + 280-550 g ai ha⁻¹), 43% with fluroxypyr + MCPA ester (108 + 560 g ai ha⁻¹) and 48% with pyrasulfotole/bromoxynil (205 g ai ha⁻¹).

In conclusion, there was 3% or less crop injury with the herbicides evaluated in corn, soybean or winter wheat for control of wild carrot. In corn, PRE application of atrazine, dicamba, dicamba/atrazine, isoxaflutole + atrazine, mesotrione + atrazine, saflufenacil and saflufenacil/dimethenamid-p provided poor (<76%) control of wild carrot in corn. Among POST treatments, prosulfuron + dicamba provided excellent (>90%) control of wild carrot with density and biomass similar to the weed-free control. In soybean, among PP herbicide treatments evaluated only glyphosate at the highest rate (2700 g ai ha⁻¹) provided good (>80%) control of wild carrot. None of the POST herbicide treatments evaluated provided adequate control of wild carrot in soybean. In winter wheat, prosulfuron + dicamba (10 + 140 g ai ha⁻¹) POST was the only herbicide that provided good control (86%) of wild carrot.

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Table 1. Corn injury 1 and 4 WAA, wild carrot control 4 and 8 WAA and wild carrot density and dry weight treated with various preemergence herbicides at various ON locations (2010, 2011). Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at $P < 0.05$.^a

Treatment	Rate (g ai ha ⁻¹)	Corn injury (%)		Wild carrot control (%)		Wild carrot density* (# m ⁻²)	Wild carrot dry weight* (g m ⁻²)
		1 WAA	4 WAA	4 WAA	8 WAA		
Weedy control		0	0	0 c	0 d	4 bc	10
Weed-free control		100	100	100 a	100 a	0 a	0
Atrazine	1500	0	0	54 b	40 c	3 ab	5
Dicamba	600	0	0	49 b	39 c	7 c	29
Dicamba/atrazine	1800	0	0	51 b	68 b	3 ab	9
Isoxaflutole + atrazine	105 + 1063	0	0	44 b	62 bc	3 ab	9
Mesotrione + atrazine	140 + 1000	0	0	56 b	64 bc	2 a	7
Saflufenacil	75	0	0	57 b	49 bc	5 bc	16
Saflufenacil/dimethenamid-p	735	0	0	43 b	61 bc	4 abc	20
Saflufenacil/dimethenamid-p + saflufenacil	735 + 25	0	0	46 b	75 a	4 abc	16
Saflufenacil/dimethenamid-p + dicamba/atrazine	735 + 1000	0	0	44 b	75 a	2 a	5

* Not statistically significant.

^aAbbreviation: WAA, weeks after herbicide application.

Table 2. Corn injury 1 and 4 WAA, wild carrot control 4 and 8 WAA and wild carrot density and dry weight treated with various postemergence herbicides at various ON locations (2002, 2010, 2011). Means followed by the same letter within a column are not significantly different according to Fisher’s Protected LSD at P<0.05.^a

Treatment	Rate (g ai ha ⁻¹)	Corn injury (%)		Wild carrot control (%)		Wild carrot density (#/m ⁻²)	Wild carrot dry weight (g m ⁻²)
		1 WAA	4 WAA	4 WAA	8 WAA		
Weedy control		0	0	0 e	0 e	4 bcd	16 de
Weed-free control		100	100	100 a	100 a	0 a	0 a
Atrazine ^b	1500	0	0	34 d	38 d	2 bc	4 bc
Dicamba	600	0	0	46 cd	46 cd	5 d	23 e
Dicamba/diflufenzopyr ^{cd}	200	0	0	66 bc	70 b	3 bcd	7 bcde
Dicamba/atrazine	1800	0	0	62 bc	63 bc	4 cd	16 cde
Bromoxynil + atrazine	280 + 1500	0	0	63 bc	63 bc	3 bcd	14 cde
Prosulfuron + dicamba ^e	10 + 140	0	0	93 a	97 a	0 a	0 a
Mesotrione + atrazine ^e	100 + 280	0	0	68 bc	61 bcd	3 bcd	6 bcde
Topramezone + atrazine ^{df}	12.5 + 500	0	0	50 cd	48 cd	3 bcd	4 bcd
Bentazon/atrazine ^g	1600	0	0	61 bc	58 bcd	2 b	2 ab
Glyphosate	900	0	0	66 bc	63 bc	4 bcd	12 bcde
Glyphosate	1800	0	0	81 ab	81 ab	3 bcd	5 bcde

^a Abbreviation: WAA, weeks after herbicide application.

^b Includes COC (1.0% v/v)

^c Includes Agral 90 (0.250% v/v)

^d Includes UAN 28% (1.25% v/v)

^e Includes Agral 90 (0.2% v/v)

^f Includes Assist (1.25% v/v)

^g Includes Assist (2 L/ha)

Table 3. Wild carrot control 4 and 8 WAA in soybean treated with various preplant herbicides at ON locations (2002, 2004, 2010-2011). Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at $P < 0.05$.^a

Treatment	Rate (g ai ha ⁻¹)	Wild carrot control (%)	
		4 WAA	8 WAA
Weedy control		0 c	0 d
Glyphosate	900	48 ab	59 bc
Glyphosate	1800	73 a	77 ab
Glyphosate	2700	84 a	86 a
Glyphosate + linuron	900 + 2250	33 b	41 c
Glyphosate + metribuzin	900 + 1120	70 ab	66 abc
Glyphosate + cloransulam-methyl	900 + 35	73 a	63 abc
Glyphosate + flufenacet/metribuzin	900 + 840	33 b	48 bc
Glyphosate + s-metolachlor + metribuzin	900 + 1357 + 469	48 ab	56 bc
Glyphosate + flumetsulam/s-metolachlor	900 + 1443	77 a	75 ab
Glyphosate + imazethapyr	900 + 100	83 a	76 ab
Glyphosate + imazethapyr + metribuzin	900 + 75 + 425	53 ab	58 bc

^a Abbreviation: WAA, weeks after herbicide application.

Table 4. Soybean injury 1 and 4 WAA, wild carrot control 4 and 8 WAA and wild carrot density and dry weight treated with various postemergence herbicides at various ON locations (2002, 2004, 2007). Means followed by the same letter within a column are not significantly different according to Fisher’s Protected LSD at P<0.05.^a

Treatment	Rate (g ai ha ⁻¹)	Corn injury (%)		Wild carrot control (%)		Wild carrot density * (# m ⁻²)	Wild carrot dry weight* (g m ⁻²)
		1 WAA	4 WAA	4 WAA	8 WAA		
Weedy control		0	0	0 e	0 f	64	215
Weed-free control		100	100	100 a	100 a	0	0
Acifluorfen	600	0	0	2 d	3 e	67	176
Fomesafen ^b	240	0	0	2 d	4 e	46	210
Bentazon	1080	0	0	9 bc	14 de	47	133
Thifensulfuron-methyl ^{cd}	6	0	0	5 cd	5 e	52	222
Chlorimuron-ethyl ^{ef}	9	1	1	69 a	75 ab	10	17
Chlorimuron-ethyl/thifensulfuron ^{ef}	14.1	3	0	43 a	52 abc	-	-
Cloransulam-methyl ^{fg}	17.5	0	1	35 a	44 bc	37	72
Imazethapyr ^{fg}	100	0	1	78 a	52 abc	27	61
Imazethapyr + bentazon ^f	75+840	0	0	44 a	44 bc	42	105
Imazamox + bentazon ^f	25+600	0	0	25 ab	31 cd	-	-
Glyphosate	900	0	1	12 bc	28 cd	54	138
Glyphosate	1800	0	1	60 a	76 ab	-	-

*Not statistically significant
^a Abbreviation: WAA, weeks after herbicide application.
^b Includes Turbocharge (0.5% v/v)
^c Includes Agral 90 (0.1% v/v)
^d Includes UAN 28% (8 L/ha)
^e Includes Agral 90 (0.2% v/v)
^f Includes UAN 28% (2 L/ha)
^g Includes Agral 90 (0.250% v/v)

Table 5. Wild carrot control 4 and 8 WAA in winter wheat treated with various postemergence herbicides at ON locations (2003, 2009-2011). Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at $P < 0.05$.^a

Treatment	Rate (g ai ha ⁻¹)	Wild carrot control (%)	
		4 WAA	8 WAA
Weedy control		0 e	0 e
2,4-D ester	528-850	21 d	23 d
MCPA ester	630-850	35 cd	40 c
Dicamba/MCPA/mecoprop	600	28 cd	35 cd
Dichlorprop-p/2,4-D ^b	1017	43 c	47 c
Clopyralid	200	61 b	71 b
Bromoxynil/MCPA	560	23 d	25 d
Thifensulfuron/tribenuron + MCPA ester ^c	15 + 280-550	73 ab	72 ab
Fluroxypyr + MCPA ester	108 + 560	29 cd	43 c
Pyrasulfotole/bromoxynil ^d	205	43 c	48 c
Prosulfuron + bromoxynil ^c	10 + 140	83 a	86 a

^a Abbreviation: WAA, weeks after herbicide application.

^b Dichlorprop/2,4-D XT (732 g ai ha⁻¹) was used in 2011.

^c Included non-ionic surfactant at 0.2% v/v.

^d Included AMS at 1 L/ha.