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Response of winter wheat (*Triticum aestivum* L.) to autumn applied saflufenacil

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ABSTRACT

There is limited information on the effect of saflufenacil application timing when applied in autumn to winter wheat. Five field experiments were conducted over a three-year period (2007-2009) at two locations (Ridgetown and Exeter, Ontario) to evaluate the tolerance of winter wheat to autumn applications of saflufenacil applied pre-plant (PP), pre-emergence (PRE), or post-emergence (POST) at 25, 50, 100 and 200 g a.i. ha^{-1}. As the dose of saflufenacil increased, the amount of injury observed also increased. By May of the following spring, injury ranged from 11% to 20% at the 25 to 200 g a.i. ha^{-1} doses of saflufenacil. Saflufenacil applied PP and PRE caused little to no injury in winter wheat. Saflufenacil applied POST and POST + Merge in the autumn caused up to 41% injury with the POST + Merge application being the most injurious. However, this injury was transient with no effect on winter wheat height or yield the following summer.

Keywords: Cereals; Injury; Height; Herbicide; Tolerance; Yield

1. INTRODUCTION

Herbicide application timing is influenced by tillage system (no-tillage, reduced tillage, conventional tillage), weed species (annual, biennial or perennial) and type of crop (wheat, maize or soybean). Spring is a very busy time of the year for many growers. Consequently, postemergence (POST) herbicide application in winter wheat may be delayed beyond the optimum application timing resulting in yield losses due to early weed interference. Most growers apply herbicides for broadleaf weed control in winter wheat in the spring, however, by exploring autumn applied herbicides, growers may be able to 1) spread out their work load; 2) obtain improved control of winter annual, biennial and perennial broadleaf weeds; and 3) increase winter wheat yield due to reduced weed interference.

Saflufenacil is a herbicide used for broadleaf weed control that is being investigated in a number of different crops including maize, soybean, cereal and pulse crops [1-5]. It has a different mode of action from other commonly used herbicides for weed control in winter wheat. As a result, there have been a number of recent studies looking at the tolerance of saflufenacil in cereal crops. However, there is minimal research that has studied the effect of saflufenacil application timing [pre-plant (PP), pre-emergence (PRE) and POST] in the autumn.

Research has shown that saflufenacil can be used as an effective tool to control winter annual weeds such as *Chorispora tenella* Pallas (blue mustard), *Descurainia Sophia* L. (flixweed), *Capsella bursa-pastoris* L. (shepherd's purse), *Thlaspi arvense* L. (field pennycress), *Lamium amplexicaule* L. (henbit) and perennials such as *Convolvulus arvensis* L. (field bindweed) and *Taraxacum officinale* Weber (dandelion) [6-8]. There is potential for saflufenacil to be used with glyphosate as an enhanced burndown prior to planting wheat as well as providing residual control of annual broadleaf weeds the following spring. Since glyphosate-resistant weeds have been documented in some areas of Ontario, growers will need herbicide options other than glyphosate for burndown in winter wheat. If there is adequate tolerance in winter wheat to autumn applications of saflufenacil, it may eliminate the need for broadleaf herbicides in the spring. Therefore, the objective of this study was to determine the sensitivity of winter wheat to autumn applications (PP, PRE and POST) of saflufenacil at various doses.

2. MATERIALS AND METHODS

A total of five field trials were established over a three-year period (2007-2009) at the Huron Research Station near Exeter, ON and the University of Guelph Ridgetown Campus, Ridgetown, ON. The soil characterristics for each field trial are presented in **Table 1**.

The experiments were established as a 2-way factorial and plots were arranged in an RCBD with four replica-

Table 1. Soil characteristics at Exeter and Ridgetown, ON in 2007-2009.

Location	Year	Sand (%)	Silt (%)	Clay (%)	OM[a] (%)	pH	CEC
Ridgetown	2007	45	29	26	4.9	7.0	11
Exeter	2008	39	37	24	4.3	7.9	38
Ridgetown	2008	52	28	20	5.9	6.4	21
Exeter	2009	28	38	34	4.1	7.9	36
Ridgetown	2009	41	34	25	6.5	6.7	22

[a]Abbreviation: OM, Organic matter.

tions. Factor one was saflufenacil dose (25, 50, 100 and 200 g a.i. ha^{-1}) and factor two was application timing [PP, PRE, POST (without adjuvant) and POST plus adjuvant (Merge; 1.0% v/v)]. Winter wheat "Pioneer 25R47" was seeded in the autumn at both locations at a rate of 140 - 170 kg·ha^{-1} in rows that were 17.5 or 19 cm apart in plots that were 2 m wide by 8 or 10 m long. Pre-plant herbicides were applied 1 day before planting, Pre-emergence herbicides were applied 3 days after planting and post-emergence herbicides were applied at 2 - 3 leaf stage with a CO_2-pressurized backpack sprayer equipped with 120-02 ultra low drift nozzles (Hypro, New Brighton, MN) calibrated to deliver 200 L·ha^{-1} at 207 or 241 kPa. A cover spray of bromoxynil/MCPA (560 g a.i. ha^{-1}) was applied in the spring to maintain the entire experimental area weed free.

Crop injury was evaluated visually 1 and 2 weeks after treatment (WAT) in the autumn and at the beginning of May and July of the following year. Crop injury was evaluated on a scale of 0 (no injury) to 100% (complete death). Wheat height was measured before harvest from 10 randomly selected plants per plot. Yield was measured at crop maturity by harvesting the middle 1.5 m of each plot with a plot combine. Yields were adjusted to 14.5% moisture.

All data were subjected to analysis of variance using the PROC MIXED procedure of SAS (software Ver. 9.1, SAS Institute, Inc., Cary, NC). The assumptions of the variance analyses (random, homogeneous, normal distribution of error) were confirmed using residual plots and the Shapiro-Wilk normality test. To meet the assumptions of variance analyses, the July injury rating was log transformed. Data were converted back to original scale for presentation of results. Injury 1 and 2 WAT as well as May injury, height and yield data met the assumptions of normality, therefore no transformations were necessary. Crop injury was not observed at any of the Ridgetown sites therefore was excluded from analysis and are not shown. Data were combined and analyzed over environments when possible (*i.e.* environment by timing by dose interactions were not significant). Means were separated using Fisher's protected LSD. Type I error was set at 0.05 for all statistical comparisons.

3. RESULTS AND DISCUSSION

There was no effect of saflufenacil dose at the PP and PRE application timings on winter wheat injury 1 WAT and in May of the following spring (**Table 2**). These results are consistent with a recent study conducted by Knezevic *et al.* [8] that also showed no injury on winter wheat when saflufenacil (at doses up to 400 g a.i. ha^{-1}) was applied PRE. There was however, a dose effect when saflufenacil was applied POST with and without the adjuvant Merge. At 1 WAT, the POST application of saflufenacil applied at 100 and 200 g a.i. ha^{-1} caused 7% and 10% injury. This injury was transient with 5% injury observed at the 200 g a.i. ha^{-1} in the following May.

There was greater injury when saflufenacil was applied POST + Merge. At 1 WAT, injury from saflufenacil (25 to 200 g a.i. ha^{-1}) applied POST with Merge was 12% - 18% higher than the POST application without an adjuvant (**Table 2**). Similarly, winter wheat injury the following May from saflufenacil (25 to 200 g a.i. ha^{-1}) applied POST with Merge was 2% - 9% higher than the POST application without an adjuvant. Saflufenacil applied POST with Merge consistently had the greatest injury at all the doses evaluated.

Other research has also shown that POST applications of saflufenacil can cause significant injury in cereals. Frihauf *et al.* [2] showed that a POST application of saflufenacil + non-ionic surfactant at 25 to 50 g a.i. ha^{-1} caused 27% - 38% injury in winter wheat at 1 WAT. In another experiment, Frihauf *et al.* [6] showed that increasing saflufenacil doses caused winter wheat injury to be as high as 30% at 3 - 6 days after treatment. Similarly, Sikkema *et al.* [4] showed injury from a POST application of saflufenacil at 50 g a.i. ha^{-1} on spring cereals to be as high as 67% at 3 days after treatment.

When data were combined for all application timings (**Table 3**), saflufenacil applied at 25 to 200 g a.i. ha^{-1}, caused 4% to 11% injury in winter wheat 2 WAT with the POST + Merge application causing the greatest injury

Table 2. Winter wheat injury as a function of saflufenacil application timing and dose. Means followed by the same letter within a column (a-e) or row (X-Z) for each section are not significantly different according to Fisher's Protected LSD at P < 0.05[a].

Saflufenacil dose (g a.i. ha^{-1})	Injury at various application timings %				SE
	PP	PRE	POST	POST + Merge	
1 WAT injury[b]					
0	0 a Z	0 a Z	0 a Z	0 a Z	0
25	0 a Z	0 a Z	4 a Z	16 b Y	1
50	0 a Z	0 a Z	5 ab Z	19 c Y	2
100	2 a Z	1 a Z	7 bc Z	24 d Y	2
200	1 a Z	2 a Z	10 c Z	28 e Y	2
SE	0	0	1	1	
May injury[c]					
0	0 a Z	0 a Z	0 a Z	0 a Z	0
25	0 a Z	2 a Z	1 a Z	3 b Z	1
50	1 a Z	1 a Z	1 a Z	9 c Y	1
100	0 a Z	1 a Z	2 ab Z	7 c Y	1
200	1 a Z	2 a YZ	5 b Y	14 d X	1
SE	0	1	1	1	

[a]Abbreviations: Merge added at 1% v/v; WAT: Weeks after treatment; PP: Pre-plant; PRE: Pre-emergence; POST: Post-emergence; [b]Data averaged for Exeter in 2008 & 2009; [c]Exeter 2008.

Table 3. Winter wheat injury, height and yield as a function of saflufenacil dose and application timing. Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD at P < 0.05[a].

	Injury%				
	2 WAT[b]	May[c]	July[b]	Height[d] cm	Yield[d] MT ha^{-1}
Saflufenacil dose (g a.i. ha^{-1})					
0	0 a	0 a	0 a	79.9 a	6.87 a
25	4 b	11 b	1 a	79.6 a	6.68 a
50	5 b	11 b	1 a	80.0 a	6.73 a
100	8 c	18 c	1 a	79.5 a	6.60 a
200	11 d	20 c	1 a	79.8 a	6.55 a
SE	1	2	0	0.2	0.05
Application timing					
Untreated	0 a	0 a	0 a	79.9 a	6.87 a
PP	1 a	1 a	0 a	80.2 a	6.87 a
PRE	1 a	2 a	0 a	80.2 a	6.85 a
POST	6 a	16 b	1 a	79.6 a	6.68 a
POST + Merge	20 b	41 c	1 a	79.1 a	6.35 a
SE	1	2	0	0.2	0.05

[a]Abbreviations: Merge added at 1% v/v; WAT, week after treatment; PP, pre-plant; PRE, pre-emergence; POST, post-emergence; [b]Data averaged for Exeter in 2008 & 2009; [c]Exeter 2009; [d]Data averaged for Exeter and Ridgetown in 2007-2009.

(20%). Saflufenacil caused 11% (25 and 50 g a.i. ha^{-1}), 18% (100 g a.i. ha^{-1}) and 20% (200 g a.i. ha^{-1}) injury in May of the following spring in winter wheat with the greatest injury occurring with the POST (16%) and POST + Merge (41%) applications (**Table 3**). As the season progressed into July, there was little to no injury from saflufenacil application the previous autumn.

There was no effect of saflufenacil on winter wheat height or yield (**Table 3**). Even though saflufenacil applied POST and POST + Merge caused up to 16% and 41% injury respectively, this injury was transient with no effect on winter wheat height or yield. These results differ from studies conducted by Knezevic *et al.* [8] who reported a significant yield reduction (up to 66%) with autumn POST applications of saflufenacil and up to 67% with spring POST applications in winter wheat.

4. CONCLUSION

This study concludes that there is an acceptable margin of crop safety in winter wheat to PP and PRE applications of saflufenacil. The POST applications caused injury that would be unacceptable to growers even though in this study it did not result in a yield loss. There was greater injury when saflufenacil was applied POST + Merge. Injury was the greatest at higher doses. Since this research has shown that saflufenacil can be applied safely to winter wheat either PP or PRE future research should focus on the control of winter annual, biennial and perennial broadleaf weeds. The autumn application of saflufenacil may eliminate the need for spring applied herbicides for broadleaf weed control.

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