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# Effects of pre-emergence applications of flufenacet plus metribuzin on weeds and soybean (*Glycine max*)

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**Abstract**

There is limited information on the effect of flufenacet plus metribuzin on selected weed species in soybeans (*Glycine max*) in Ontario. Field trials were conducted at two Ontario locations (Exeter and Ridgetown) in 1998 and 1999 to evaluate the tolerance of soybeans to pre-emergence applications of a flufenacet plus metribuzin mixture at doses from 0.67 to 1.68 kg ai $ha^{-1}$. The application of flufenacet plus metribuzin caused visual crop injury at 7, 14, and 28 days after treatment (DAT), but resulted in no yield reduction in soybeans compared to weed-free control at all doses evaluated. The PRE application of metribuzin plus flufenacet at the lowest dose (0.67 kg $ha^{-1}$) provided full season control of *Chenopodium album* L. (common lambsquarter), *Amaranthus retroflexus* L. (redroot pigweed), and *Ambrosia artemesiifolia* L. (common ragweed). Higher doses (1.00 g $ha^{-1}$) were needed to effectively control *Sinapis arvensis* L. (wild mustard) and *Setaria viridis* (L.) Beauv. (green foxtail) while the highest dose (1.68 kg ai $ha^{-1}$) was required for the control of *Abutilon theophrasti* Medic. (velvetleaf). At 28 DAT, the biologically effective dose for 50%, 80%, and 90% control of *Chenopodium album* L. was 0.2, 0.6 and 0.7 kg $ha^{-1}$, for 50%, 80%, and 90% control of *Setaria viridis* (L.) Beauv. was 0.7, 0.9 and 1.1 kg $ha^{-1}$ and for 50%, 80%, and 90% control of *Sinapis arvensis* was 1.0, 1.1, 1.3 kg $ha^{-1}$, respectively. This research concludes that soybeans were tolerant to flufenacet plus metribuzin at all doses evaluated. Weed species differed in their sensitivity to the herbicide mixture. *Chenopodium album* L. was the most sensitive to flufenacet plus metribuzin followed by *Setaria viridis* (L.) Beauv. followed by *Sinapis arvensis* L.


*Keywords:* Crop injury; Flufenacet; Metribuzin; *Glycine max*; Soybeans

## 1. Introduction

Soybean (*Glycine max*) is an important crop for growers in Ontario. Effective weed control is an essential component of a profitable soybean production management program (Miller, 1974). Flufenacet plus metribuzin, is a oxyacetamide plus triazinone herbicide that is only available as a pre-mixed formulation in Ontario that can effectively control a broad spectrum of grass and broadleaf weeds such as *Echinochloa crusgalli* (L.) Beauv. (barnyardgrass), *Setaria faberii* Herrm. (giant foxtail), *Setaria viridis* (L.) Beauv. (green foxtail) *Setaria glauca* (L.) Beauv. (yellow foxtail), and *Amaranthus retroflexus* L. (redroot pigweed). It also suppresses *Chenopodium album* L. (common lambsquarter), *Ambrosia artemesiifolia* L. (common ragweed) and *Sinapis arvensis* L. (wild mustard), *Polygonum persicaria* L. (ladysthumb) (Ontario Ministry of Agriculture and Food and Rural Affairs [OMAFRA], 2004; Vencill, 2002). Flufenacet is absorbed through shoots and roots of emerging weeds while metribuzin is primarily absorbed through roots although it can also be absorbed by foliar uptake (Ontario Ministry of Agriculture and Food and Rural Affairs [OMAFRA], 2004). Residual

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activity in soils can last for 10–14 weeks after pre-emergence applications (Ontario Ministry of Agriculture and Food and Rural Affairs [OMAFRA], 2004).

The "biologically effective dose" or the weed-specific herbicide dose is a critical component of integrated weed management (IWM) (Dieleman et al., 1996; Knezevic et al., 1998; Sikkema et al., 1999). In IWM, depending on the level of weed control desired at a particular site, herbicide doses are adjusted to either control the weed or reduce its growth to a level so that it is no longer competing with the crop. Since label doses are recommended to control a broad range of weed species and are often greater than biologically effective dose for the weed species desired, information on weed-specific herbicide doses can help growers reduce herbicide doses and thus optimise profit while minimizing their environmental impact (Bosnic and Swanton, 1996; Green, 1991; Knezevic et al., 1998).

There is currently little information on the biologically effective dose for controlling weed species with PRE applications of flufenacet plus metribuzin in soybeans. The objective of this study was to evaluate the responses of soybeans to PRE applications of flufenacet plus metribuzin and to determine the biologically effective dose for control of selected weed species under Ontario growing conditions.

## 2. Materials and methods

Field experiments were conducted in 1998 and 1999 at the Huron Research Station, Exeter, Ontario and at Ridgetown College, Ridgetown, Ontario. The soil type at Exeter was a Brookston clay loam (Orthic Humic Gleysol) with 38% sand, 31% silt, 31% clay, 4.0% organic matter and a pH of 8.1 in 1998, and 43% sand, 33% silt, 24% clay, 5.0% organic matter and a pH of 7.8 in 1999. The soil type at Ridgetown was a Wattford/Brady sandy clay loam (Grey–Brown Podzolic) with 37% sand, 36% silt, 27% clay, 6.34% organic matter and a pH of 6.9 in 1998, and 60% sand, 24% silt, 15% clay, 4.09% organic matter and a pH of 7.1 in 1999. Seedbed preparation at both locations consisted of fall moldboard plowing followed by two passes with a field cultivator in the spring.

The experimental design was a randomized complete block design (RCBD) with four replications. Treatments consisted of a weedy and weed-free control and flufenacet plus metribuzin (Axiom™ 68 DF, pre-mix of flufenacet and metribuzin at 54.4 + 13.6% ai.) at 0.67, 0.76, 0.84, 1.00, 1.34, 1.52, and 1.68 kg ai ha$^{-1}$. Plots were 3 m wide (four rows) and 10 m long at Exeter and 3 m wide and 8 m long at Ridgetown. Each plot consisted of four rows of 'Pioneer 9294' soybeans spaced 0.75 m apart. Soybeans were planted on 28 May 1998 and 21 May 1999 at Exeter and on 15 May 2001 and 11 May 1999 at Ridgetown, at a rate of 480,000 seeds ha$^{-1}$.

Herbicide applications were made with a $CO_2$ pressurized backpack sprayer calibrated to deliver 200 L ha$^{-1}$ of spray solution at a pressure of 241 kPa at Exeter and 200 kPa at Ridgetown. The boom was 1.5 m long with four 8002 flat-fan nozzles (Teejet 8002 flat-fan nozzle tip; Spraying Systems Co., Wheaton, IL) spaced 0.5 m apart. Herbicide applications were made 1–2 days after planting to the soil surface. Weed-free plots were kept weed free by inter-row cultivation and hand hoeing as required.

Crop injury was rated visually 7, 14 and 28 days after treatment (DAT), and weed control was rated visually 28 and 56 DAT on a scale of 0–100%. A rating of 0 was defined as no visible crop/weed injury, and a rating of 100 was defined as total crop/weed necrosis. Yields were measured at crop maturity by harvesting with a plot combine. At Exeter, soybean was harvested on 8 October 1998 and 27 September 1999. At Ridgetown, soybean was harvested on 3 October 1998 and 11 October 1999. Yields were adjusted to 13% moisture.

All data were subjected to analysis of variance (ANOVA) and were combined over locations and years and analyzed using the Proc Mixed procedure of SAS (Ver. 8, SAS Inst., Cary, NC). Variances of percent injury at 7, 14, and 28 DAT, and yield (all sites), were partitioned into the fixed effects of herbicide treatment and into the random effects of test and block (test). Significance of random effects were tested using a $Z$-test of the variance estimate and fixed effects were tested using $F$-tests. Error assumptions of the variance analyses (random, homogeneous, normal distribution of error) were confirmed using residual plots and the Shapiro–Wilk normality test. To meet assumptions of the variance analysis, percent injury at 7, 14, and 28 DAT and percent weed control were subjected to an arcsine square root transformation (Bartlett, 1947). Treatment means were separated using Fisher's protected LSD at $P = 0.05$. Means of percent injury were compared on the transformed scale and were converted back to the original scale for presentation of results. Type I error was set at 0.05 for all statistical comparisons. The biologically effective dose (ED) for 50%, 80%, and 90% control of *C. album* L., *S. arvensis* L., and *S. viridis* (L.) Beauv. were estimated using the Proc Nlin procedure of SAS using the Log-logistic model of Schabenberger et al. (1999).

## 3. Results and discussions

Visual crop injury symptoms included chlorosis, necrosis and crinkling of the leaves and growth reduction. Statistical analysis showed significant differences among the doses of flufenacet plus metribuzin