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# Response of dry bean to pre-plant incorporated and pre-emergence applications of S-metolachlor and fomesafen

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ABSTRACT

There is limited information on the tolerance of various market classes of dry bean to the soil application of fomesafen alone or in tank mix combination with S-metolachlor. Field trials were conducted in Ontario over a two year period (2006 and 2007) to evaluate the tolerance of black, cranberry, kidney, and white (navy) bean to the pre-plant incorporated (PPI) and pre-emergence (PRE) application of S-metolachlor and fomesafen alone and in tank mix combination. Treatments included a non-treated check. All treatments were maintained weed free during the growing season. Visible injury differed among the four market classes of dry bean at 14 days after emergence. Visible injury was generally greater in the smaller seed market classes (black and white bean) compared to the larger seeded market classes (kidney and cranberry bean). Visible injury seen in some market classes of dry bean early in the season was minimal and transitory and caused no adverse effects on plant height, shoot dry weight, seed moisture content, and yield. Based on these results, S-metolachlor and fomesafen alone and in combination applied PPI or PRE at the proposed maximum use dose can be safely used for weed management in black, cranberry, kidney, and white bean production in Ontario.



## 1. Introduction

Dry bean (*Phaseolus vulgaris* L.) is an important field crop grown in Ontario. Growers planted 66,000 hectares and harvested 146,000 tonnes of dry bean with a farm gate value of $72,000,000 in 2006 (Anonymous, 2008). Weeds are one of the most important production concerns for dry bean growers and can result in significant financial losses if not efficiently controlled. Current problem weeds in the region include *Chenopodium album* L. (common lambsquarter), *Amaranthus retroflexus* L. (redroot pigweed.), *Ambrosia artemisiifolia* L. (common ragweed), *Abutilon theophrasti* Medic. (velvetleaf), *Sinapis arvensis* L. (wild mustard), *Polygonum* spp. (smartweed), *Xanthium strumarium* L. (common cocklebur), *Solanum* spp. (nightshades), *Setaria* spp. (foxtails), and *Digitaria* spp. (crabgrass) [Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) 2006]. More research is needed to identify herbicides that have an adequate margin of crop safety and provide consistent control of troublesome weeds in various market classes of dry bean.

S-metolachlor is a chloroacetanilide herbicide with both root and shoot activity. S-metolachlor inhibits meristematic growth of germinating seedlings and leaf emergence (Osborne et al., 1995; Rowe and Penner, 1990). S-metolachlor can provide effective control of a number of annual grasses such as *Setaria faberii* Herrm. (giant foxtail), *Setaria viridis* (L.) Beauv. (green foxtail), *Setaria glauca* (L.) Beauv. (yellow foxtail), *Echinochloa crusgalli* (L.) Beauv. (barnyardgrass), *Digitaria sanguinalis* (L.) Scop. (large crabgrass), *Digitaria ischaemum* (Schreb) Muhl. (smooth crabgrass), *Panicum dichotomiflorum* Michx. (fall panicum) and *Panicum capillare* L. (witchgrass) (Moseley and Hagood, 1990; OMAFRA, 2006; Osborne et al., 1995; Senseman, 2007).

Fomesafen is a diphenyl ether herbicide with both root and shoot activity that can control broadleaved weeds such as *S. arvensis*, *A.* retroflexus, *A. artemisiifolia*, *Polygonum persicaria*, *X. strumarium* and *Solanum* spp. (OMAFRA, 2006; Senseman, 2007). Fomesafen inhibits protoporphyrinogen oxidase (Protox), an enzyme needed for chlorophyll and heme biosynthesis (Senseman, 2007). Visible injury symptoms of susceptible plants include chlorotic and necrotic leaves (OMAFRA, 2006; Senseman, 2007).

S-metolachlor provides only partial control of some small-seeded broadleaved weeds such as *Solanum* spp., *C. album*, and *A. retroflexus*. However, S-metolachlor in combination with fomesafen can effectively control a wider spectrum of weeds including

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troublesome broadleaved weeds such as *A. retroflexus*, *A. artemisiifolia*, *S. arvensis*, *P. persicaria*, *Solanum* spp., and *X. strumarium* (OMAFRA, 2006; Senseman, 2007; Wilson, 2005).

Research has shown that for the most part, tolerance of dry bean to various herbicides is influenced by dose, application timing, cultivar and environmental conditions (Bauer et al., 1995; Newsom and Shaw, 1992; Osborne et al., 1995; Renner and Powell, 1992; Urwin et al., 1996; VanGessel et al., 2000; Ward and Weaver, 1996; Wilson and Miller, 1991). More information is needed on the tolerance of various market classes of dry bean to S-metolachlor and fomesafen alone or in combination for selective weed control in Ontario. Currently, fomesafen can only be used as a post-emergence (POST) application in dry bean. There is no registration for the use of fomesafen or S-metolachlor plus fomesafen applied pre-plant incorporated (PPI) or pre-mergence (PRE) in dry bean production in Ontario. Expanding the registration of these herbicides will provide dry bean growers with a broad spectrum weed management option.

The objective of this study was to determine the tolerance of black, cranberry, kidney, and white bean to S-metolachlor and fomesafen alone and in tank mix combination under Ontario growing conditions and to determine if there was a difference in crop tolerance among these market classes of dry bean to the PPI and PRE application timings.

## 2. Materials and methods

Field experiments were conducted in 2006 and 2007 at the Huron Research Station, Exeter, Ontario and in 2007 at University of Guelph Ridgetown Campus, Ridgetown, Ontario. The soil at Exeter was a Brookston clay loam (Orthic Humic Gleysol, mixed, mesic, and poorly drained) with 34% sand, 33% silt, 33% clay, 3.0% organic matter and pH of 7.9 in 2006, and 32% sand, 41% silt, 27% clay, 4.6% organic matter and pH of 7.9 in 2007. The soil at Ridgetown was Wattford (Grey-Brown Brunisolic, mixed, mesic, sandy, and imperfectly drained)-Brady (Gleyed Brunisolic Grey-Brown Luvisol, mixed, mesic, sandy, and imperfectly drained) with 69% sand, 19% silt, 12% clay, 4.5% organic matter and pH of 7.2 in 2006. Seedbed preparation consisted of autumn moldboard plowing followed by two passes with a field cultivator in the spring.

The experimental design was a split-plot randomized block design with four replications. The main plots were herbicide treatments and the sub-plots were four market classes of dry bean. The treatments consisted of a non-treated check and two doses, the proposed dose (1×) and twice that dose (2×), for S-metolachlor (1373 and 2746 g a.i. $ha^{-1}$), fomesafen (280 and 560 g a.i. $ha^{-1}$), and S-metolachlor plus fomesafen (1373 + 280 and 2746 + 560 g a.i. $ha^{-1}$) applied PPI and PRE. Sub-plots, which consisted of four rows of dry bean representing four market classes of dry bean, were 3 m wide (4 rows spaced 0.75 m apart) and 10 m long at Exeter and 3 m wide and 8 m long at Ridgetown. The market classes and cultivars were: black beans (Black Knight), cranberry beans (Etna), kidney beans (Red Hawk), and white (navy) beans (OAC Rex). Cranberry and kidney beans are larger in size and are approximately 1.6 cm in length while black and white beans are approximately 0.8 cm in length. Beans were planted to a depth of 5 cm in late May or early June at a rate of 390,000 seeds $ha^{-1}$ for black and white beans and 175,000 seeds $ha^{-1}$ for cranberry and kidney beans.

The PPI applications were made one to two days before planting and were immediately incorporated into the soil to a depth of 5 cm with two passes (in opposite directions) of an S-tine cultivator with rolling basket harrows. The PRE applications were made to the soil surface one to two days after planting. 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 200 kPa using 8002 flat-fan nozzles (Teejet 8002 flat-fan nozzle Tip, Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60188). The boom was 2.5 m wide with six nozzles spaced 0.5 m apart. Environmental conditions for study sites are shown in Table 1. All plots including the non-treated control were maintained weed free by cultivation and hand hoeing as required to eliminate the confounding factor of weed interference.

Crop injury was evaluated visually 7, 14 and 28 days after emergence (DAE) using a scale of 0–100% where a rating of 0 was defined as no visible plant injury and a rating of 100 was defined as plant death. At 28 DAE, ten plants per plot were randomly selected and the height from the soil surface to the highest growing point was measured. At 42 DAE, a 1 m section of row for each cultivar was hand harvested at the ground level, oven dried at 60 °C to a constant moisture and the dry weight was recorded. Yields were measured at crop maturity by hand-harvesting the remaining 9 m from each plot at Exeter and 7 m from each plot at Ridgetown and threshing in a plot combine. Crops were considered physically mature when 90% of the pods in the non-treated plots of each market class had turned from green to a golden colour. Dry beans were harvested at Exeter from August 31 to Sept. 10 in 2006 and 2007; and at Ridgetown from Oct. 10 to Oct. 25 in 2007. All yields were adjusted to 18% moisture.

All data were subjected to analysis of variance (ANOVA) using SAS statistical software (SAS, 1999). Data were analyzed as a 4-way factorial with factors 1) dry bean market class (black, white, cranberry and kidney bean); 2) herbicides (S-metolachlor, fomesafen, S-metolachlor plus fomesafen); 3) application timing (PPI and PRE); and 4) herbicide dose (1× and 2×). Variance analyses combined over years and locations were performed using the *Proc Mixed* procedure of SAS. Variances were partitioned into the random effects of locations, years, and years by locations, blocks within years by locations, and their interactions with fixed effects, and into the fixed effects of herbicide treatment, market class, variety within market class, herbicide by market class and herbicide by cultivar within market class. 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 DAE were subjected to an arcsine square root transformation (Bartlett, 1947). Seed moisture content were log-transformed. Means were compared using Fisher's Protected LSD. The Type I error was set at 0.05 for all statistical comparisons.

**Table 1**
Weather conditions for experimental sites in 2006 and 2007.

| Location | Year | Month | | | | |
|---|---|---|---|---|---|---|
| | | May | June | July | August | September |
| *Mean rainfall (mm)* | | | | | | |
| Exeter | 2006 | 54.4 | 40.6 | 83.8 | 110.0 | 83.4 |
| | 2007 | 55.6 | 31.0 | 101.7 | 66.2 | 67.3 |
| Ridgetown | 2006 | 83.8 | 55.0 | 98.2 | 75.6 | 110.0 |
| *Temperature (°C)* | | | | | | |
| Exeter | | | | | | |
| Mean max. | 2006 | 19.3 | 24.6 | 27.5 | 25.5 | 19.4 |
| Mean min. | | 9.3 | 13.5 | 16.9 | 16.1 | 11.3 |
| Mean max. | 2007 | 18.8 | 26.5 | 26.3 | 27.7 | 25.1 |
| Mean min. | | 13.1 | 18.4 | 16.5 | 21.4 | 17.5 |
| Ridgetown | | | | | | |
| Mean max. | 2006 | 19.1 | 22.4 | 25.0 | 23.4 | 19.6 |
| Mean min. | | 9.4 | 14.2 | 18.8 | 16.2 | 10.9 |