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Response of four market classes of dry bean to mesotrione soil residues

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Abstract

Field trials were established in 2001 and 2003 in Ontario to determine the potential of mesotrione applied pre-emergence (175 and 350 g a.i./ha) and post-emergence (100 and 200 g a.i./ha) to cause injury to cranberry, kidney, black, and white beans grown in rotation with maize, one and two years after application. Mesotrione applied pre-emergence at 175 and 350 g a.i./ha or post-emergence at 100 and 200 g a.i./ha to field maize in the previous year caused minimal visual injury (6% or less) and had no effect on shoot dry weight and yield of black and white beans except for black bean shoot dry weight and yield which were both reduced 12% with post-emergence mesotrione at 200 g a.i./ha. Mesotrione caused as much as 42% visual injury, 31% shoot dry weight reduction, and 42% yield reduction in cranberry and kidney beans. Post-emergence mesotrione caused more crop injury than pre-emergence mesotrione. Mesotrione applied pre-emergence or post-emergence at the labeled or twice the labeled doses in maize did not injure cranberry, kidney, black, and white beans two years after application. Based on these results, black and white beans can be safely grown in rotation with field maize treated with mesotrione pre-emergence or post-emergence at the labeled dose. However, a re-cropping interval of two years is recommended following application of mesotrione for cranberry and kidney beans.

Keywords: Black bean; Carryover; Cranberry bean; Kidney bean; Mesotrione; White bean

1. Introduction

Many agricultural producers in southern Ontario grow dry bean (*Phaseolus vulgaris* L.) in rotation with other field crops such as maize (*Zea mays* L.), as they offer growers a higher value crop than traditional agronomic crops, and can break up pest cycles common to continuous maize production. Growth responses of various market classes of dry bean differ with various herbicides in the year of application (Sikkema et al., 2004a, b; Soltani et al., 2003, 2004a, b, 2005; Urwin et al., 1996; Wilson and Miller, 1991), and can also differ due to residues of herbicides applied to maize in previous years (Felix and Doohan, 2005; Greenland, 2003; Johnson and Talbert, 1993; Monks and Banks, 1991; Robinson et al., 2006).

Mesotrione is a recently registered triketone herbicide for pre-emergence and post-emergence broadleaved weed control in field maize (Mitchell et al., 2001; OMAFRA, 2006; O'Sullivan et al., 2002). Typically, the dose for a soil application of mesotrione is higher than the dose when applied post-emergence. Mesotrione is a competitive *P*-hydroxy-phenylpyruvate dioxygenase (HPPD) inhibitor that in susceptible plants can block biosynthesis of plant pigments and cause plant death (Duke et al., 2000; O'Sullivan et al., 2002; Wichert et al., 1999). Mesotrione is a very effective residual herbicide for the control of a number of important broadleaved weeds and selected annual grasses in maize including *Chenopodium album* L. (common lambsquarters), *Amaranthus retroflexus* L. (redroot pigweed), *Abutilon theophrasti* Medicus (velvetleaf), *Polygonum pensylvanicum* L. (Pennsylvania smartweed), *Xanthium strumarium* L. (jimsonweed), and *Solanum* and *Digitaria* spp. (Sutton et al., 1999; O'Sullivan et al., 2002). Injury from soil residues of herbicides applied in the previous years is well documented and has resulted in restrictions in the selection of rotational crops (Felix and Doohan, 2005; Greenland, 2003; Johnson and Talbert, 1993; Monks and Banks, 1991; Vencill, 2002). Felix and Doohan (2005) reported up to 90% visual injury

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and 100% yield reduction in snap bean (*P. vulgaris* L.) 12 months after pre-emergence application of isoxaflutole, a HPPD inhibiting herbicide. Residues of isoxaflutole reduced shoot dry weight and yield as much as 81% and 44% in cranberry, 52% and 39% in black, 53% and 19% in kidney, and 42% and 19% in white bean, respectively, but had no effect on dry bean yield two years after application (Robinson et al., 2006).

Dry bean market classes have different geographic origins and therefore different gene pools which may impact their tolerance to herbicides or their residues. Other studies have shown differential sensitivity between various market classes of dry beans in response to some herbicides (Sikkema et al., 2004a; Soltani et al., 2003, 2004a, b, 2005; Urwin et al., 1996; Wilson and Miller, 1991). To our knowledge, no published paper has compared responses of various market classes of dry beans to mesotrione residues in the years following application. Such information is needed by maize growers to plan their rotation options when they use mesotrione.

The objective of this study was to determine the potential of mesotrione residues to cause injury to various market classes of dry bean grown in rotation with field maize one and two years after application.

2. Materials and methods

Two trial runs were established—one in 2001 and a second in 2003—at the University of Guelph, Ridgetown Campus, Ridgetown, Ontario, Canada. Glufonsinate-tolerant field maize was planted in a Brady fine sandy loam soil (pH 6.4, OM 4.5%, sand 79%, silt 15% and clay 6%) in 2001, and Brookston loam soil (pH 7.3, OM 4.5%, sand 45%, silt 29% and clay 26%) in 2003. Seedbed preparation consisted of autumn mouldboard plowing followed by two passes with a field cultivator in the spring.

In the year of herbicide application (i.e. 2001 and 2003), the experimental design was a randomized complete block design with four replications. Each plot was 6 m wide and 22 m long. The following treatments were applied: mesotrione pre-emergence (PRE) at 175 and 350 g a.i./ha and mesotrione post-emergence (POST) at 100 and 200 g a.i./ha, representing the label dose and twice the label dose of mesotrione in field maize. PRE treatments were made 1–2 days after planting to the soil surface and POST treatments were applied to maize at the six to seven leaf stage of growth. POST treatments included 0.2% and 0.4% (v/v) of non-ionic surfactant (Agral 90, Norac Concepts, Orleans, Ontario, Canada), respectively. Treatments included a non-treated weed-free check. Field maize was maintained weed free with two applications of glufosinate-ammonium (500 g a.i./ha), grown to maturity and harvested according to standard agronomic practices (OMAFRA, 2002). Herbicide applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 200 L/ha of spray solution at a pressure of 200 kPa using Teejet 8002 (Teejet 8002 flat-fan nozzle Tip, Spraying Systems Co., P.O. Box 7900, Wheaton, IL) flat-fan nozzles. The boom was 2.5 m long with six nozzles spaced 0.5 m apart.

One and two years following herbicide application, the trial areas were shallow disked (10 cm depth) followed by two passes with a field cultivator. The experimental design was a randomized complete block with a split-plot arrangement and four replications with herbicide treatment as main plots and dry bean market classes as sub-plots. Sub-plots were planted perpendicular to the maize plots with one row each of cranberry bean ('SVM Taylor'), kidney bean ('Montcalm'), black bean ('Midnight Black Turtle'), and white bean ('AC Compass') in rows that were 0.75 m apart and 6 m long. Dry beans were planted to a depth of 5 cm at a rate of 390,000 seeds/ha for black and white beans and 175,000 seeds/ha for cranberry and kidney beans during late May to early June and were fertilized according to recommended Ontario agronomic crop production practices (OMAFRA, 2002). Trials were maintained weed free by hand weeding to eliminate the confounding effect of herbicide residues with weed interference.

Percent visual injury was determined on a scale of 0–100% at 7, 14, and 28 days after emergence (DAE). A rating of 0 was defined as no visible plant injury and a rating of 100 was defined as plant death. At 28 DAE, above ground biomass of each cultivar was removed from 1 m of row in each herbicide treatment and in the non-treated check. The plant samples were dried to constant weight at 60 °C and the dry weight was recorded. Yields were measured at crop maturity by hand harvesting. Dry bean cultivars were considered physically mature when 90% of pods had turned from green to golden color. Yields were adjusted to 18% moisture.

All data were subjected to analysis of variance (ANOVA) using SAS statistical software (Statistical Analysis Systems, version 8e, Box 8000, SAS Institute Inc., Cary, NC). Variance analyses for one year after application and two years after application were performed using the PROC MIXED procedure of SAS. Variances were partitioned into the fixed effects of herbicide treatment, market class and herbicide by market class, and into random effects of trial runs, blocks within trial runs, and trial run interactions with fixed effects. Significance of random effects was 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 and normal distribution of error) were confirmed using residual plots and the Shapiro-Wilk normality test. To compare responses among market classes, shoot dry weight and yield data were analyzed as the percentages of the non-treated check. To meet assumptions of the variance analysis, percent injury at 7, 14, and 28 DAE, shoot dry weight, and yield were subjected to an arcsine square root transformation (Bartlett, 1947). Treatment means were separated using orthogonal contrasts ($\alpha = 0.05$) to compare dry bean visual injury, biomass, and yield between each herbicide treatment and the non-treated check. The Type I error was set at 0.05 for all statistical comparisons.