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Effect of clomazone on various market classes of dry beans

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Abstract

Tolerance of eight cultivars of dry beans representing eight market classes (black, brown, cranberry, kidney, otebo, pinto, white, and yellow eye beans) to the pre-emergence application of clomazone at the dose of 1116 and 2232 g a.i. ha^{-1} was studied at Exeter and Ridgetown, Ontario, Canada in 2003 and 2005. Clomazone applied pre-emergence caused 5%, 4%, and 1% visual injury at 1116 g ha^{-1} and 11%, 10%, and 4% visual injury at 2232 g ha^{-1} in dry beans at 7, 14, and 28 days after emergence (DAE), respectively. Visual injury increased with dose and decreased over time. Visual injury was minimal by 28 DAE (less than 5%) and had no adverse effect on plant height, shoot dry weight and yield of any market class of dry beans evaluated. Seed moisture content measured at harvest ranged from 17% to 24% for the various market classes of dry beans and was not affected by the application of clomazone. White bean exhibited the least visual injury followed by brown, kidney, yellow eye, otebo, pinto, and then black and cranberry beans. Based on these results, clomazone applied pre-emergence at 1116 g ha^{-1} has an adequate margin of crop safety for use in black, brown, cranberry, kidney, otebo, pinto, white, and yellow eye beans.

Keywords: Clomazone; Dry bean; *Phaseolus vulgaris*; Pre-emergence; Sensitivity; Tolerance; Visual injury; Yield

1. Introduction

Weed control is one of the major production problems for Ontario dry bean growers. Weed species that commonly cause problems in dry bean production in Ontario include *Chenopodium album* L. (common lamb's-quarters), *Amaranthus retroflexus* L. (redroot pigweed), *Abutilon theophrasti* Medic (velvetleaf), *Sinapis arvensis* L. (wild mustard), *Ambrosia artemesiifolia* L. (common ragweed), *Polygonum* spp. (smartweed), *Solanum* spp. (annual nightshades), *Setaria viridis* (L.) Beauv. (green foxtail), and *Echinochloa crusgalli* (L.) Beauv. (barnyardgrass). With recent withdrawal of monolinuron and metobromuron from the market, there are a few herbicides available for broadleaved weed control in dry beans in Ontario. Imazethapyr is the only soil applied broad leaf herbicide registered for use in some market classes of dry beans. However, imazethapyr provides marginal control of *Ambrosia artemesiifolia* and *C. album* and has a narrow margin of crop safety in some market classes of dry beans (OMAF, 2006). More research is needed to identify herbicides that provide consistent control of annual grass and broadleaved weeds in dry bean with an adequate margin of crop safety.

Clomazone inhibits the biosynthesis of carotenoids and causes loss of photosynthetic pigmentation in sensitive species (Vencill, 2002). Clomazone can effectively control broadleaved weeds such as *C. album* (including triazine-resistant biotypes) and *Abutilon theophrasti* at doses ranging from 280 to 1100 g ha^{-1} (Brown and Masiunas, 2002; Burnside et al., 1994; Porter, 1990; Vencill, 2002; Westberg et al., 1989). Clomazone also can effectively control many annual grasses including *E. crusgalli*, *Digitaria* spp. (crabgrass) and *Setaria* spp. (foxtails) (Burnside et al., 1994; Renner and Powell, 1992; Scott et al., 1995; Vencill, 2002; Westberg et al., 1989).

Singh et al. (1991a–c) studied numerous landraces of dry beans from various primary centres of domestication (geographical and ecological regions) in America including Mexico, Nicaragua, El Salvador, Honduras, Costa Rica, Dominican Republic, Columbia, Argentina, and Brazil.

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They found that origin influences agronomic traits, morphological characteristics, environmental adaptation, and disease resistance in dry beans. Market classes of dry beans have different geographic origins and therefore different gene pools which may impact their tolerance to herbicides. There is little information on the tolerance of various market classes of dry beans to clomazone. Registration of clomazone in Ontario for weed management in dry beans would provide growers with an additional mode of action to manage troublesome weeds such as *E. crusgalli*, *Panicum* spp., *Digitaria ischaemum*, *Setaria* spp., *C. album*, and *Abutilon theophrasti*.

The objective of this study was to determine the tolerance of eight cultivars of dry beans, representing eight market classes (black, brown, cranberry, kidney, otebo, pinto, white, and yellow eye beans) to clomazone applied pre-emergence under Ontario environmental conditions.

2. Materials and methods

Field experiments were conducted in 2003 and 2005 at the Huron Research Station, Exeter, Ontario and at the 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 31% sand, 38% silt, 31% clay, 4.6% organic matter and pH 8.0 in 2003; and 38% sand, 41% silt, 21% clay, 4.3% organic matter and pH 7.9 in 2005. The soil at Ridgetown was a fine Wattford sandy loam (Grey-Brown Brunisolic, mixed, mesic, sandy, and imperfectly drained)-Brady (Gleyed Brunisolic Grey-Brown Luvisol, mixed, mesic, sandy, and imperfectly drained) with 51% sand, 33% silt, 16% clay, 5.5% organic matter and pH of 7.2 in 2003; and 74% sand, 18% silt, 8% clay, 3.6% organic matter and pH of 6.4 in 2005. The seedbed was prepared by moldboard ploughing in the autumn followed by two passes with a field cultivator in the spring.

The experiments were established in a split-plot design with four replications. Main plots were herbicide treatments which consisted of a non-treated check and clomazone applied pre-emergence at 1116 and 2232 $g\,ha^{-1}$, representing once and twice the maximum proposed use dose in dry beans in Ontario. Sub-plots were eight cultivars of dry beans which consisted of one row of black ('AC Harblack'), otebo ('Hime'), pinto ('GTS 900'), white ('OAC Thunder'), brown ('Berna'), cranberry ('Hooter'), kidney ('Montcalm'), and yellow eye ('GTS 1701') beans. The plots were 6 m wide (eight rows spaced 0.75 m apart) at all sites and 10 m long at Exeter and 8 m long at Ridgetown. Beans were planted to a depth of 5 cm on June 18, 2003 and June 7, 2005 at Exeter and June 3, 2003 and June 8, 2005 at Ridgetown at a rate of 400,000 seeds ha^{-1} for black, otebo, pinto and white beans and 200,000 seeds ha^{-1} for brown, cranberry, kidney, and yellow eye beans.

Clomazone was applied pre-emergence to the soil surface 1 or 2 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., Wheaton, IL.). The boom was 1.0 m wide with three nozzles spaced 0.5 m apart. Plots were maintained weed free by cultivation and hand hoeing as required to eliminate the confounding factor of weed interference.

Visual crop injury was rated 7, 14, and 28 days after emergence (DAE), on a scale of 0% (no visible plant injury) to 100% (total plant necrosis). Ten plants per plot were randomly selected and the height from the soil surface to the highest growing point was measured 28 DAE. 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 weight and the dry weight was recorded. Yield and seed moisture content 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 pods in the non-treated plots of each cultivar had turned from green to a golden colour. Dry beans were harvested at Exeter from Septmeber 19 to October 7 in 2003 and from September 7 to September 22 in 2005; and at Ridgetown from September 17 to October 9 in 2003 and September 21 to October 4 in 2005. All yields were adjusted to 18% moisture.

All data were subjected to analysis of variance (ANOVA) using SAS statistical software (SAS, 1999). 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 and herbicide by market class. 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, 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 days after emergence and seed moisture content were subjected to square root transformation (Bartlett, 1947), compared on the transformed scale, and converted back to the original scale for presentation of results. Means were compared using Fisher's protected LSD. The Type I error was set at 0.05 for all statistical comparisons.

3. Results and discussions

Statistical analysis of the data on visual injury, plant height, shoot dry weight, seed moisture content, and yield showed that the random effects of location, year, year by location, and interactions with treatments was not significant. Therefore, data were pooled and averaged over years and locations (Tables 1–5). Data were also pooled