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Weed management in dry beans (*Phaseolus vulgaris*) with dimethenamid plus reduced doses of imazethapyr applied preplant incorporated

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Abstract

Three field trials were conducted over a 3-year period (2003, 2004 and 2005) near Exeter, Ontario to determine if dimethenamid tank-mixed with reduced doses of imazathapyr applied preplant incorporated (PPI) can be used as an efficacious, environmentally acceptable, and economically feasible weed management strategy for broad spectrum weed control in white and kidney beans. There was no additional injury in white or kidney beans with the imazethapyr plus dimethenamid tank-mix treatments evaluated. Based on regression analysis, the dose of imazethapyr required to provide a minimum of 95% control of *Amaranthus retroflexus*, *Ambrosia artemesiifolia*, *Chenopodium album*, *Sinapis arvensis*, and *Setaria viridis* was reduced significantly when tank-mixed with dimethenamid (1000 g ha^{-1}). There was no adverse effect on the yield of white and kidney beans with any of the herbicides evaluated. The low application dose of imazethapyr compared to dimethenamid (75 vs. 1000 g ai ha^{-1}, respectively) resulted in an environmental impact (EI) of imazethapyr that was seven-times less than dimethenamid. The application of dimethenamid at 1000 g ai ha^{-1} or imazethapyr at 15 g ai ha^{-1} produced the lowest profit margins. Application of higher doses of imazethapyr alone and tank-mixing dimethenamid with imazethapyr increased the profit margins for both white and kidney beans. Based on these results, dimethenamid tank-mixed with reduced doses of imazathapyr applied PPI results in acceptable weed control, crop yield and net returns with an acceptable minimal increase in environmental impact.

Keywords: Crop injury; Dimethenamid; Environmental impact quotient (EIQ); Imazethapyr; 'Montcalm'; 'OAC Thunder'; *Phaseolus vulgaris* L.; Profit margin

1. Introduction

Dry bean (*Phaseolus vulgaris* L.) is an important cash crop grown in rotation with maize, soybean, and cereals in southwestern Ontario. Weed management is one of the most important problems facing dry bean growers. Weeds compete with dry bean for light, moisture and nutrients, and can drastically reduce dry bean quality and yield (Bauer et al., 1995; Urwin et al., 1996). Presence of certain weeds at harvest time interferes with harvesting efficiency and can stain the beans, which lowers marketability (Arnold et al., 1993; Bauer et al., 1995; Urwin et al., 1996; Wilson and Miller, 1991). Currently, there are a limited number of broad spectrum weed control options available to dry bean growers. This lack of registered herbicides has resulted in higher input costs for mechanical cultivation and hand hoeing, making dry bean a less attractive cash crop. Identification of herbicides or herbicide tank-mixes that provide consistent broad spectrum weed control, have low environmental impact and maximize dry bean yield and net returns are crucial for dry bean production in Ontario.

Dimethenamid is a chloroacetamide herbicide that controls annual grasses and some small-seeded broadleaf weeds including *Setaria faberii* Herrm. (giant foxtail), *S. viridis* (L.) Beauv. (green foxtail), *S. glauca* (L.) Beauv. (yellow foxtail), *Digitaria sanguinalis* (L.) Scop. (large crabgrass), *D. ischaemum* (Schreb) Muhl. (smooth crabgrass), *Echinochloa crusgalli* (L.) Beauv. (barnyardgrass.), *Panicum dichotomiflorum* Michx. (fall panicum), *P. capillare* L. (witchgrass), *Amaranthus retroflexus* L. (redroot pigweed.), and *Solanum ptycanthum* Dunal (eastern black nightshade) (Arnold et al., 1993; Bauer et al., 1995; Vencill,

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2002; Ontario Ministry of Agriculture and Food and Rural Affairs (OMAFRA), 2006). Dimethenamid has an adequate margin of crop safety in various market classes of dry bean (Arnold et al., 1993; Urwin et al., 1996; Poling, 1999; Sikkema et al., 2004; Sikkema and Soltani, 2005; Soltani et al., 2003, 2004a, b, 2006).

Imazethapyr is an imidiazolinone herbicide that controls annual broadleaf and grass weeds including *Chenopodium album* L. (lambsquarters), *A. retroflexus*, *Sinapis arvensis* L. (wild mustard), *Ambrosia artemisiifolia* L. (common ragweed), *Abutilon theophrasti* Medic (velvetleaf), *Polygonum convolvulus* L. (wild buckwheat), and *S. ptycanthum* (Vencill, 2002; Ontario Ministry of Agriculture and Food and Rural Affairs (OMAFRA), 2006). However, imazethapyr has a narrow margin of crop safety in dry bean and causes unacceptable crop injury in some market classes of dry bean (Wilson and Miller, 1991; Renner and Powell, 1992; Arnold et al., 1993; Blackshaw and Saindon, 1996; Bauer et al., 1995; Vencill, 2002; Soltani et al., 2004a, b; Sikkema and Soltani, 2005). There is little information on the effect of dimethenamid and imazethapyr tank-mixes in dry bean. Combining herbicides at lower than recommended doses in a tank-mix often can provide similar or better control of susceptible weeds than when those herbicides are applied individually. A tank-mix combination of dimethenamid plus reduced doses of imazethapyr can be an effective option for the broad spectrum control of annual grass and broadleaf weeds in dry bean.

The environmental impact (EI) of different weed control strategies should also be considered when making weed management decisions. The EI of weed control may be reduced by using lower herbicide application doses and/or safer products. Several indices and models have been developed based on toxicological and physicochemical properties of pesticides (Van der Werf and Zimmer, 1998; De Jong and De Snoo, 2002; Sanchez-Bayo et al., 2002), including the environmental impact quotient (EIQ; Kovach et al., 1999). The EIQ uses three risk components: farm worker, consumer, and environment to estimate the relative potential risk of pesticide active ingredients (ai). The EI of a particular pesticide treatment is obtained by multiplying the EIQ by the application dose. Thus, a higher EI indicates a greater risk of detrimental impact. The EIQ was designed to provide growers and weed management practitioners with a single number that indicates the magnitude of relative risk.

Despite criticism mainly due to simplicity (Dushoff et al., 1994), the EIQ has been used by several researchers to compare environmental risk of different pesticides and/or production systems (Fernandez-Cornejo, 1998; Edwards-Jones and Howells, 2001; Ziegler et al., 2002; Bues et al., 2003, Lan et al., 2003; Brimner et al., 2005). The EIQ can be used as a decision tool, along with herbicide efficacy, crop safety, and profit margins to identify the most advantageous weed management strategy in dry bean.

The objectives of this study were to determine if dimethenamid tank-mixed with reduced doses of imazathapyr applied preplant incorporated (PPI) would provide acceptable control of common weeds in Ontario, and to determine the implications of this weed management strategy on the environmental impact, yield and net returns of white and kidney beans.

2. Materials and methods

Field experiments were conducted in 2003, 2004 and 2005 at the Huron Research Station, Exeter, Ontario. The soil was a Brookston clay loam (Orthic Humic Gleysol, mixed, mesic, and poorly drained) (Table 1). The seedbed was prepared by moldboard plowing in the fall which was followed by two passes with a field cultivator in the spring.

There were 13 treatments which consisted of a non-treated weedy check and a weed-free check, dimethenamid at 1000 g ai ha^{-1}, imazethapyr at 15, 30, 45, 60 and 75 g ai ha^{-1} individually and in tank-mix combination with dimethenamid at 1000 g ai ha^{-1}. Plots were arranged in a randomized block design with four replications and consisted of two rows of 'OAC Thunder' white bean and two rows of 'Montcalm' kidney beans spaced 0.75 m apart in rows that were 10 m long and planted at 200,000 and 150,000 seeds ha^{-1}, respectively (Table 1).

Herbicides were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 200 L ha^{-1} aqueous solution at 241 kPa. The boom was 1.5 m long with four Teejet 8002 flat-fan nozzles tip (Spraying Systems Co., Wheaton, IL) spaced 0.5 m apart. Herbicides were applied 1–2 days before planting and were immediately incorporated into the soil with two passes (in opposite directions) of an S-tine cultivator with rolling basket harrows. Weed-free plots were maintained weed free during the growing season by inter-row cultivation and hand hoeing as required.

Crop injury was evaluated visually 7, 14, and 28 days after emergence (DAE), on a scale of 0–100% (0% = no visible plant injury and 100% = total plant necrosis). Weed control was rated 56 DAE on a scale of 0–100% (0% = no control and 100% = complete control). Dry bean yield was determined at crop maturity (i.e. 90% golden pods) by hand harvesting the interior row of each variety and

Table 1
Soil characteristics and production practices of experimental sites in 2003–2005

Characteristic	Year		
	2003	2004	2005
% sand:silt:clay	31:38:31	33:35:32	38:41:21
% organic matter	4.6	3.4	4.3
pH	8.0	8.0	7.9
Planting date	6 June	5 June	26 May
Harvest date			
White bean	8 September	15 September	2 September
Kidney bean	9 September	17 September	6 September