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Adzuki bean (*Vigna angularis*) responses to post-emergence herbicides

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Abstract

There are few herbicide options available for weed management in adzuki beans in Ontario. Six field trials were conducted in Ontario over a 2-year period (2003 and 2004) to evaluate the tolerance of adzuki bean to the post-emergence application of bentazon, fomesafen, sethoxydim, quizalofop-*p*-ethyl, imazamox plus fomesafen and imazamox plus bentazon. All treatments including the non-treated control were maintained weed free for the complete growing season. The application of bentazon and imazamox plus bentazon caused visual injury and reduced plant height up to 43%, reduced shoot dry weight up to 65%, delayed maturity and reduced adzuki bean yield as much as 56%. Fomesafen, sethoxydim, quizalofop-*p*-ethyl, and imazamox plus fomesafen caused visual injury but this was transient and there was no adverse affect on plant height, shoot dry weight, seed moisture content and yield of adzuki bean. Fomesafen and imazamox plus fomesafen reduced shoot dry weight by 16% and delayed maturity at the high dose. Based on these results, the application of fomesafen, sethoxydim, quizalofop-*p*-ethyl and imazamox plus fomesafen has an adequate margin of crop safety for weed management in adzuki beans in Ontario, but bentazon and imazamox plus bentazon do not.

Keywords: Bentazon; Crop injury; Fomesafen; Imazamox; *Vigna angularis*; Quizalofop-*p*-ethyl; Sedoxydim; Sensitivity

1. Introduction

Adzuki bean (*Vigna angularis*) is a new market class of dry bean grown in southwestern Ontario. Adzuki bean originated in the Orient, where it has been cultivated and used for many centuries and has become the sixth largest crop in Japan (Sacks, 1977). The adzuki bean plant grows approximately 30–60 cm high and produces pods, each containing two or three primarily dark red seeds with a white ridge on the side. Adzuki bean has a sweet flavour with a nutty taste, and is primarily used in confectionery products (Lumpkin et al., 1993; Rubatzky and Yamaguchi, 1997). The primary use of adzuki bean in North America is bean sprouts. Japanese growers can only grow 5% of the demand and adzuki bean imported from other Asian countries do not meet Japan's standards for quality (Hang et al., 1993). Recent studies have shown that adzuki bean grown in the temperate climates of the North America provides the needed quality for the export market to Japan and has resulted in keen interest in adzuki bean production in North America (Hang et al., 1993; McGill, 1995; McClary et al., 1989, 1993).

Adzuki bean provides an alternative high-value crop that growers can rotate with wheat, corn and soybean in Ontario. Efficient weed management programs are an important component of profitable adzuki bean production. When this study was initiated, adzuki bean growers had only one herbicide registered for use in Ontario. Lack of registered herbicides means high input costs for cultivation and hand hoeing. In addition, adzuki bean yield and quality are reduced. Therefore, there was a great need for new weed control products to make Ontario adzuki bean production competitive.

Bentazon is a benzothiadiazole herbicide that can selectively control broadleaved weeds such as *Sinapis arvensis* L. (wild mustard), *Ambrosia artemesiifolia* L. (common ragweed), *Ambrosia trifida* L. (giant ragweed), *Polygonum persicaria* L. (ladysthumb), *Chenopodium album* L. (common lambsquarter L.), *Amaranthus retroflexus* L. (redroot pigweed), *Abutilon theophrasti* Medic. (velvetleaf), *Portulaca oleracea* L. (purslane), *Raphanus raphanistrum* L.

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(wild radish), *Galinsoga ciliata* (hairy galinsoga), *Senecio vulgaris* (common groundsel), *Datura stramonium* L. (jimsonweed), *Xanthium strumarium* L. (cocklebur), *Capsella bursa-pastoris* (L.) Medic. (shepherdspurse) and *Stellaria media* (L.) Vill. (common chickweed) including group II and V resistant biotypes (Ontario Ministry of Agriculture and Food (OMAF), 2004; Vencill, 2002).

Fomesafen is a diphenyl ether herbicide that can control broadleaved weeds such as *S. arvensis* L., *Abutilon theophrasti* Medic., *A. retroflexus* L., *A. artemesiifolia* L., *P. persicaria* L., *X. strumarium* L. and *Solanum* spp. (black nightshade) (OMAF, 2004; Vencill, 2002).

Sethoxydim and quizalofop-*p*-ethyl are herbicides that inhibit acetyl-CoA carboxylase (ACCase), the enzyme needed for fatty acid synthesis and subsequent production of phospholipids needed for cell membranes in plants. These herbicides can provide effective control of annual and perennial grass species such as *Panicum dichotomiflorum* Michx (fall panicum), *Echinochloa crusgalli* L. (barnyard grass), *Setaria viridis* (L.) Beauv. (green foxtail), *Digitaria sanguinalis* (L.) Scop. (large crabgrass), *Panicum miliaceum* L. (proso millet), *Panicum capillare* L. (witchgrass), *Elytrigia repens* (L.) Nevski (quackgrass), and *Zea mays* L. (volunteer maize) (OMAF, 2004; Vencill, 2002).

Imazamox plus fomesafen is an imidazolinone plus diphenyl ether herbicide and imazamox plus bentazon is an imidazolinone plus benzothiadiazole herbicide that are only available as a co-pack in Ontario. They provide control of a broad spectrum of weeds including *Setaria faberii* Herrm. (giant foxtail), *S. viridis* (L.) Beauv., *Setaria glauca* (L.) Beauv. (yellow foxtail), *E. crusgalli* (L.) Beauv., *A. theophrasti* Medic., *X. strumarium* L., *P. persicaria* L., *S. arvensis* L., *A. artemesiifolia* L., *C. album* L., *A. retroflexus* L. and *Solanum ptycanthum* Dun. (eastern black nightshade) including group V resistant biotypes (OMAF, 2004; Vencill, 2002).

There is currently little information on the sensitivity of adzuki bean to post-emergence application of bentazon, fomesafen, sethoxydim, quizalofop-*p*-ethyl, imazamox plus fomesafen, and imazamox plus bentazon. The objective of this study was to examine this under field conditions.

2. Materials and methods

Field studies were conducted in 2003 and 2004 at the Huron Research Station, Exeter, Ontario and at two locations at Ridgetown College, 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 of 8.0 in 2003, and 33% sand, 35% silt, 32% clay, 3.4% organic matter and pH of 8.0 in 2004. Soils in both locations at Ridgetown were Wattford (Grey-Brown Brunisolic, mixed, mesic, sandy and imperfectly drained) –and Brady (Gleyed Brunisolic Grey-Brown Luvisol, mixed, mesic, sandy and imperfectly drained). The soil at first location consisted of 74% sand, 18% silt, 8% clay, 3.6% organic matter and pH of 6.3 in 2003, and 51% sand, 33% silt, 16% clay, 5.5% organic matter and pH of 7.2 in 2004. The soil at second location consisted of 43% sand, 31% silt, 26% clay, 4.8% organic matter and pH of 7.0 in 2003, and 54% sand, 25% silt, 21% clay, 5.2% organic matter and pH of 6.7 in 2004. Seedbed preparation at all sites consisted of fall moldboard plowing followed by two passes with a field cultivator in the spring.

The experiment was arranged in a randomized block design with treatments replicated four times. Treatments consisted of a non-treated check, bentazon at 1080 and 2160 g ai/ha, fomesafen at 240 and 480 g ai/ha (plus a non-ionic surfactant at 0.255 and 0.5% v/v, respectively), sethoxydim at 500 and 1000 g ai/ha (plus Merge® at 2.0 and 4.0 L/ha, respectively), quizalofop-*p*-ethyl at 72 and 144 g ai/ha (plus Sure-Mix® at 0.5% and 1.0% v/v, respectively), imazamox plus fomesafen at 25 + 200 and 50 + 400 g ai/ha (plus a non-ionic surfactant at 0.25% and 0.5% v/v, and 2 and 4 L/ha of 28% urea ammonium nitrate, respectively), and imazamox plus bentazon at 25 + 600 and 50 + 1200 g ai/ha (plus 2 and 4 L/ha of 28% urea ammonium nitrate, respectively) representing once and twice the maximum labelled used dose in dry bean or soybean in Ontario.

Each plot was 1.5 m wide and consisted of one row of 'Erimo' adzuki beans and a guard row spaced 0.75 m apart in rows that were 10 m long at Exeter and 8 m long at both Ridgetown locations. Adzuki bean was planted at a rate of 270,000 seeds/ha on June 18, 2003, and June 5, 2004 at Exeter and on June 3, 2003, and June 8, 2004 at the first location and on June 18, 2003, and June 9, 2004 at the second location in Ridgetown. All plots including the non-treated check were maintained weed free during the growing season by inter-row cultivation and hand hoeing as required.

Herbicide treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 200 L/ha aqueous solution at 241 kPa at Exeter and 200 kPa at Ridgetown locations. The boom was 1.0 m long with three 8002 flat-fan nozzles (Teejet 8002 flat-fan nozzle tip, Spraying Systems Co., Wheaton, IL.) spaced 0.5 m apart. Herbicides were applied 20–26 days after planting at the 1–2 trifoliate leaf stage.

Crop injury was rated visually 7, 14 and 28 days after treatment (DAT), 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. Ten adzuki bean plants from each plot were randomly selected and the height from the soil surface to the highest growing point was measured 28 DAT. A 1 m section of row of adzuki bean was hand harvested from each plot 42 DAT and dried at 60 °C to constant moisture and the shoot dry weight was determined. Yield was measured at crop maturity by hand harvesting the remaining 9 m from each plot at Exeter and 7 m from each plot at Ridgetown. At Exeter, adzuki bean was harvested on October 6, 2003, and September 21, 2004.