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Is the application of a residual herbicide required prior to glyphosate application in no-till glyphosate-tolerant soybean (*Glycine max*)?

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Abstract

In no-till glyphosate-tolerant soybean multiple applications of glyphosate may be required to maintain weed control throughout the season. Another approach that may improve weed control and aid in the stewardship of glyphosate use is to apply a pre-emergence residual herbicide such as flufenacet plus metribuzin prior to a single in-crop application of glyphosate. There is limited information on the optimal glyphosate application timing in glyphosate-tolerant soybeans (*Glycine max*) following the application of a residual herbicide such as flufenacet plus metribuzin. Field trials using factorial designs were conducted at three Ontario locations, in 1999 and 2000 to evaluate the efficacy of flufenacet plus metribuzin applied pre-plant or pre-emergence followed by a post-emergence application of glyphosate in glyphosate-tolerant soybean. Crop tolerance was acceptable for all treatments (flufenacet plus metribuzin, glyphosate and flufenacet plus metribuzin followed by glyphosate). Control of *Echinochloa crus-galli* and *Setaria viridis* was excellent using glyphosate and thus soil-applied applications of flufenacet plus metribuzin did not improve control. Control of *Chenopodium album*, *Ambrosia artemisiifolia* and *Abutilon theophrasti* with flufenacet plus metribuzin was poor at all application timings whereas a post-emergence application of glyphosate provided excellent annual broadleaved weed control. There was no difference in soybean yield among the three glyphosate timings evaluated. Overall, there was no benefit from the application of the residual herbicide applied prior to glyphosate.

Keywords: Flufenacet; Metribuzin; Integrated weed management; Canada; Herbicide-tolerance

1. Introduction

Many crops have a critical period during which a high efficacy of weed control is required to prevent yield loss due to competition with weeds. This is an important component of an integrated weed management system and is a major factor in deciding the optimal timing of herbicide application (Swanton et al., 1999). In no-till soybean early season weed control is important because vigorous weed growth may allow economically important weed species such as *Abutilon theophrasti*, *Ambrosia artemisiifolia, Amaranthus* spp., *Chenopodium album* and *Setaria* spp. to grow above the soybean canopy and capture limiting resources, such as light and nutrients. Mulugeta and Boerboom (2000) showed that to prevent yield loss, no-till glyphosate-tolerant soybean must be kept weed free until the V4 (4-trifoliate) stage. Otherwise, interspecific competition with weeds may reduce yield (Chhokar and Balyan, 1999; Marwat and Nafziger, 1990; Mosier and Oliver, 1995). Seed production by these weeds may have minimal consequences as Chandler et al. (2001) demonstrated that seed production by weeds allowed to emerge after the unifoliate to 2-trifoliate stage of soybean growth did not increase the number of seeds entering the soil seedbank.

The reliance on glyphosate for weed control in no-till soybean is increasing because of the widespread use of glyphosate-tolerant soybean varieties. Glyphosate lacks

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residual soil activity, and multiple applications may be required to provide adequate control of weed species throughout the critical period. The appearance of glyphosate resistance in some weed species means stewardship of glyphosate use will be important to reduce the reliance on this herbicide mode of action for weed control. An alternative approach that may reduce the amount of glyphosate used and improve season long weed control is the application of a pre-emergence residual herbicide prior to the in-crop application of glyphosate (Monsanto Company, 2005). Preceding glyphosate application with a pre-emergence residual herbicide may also allow the in-crop application of glyphosate to be delayed. Vangessel et al. (2000) showed that an application of glyphosate alone may be delayed until the four-trifoliate stage of soybean growth when preceded by the residual herbicides clomazone or imazethapyr in New Jersey and Delaware.

Many soil applied pre-emergence herbicides are currently registered for use on soybeans in Ontario. However, it remains prudent to continue research on new modes of action or tank-mixes in order to reduce the development of target site resistance to commonly used herbicides. One such example is flufenacet plus metribuzin which is an oxyacetamide plus triazinone herbicide that is currently registered for pre-emergence application on soybeans in Ontario (Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA), 2004). Flufenacet plus metribuzin provides effective control of many grass and broadleaved weed species including *Abutilon theophrasti*, *A. artemisiifolia*, *C. album*, *Echinochloa crus-galli*, and *Setaria* spp. Soil residual activity may be maintained for 10–14 weeks, but, late germinating broadleaved weeds may not be controlled satisfactorily. Nonetheless, in a glyphosate-tolerant soybean system flufenacet plus metribuzin may allow a delay of the in-crop application of glyphosate, resulting in better full season weed control and higher soybean yield.

For soybean, no data exists describing whether or not a flufenacet plus metribuzin application prior to an in-crop application of glyphosate would increase weed control, improve soybean yield and eliminate the need for multiple glyphosate applications. Therefore, our main objective was to determine if a flufenacet plus metribuzin followed by glyphosate program provides better weed control and higher soybean yield than one in-crop application of glyphosate. Other objectives were (1) to determine if this is dependent on flufenacet plus metribuzin timing, (2) to determine if results vary by weed species and (3) to determine if there is an optimal flufenacet plus metribuzin timing that enables glyphosate application to be delayed.

2. Materials and methods

Field studies were conducted at Agriculture and Agri-Food Canada, Harrow, Ontario; Ridgetown College, University of Guelph, Ridgetown, Ontario; and at the Woodstock Research Station, University of Guelph, Woodstock, Ontario in 1999 and 2000. The soil at Harrow was a Fox sandy loam (Brunisolic Gray Brown Luvisol) with 83% sand, 5% silt, 12% clay, 2.6% organic matter and pH of 6.4 and 6.2 in 1999 and 2000, respectively. The soil at Ridgetown was a Wattford/Brady loam (Gleyed Brunisolic Gray Brown Luvisol) with 55% sand, 24% silt, 21% clay, 4.3% organic matter and pH of 7.3 in 1999, and 78% sand, 14% silt, 8% clay, 4.2% organic matter and pH of 6.9 in 2000. The soil at Woodstock was a Guelph silt loam (Gray Brown Podzolic) with 40% sand, 43% silt, 17% clay, 4.8% organic matter and pH 7.7 in 1999 and 2000. The soil seed-bed at all sites was maintained as no-till with at least 30% of the crop residue from the previous crop remaining on the soil surface. Glyphosate was applied at 900 g/ha as a burn down to ensure a weed-free environment was present prior to the commencement of the experiments.

The experiment was arranged as a 5×4 factorial, randomized complete block design with 20 treatments and four replications. Factor one was the application timing of flufenacet plus metribuzin; no application, application 21 days before planting (DBP), 14 DBP, 7 DBP, and pre-emergence. Factor two was glyphosate timing; no application and application at the unifoliate, 2-trifoliate, and 3-trifoliate leaf stage of soybean growth.

Each plot was 3 m wide and consisted of glyphosate-tolerant soybeans planted in rows 8 m long at Harrow and Ridgetown and 7 m long at Woodstock. Soybean rows were spaced 0.75 m apart at Harrow and Ridgetown and 0.38 m apart at Woodstock. Soybean planting at all locations was done using a precision planter at a rate of 400,000 seeds/ha on May 18, 1999 and May 17, 2000 at Harrow; June 5, 1999 and May 17, 2000 at Ridgetown and May 21, 1999 and May 26, 2000 at Woodstock.

Herbicide treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 333 L/ha aqueous solution at 210 kPa at Harrow, and 200 L/ha at 207 and 170 kPa at Ridgetown and Woodstock, respectively. Flat-fan 11004XR nozzles (Teejet Spraying Systems Co., Wheaton, IL) at Harrow and 8002XR nozzles at Ridgetown and Woodstock were used with a spacing of 0.5 m. The herbicide flufenacet plus metribuzin was applied pre-plant or pre-emergence as a broadcast application over the soil surface at 840 g ai/ha and glyphosate was applied post-emergence as a foliar broadcast application at a dose of 900 g ai/ha.

Weed dry biomass and weed population density were recorded approximately 80 d after the first application of flufenacet plus metribuzin from a 1-m^2 area within each plot at all locations. For dry biomass plants were removed at the soil surface, separated by species, and dried to a constant weight at 80 °C. Additionally, visual injury of soybean was assessed on a scale ranging from 0 (no visible injury) to 100 (total plant necrosis) 40 d after glyphosate application in Harrow and Woodstock only. At all sites, soybean was mechanically harvested at physiological maturity and threshed using a plot combine and yields were adjusted to a 13% moisture level.