Crop Protection 28 (2009) 619–622

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Short communication

Effect of glyphosate and fungicide combinations on weed control in soybeans

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ARTICLE INFO

Article history:
Received 13 May 2008
Received in revised form
10 March 2009
Accepted 11 March 2009

Keywords:
Antagonism
Azoxystrobin
Crop yield
Efficacy
Glyphosate
Pyraclostrobin
Tebuconazole
Tetraconazole

ABSTRACT

Field studies were conducted in 2005 and 2006 along the upper Texas Gulf Coast near Yoakum, Texas and in 2005 near Tifton, Georgia to determine weed control and soybean response to glyphosate plus fungicide tank-mixes. In Texas, glyphosate at 0.77 kg a.e./ha in combination with azoxystrobin, tebuconazole, pyraclostrobin, and tetraconazole applied at the V3 or R1 soybean growth stage controlled *Amaranthus palmeri* and *Panicum texanum* at least 97% control while glyphosate alone controlled both weeds 100%. In Georgia, glyphosate applied alone to a mixed stand of annual grasses [*P. texanum* L., *Digitaria ciliaris* (Retz.) Koel., and *Dactyloctenium aegyptium* (L.) Willd.] at the V3 stage of soybean development provided only 68% control and at the R1 stage provided 94% control. When rated approximately four weeks after treatment application, increased control of the mixed stand of annual grasses was obtained with glyphosate plus azoxystrobin or pyraclostrobin applied at the R1 stage rather than the V3 growth stage. No yield results were obtained at the Georgia location; however, at the Texas location, soybean yields were higher when glyphosate plus azoxystrobin or tetraconazole was applied at V3 compared with the R1 stage. In conclusion, tank mixing of glyphosate with a fungicide is a good option and can be used to reduce production costs. If glyphosate applications are delayed too long, yield reductions can occur due to early season weed competition.

1. Introduction

Glyphosate is one of the safest and most frequently used herbicides in the world (Tao et al., 2007). It is a non-selective herbicide that controls many weed species. Products containing glyphosate are registered in more than 130 countries and are approved for weed control in more than 100 crops (Fernandez-Cornejo and McBride, 2000). Use of glyphosate increased dramatically with the introduction of glyphosate-resistant (GR) crops. Crops which are GR allow glyphosate to be used as a selective herbicide and have offered additional options for weed control and have brought tremendous economic and agronomic benefits to growers around the world.

Net returns from glyphosate-resistant soybean are generally greater than those of nontransgenic soybean (Culpepper et al., 2000; Reddy and Whiting, 2000; Roberts et al., 1999). Therefore, the use of GR soybean has increased dramatically since released in 1996 and is now a fundamental part of US soybean production (Fernandez-Cornejo and McBride, 2000; Prostko et al., 2003).

Soybean was produced on 30.6 million ha in the United States in 2006, with less than 2 million ha produced in the southern U.S. (American Soybean Association, 2008). Soybean yields throughout the southern United States are extremely low compared with those of other soybean producing regions (American Soybean Association, 2008); therefore, producers must minimize inputs to maintain profitability. One such way to reduce costs is through the combination of multiple pesticides in tank-mixes (Lancaster et al., 2005a).

With the emergence of Asian soybean rust (*Phakopsora pachyrhizi*) along the upper Texas Gulf Coast and in the southeast US, soybean growers have begun to apply fungicides to manage this disease. Timing of application for fungicides and glyphosate often coincide (author's personal observation). Applying herbicides and fungicides simultaneously reduces application costs and saves time and labor associated with pesticide applications (Lancaster et al., 2005a).

The compatibility of herbicides with other pesticides has been addressed in previous research (Prostko et al., 2003; Ahrens, 1990; Heckman et al., 1999; Jordan et al., 2003; Lancaster et al., 2005a,b). In peanut (*Arachis hypogaea* L.), the compatibility and phytotoxicity of fungicides and other pesticides in combination with postemergence applied grass herbicides has also been addressed (Jordan et al., 2003; Lancaster et al., 2005a,b). In soybean,

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doi:10.1016/j.cropro.2009.03.006

insecticide combinations with thifensulfuron increased both crop and weed response (Ahrens, 1990). Conversely, the addition of manganese sulfate to post-emergence applied herbicides did not influence crop injury or weed control (Heckman et al., 1999).

The mixing of different herbicides can result in reduced weed control. Efficacy of graminicides was reduced when mixed with herbicides for control of broadleaf weeds and sedges (*Cyperus* spp.) because of reduced absorption and translocation of graminicides (Culpepper et al., 1999a,b; Ferreira et al., 1995). Altered metabolism is generally not the mechanism for reduced grass control by mixtures of gramincides and other herbicides (Burke and Wilcut, 2003; Culpepper et al., 1999b). The efficacy of graminicides may also be reduced when mixed with fungicides; however, the mechanism of reduced grass control by graminicides has not been reported (Jordan et al., 2003).

Efficacy of post-emergence herbicides can be reduced when applied in mixtures with other agrichemicals (Hatzios and Penner, 1985; Grichar, 1991; Meyers and Coble, 1992; Corkern et al., 1998). Although considerable published research exists concerning interactions among herbicides, few experiments have evaluated interactions among herbicides and fungicides. Understanding the potential for interactions when using glyphosate and fungicides is necessary to develop effective management strategies for soybean. Therefore, research was conducted to determine: (1) annual grass and broadleaf weed control by glyphosate when applied with selected fungicides, and (2) response of soybean to combinations of glyphosate and fungicides.

2. Materials and methods

2.1. Test location and soil characteristics

Field experiments were conducted near Yoakum, Texas at the Texas AgriLife Research site during the 2005 and 2006 growing seasons and near Tifton, Georgia at the Ponder Farm in 2005. Soils at Yoakum site were a Denhawken–Elmendorf complex (fine, montmorillonitic, hyperthermic Vertic Ustochrepts–Argiustolls) with less than 1% organic matter and pH 7.2 while soils at the Ponder Farm were a Tifton sand (fine-loamy, kaolinic, thermic Plinthic Kandiudults) with 1.2% organic matter and pH 6.0.

2.2. Experimental design

The experimental design was a six by two factorial in 3–4 randomized complete blocks. One factor was glyphosate–fungicide combinations: no glyphosate or fungicide, glyphosate (Roundup Glyphomax® at Yoakum; Roundup Original Max® at Tifton; Monsanto Company, St. Louis, MO 63166) only, and glyphosate plus either azoxystrobin (Quadris® fungicide, Syngenta Crop Protection, Inc., P.O. Box 18300, Greensboro, NC 27409) at 0.2 kg/ha, tebuconazole (Folicur® fungicide, Bayer Crop Science, Research Triangle Park, NC 27709) at 0.126 kg/ha, pyraclostrobin (Headline® fungicide, BASF Corporation, 26 Davis Dr., Research Triangle Park, NC 277090) at 0.165 kg/ha, or tetraconazole (Domark® fungicide, ValentCorp., Walnut Creek, CA 94596) at 0.2 kg/ha. The other factor was application timings based on soybean growth stage, V3 or R1 (Ritchie and Benson, 1994). An untreated check was included each year. Glyphosate was applied at 0.77 kg a.e./ha (Yoakum) and 0.95 kg a.e./ha (Tifton). Glyphosate rates reflect commonly used rates for each region. Each plot consisted of two rows spaced 97 cm apart and 7.6 m long. Soybean was planted on April 13, 2005 and March 27, 2006 at Yoakum and March 30, 2005 at the Tifton location. Soybean varieties used at Yoakum were DP 5414RR and Garst 4999RR in 2005 and 2006, respectively. At the Tifton location, AG 5905 was planted. Soybean was planted each year at a depth of approximately 4 cm with a Monosem vacuum planter (Monosem ATI, Inc., 17135 W. 116th Street, Lenexa, KS 66219) at the rate of 48,800 seeds/ha. The Yoakum location was naturally infested with *Panicum texanum* and *Amaranthus palmeri* (10–12 plants/m^2) while at the Georgia location a mixed stand of *P. texanum*, *Digitaria ciliaris*, and *Dactyloctenium aegyptium* was present (10 plants/m^2).

The initial plan was to include foliar disease evaluations in the data. However, since foliar diseases did not develop on soybean at either location, no disease evaluations were attempted.

2.3. Pesticide application

Treatment applications at the V3 soybean growth stage were made when weeds were 10–15 cm in height while R1 applications were made when weeds were 25–36 cm in height. Typically, soybean at the V3 growth stage are 18–23 cm tall and leaflets on the first (unifoliolate) through the fourth node leaf are unrolled and typically occur 30–35 days after planting. At the R1 growth stage, soybean plants are typically 38–46 cm tall and are vegetatively in the V7–V10 stage (7–10 nodes are fully developed). Flowering begins on the third to sixth node of the main stem, depending on the vegetative stage at the time of flowering, and progress upward and downward from there. Usually this stage begins about 45–50 days after planting (Ritchie and Benson, 1994).

Glyphosate alone or in combination with various fungicides were applied in water with a CO_2 backpack sprayer using Teejet 11002 flat fan nozzles (Spraying Systems Co., North Avenue and Schmale Road, Wheaton, IL 60188) which delivered a spray volume of 140–190 L/ha at 180–315 kPa. Soybeans were harvested at Yoakum but not at Tifton. Harvesting was accomplished with a small plot combine and yields adjusted to 12% moisture.

2.4. Weed efficacy and soybean stunting ratings

Weed control and soybean stunting ratings were recorded four weeks after each application timing and every 4 wk thereafter throughout the growing season. Since weed control ratings taken 4 wk after herbicide application reflect optimum control with the glyphosate combinations, only those weed ratings are presented. Weed control and soybean stunting were recorded on a scale of 0–100, where 0 = no weed control or soybean plant stunting and 100 = complete weed control or soybean plant death.

2.5. Statistical analysis

Weed control data were arcsine transformed prior to analysis of variance but are expressed in their original form for clarity since the transformation did not alter mean rank. Visual estimates of weed control and soybean yield were subjected to analysis of variance to test effects of herbicide–fungicide combinations and application timings. Means were compared with the appropriate Fisher's protected LSD Test at the 5% probability level.

3. Results and discussion

3.1. Weed control

There was no treatment by timing by year interaction for *A. palmeri* and *P. texanum*. However, there was a treatment by timing interaction for the mixed stand of *P. texanum*, *D. ciliaris*, and *D. aegyptium*.

A. palmeri control was at least 98% with glyphosate alone or glyphosate plus fungicide combinations regardless of application timing (Table 1). *P. texanum* control was no less than 97% with all