EFFECT OF TEMPERATURE AND CHEMICAL ADDITIVES ON THE EFFICACY OF THE HERBICIDES GLUFOSINATE AND GLYPHOSATE IN WEED MANAGEMENT OF LIBERTY-LINK® AND ROUNDUP-READY® SOYBEANS

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ABSTRACT

The introduction of herbicide resistant crops offers producers many more options for weed control systems. These crops allow environmentally safe, non-selective herbicides to be used as selective herbicides, broadening the spectrum of weeds controlled, while not harming the crop. As these crops are very new on the market, investigation of their performance under various environmental conditions as well as in various weed control programs is needed. Liberty-link® soybeans are resistant to the herbicide glufosinate, because of the incorporation of a gene encoding phosphinothricin acetyl-transferase (*pat)*, which is able to detoxify glufosinate. Roundup-Ready® soybeans are transformed with an altered, non-sensitive form of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), which confers glyphosate resistance. Field and greenhouse studies were conducted to determine the efficacy of glufosinate and glyphosate on annual and perennial weeds. Also to determine whether the use of ammonium sulfate (AMS) or pelargonic acid (PA), a 9-carbon fatty acid, as additives of glufosinate or glyphosate would increase their efficacy, while maintaining their safety on the transgenic soybeans. Three annual weeds: common lambsquarters, giant foxtail, sicklepod, as well as two perennial weeds: common milkweed and horsenettle were included in studies. Uptake, translocation, and metabolism of ^{14}C-glufosinate + AMS or PA, were studied in the five weeds in order to determine the basis for their differential

weed sensitivity to glufosinate, and the effect of the two additives. The effect of temperature on Liberty-Link® and Roundup-Ready® soybeans after application of glufosinate or glyphosate was investigated. Injury was quantified by measuring chlorophyll content of herbicide treated soybean trifoliolates. Uptake, translocation, and metabolism studies of ^{14}C-glufosinate and ^{14}C-glyphosate in transgenic soybeans were conducted to determine the potential cause for the observed temperature-dependent sensitivity. Since glufosinate is a synthetic analog of a naturally occurring bacterial toxin, it was tested for possible bactericidal activity on the soybean pathogen *Pseudomonas syringae*. Greenhouse and field-studies showed that the 5 weeds responded differently to glufosinate and glyphosate. Common milkweed was the most tolerant to glufosinate and common lambsquarters to glyphosate while giant foxtail was the most sensitive species to both herbicides. Some interactions between AMS or PA and glufosinate or glyphosate were also observed. Uptake and translocation studies showed that AMS increased the uptake of ^{14}C-glufosinate in some weeds, whereas PA had only minimal effects on absorption and translocation of glufosinate. Metabolism of glufosinate was detected only in common lambsquarters. A rate dependent loss of chlorophyll in Liberty-Link® soybeans treated with glufosinate was observed that was greater at 15° C than at 25° or 35° C. Metabolism studies showed a decrease in the rate of glufosinate metabolism 3 hours after treatment in Liberty-Link® soybeans grown at 15° C versus 25° C. Conversely, chlorophyll loss in glyphosate-treated Roundup-Ready® soybeans was greater at 35° C than at 15° or 25° C. Translocation studies showed a significantly greater percentage of absorbed ^{14}C-glyphosate translocated to developing meristems at 35° C than at 15° C in Roundup-Ready® soybeans. Glufosinate concentrations of 1 mM and higher significantly inhibited the growth of *Pseudomonas syringae (L-529)* in liquid media cultures. Typical field use rates of glufosinate also reduced the number of live *P. syringae* on Liberty-Link® soybean leaves. Overall, the results of this research show that annual and perennial weeds differ in their sensitivity to glufosinate and glyphosate. Additives such as AMS and PA may enhance the efficacy of glufosinate on perennial weed species, and glyphosate in most weeds. Differences in weed sensitivity to herbicides and effects of additives can in most cases be explained by differences in absorption or metabolism. Variable temperatures may affect the engineered resistance of

transgenic soybeans to the herbicides glufosinate and glyphosate. The herbicide glufosinate has some bacteriocidal activity on *P. syringae*.

Nomenclature: Glufosinate, 2-amino-4-(hydroxymethylphosphinyl) butanoic acid; Glyphosate, *N*-(phosphonomethyl)glycine; PA, pelargonic acid (nanoic acid); AMS, ammonium sulfate; giant foxtail, *Setaria faberi* Herrm.; common lambsquarters, *Chenopodium album* L.; and sicklepod *Cassia obtusifolia* L.; horsenettle, *Solanum carolinense* L.; common milkweed, *Ascleipias syriaca* L. *pat*, phosphinothricin acetyl transferase; EPSPS, 5-enolpyruvylshikimate-3-phosphate synthase.

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