Characterization of Acetolactate Synthase-Inhibiting Herbicide-Resistant Smooth Pigweed and Corn Weed Management Programs Utilizing Mesotrione in Combinations with Other Herbicides

Cory Miller Whaley

Dissertation submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Plant Pathology, Physiology, and Weed Science

Henry P. Wilson, Chair
Daniel E. Brann
Edward S. Hagood
Craig L. Nessler
James H. Westwood

March 1, 2005
Blacksburg, Virginia

Keywords: Smooth Pigweed (*Amaranthus hybridus* L.), Mesotrione, Corn Weed Control, Acetolactate Synthase, Herbicide Resistance

Characterization of Acetolactate Synthase-Inhibiting Herbicide-Resistant Smooth Pigweed and Corn Weed Management Programs Utilizing Mesotrione in Combinations with Other Herbicides

Cory M. Whaley

ABSTRACT

Repeated use of acetolactate synthase (ALS)-inhibiting herbicides in recent years has resulted in the selection of 89 weed species resistant to these herbicides. One management strategy that can eliminate or slow the development of resistance is applying mixtures of herbicides with different modes of action. This research involved the characterization of ALS-inhibiting herbicide-resistant smooth pigweed (*Amaranthus hybridus* L.), as well as investigations on weed management programs in corn (*Zea mays* L.) utilizing mesotrione, a triketone, in mixtures with other herbicides. ALS-inhibiting herbicide-resistant smooth pigweed biotypes were collected from fields in Virginia, Delaware, Maryland, and Pennsylvania to evaluate response to ALS-inhibiting herbicides and to determine the molecular mechanisms of resistance. Sequencing of the ALS genes from these biotypes revealed two amino acid substitutions known to confer resistance, Ala_{122} to Thr and Ser_{653} to Asn, and one that has not been previously reported in plants, Asp_{376} to Glu. The smooth pigweed biotype with an Asp_{376} substitution displayed resistance to four classes of ALS-inhibiting herbicides that included imidazolinone (IMI), sulfonylurea (SU), pyrimidinylthiobenzoate (PTB), and triazolopyrimidine sulfonanilide (TP) chemistries. Transformation of this smooth pigweed ALS gene into *Arabidopsis thaliana* confirmed that the Asp_{376} substitution is responsible for the resistance. Other biotypes that had a substitution at Ala_{122} exhibited resistance to an IMI herbicide, little to no resistance to SU herbicides, and increased sensitivity to a PTB and a TP herbicide, whereas, biotypes that had a substitution at Ser_{653} exhibited high-level resistance to an IMI herbicide and lower resistance to PTB and SU herbicides. Experiments were also conducted to investigate the effectiveness of mesotrione in preemergence (PRE) and postemergence (POST) corn weed management programs in Virginia. Mesotrione

applied PRE in mixtures with *S*-metolachlor and atrazine controlled common lambsquarters (*Chenopodium album* L.), smooth pigweed, common ragweed (*Ambrosia artemisiifolia* L.), and morningglory (*Ipomoea spp*.) species when a timely rainfall followed application. POST applications of mesotrione controlled common lambsquarters and smooth pigweed, but common ragweed and morningglory species were not always controlled. Common ragweed and morningglory species were controlled by mesotrione in a mixture with atrazine POST. Large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and giant foxtail (*Setaria faberi* Herrm.) control was generally better when the ALS-inhibiting herbicides nicosulfuron plus rimsulfuron or rimsulfuron plus thifensulfuron plus atrazine were applied in a mixture with mesotrione. Mixtures of mesotrione with other POST herbicides in a total POST program produced corn yields comparable to standard PRE followed by POST weed management programs.