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ALS Resistant Smooth Pigweed in Western Kentucky

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ALS[1] RESISTANT SMOOTH PIGWEED IN WESTERN KENTUCKY

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Introduction

Pigweeds The pigweed, or Amaranthus, family contains some of the most commonly occurring weeds of midwest agriculture. Species from this family that occur in Kentucky include smooth pigweed (*Amaranthus hybridus*, most common), tumble pigweed, prostrate pigweed, spiny amaranth, Palmer amaranth, common waterhemp, and tall waterhemp. Research has shown that some pigweed species respond differently to various herbicides, therefore, proper identification is necessary to achieve acceptable control. Pigweed identification in early stages of seedling growth can be difficult because the distinguishing physical characteristics do not appear until plants are mature or have produced seed. Also, some pigweed species may cross-pollinate to produce hybrid plants that exhibit characteristics of both parents.

Weed Resistance The potential to develop resistance to herbicides may exist in all weed populations. A portion of plants within a weed population may possess a different genetic makeup, known as a biotype, that enables them to survive a particular herbicide treatment. Selection for the resistant population occurs when these plants are able to survive and produce seed while the susceptible population is controlled. Selection pressure increases with multiple applications within a season, or year to year, of the same herbicide or herbicides with the same mode of action. Triazine-resistant smooth pigweed populations have been documented in Kentucky where several consecutive years of corn production have included the use of atrazine or simazine.

A smooth pigweed population in Ballard County, Kentucky was suspected of having developed resistance to the imidazolinone herbicides (i.e. Pursuit, Scepter) in 1992. This class of chemicals contain active ingredients known as ALS (acetolactate synthase) inhibitors. The field in question had a crop rotation of corn, milo, soybeans (full season and double-crop), and wheat for the previous six years. Consequently, the use of imidazolinone herbicides in soybeans was interspersed between years of corn and wheat production,

[1] acetolactate synthase

or non-imidazolinone use. In spite of rotating crops and herbicide classes, smooth pigweed control in soybean, with ALS inhibitors, had declined to unacceptable levels in 1992.

Experimentation

Field Studies Two experiments were conducted at the Ballard County site in 1995 and 1996 with the following objectives: 1) confirm the resistance to the imidazolinone herbicides, 2) determine if this population was also resistant to sulfonylurea herbicides (i.e. Pinnacle, Classic), another class of herbicides with the same mode of action as the imidazolinone herbicides, and 3) evaluate the control of this smooth pigweed population with non-ALS soybean herbicides. The experimental area received an application of Roundup herbicide 10 days before planting to control all emerged weeds. Another flush of weeds had emerged by planting in 1996, therefore, a second application was made at planting. Dates of application were June 10 and 5 for preemergence (PRE) treatments, and June 30 and 26 for postemergence (POST) treatments in 1995 and 1996, respectively. Smooth pigweed plants ranged in size from 0.5 inch to 3 inches tall with 1 to 6 true leaves, and soybeans were 6 inches tall with 2 fully expanded trifoliate leaves (V3) at the time of the post application. Plots were 6.3 by 30 feet with three replications. Smooth pigweed control was evaluated visually 3 and 6 weeks after treatment.

Results and Discussion Several commonly used PRE soybean herbicides provided very good (> 80%) smooth pigweed control 6 weeks after application (Table 1). The chloroacetamide herbicides (ex. Dual, Micro Tech, Frontier), treatments 1 - 6, performed very well alone or premixed with other products, whereas the imidazolinone herbicides (treatments 16, 17), which are normally very effective against smooth pigweed, provided little to no control of this smooth pigweed population (Table 1). The use of ALS herbicides would not be recommended where ALS inhibitor resistance has been confirmed, however, the use of ALS herbicides that are premixed with a herbicide with a different mode of action (treatments. 3,6) and that is effective for controlling smooth pigweed may still be considered because of other problem weeds. Authority provided smooth pigweed control equal to the chloroacetamide treatments. The addition of chlorimuron with Sencor (Canopy) provided no additional smooth pigweed control. Lorox performed well in 1995, yet the addition of chlorimuron (Lorox Plus) again showed no added control. The addition of an ALS herbicide either premixed or sequentially applied with Prowl (treatments 14 and 15 respectively) tended to improve pigweed control compared with Prowl alone.

Smooth pigweed control ranged from 84 to 100% with POST applications of non-ALS inhibiting herbicides (Cobra, Reflex, Flexstar, Blazer, Storm) with the exception of Basagran in 1995 (Table 2). The sulfonylurea herbicides (Classic, Pinnacle), as well as the imidazolinones (Pursuit, Scepter), provided less than 50% control of smooth pigweed when applied POST (Table 2).

Overall, the data from our field experiments confirmed the suspected resistance to the imidazolinones, and indicated that this smooth pigweed population was also cross-resistant to the sulfonylurea herbicides.

Greenhouse and Laboratory Studies Experiments were conducted to quantify the extent of cross-resistance to the ALS inhibitors. Results indicated that ALS inhibitor resistant smooth pigweed from the field site was highly tolerant of all the imidazolinone and sulfonylurea herbicides available for corn and soybean production.

ALS inhibition assays demonstrated that herbicide resistance was due to an insensitive target site enzyme. Furthermore, this alteration confers broad-based resistance to the three classes of ALS inhibitors tested (i.e. the imidazolinones, sulfonylureas, and the sulfonanilides).

We have shown that the smooth pigweed population in Ballard County, Kentucky has developed resistance to several classes of ALS-inhibitor herbicides in a short period of time, even though the primary selection was by one class, the imidazolinones. The resistance is conferred by a target site mutation resulting in an insensitive form of ALS enzyme. However, several viable options utilizing non-ALS herbicides exist for successful management of this smooth pigweed population in soybean.

Summary

ALS inhibitor herbicides are widely used because they are extremely effective for control of many troublesome weeds such as common cocklebur, giant ragweed, and many of the pigweeds. Recent developments in plant breeding and biotechnology have produced ALS inhibitor herbicide-resistant crops (i.e. STS soybean, IR corn) and this, combined with the release of new commercial ALS inhibitors, provide even more opportunities for the use these herbicides in both corn and soybean. Therefore, the grower must be aware of the frequency with which ALS inhibitor herbicides are being utilized in their weed control programs. The following strategies should be considered when using any herbicide to avoid herbicide-resistant weeds:

1. Rotate to herbicides with different modes of action. This would include applications within a growing season or from year to year in a given field.

2. Use tank mixtures, prepackaged formulations, or sequential treatments that contain herbicides with more than one mode of action.

3. In fields where herbicide resistance has been confirmed, or suspected, tillage and harvesting equipment should be cleaned thoroughly before moving to other fields.

To aid in making herbicide selection, based on the above strategies, Table 3 contains the ALS inhibiting herbicides available for soybean, corn, and grain sorghum production.

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Table 1. Smooth pigweed control with PRE herbicides, evaluated 6 weeks after treatment, in western Kentucky in 1995 and 1996. PRE - soil applied at planting, EP - 2 to 4 inch pigweed.

Product Treatment	Active Ingredient (ai)	Rate prod/A	Time of Appl.	% Smooth Pigweed Control 1995	1996
1 Dual 8EC	metolachlor	2.0 pt	PRE	95	92
2 Turbo 8EC	metolachlor+metribuzin	2.2 pt	PRE	96	89
3 Broadstrike	flumetsulam*+metolachlor	2.5 pt	PRE	93	89
+ Dual 7.67SC					
4 Micro Tech 4ME	alachlor	2.5 qt	PRE	89	87
5 Frontier 7.5EC	dimethenamid	1.5 pt	PRE	95	81
6 Detail 4.1EC	dimethenamid+imazaquin*	2.0 pt	PRE	92	89
7 Authority 75DF	sulfentrazone	0.5 lb	PRE	99	99
8 Sencor 75DF	metribuzin	0.5 lb	PRE	74	73
9 Canopy 75DF	metribuzin+chlorimuron*	6 oz	PRE	75	63
10 Canopy 75DF	metribuzin+chlorimuron*	8 oz	PRE	–	73
11 Lorox DF 50DF	linuron	1.5 lb	PRE	92	77
12 Lorox Plus 60DF	linuron+chlorimuron*	1.0 lb	PRE	86	80
13 Prowl 3.3EC	pendimethalin	2.4 pt	PRE	66	67
14 Squadron 2.33EC	pendimethalin+imazaquin*	3.0 pt	PRE	78	68
15 Prowl 3.3EC	pendimethalin	2.4 pt	PRE	88	80
Pursuit	imazethapyr*	1.4 oz	EP		
Sunit II		0.75 qt	EP		
Liquid N		1.0 qt	EP		
16 Scepter 70DF	imazaquin*	2.8 oz	PRE	27	7
17 Pursuit 70DF	imazethapyr*	1.4 oz	PRE	23	25
LSD (0.05)				10	19

* - Indicates an ALS herbicide

Table 2. Smooth pigweed control with POST herbicides in western Kentucky in 1995 and 1996. EP - 2 to 4 inch pigweed, 6 inch (V3) soybean.

Product Treatment	Active Ingredient (ai)	Rate prod/A	Time of Appl.	% Smooth Pigweed Control 1995	1996
1 Pursuit 70DF	imazethapyr*	1.4 oz	EP	30	45
Sunit II		0.75 qt			
Liquid N		1 qt			
2 Scepter 70DF	imazaquin*	2.8 oz	EP	27	35
COC		1 qt			
3 Classic 25DF	chlorimuron*	0.5 oz	EP	23	30
X-77		0.25 %			
Liquid N		1 qt			
4 Pinnacle 25DF	thifensulfuron*	0.25 oz	EP	32	43
X-77		0.25 %			
Liuid N		1 qt			
5 Cobra 2L	lactofen	3.0 pt	EP	84	100
COC		0.5 qt			
6 Blazer 2EC	acifluorfen	1.5 pt	EP	95	98
COC		0.125 qt			
7 Reflex 2EC	fomesafen	2.4 pt	EP	98	100
COC		1 qt			
8 Flexstar 2EC	fomesafen	3.0 pt	EP	98	100
Liquid N		2 qt			
9 Basagran 4EC	bentazon	2.0 pt	EP	64	97
COC		1 qt			
10 Storm 4EC	acifluorfen+bentazon	1.5 pt	EP	89	100
COC		1 qt			
LSD (0.05)				11	21

* - Indicates an ALS herbicide

Table 3. ALS inhibitor herbicides for use in soybeans, corn, and grain sorghum. A single component herbicide has one active ingredient (ai) while a mixture contains more than one ai. Not all ai's for the mixtures are given in this table, only those that are ALS inhibitors. For specific rates and times of application, refer to AGR-6, 1997 Chemical Control of Weeds in Kentucky Farm Crops.

	Active	Trade Names				Grain
Herbicide Family	Ingredient (ai)	Alone	Premixes	Soybean	Corn	Sorghum
Imidazolinone	imazethapyr	Pursuit		X	X	
			Resolve		X	
			Contour		X	
	imazaquin	Scepter		X		
			Squadron	X		
			Tri-Scept	X		
			Detail	X		
Sulfonylurea	chlorimuron	Classic		X		
			Canopy	X		
			Synchrony STS	X		
	thifensulfuron	Pinnacle		X		
			Synchrony STS	X		
	nicosulfuron	Accent			X	
			Basis Gold		X	
	rimsulfuron		Basis Gold		X	
	primisulfuron	Beacon			X	
			Exceed		X	
	prosulfuron	Peak				X
			Exceed		X	
	halosulfuron	Permit			X	X
Triazolopyrimidine sulfonanilide	flumetsulam		Broadstrike/Dual	X	X	
			Broadstrike/Treflan	X		
			Broadstrike Plus		X	
			Scorpion III		X	

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