

6-07

## FINAL REPORT

### 1. TITLE: Clearfield \* Winter Wheat Risk Assessment

### 2. PERSONNEL:

Phillip W. Stahlman Research Weed Scientist KSU Agric. Research Center-Hays  
T. Joe Martin Wheat Breeder KSU Agric. Research Center-Hays.

3. TIME LINE: Initiated - August 2001; Projected termination – initially August 2006; extended one year to August 2007.

4. ORIGINAL HYPOTHESIS: The prolonged use of Clearfield \* (imidazolinone-resistant) winter wheat will increase the risk of transferring herbicide resistance to jointed goatgrass (*Aegilops cylindrica* Host) and hasten selection of herbicide resistant biotypes in other winter annual grass weed species.

5. SUMMARY OF PROGRESS: 2001-2007: The study was conducted for six crop years. A total of 1,286 winter wheat-jointed goatgrass hybrids were collected from within the experimental area in four of six years; none were found in 2002 or 2004. The percentage of spikelets producing viable seed in those years ranged from 0.1 to 1.1% with an average of 0.6%. Several plants from those seed survived spraying twice with high rates of imazamox, but the plants produced no viable seed. More than 104,000 plants from spikelets collected from border areas between plots were sprayed with 0.047 lb/A of imazamox. Plants that survived were resprayed with 0.094 lb/A of imazamox. All but seven plants died after being resprayed. The surviving plants were vernalized and grown to maturity but none produced a reproductive spike. Combining Best Management Practices (BMPs) and imazamox herbicide use in Clearfield \* wheat dramatically reduced jointed goatgrass populations compared to conventional wheat grown using BMP production practices. Jointed goatgrass densities in conventional wheat varied widely from year to year depending on fall environmental conditions. However, jointed goatgrass densities in Clearfield \* wheat remained low after the initial year of spraying with imazamox. Although not an objective of this study, this finding suggests the Clearfield \* system probably doesn't need to be used more than two consecutive years before alternating back to conventional wheat. This also supports BASF's Stewardship Recommendation of not using the Clearfield Production System more often than 2 of 4 years unless other control practices are implemented.

### 6. OBJECTIVES:

1. Assess the risk of moving imidazolinone herbicide resistance into a jointed goatgrass population and the possibility of selecting for resistance in other winter annual weed species in cropping systems using Clearfield \* winter wheat.
2. Determine the rate of resistance integrating into grass weed populations and investigate jointed goatgrass-wheat hybrid population dynamics.
3. Investigate management strategies to reduce the occurrence of herbicide-resistant hybrids/biotypes.

**7. EXPERIMENTAL DESIGN:** The experiment is set up as a randomized complete block design with three replications. Plot size, currently 54 by 110 feet, was modified from the original proposal (55 by 120 feet) to fit the experimental area. A total of 10 treatments were applied to the experimental area. Additional information on individual treatments is listed in Table 1. The CONV treatments were seeded using a Marliiss double disk drill set on 10-inch row spacing and BMP treatments were seeded using a Great Plains double disk opener drill set on 7.5-inch row spacing. Jointed goatgrass count means are the average of four subsample quadrates (1 m<sup>2</sup>/quadrate) in each plot.

Methods in the original proposal indicated using 0.031 and 0.047 lb/A of imazamox.

However, many producers in this area tend to use reduced herbicide rates in wheat to cut production costs. This practice may lead to a more rapid development of resistance in jointed goatgrass populations. Therefore, imazamox rates were reduced to 0.023 and 0.039 lb/A to better represent herbicide selection pressure from current production practices.

Deep inversion tillage (moldboard plowing) was scheduled to take place in all BMP treatments after the 2003 crop. Deep tillage combined with crop rotation in the same year would not have provided unique treatments necessary to separate possible jointed goatgrass plant density differences among BMP treatments. Therefore, plots remaining in continuous wheat were moldboard plowed on July 14, 2004 (Table 1; treatments 1-5). This altered treatment structure will provide a better understanding of separate inversion tillage and crop rotation effects on jointed goatgrass populations in a Clearfield \* winter wheat production system.

## **8. PROGRESS 2007:**

**Objective 1. Assess the risk of moving imidazolinone herbicide resistance into a jointed goatgrass population and the possibility of selecting for resistance in other winter annual weed species in cropping systems using Clearfield \* winter wheat.**

Crop year six was initiated by seeding Clearfield \* and conventional wheat on October 2, 2006 according to the experimental protocol. Jointed goatgrass plant density was determined in mid-November in four permanent subplots per plot to establish a population baseline (Table 2; Nov 2006). See objective 3 for result comparisons between treatments.

Nine of more than 42,000 plants collected at the time of the 2006 harvest survived spraying with 0.047 and respraying with 0.094 lb/A of imazamox. Those plants were vernalized for nearly 7 weeks and then placed in a growth chamber, but none produced a spike. Harvest in 2007 was delayed three weeks because of numerous rainfall events and wet field conditions. The extended wet conditions allowed dense large crabgrass to grow considerably taller than the wheat requiring all plots to be sprayed with glyphosate in order to harvest the wheat. By the time wheat was harvested, most jointed goatgrass spikelets had dislodged from stems and fallen to the ground. Thus, no spikelets were collected from between plots as in previous years. Other results pertinent to this objective are included in objectives 2 and 3.

**Objective 2. Determine the rate of resistance integrating into grass weed populations and investigate jointed goatgrass-wheat hybrid population dynamics.**

One hundred fifty-five (155) jointed goatgrass-wheat hybrid spikes were collected from border areas between plots prior to the onset of extended wet conditions. No hybrids were found growing within plots. Fourteen (14) seed were recovered from a total of 1,533 spikelets. Only 2 of the 14 seed germinated. The two germinating seed were placed in pots containing soil and kept in a greenhouse for several weeks. When plants had 4 tillers, they were vernalized for 7 weeks and returned to greenhouse conditions a few days prior to spraying with spraying with 0.070 lb/A of imazamox. Neither plant was visibly affected by the imazamox treatment after 3 weeks. The plants will be resprayed in the near future and kept to maturity to determine if they produce seed.

**Objective 3. Investigate management strategies to reduce the occurrence of herbicide-resistant hybrids/biotypes.**

Clearfield \* and conventional wheat was seeded October 2, 2006 according to the plan in Table 1. Jointed goatgrass plant densities in the wheat prior to herbicide application in mid-November were less than 1 plant/yard<sup>2</sup> (Table 2). Jointed goatgrass density in the conventional wheat treatment where sorghum was inserted in the rotation in 2004 was statistically higher than in all Clearfield \* wheat treatments. However, differences between Clearfield \* and conventional wheat treatments were not significant in the continuous wheat phase of the rotation. Most treatments had no jointed goatgrass present and densities did not increase in the spring as occurred in some prior years. Winter wheat was harvested July 17, 2007, nearly 3 weeks after it was mature, because of extended wet weather. Grain yields were reduced considerably by the adverse weather conditions and yields did not differ between treatments (Table 2). Grain dockage percentages for all imazamox treatments were less than 0.1% compared to an average of 0.063% for the two conventional wheat treatments.

**9. PUBLICATIONS:** Cumulative record.

Stahlman, P.W. and P.W. Geier. 2007. Best management practices and imidazolinone-tolerant winter wheat. Proc. West. Soc. Weed Sci. 60:61-62.

Stahlman, P.W. 2006. Jointed Goatgrass Management: Importance of Cultural Practices. Proc. 3<sup>rd</sup> Annual Cover Your Acres Winter Conference, Oberlin, KS. (Feb. 2006).

Stahlman, P.W., A.D. White, P.W. Geier and J.C. Frihauf. 2005. Imidazolinone-tolerant winter wheat risk assessment. Weed Sci. Soc. Am. Abst. 205. [CD-ROM Computer File]. North Central Weed Sci. Soc., Champaign, IL. (Dec. 2005).

White, T. 2005. Jointed goatgrass education in the Southern Great Plains. National Jointed Goatgrass Research Program. Current internet location: [www.jointedgoatgrass.org](http://www.jointedgoatgrass.org).

Wicks G., R. Anderson, T. White, P. Stahlman, D. Morishita. 2005. Jointed Goatgrass: Control Tactics. National Jointed Goatgrass Research Program. Wash. State Univ. Coop. Ext. Serv. EB1935.

White, A. P. W. Geier, P. W. Stahlman, and J. C. Frihauf. 2004. Nitrogen, adjuvant, and application timing effects on imazamox efficacy in wheat. Proc. West. Soc. Weed Sci. Colorado Springs, CO. 57:75.

White, T. and P. Stahlman. 2003. Control of jointed goatgrass using best management practices. The 6th Annual National Wheat Industry Research Forum Proceedings, Albuquerque, NM. National Association of Wheat Growers Wheat Industry Resource Committee. p.22-24.

Stahlman, P., P. Geier, T. White, D. Lyon, S. Miller, and P. Westra. 2003. Performance of Beyond herbicide in Clearfield\* wheat in the central Great Plains. The 6th Annual National Wheat Industry Research Forum Proceedings, Albuquerque, NM. National Association of Wheat Growers Wheat Industry Resource Committee. p.18.

White, T. 2003. Jointed goatgrass: What do we know? Wheat Life. December. 46:41-43.

White, T. 2003. Goatgrass weapons. Western Farmer-Stockman. October. p.34.

White, T. 2003. Non-GMO herbicide technology to control jointed goatgrass and other weeds. The Wheat Farmer/Row Crop Farmer-Central Plains. April. p. 9.

**10. TECHNOLOGY TRANSFER:** This study was the topic of several oral and print presentations during the course of the study. These included presentations at the North Central Weed Science Society, the Western Society of Weed Science, and to large grower audiences at the National Association of Wheat Growers annual meeting and at a featured symposium on jointed goatgrass management at the Cover Your Acres Annual Conference in Kansas.

**11. PRODUCER RECOMMENDATIONS IN THE CENTRAL GREAT PLAINS:**

• **Follow current Clearfield \* wheat stewardship guidelines to prolong the technology.** To ensure that the benefits of Clearfield \* wheat are available to producers in the future, certain stewardship guidelines should be followed. Some of these practices include using crop rotation, herbicides with different modes-of-action, and proper weed management in fallow.

• **Implement Best Management Practices to battle jointed goatgrass.** Integrating other management strategies with the Clearfield \* wheat system will increase jointed goatgrass control over conventional practices or only single components.

**12. BUDGET REQUEST FOR FY-2007:** None

Fiscal year	2001	2002	2003	2004	2005	2006
Requested	\$18,000	\$18,500	\$19,000	\$19,500	\$20,000	\$21,000
Received	\$18,000	\$18,000	\$19,500	\$19,500	\$21,392	\$10,000

Total funding received = \$106,392

Originally this project was scheduled for completion in August 2006. However, the project was extended one year to allow more time/chance of developing imidazolinone herbicide resistance in the jointed goatgrass population. The greater the numbers of iterations without evidence of resistance development in jointed goatgrass, the greater our confidence that the risk of resistance introgression or selection in jointed goatgrass populations is low. Treatments for 2006-07 would be the same as in 2003-04 and would provide data for two complete three-year rotation cycles (Treatments 4 and 6-10). Other treatments are continuous wheat and would be used for comparison in the given year.

**13. STATEMENT OF WORK TO BE CONDUCTED: 2008.** No field work will be conducted as the study is completed. A manuscript will be prepared to report study findings.

Table 1. Treatments and timeline for Clearfield™ Winter Wheat Risk Assessment.

		Treatments					36 ft alley
Crop year		1	2	3	4	5	
2001-02	wheat	CRCF .048-BMP	CRCF .032-BMP	CRCF-.032-Conv	CRCF-.048-BMP	Jagger-BMP	↓
2002-03	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	BRCF-.032-BMP	Jagger-BMP	↑
2003-04	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	Jagger-BMP	Jagger-BMP	110 ft
2004-05	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	CRCF-.048-BMP	Jagger-BMP	
2005-06	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	BRCF-.032-BMP	Jagger-BMP	↓
2006-07	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	Jagger-BMP	Jagger-BMP	36 ft alley
		6	7	8	9	10	
2001-02	wheat	CRCF .048-BMP	CRCF .032-BMP	CRCF-.032-Conv	CRCF-.048-BMP	Jagger-BMP	↑
2002-03	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	BRCF-.032-BMP	Jagger-BMP	
2003-04	row crop	crop rotation	crop rotation	crop rotation	crop rotation	crop rotation	110 ft
2004-05	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	CRCF-.048-BMP	Jagger-BMP	
2005-06	wheat	CRCF .048-BMP	CRCF .032-BMP	BRCF-.032-Conv	BRCF-.032-BMP	Jagger-BMP	↓
2006-07	row crop	crop rotation	crop rotation	crop rotation	crop rotation	crop rotation	36 ft alley
		54 ft; 50 ft sprayed	54 ft; 50 ft sprayed	54 ft; 50 ft sprayed	54 ft; 50 ft sprayed	54 ft; 50 ft sprayed	↑

Total area: 328 by 810 ft including 3-36 ft alleys = 6.1 acres

**CRCF** = Certified Clearfield™ winter wheat; sprayed late fall or early spring with imazamox at 0.024 or 0.040 lb ai/A

**BRCF** = Bin-run Clearfield™ winter wheat; sprayed late fall or early spring with imazamox at 0.024 lb ai/A

**BMP = Best Management Practices**

- inversion tillage after second crop; noninversion tillage other years
- 50% higher-than-normal seeding rate, 90 lb/A
- narrow row spacing, 6-7.5-inch
- in-furrow starter fertilizer plus spring N topdress
- large-sized seed

**Conv = Conventional Practices**

- noninversion tillage
- normal seeding rate, 60 lb/A
- 10-inch row spacing
- broadcast fertilizer without in-furrow starter plus spring N topdress
- nonsized seed

Table 2. Jointed goatgrass population density and wheat yield, 2006-2007<sup>a</sup>.

Treatment <sup>b</sup>	Current treatment phase <sup>c</sup>	Jointed goatgrass density <sup>d</sup>			Winter wheat	
		Nov 13, 2006	Mar 6, 2007	Apr 24, 2007	Grain yield	Dockage
		—————plants/yd <sup>2</sup> —————			bu/A	% w/w
<b>Continuous winter wheat since 2001</b>						
1	Certified Clearfield™ - BMP Imazamox (0.04 lb/A)	0.0 aA	0.0 aA	0.0 aA	17.6 aA-D	0.000 bA
2	Certified Clearfield™ - BMP Imazamox (0.024 lb/A)	0.0 aA	0.0 aA	0.2 aA	15.3 aB-D	0.007 bA
3	Bin-run 4X Clearfield™ - Conv. Imazamox (0.024 lb/A)	0.2 aA	0.1 aA	0.0 aA	13.3 aCD	0.010 bA
4	Bin-Run 1X Clearfield™ - BMP Imazamox (0.04 lb/A)	0.0 aA	0.0 aA	0.0 aA	22.9 aA	0.001 bA
5	Jagger – BMP Sulfosulfuron (0.023 lb/A)	0.4 aA	0.8 aA	0.8 aA	19.6 aA-C	0.063 aA
<b>Winter wheat in 2002 and 2003; grain sorghum in 2004; wheat in 2005, 2006, 2007</b>						
6	Certified Clearfield™ - BMP Imazamox (0.04 lb/A)	0.0 zA	0.0 zA	0.0 zA	14.3 yzB-D	0.000 zA
7	Certified Clearfield™ - BMP Imazamox (0.024 lb/A)	0.0 zA	0.0 zA	0.0 zA	18.6 xyA-C	0.004 zA
8	Bin-run 4X Clearfield™ - Conv. Imazamox (0.024 lb/A)	0.0 zA	0.0 zA	0.0 zA	11.9 zD	0.005 zA
9	Bin-run 1X Clearfield™ - BMP Imazamox (0.04 lb/A)	0.0 zA	0.0 zA	0.0 zA	13.7 yzCD	0.003 zA
10	Jagger – BMP Sulfosulfuron (0.023 lb/A)	0.7 yA	1.0 yA	0.6 yA	20.5 xAB	0.056 zA

<sup>a</sup> Means within columns and rotation (treatments 1-5 vs. treatments 6-10) followed by the same small case letter and means within columns across rotations (treatments 1-10) followed by the same capital letter do not differ significantly ( $\alpha = 0.05$ ).

<sup>b</sup> Treatment numbers correspond to those listed in Table 1.

<sup>c</sup> Bin-run treatments 3 and 8 were planted with seed saved 5 consecutive years (5X); Bin-run treatments 4 and 9 were planted with seed saved 1 year (1X).

<sup>d</sup> In-crop data.