

1-07

## 2007 Progress Report

**TITLE:** Managing Imazamox-Resistant Wheat in Crop Rotations

**PERSONNEL:** Philip Westra, Principle Investigator, Lynn Fandrich, Research Scientist, Todd Gaines, Graduate Student.

**TIME LINE:** Initiated fall, 2000; project terminated in Nov. of 2007

**ORIGINAL HYPOTHESIS:** Use of Clearfield wheat every 2 or 3 years in conjunction with crop rotations will provide more sustainable jointed goatgrass control and less risk of developing herbicide resistant jointed goatgrass than continuous use of Clearfield wheat.

**SUMMARY OF PROGRESS:** There was good fall moisture in 2006 for germination of wheat and jointed goatgrass, and good growing conditions during the summer of 2007 helped produce some of the best wheat yields seen over the 7 years of this study. Clearfield winter wheat yields were in the 50 bu per acre range at Haxtun and 40 bu per acre at Otis. Yield differences between Clearfield and convention wheat were not great, although the 2007 Clearfield plots produced the highest yields. At the Haxtun site, 160 quadrat samples contained 984 jointed goatgrass reproductive tillers. At the Otis site, 160 quadrat samples contained 768 jointed goatgrass reproductive tillers. Both sites recorded a large increase in jointed goatgrass tillers compared to 2006. All the goatgrass was found in the non-Beyond treated portions of both sites. Although a tour of all plots generally showed only moderate jointed goatgrass pressure in 2007, patches of jointed goatgrass were still present in both study areas. These long-term studies have captured the effects of both extreme drought and excellent moisture conditions on jointed goatgrass population dynamics. This project was in excellent shape in 2007 with outstanding collaboration from our farmer cooperators, Dave and Dan Anderson and Larry Paulser. We are using this information to enhance wheat grower options for dealing with jointed goatgrass. Use of Clearfield wheat continues to expand in the Central Great Plains, suggesting that the rapid adoption of this new technology will parallel the jointed goatgrass management insights developed in this research project. A major long-term goal of this project will be to help farmers manage Clearfield wheats in a way that promotes sustainable use of this technology.

**OBJECTIVES:**

- A. Determine the best use of Clearfield wheat for control of jointed goatgrass in wheat-based cropping systems of the Central Great Plains
- B. Determine the risk of developing Imazamox-resistant jointed goatgrass in cropping systems using Clearfield wheat
- C. Monitor the impact of Clearfield wheat technology on jointed goatgrass and jointed goatgrass x wheat hybrid population dynamics
- D. Determine if use of a summer crop improves jointed goatgrass control with Clearfield wheat while reducing potential development of imazamox resistant jointed goatgrass

**EXPERIMENTAL DESIGN:** Two research sites were established in the summer of 2000 with two farmers in eastern Colorado. The Anderson farm is located at Haxtun, CO, while the

Paulser farm is located at Otis, CO. Both sites include 2 studies. One study consists of a wheat-fallow rotation, while the other study includes more complex crop rotations. The Paulser site uses a winter wheat-fallow-proso millet rotation on 12.1 acres, while the Anderson site uses a winter wheat-dryland corn-sunflower-fallow rotation on 13.2 acres for the second studies. Sub plots are 15 X 100 feet in size and there are 4 sub plots per treatment combination. The wheat plots at Haxtun and Otis were drilled with Clearfield winter wheat 'Bond' in September, 2006, at 50 lbs per acre. Beyond herbicide at the rate of 4 ounces per acre was applied by the CSU weed science program with a tractor mounted sprayer applying 15 gallons per acre of spray solution on 4-17 & 18-2007. NIS at 0.25% v/v + UAN at 2.5% v/v were added to the spray solution. Wheat was harvested in mid July, 2007, at both locations. Four 10 square foot sub samples are collected at harvest in each of the sub-plots where wheat is grown. At the Haxtun location, 160 sub plots of wheat were hand harvested in 2007, and at the Otis site, 160 sub plots were hand harvested. For all these samples, wheat and jointed goatgrass reproductive tiller counts are made, and the wheat threshed to calculate yields. In addition, a Hege plot combine was used in mid-July, 2007, to harvest a 5 foot X 100 foot long sample in each sub plot in the field to calculate field-level wheat yields.

In each year, half of the Clearfield wheat is treated as conventional wheat while the other half is treated with imazamox. The farmers conduct the field operations on these large-scale studies except for wheat sample harvesting which is done by our research team. On 4-17 & 18, 2007, the CSU weed science team made the Beyond herbicide applications in the Clearfield wheat.

#### **PROGRESS/CONCLUSIONS:**

- A. Determine the best use of Clearfield wheat for control of jointed goatgrass in wheat-based cropping systems of the Central Great Plains

**Jointed Goatgrass Reproductive Tiller Counts** – In 2007, 984 jointed goatgrass reproductive tillers were found in 160 quadrats sampled at the Haxtun site (Table 1). At the Otis site, in the 160 quadrats sampled, 768 jointed goatgrass tillers were found. There was excellent fall moisture in 2007 for germination of winter annual grasses, and above normal moisture following planting ensured jointed goatgrass growth from seeds still in the soil. This long-term study is capturing the effects of both extreme drought (2002 and 2003) and excellent moisture conditions on jointed goatgrass population dynamics (2001 and 2007). Although these two studies saw an 83 – 87% reduction in jointed goatgrass reproductive tillers after 5 years, a residual jointed goatgrass population still persists in the system and was able to increase in a favorable year in 2007. Imazamox has provided nearly 100% control of jointed goatgrass over the life of this project.

One half of all the plots were treated with Beyond; every treated 60 X 100 foot subplot has a same sized adjacent plot of Bond wheat that is not sprayed. Each site has 4 replications of these paired plots, and imbedded within each replication are 4 treated sub plots and 4 non-treated sub plots. Each sub plot is 60 X 100 feet in size.

**Table 1.** Total number of jointed goatgrass reproductive tillers in the untreated wheat plots for Otis and Haxtun.

	<b>Otis</b>	<b>Haxtun</b>
<b>2001</b>	3512	3554
<b>2002</b>	255	317
<b>2003</b>	251	85
<b>2004</b>	629	0
<b>2005</b>	469	613
<b>2006</b>	36	0
<b>2007</b>	<b>768</b>	<b>984</b>

**Winter Wheat Yield** – Yields were calculated on a bushel per acre basis. In general, the 2007 wheat crop in Colorado was excellent. Adequate fall 2006 and early spring 2007 growing conditions helped produce one of the best wheat crops in the past 10 years. No crop injury from imazamox was observed in 2007. Weed pressure was higher than in 2006, but did not affect wheat yields very much, although the Beyond treated wheat provided the highest yields at both locations.

**Table 2.** Winter wheat yields, in bu/acre, at Otis and Haxtun, CO.

	<b>Otis Conven.</b>	<b>Otis Clearfield</b>	<b>Haxtun Conven.</b>	<b>Haxtun Clearfield</b>
<b>2001</b>	41.0	43.3	24.0	30.2
<b>2002</b>	29.2	31.5	34.1	37.0
<b>2003</b>	15.8	17.5	31.9	31.9
<b>2004</b>	23.5	19.3	36.1	39.3
<b>2005</b>	20.4	23.6	44.0	47.1
<b>2006</b>	21.1	23.3	32.2	36.4
<b>2007</b>	<b>38.4</b>	<b>41.4</b>	<b>49.6</b>	<b>51.6</b>

**Follow Crop Yield** - Spring follow crops were planted at each location in 2005 under initial good moisture conditions in the spring. Due to dry conditions and heat stress during the summer of 2004, the dryland corn, millet, and sunflower yields were below normal (Table 3).

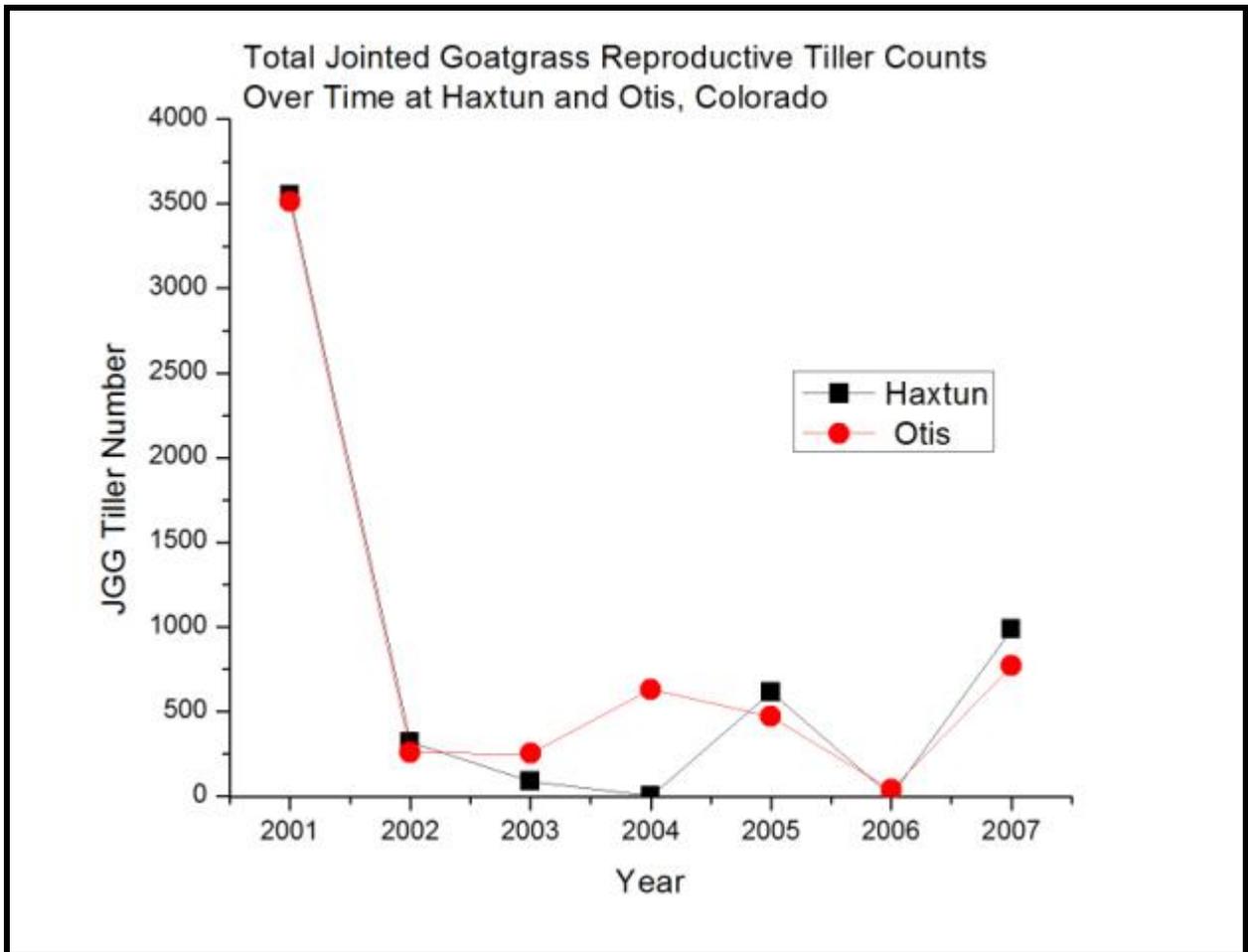
**Table 3.** Rotational spring-seeded crop yields.

	<b>Sunflower (lbs/acre)</b>	<b>Corn (bu/acre)</b>	<b>Millet (bu/acre)</b>
<b>2001</b>	4604	87.4	49.5
<b>2002</b>	1260	--- <sup>a</sup>	--- <sup>a</sup>
<b>2003</b>	1379	61.0	32.5*
<b>2004</b>	819	100.0	27.0*
<b>2005</b>	599	50.0	17.0
<b>2006</b>	<b>555</b>	<b>5.0<sup>b</sup></b>	<b>17.0*</b>
<b>2007</b>	<b>Pending</b>	<b>Pending</b>	<b>Pending</b>

<sup>a</sup> The Colorado drought was so severe in 2002 that neither corn nor millet produced harvestable grain.

\* Denotes yield from farmer's commercial field adjacent to the research site area.

<sup>b</sup> Severe drought in 2006 virtually eliminated dryland corn yields.



B. Determine the risk of developing Imazamox-resistant jointed goatgrass in cropping systems using Clearfield wheat

We have no evidence to date that imazamox resistant jointed goatgrass has developed at either research site.

C. Monitor the impact of Clearfield wheat technology on jointed goatgrass and jointed goatgrass x wheat hybrid population dynamics

To date, no obvious failures in the control of jointed goatgrass or hybrids with imazamox have been detected at either site. Jointed goatgrass samples collected through 2004 were sent to Carol Mallory-Smith for testing to determine if any imazamox resistance is developing. Samples for 2007 will be tested for imazamox response.

D. Determine if use of a summer crop improves jointed goatgrass control with Clearfield wheat while reducing potential development of imazamox resistant jointed goatgrass

To date, no reproductive jointed goatgrass has been observed in the spring seeded rotational crops. Generally fair to poor growing conditions for spring seed crops the past 5 years have precluded an opportunity to make major judgements regarding the impacts of the crop rotations on jointed goatgrass populations. Clearly growers believe that diverse crop rotations benefit jointed goatgrass control measures, but rarely will such rotations eliminate jointed goatgrass. If 2007 is a good year for dryland crop production, we may see significant impacts of the spring seeded crop rotations on jointed goatgrass numbers at these sites.

#### **PUBLICATIONS:**

1. Gaines, T., W.B. Henry, P.F. Byrne, **P. Westra**, S.J. Nissen, and D.L. Shaner. 2008. Jointed goatgrass (*Aegilops cylindrica*) by imidazolinone-resistant wheat hybridization under field conditions. *Weed Sci.* 56:32-36
2. Belles, D., P. Westra, and B. Hanson. 2005. Managing imazamox resistant wheat in crop rotations for jointed goatgrass control. *Proceedings WSWS* 58:22.
3. Westra, P., Brad D. Hanson, David S. Belles, and Todd Gaines. 2005. Jointed goatgrass by winter wheat hybrid dynamics in Colorado wheat fields. *Proceedings WSWS* 58:22.
4. Gaines, T., P. Byrne, P. Westra, and S. J. Nissen. 2005. Estimation of landscape level gene flow in wheat and jointed goatgrass. *Proceedings WSWS* 58:15.

**TECHNOLOGY TRANSFER ACTIVITIES:** These field studies will be shown to wheat producers on 2007 summer field tours. Research results were presented at wheat grower field days and research meetings. Drs. Brad Hanson, Mark Dahmer, and Lynn Fandrich have seen these studies or been involved in the project. Jointed goatgrass joints from this project have been sent to Dr. Carol Mallory-Smith. Results of this research will be published in research journals and will serve as the basis for development of best management practices for jointed goatgrass based on Clearfield wheat technology. The Clearfield wheat project at Colorado State University has been cited as a model for additional wheat improvement projects being developed. A presentation on this project was made at the 2005 WSWS meeting in Vancouver, BC.

#### **RECOMMENDATIONS FOR PRODUCERS:**

Use of Clearfield wheat continues to expand in the Central Great Plains, suggesting that the rapid adoption of this new technology will parallel the jointed goatgrass management insights developed in this research project. At present, we recommend that where possible, growers utilize a combination of rotational crops along with Clearfield wheat to successfully reduce jointed goatgrass populations and retain the long-term viability of Clearfield wheat technology. Growers who choose to strictly use Clearfield wheat in a wheat-fallow rotation are advised to scout their fields for any jointed goatgrass escapes that might be resistant to imazamox. By project termination, we will develop a set of guidelines for wheat producers concerning how to fit Clearfield wheat into diverse cropping systems to manage winter annual weeds and sustain the Clearfield technology well into the future.

**STATEMENT OF WORK TO BE CONDUCTED:** This study has now terminated. Data analysis will be conducted during the spring of 2008 and the results will be written up for publication. A more complete report will be provided at the March 2008 jointed goatgrass research meeting.