

27-05

PROGRESS REPORT

1. **TITLE:** Determining Best Crop Rotation for Effective Jointed Goatgrass Control Using Imidazolinone Resistant Wheat.
2. **PERSONNEL:** Principal Investigators: Frank L. Young
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3. **TIME LINE:** Initiation: August 2000
Termination: August 2007. This project is on schedule.
4. **ORIGINAL HYPOTHESIS:** Crop rotation strategies can prevent the development and spread of herbicide-resistant weeds when imidazolinone-resistant (Clearfield[®]) wheat is used to manage jointed goatgrass.
5. **SUMMARY OF PROGRESS:** Researchers collected data during the fifth year of a long term study in eastern Washington to determine the frequency and time to use a herbicide-resistant winter wheat crop to manage jointed goatgrass (*Aegilops cylindrica*). Research activities continued at two locations: a) 18-22 inch (high) rainfall zone with a winter wheat/spring cereal/grain legume rotation, located near Pullman, WA, and b) 9-11 inch (low) rainfall zone with a winter wheat/summer fallow rotation, located near Pasco, WA. At the Pasco south site, imidazolinone-resistant winter wheat (ID 587) planted in the fall of 2004 was treated twice with imazamox herbicide at rate of 4 oz/A + 2.5% Sol 32 (v/v) + 0.25% surfactant (v/v), on November 17, 2004 and April 5, 2005. Control of jointed goatgrass was good, with imidazolinone-resistant winter wheat plots averaging 1.5 jointed goatgrass spikelets yd⁻², compared to 661 spikelets yd⁻² in conventional winter wheat (Stephens) plots. Average crop yields (clean grain) were 54 bu/A for the imidazolinone-resistant winter wheat and 48 bu/A for the conventional winter wheat. The Pasco north site was fallow in the 2005 growing season and was seeded with Clearfield[®] (ID587) and Stephens winter wheat in October 2005.
6. **OBJECTIVES:**
 - a. Determine jointed goatgrass seed bank response to crop rotations, which includes imidazolinone-resistant wheat and selective applications of imazamox.
 - b. Determine the risk of developing imazamox-resistant jointed goatgrass/winter wheat hybrids and populations of resistant jointed goatgrass biotypes.
 - c. Identify a stable crop production system based on time and frequency of introduction of HRC for the integrated management of jointed goatgrass.
7. **EXPERIMENTAL DESIGN:** Crop rotation cycles (frequency and time of imi-resistant winter wheat) will be conducted through 2007. At Pullman, plots were initially established in chickpea stubble and arranged in a randomized complete block with four replications. The rotation for the experimental site was winter wheat in 2000/01, spring cereal in 2002, grain legume in 2003, winter wheat in 2003/04, spring cereal in 2005, and will be grain legume in 2006, then winter wheat in 2006/07. Imidazolinone-resistant (Clearfield[®]) winter wheat and

a standard local variety (Madsen) were planted in October of 2000 and 2003. Plots established at Pasco follow a winter wheat/ fallow rotation. Winter wheat is being grown at two sites (Pasco North and South) in alternate years so that data can be collected every crop year from 2002 through 2007. A winter wheat crop was harvested from the Pasco N field in 2002, 2004, and will be harvested in 2006. Winter wheat was harvested in the Pasco S field in 2003, 2005 and will be harvested in 2007. Treatments are replicated four times. At both Pullman and Pasco, plots planted with Clearfield[®] wheat are treated during the spring of each winter wheat rotation year with ≥ 0.03 lbs/A imazamox, 0.25% non-ionic surfactant, and UAN solution at 2.5% v/v for selective jointed goatgrass control. The Pasco S 2004/05 Clearfield[®] winter wheat plots received both a fall and a spring application of imazamox due to favorable jointed goatgrass growing conditions. Clearfield[®] plots are also managed using selected integrated management practices (deep banding fertilizer and preplant, nonselective herbicide applications for jointed goatgrass control). Plots planted with conventional wheat are managed using integrated management practices for jointed goatgrass control.

8. PROGRESS/DATA:

Objective 1. In the fall of 2003, Clearfirst[®], a WA-based herbicide-resistant variety, and Madsen winter wheat were planted in the herbicide-resistant and conventional plots, respectively. In the flex crop system, Madsen wheat was planted in plots that had previously been planted to herbicide-resistant wheat (Treatment 4). Clearfirst[®] wheat was planted in plots previously planted to Madsen wheat (Treatment 8)(Table 1). Regardless of the previous crop, when Clearfield[®] was grown in 2003-2004, spikelets were undetected in quadrats. In contrast, when conventional wheat was planted in 2003-2004, jointed goatgrass spikelets ranged from 300 to almost 500 spikelets yd^{-2} .

The Pasco N site was fallow in the 2003 growing season and was seeded with Clearfield[®] (ORCF101) and Stephens winter wheat in September 2003 to begin the second cycle of the study. Imidazolinone was applied in March 2004 at 5 oz/A + 2.5% Sol 32 (v/v) + 0.25% surfactant (v/v). Jointed goatgrass density in herbicide-resistant wheat averaged 68 spikelets yd^{-2} , while density in conventional wheat averaged 1286 spikelets yd^{-2} (Table 2).

In the fall of 2003, Clearfield (ORCF101) and Stephens wheat were planted in fallow with a deep-furrow drill. In the flex crop system, the herbicide-resistant wheat was planted in all plots, regardless of the variety planted the first time in 2001-2002. In plots with two consecutive imi-resistant winter wheat crops, no jointed goatgrass was detected in quadrats. When imi-resistant wheat followed conventional wheat, jointed goatgrass spikelets ranged from < 50 to 310 spikelets yd^{-2} . In contrast, jointed goatgrass produced 435 and 2138 spikelets yd^{-2} in the two conventional wheat plots. The high number of spikelets was produced when conventional wheat was grown twice in a row.

At the Pasco S site, both imidazolinone-resistant (Clearfirst[®]) and conventional winter wheat (Madsen) were planted in September 2002 in less-than-optimal conditions. Initial jointed goatgrass population at this site was high with an initial population of 335 spikelets yd^{-2} in the research cooperator's 2001 winter wheat plots. Herbicide applications were similar to the other two sites in the study with the imidazolinone-resistant winter wheat being treated with imazamox in the spring of 2003. The Clearfirst[®] wheat was injured after the March herbicide application and jointed goatgrass control was ineffective. Imidazolinone-resistant winter wheat plots averaged 750 spikelets yd^{-2} compared to a 593 spikelets yd^{-2} in conventional winter wheat plots (Table 2). The Pasco S site was fallow during the 2004

growing season and was seeded with Clearfield® (ID587) and Stephens winter wheat in September 2004. Clearfield wheat was sprayed with 4 oz/A imidazolinone + 2.5% UAN (v/v) + 0.25% surfactant (v/v) and Stephens received 0.66 oz/A Maverick in November 2004. The Pasco S site Clearfield® winter wheat was treated a second time in April 2005 with 4 oz/A imidazolinone + 2.5% UAN (v/v) + 0.25% surfactant (v/v). Jointed goatgrass control was excellent in Clearfield® wheat, which averaged 1.5 spikelets yd⁻². This compares to 661 spikelets yd⁻² in the Stephens winter wheat plots. In three of four treatments that received imidazolinone, no jointed goatgrass plants were observed (Table 3).

Objective 2. Experiments in the greenhouse to determine imidazolinone resistant jointed goatgrass x winter wheat hybrids and jointed goatgrass biotypes were initiated in 2005. Prior to harvest in 2004 at the Pullman site and in 2004 and 2005 at the Pasco research sites, a string was run diagonally across each plot and at each 10' mark, spikes of two jointed goatgrass plants and one hybrid plant were collected. If no hybrids were present along the string, they were collected from within the plot. Up to one hundred spikelets representing each 10' plot mark were collected and planted in flats for herbicide resistance screening. Emerged greenhouse plants were sprayed twice with 4 oz/A imidazolinone + 2.5% UAN (v/v) + 0.25% surfactant (v/v). Plants surviving the two, 4 oz/A imidazolinone treatments were identified then moved to a vernalization chamber for at least 60 days. From the Pullman site collection from 2004, 15 hybrid plants survived herbicide screening and vernalization. An additional 15 regular jointed goatgrass plants survived that appear to be jointed goatgrass. From the Pasco N site collection from 2004, 4 plants that appear to be jointed goatgrass survived.

Objective 3. Pullman and Pasco N sites were not in winter wheat production during the 2004-05 growing season. Average yields (clean grain) at Pasco S in 2003 were about 11 bu/A for both varieties. Jointed goatgrass dockage was 4.2% in the resistant wheat and 7.5% in the conventional wheat. In 2005 average Pasco S crop yields (clean grain) were 54 bu/A for the imi-resistant winter wheat and 48 bu/A for the conventional winter wheat. Jointed goatgrass spikelet dockage was <0.001% in the imi-resistant wheat and 0.1% spikelet dockage in the conventional wheat.

9. PUBLICATIONS: None.

10. TECHNOLOGY TRANSFER ACTIVITIES: Data presented at the PNW Tri-State Wheat Growers meeting on December 1, 2005. Jointed goatgrass management recommendations: Beware of weed resistance with this technology.

11. BUDGET: None requested this year. (see budget table on next page)

12. STATEMENT OF WORK TO BE CONDUCTED: The Pasco N site will be sprayed with imazamox in the spring of 2006. Jointed goatgrass spike, spikelet, and plant counts will be recorded prior to herbicide application and at harvest. Spikes and spikelets will be collected for jointed goatgrass herbicide resistance screening. Plots will be harvested and crop yield and quality (dockage) will be determined. The Pasco S site will be maintained with spring jointed goatgrass populations counted and winter wheat planted in the fall of 2006. Jointed goatgrass seed collected in 2005 at Pasco S may be evaluated for herbicide resistance in the greenhouse.

BUDGET TABLE:

Item	Req 2000-01	Rcv'd 2000-01	Req 2001-02	Rcv'd 2001-02	Req 2002-03	Rcv'd 2002-03	Req 2003-04	Rcv'd 2003-04	Req 2004-05	Rcv'd 2004-05	Req 2005-06	Rcv'd 2005-06
Salary:												
Associate												
in Research	\$25,000	\$25,000	\$26,000	\$26,000	\$27,000	\$27,000	\$28,000	\$28,000	\$28,000	\$28,000	\$28,000	\$28,000
Wages:												
Hourly	7500	3,400	5,000	3,000	0	0	0	0	0	0	0	0
*Benefits:	9,200	8,305	9,120	8,800	*8,640	*9,396	*9,800	*9,800	*9,800	*9,800	*9,800	*9,800
Travel:	0	0	0	0	1,260	1,260	0	0	0	0	0	0
Materials												
& Supplies:	12,500	1,295	250	200	1,100	344	200	200	200	200	200	200
Total:	\$42,950	\$38,000	\$40,370	\$38,000	\$38,000	\$38,000	\$38,000	\$38,000	\$38,000	\$38,000	\$38,000	\$38,000

*Employee Benefits Calculated at 35% for Associate in Research

Table 1. Treatment structure at Pullman and Pasco experimental sites.

<u>Pullman</u>			<u>Pasco North</u>			<u>Pasco South</u>		
Treatment	Year	Technology	Treatment	Year	Technology	Treatment	Year	Technology
1	Year 1	Clearfield	1	Year 1	Clearfield	1	Year 1	Clearfield
	Year 4	Clearfield		Year 3	Clearfield		Year 3	Clearfield
	Year 7	Clearfield		Year 5	Clearfield		Year 5	Clearfield
2	Year 1	Clearfield	2	Year 1	Clearfield	2	Year 1	Clearfield
	Year 4	Clearfield		Year 3	Clearfield		Year 3	Clearfield
	Year 7	nonClear		Year 5	nonClear		Year 5	nonClear
3	Year 1	Clearfield	3	Year 1	Clearfield	3	Year 1	Clearfield
	Year 4	nonClear		Year 3	nonClear		Year 3	nonClear
	Year 7	Clearfield		Year 5	Clearfield		Year 5	Clearfield
4	Year 1	Clearfield	4	Year 1	Clearfield	4	Year 1	Clearfield
	Year 4	nonClear (Flex)		Year 3	Clearfield (Flex)		Year 3	Clearfield (Flex)
	Year 7	Flex		Year 5	Flex		Year 5	Flex
5	Year 1	nonClear	5	Year 1	nonClear	5	Year 1	nonClear
	Year 4	Clearfield		Year 3	Clearfield		Year 3	Clearfield
	Year 7	Clearfield		Year 5	Clearfield		Year 5	Clearfield
6	Year 1	nonClear	6	Year 1	nonClear	6	Year 1	nonClear
	Year 4	Clearfield		Year 3	Clearfield		Year 3	Clearfield
	Year 7	nonClear		Year 5	nonClear		Year 5	nonClear
7	Year 1	nonClear	7	Year 1	nonClear	7	Year 1	nonClear
	Year 4	nonClear		Year 3	nonClear		Year 3	nonClear
	Year 7	Clearfield		Year 5	Clearfield		Year 5	Clearfield
8	Year 1	nonClear	8	Year 1	nonClear	8	Year 1	nonClear
	Year 4	Clearfield (Flex)		Year 3	Clearfield (Flex)		Year 3	Clearfield (Flex)
	Year 7	Flex		Year 5	Flex		Year 5	Flex

Table 2. Imi-resistant and conventional winter wheat yield, jointed goatgrass dockage, and jointed goatgrass spikelet counts at Pullman and Pasco, WA, 2001-2005.

Location	Year	Yield (clean grain)		JGG Dockage		Spikelets	
		Clearfield (bu/A)	Conventional	Clearfield (%)	Conventional	Clearfield (yd ²)	Conventional
Pullman	2000-2001	116	107	0	0.67	0	115
Pullman	2003-2004	106	113	0.0008	0.05	0	420
Pasco North	2001-2002	28	22	0.07	1.03	5	51
Pasco South	2002-2003	11	11	4.2	7.5	750	593
Pasco North	2003-2004	50	67	0.0016	0.27	68	1286
Pasco South	2004-2005	54	48	<0.001	0.1	1.5	661

Table 3. Winter wheat yield, dockage, and jointed goatgrass spikelets for the second winter wheat rotation cycle at Pasco S in 2005.

Pasco S	Wheat cycle technology	Yield (clean grain) (bu/A)	JGG Dockage (%)	Spikelets (yd ²)
Trt 1 + 2	Clearfield--Clearfield	53	<0.001	4.6
Trt 3	Clearfield--nonClearfield	46	0.086	586
Trt 4	Clearfield--Flex (Clearfield)	57	0	0
Trt 5 + 6	nonClearfield--Clearfield	54	0	0
Trt 7	nonClearfield--nonClearfield	49	0.102	736
Trt 8	nonClearfield--Flex (Clearfield)	57	0	0