Controlling Jointed Goatgrass in the Central Great Plains

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ABSTRACT

Several studies have been conducted in North Platte, NE since 1996 with the goal of managing jointed goatgrass (Aegilops cylindrica) growing in winter wheat (Triticum aestivum). Since 1996 long-term studies were conducted that examined the effects of altering crop rotations, wheat cultivars, no-till/till practices, tillage timing, selective grass herbicides, and plowing and burning as tools to manage jointed goatgrass (JGG) populations in a winter wheat-fallow rotation (W-F). Inserting row crops (corn) into the W-F rotation had the greatest effect on reducing JGG. The row crops allowed the use of herbicides effective in JGG control. The W-C-F and W-C-C-F rotations almost eliminated JGG from the succeeding wheat crop, with two years of row crops having the greatest effect; reducing the JGG seed bank more than one year of row crops. The effect of wheat cultivars in our study was minimal. The use of taller/more competitive cultivars may reduce the number of JGG spikelets (the JGG seed structure) per JGG plant in the growing wheat, thus reducing the subsequent JGG seed rain. Cultivars that produce taller/denser crop residue interfere with JGG germination in subsequent crops in the rotation. However, much of this ungerminated JGG can remain dormant in the residue, and available to re-infest wheat later in the rotational cycle. The most effective use of cultivars is through the use of imazamox resistant wheat cultivars allowing the control of JGG in the growing wheat crop. Altering tillage timing has only a minor effect on JGG densities. In the tillage timing study, JGG density was far more affected by timely precipitation, regardless of tillage timing. While tillage did result in greater germination of JGG, the effect was not enough to subsequently reduce the number of JGG spikelets in the wheat phase of the crop rotation. Altering the method of tillage was far more effective than altering tillage timing. Plowing to a depth of 20 cm with complete soil inversion succeeded in burying the JGG spikelets deep enough that germination of JGG was prevented. No JGG spikelets were found less than 10 cm deep. Burning was also effective in preventing JGG spikelets from germinating, but not as effective as plowing.

OBJECTIVE

To determine the influence of best-integrated weed management practices for controlling JGG in winter wheat rotations. Practices similar to those available to farmers using ecofallow will be followed. Such practices could include competitive wheat cultivars, increasing wheat seeding rates, altering fertilizer application timing, or altering crop rotations. Weed control practices might employ eliminating weeds following wheat harvest, use of minimum or no-till practices, timing of tillage to encourage weed germination, the use of plowing or burning to eliminate JGG spikelets, and careful choice of a herbicide program, including herbicide resistant winter wheat varieties, throughout the crop rotation.

INTRODUCTION

Jointed goatgrass is a major weed problem for producers of winter wheat in the U.S. It is distributed from the Pacific Northwest through the Great Plains, infesting wheat in all western states except North Dakota, Arizona, and Nevada. It is very difficult to control in winter wheat because of the similarity in life styles of the two:

- Both emerge in the fall
- Young plants have similar appearance (Fig. 1a)
- JGG spikelets and wheat seeds are similar in size and difficult to mechanically separate from each other (Fig. 1b).
- JGG seed is persistent, lasting 3 to 5 years, and will remain viable through the fallow phase of the crop rotation and into the next wheat phase.

TREATMENTS:

Study 1. 'Controlling Jointed Goatgrass in Winter Wheat in Nebraska with Rotations, Tillage, and Cultivars'. This study examined if jointed goatgrass (JGG) infestations in winter wheat grown in a winter wheat-fallow crop rotation could be controlled by best weed and crop management practices and by inserting row crops into winter wheat rotations.

Rotations:

- Wheat-fallow (W-F)
- Wheat-ecofallow corn-fallow (W-C-F)
- Wheat-ecofallow corn-corn-fallow (W-C-C-F)

Tillage Treatments:

- Tillage: Corn – tillage used early in spring to prepare a seedbed, plus herbicides and inter-row cultivation.
  Fallow – wheat seedbed tillage in spring; till and spray to control weeds until wheat planted.
- No-till: Corn – no-till seedbed (ecofallow corn), PRE and POST herbicides used to control weeds.
  Fallow – glyphosate used to control weeds

Winter wheat cultivars:

- 'Pronghorn' – Tall height, long coleoptile length, good winter hardiness
- 'Alliance' – Medium height, medium coleoptile length, fair winter hardiness
- 'Vista' – Short height, short coleoptile length, fair-good winter hardiness

Study 2. 'Influence of Fallow Tillage on Jointed Goatgrass Emergence and Competition in Winter Wheat'. The timing of the fallow tillage timing after wheat harvest was altered to determine this effect on JGG germination and its effect in the subsequent winter wheat crop.

Tillage Treatment: Four single disking treatments: August, October, March, or May;
One multiple disking treatment;
One no-till treatment.

JGG Density: Low density (5 joints/m²) and high density (75 joints/m²)

Study 3. 'Controlling Jointed Goatgrass with Moldboard Plowing'. The objective of this study was to determine the usefulness of unconventional weed control methods to aid in the control of JGG in winter wheat. Specifically, to determine if a single instance of moldboard plowing and/or burning will enhance the depletion of jointed goatgrass in the soil seedbank compared with using tandem disking, or no-till. All tillage treatments were performed alone and also with imazamox herbicide in the growing wheat.

Fallow Tillage:

- Burning stubble after wheat harvest;
- Disk in fall after wheat harvest;
- Moldboard plowing;
- No-till
- Burning + moldboard plowing;
- Disk in following spring;
- Moldboard plowing (heavy JGG);

Herbicide: ■ None ■ imazamox (0.035 kg ha⁻¹)

RESULTS AND DISCUSSION:

Study 1. This study considered crop rotations, wheat cultivars, and tillage as avenues to control JGG. Crop rotations was the most effective in reducing JGG. By adding one or two years of corn into the W-F rotation JGG seed rain (Table 1), and JGG density (Table 2) were reduced. Common herbicides for controlling grasses in corn have good efficacy against JGG, and can be applied at times which are effective in interrupting the life cycle of JGG. Tillage also reduced JGG numbers (Table 3). Light disking or cultivation applied in the spring of the corn or fallow phases of the rotations put JGG spikelets into better contact with the soil than in no-till plots (Figure 4). The increased germination of JGG was followed by weed control measures which typically killed all germinated JGG. However, tillage did not reduce JGG enough to stop JGG reproduction in the growing winter wheat crop, where no effective herbicides exist for controlling JGG. The main effect of cultivars (data not shown) was a slight reduction of JGG density in taller cultivars. *(cont.)*

(cont.) RESULTS AND DISCUSSION:

Study 2. This study considered altering tillage timing after winter wheat harvest, looking at its effect on JGG density in the following winter wheat crop. The timing of tillage in fallow was found to only have a minor influence on JGG density (Table 4). While the shallow tillage brought JGG spikelets in closer contact with the soil, it often left the soil too dry for germination to occur. Adequate and timely precipitation was a more important factor in germinating JGG than the timing of tillage. Similar studies in Oregon and Utah (see poster by Daniel A. Ball in this session) found that JGG density was among the least in the multiple disking treatment. In North Platte , the total JGG in fallow, after wheat planting, and before the winter freeze was least in the no-till treatment (Table 5); with no signifcant differences among the tilled treatments. After the wheat broke dormancy in the spring the no-till plots then had the highest JGG density. The late spring fallow tillage germinated the most JGG before the winter freeze and had the least JGG in the growing wheat in spring. As in study 1, tillage did not germinate enough JGG to aid in eliminating JGG from the plots.

Study 3. Moldboard plowing and burning, not currently considered best management practices, were considered for controlling JGG in this study. Plowing was very effective in almost eliminating JGG in the subsequent winter wheat crop (Table 6). The plow was set for 20 cm depth and performed complete inversion, burying the JGG too deep to allow germination. JGG density in burned plots was equal to or slightly greater than plowed plots. In the first repetition of this study, a slower burn resulted in better destruction of JGG spikelets than in the second repetition of the study when the fire was hurried through the plots. JGG density in disked was intermediate; greater than plowed but less or equal to no-till. No-till germinated the most joints in fallow (data not shown), yet still allowed the greatest JGG density in the growing winter wheat. As another factor in this study, imazamox herbicide was sprayed on the resistant winter wheat cultivar ('Above') in half of the plots. Imazamox was effective in reducing JGG and downy brome density. Densities of JGG remained low during the fallow and winter wheat rotation periods in the imazamox plots. In the first winter wheat crop after plowing, winter wheat grain yields in both repetitions of the study were greatest in the plowed plots and the burn+plow plots (data not shown). The burned plots had lower grain yield than the burn+plow plots; showing that the yield increase was a result of the turning of the soil rather than the effects of residue decomposition. The final winter wheat crop's yield in the study's second repetition showed no advantage from plowing (Table 6).

CONCLUSIONS:

- Traditional best weed-management practices fail to adequately control JGG in W-F rotation . Timely tillage reduced JGG density in the fallow phase of the rotation, but the remaining JGG renewed the population in the wheat phase. Herbicide application in the fallow phase was partly effective only if timely precipitation germinated JGG.
- JGG density in the winter wheat was reduced most by extending the rotation. Herbicides available for use in corn phases of W-C-F or W-C-C-F rotations were effective in controlling JGG. Extending the rotation also allowed for large percentages of JGG spikelets to naturally lose viability.
- The use of deep moldboard plowing with complete inversion almost eliminated JGG infestation in a W-F rotation. Burning wheat stubble infested with JGG was also highly effective. Due to the complete elimination of crop residues on the soil surface, these methods are only recommended in extreme circumstances.
- Imazamox is very effective at reducing JGG in resistant winter wheat cultivars, providing perhaps the best avenue for control of JGG in W-F rotations. Selection of competitive cultivars is only partially effective as the life-cycles of JGG and winter wheat are very similar.

Table 1. Influence of rotation on jointed goatgrass seed production in winter wheat averaged across all tillages and cultivars.[a]

Crop rotation	2003	2004	2005	*Prior Rotation*[b]	*Final Rotation*[c]
	----- Jointed goatgrass seed rain (spikelets/m²) -----				
F-Wheat	4200 a	10 b	11880 a	*4200*	*11880*
C-F-Wheat	0 b	219 a	1 b	*3970*	*220*
C-C-F-Wheat	0 b	0 b	0 b	*6130*	*0*

[a] Numbers within columns followed by the same letter are not significantly different at the $\alpha = 0.05$ level.
[b] Total seed rain (sum of all years) for complete rotation, prior to final rotation.
[c] Total seed rain (sum of all years) for final complete rotation

Figure 1. Photos of jointed goatgrass and winter wheat. a. Left leaf is jointed goatgrass and winter wheat is on the right. Note erect hairs on leaf margin of jointed goatgrass. b. Spikelets in a winter wheat sample.

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Table 2. Influence of rotation on jointed goatgrass density in winter wheat averaged across all tillages and cultivars.[a]

Crop rotation	1999	2000	2001	2002	2003	2004	2005
	---------------------- Jointed goatgrass (no./m²) ----------------------						
In winter wheat in April							
F-Wheat	21 a	11.7 a	45 a	0	----	0 b	453 a
C-F-Wheat	5 b	0.1 b	17 b	0	----	8 a	0 b
C-C-F-Wheat	14[b] a	0.3 b	0.1 c	0	----	0 b	0 b
In winter wheat stubble in fall							
F-Wheat	0	0	1040 b	2 a	----	0 b	74 a
C-F-Wheat	0	0	1551 a	0 b	----	6 a	0 b
C-C-F-Wheat	2[b]	0	1 c	0 b	----	0 b	0 b

[a] Numbers within columns followed by the same letter are not significantly different at the $\alpha = 0.05$ level.
[b] Not all phases of rotation had occurred before this year.

Table 3. Influence of tillage on jointed goatgrass density in winter wheat averaged across all rotations and cultivars.[a]

Tillage	1998	1999	2000	2001	2002	2003	2004	2005
	-------------------------- Jointed goatgrass (no./m²) -----------------------------							
In April								
Till	29 b	12	1 b	13 b	0	34 b	1 b	125 a
No-till	79 a	15	8 a	29 a	0.01	341 a	5 a	177 a
In winter wheat stubble in fall								
Till	147	0	0	286 b	0 b	0	0 b	20
No-till	224	0	0	1442 a	1.2 a	0	4 a	29

[a] Numbers within columns followed by the same letter are not significantly different at the $\alpha = 0.05$ level.

Table 4. Influence of tillage timing on jointed goatgrass density in the fallow period.[a]

	8-23-01	9-25-01	5-21-02	7-16-02	9-20-02	Total
	---------------------- Jointed goatgrass (no./m²) ----------------------					
Tillage timing						
Post-harvest	251 a	58 bc	0.04 c	0	295 bc	605 ab
Fall	89 b	77 abc	0.60 c	0	379 ab	545 b
Early spring	89 b	96 ab	8.2 a	0	352 bc	546 b
Late spring	128 b	109 a	0.02 c	0	467 a	704 a
Multiple	235 a	43 c	4.5 b	0	250 cd	533 b
No-till	126 b	95 ab	0 c	0	146 d	367 c

[a] Numbers within columns followed by the same letter are not significantly different at the $\alpha = 0.05$ level.

Table 5. Influence of tillage timing on jointed goatgrass density in the winter wheat period.[a]

	Residue cover	11-05-02	Total	4-11-03	Winter survival
	%	------ Jointed goatgrass (no./m²) -----			%
Tillage timing					
Post-harvest	28 bc	73 c	677 a	70 c	66
Fall	37 ab	96 b	641 ab	76 bc	79
Early spring	28 bc	109 b	655 ab	88 ab	81
Late spring	24 c	69 c	774 a	62 c	89
Multiple	9 d	88 bc	621 ab	73 bc	83
No-till	47 a	139 a	505 b	95 a	68

[a] Numbers within columns followed by the same letter are not significantly different at the $\alpha = 0.05$ level.

Table 6. The effect of post-harvest tillage and burning on jointed goatgrass density in winter wheat and winter wheat yield.[a]

	Nov 9, 2006		Jun 26, 2007		wheat grain yield	
Imazamox herbicide	no	yes	no	yes	no	yes
Fallow Treatment	-------- Jointed goatgrass (no./m²) -------				------- kg ha⁻¹ -------	
Burn	0 b	0 b	0 c	0 c	3490	3520
Burn + plow	0 b	0 b	0 c	0 c	3470	3490
Disk in spring	8 a	1 b	18 b	1 c	3200	3420
Disk in Fall	10 a	0 b	16 b	0 c	3130	3660
Plow	0 b	0 b	3 c	0 c	3690	3480
Plow (heavy JGG)	0 b	0 b	0 c	0 c	3430	3400
No-till	11 a	2 b	29 a	1 c	3160	3590

[a] Numbers within groups followed by the same letter are not significantly different at the $\alpha = 0.05$ level.

Figure 4. Jointed goatgrass infestation in winter wheat 2 months after seeding. a. 216 plants/m² in W-F rotation, tilled plot. b. 900 plants/m² in W-F rotation, no-till plot.

Figure 5. Controlling JGG in the fallow period of a winter wheat-fallow rotation: a. moldboard plowing with complete inversion to bury JGG, b. burning wheat residue to destroy jointed goatgrass, and c. disking residue to bring JGG spikelets into contact with soil to enhance germination