Integrated management of jointed goatgrass (*Aegilops cylindrica*) in Pacific Northwest dryland cropping systems

Frank L. Young[1], Dan Ball[2], Donn Thill[3], Joseph P. Yenish[4] and J. Richard Alldredge[5]
[1] USDA-ARS, Rm 161 Johnson Hall, Washington State University, Pullman, WA, USA
[2] Oregon State University, Pendleton, OR, USA
[3] University of Idaho, Moscow, ID, USA
[4] Rm 163 Johnson Hall, Washington State University, Pullman, WA, USA
[5] Rm 413 Neill Hall, Washington State University, Pullman, WA, USA

Summary In lieu of single component weed science research, scientists have recently begun to conduct multi/inter-disciplinary systems research for managing specific weed species. In the Pacific Northwest (PNW), jointed goatgrass (*Aegilops cylindrica* Host) is a major deterrent to reduced or no-till winter wheat (*Triticum aestivum* L.) cropping systems. Since the early 1970s individual chemical, cultural, mechanical, and preventive methods of managing jointed goatgrass have been evaluated. In 1996 a three-state integrated system for the management of jointed goatgrass was initiated in the field in the traditional winter wheat-fallow region of the PNW. Specific treatments evaluated include a one-time stubble burn, length of time out of winter wheat production (one or three years), and integrated winter wheat planting practices such as planting large seed of a competitive variety at an increased rate, fertilising at the time of planting, and using starter fertiliser.

At the site with the most severe weed density, one time burning reduced the number of spikelets located on the soil surface as well as seed viability. After a year of fallow, either winter or spring wheat was grown during the 1998 season. On a short term basis (first crop cycle) the production system with the best combination of treatments (based on yield) was a one-time burn, and planting winter wheat with integrated systems. Dockage in this system was 0.36% compared to 0.04% when spring wheat was grown in burned stubble. In contrast to the first crop rotation cycle, the best combination of treatments for winter wheat yield the second cycle was winter wheat grown with integrated practices following spring wheat, in plots not previously burned. However, burned, integrated winter wheat following spring wheat had the least dockage and lowest jointed goatgrass population at the end of the study. Results from the study at this location reinforces the importance of combining several beneficial strategies to reduce the competitive effects of jointed goatgrass. Data from the other two locations indicate the initial weed density may affect results differently than the OR site.

Keywords Burning, crop rotations, competitive varieties, seed size, seeding rate, conservation tillage.

INTRODUCTION

Jointed goatgrass is a winter annual grass weed that was introduced into the United States from Eurasia and is genetically similar to winter wheat. In the United States this weed currently infests more than three million ha of winter wheat and fallow and costs USA growers more than $145 million annually. This weed generally precludes producers from growing consecutive winter wheat crops. Jointed goatgrass is of such economic importance that the Federal Government established a National Jointed Goatgrass Research Initiative in 1994 which has provided more than three million dollars in research funds to scientists in 13 western states.

In the PNW, water (Batie 1983) and wind erosion (Papendick and Veseth 1996) are severe, which precludes tillage as an accepted option for jointed goatgrass control. In addition, development of selective herbicides for control of this weed in winter wheat is problematic because both plant species are genetically similar and share the D genome (Seefeldt *et al.* 1998). However, results from field studies (Ball *et al.* 1999) showed that by using herbicide-resistant wheat, jointed goatgrass can be selectively removed from the growing crop without injuring the wheat. The disadvantage of this technology (herbicide-resistant crops) was that herbicide-resistant jointed goatgrass × wheat hybrids were produced in the field by natural hybridisation (Seefeldt *et al.* 1998).

Since the 1970s many studies have been conducted examining single component management strategies for the suppression/control of jointed goatgrass. In 1996, a tri-state (WA, OR, ID) research program was initiated and funded through the National Jointed Goatgrass Research Initiative to examine and develop a production system that integrated several single component management practices to suppress the competitive effects of jointed goatgrass against wheat. Integrated management practices included one-time stubble burning (Young *et al.* 1990), rotate out of winter wheat production (Young *et al.* 2000), and improved winter wheat planting practices. Integrated winter wheat planting strategies included the application of starter fertiliser at time of planting (Mesbah and Miller 1998). Also, nonclassical biological control practices were integrated into the system which included the use of competitive wheat varieties (Ogg Jr. and Seefeldt 1999), increased seeding rate, and large crop seed.

Objectives of the project were numerous for the three experimental site locations. Our focus will be to determine the effect of one-time burning, crop rotation, and integrated practices for planting winter wheat on a) crop yield and quality and b) jointed goatgrass plant density at the Gooseberry, OR site.

MATERIALS AND METHODS

Although this study was conducted in three states, only the Gooseberry, OR site will be discussed. Two characteristics are unique to this site. First of all, this site had the highest population of jointed goatgrass and secondly, by coincidence, both the grower and researcher chose the same winter wheat variety, 'Stephens.' This variety was determined previously to be very competitive (Ogg Jr. and Seefeldt 1999). In August 1996, all plots were sampled for jointed goatgrass spikelets before and after burning. Sampling locations were on the soil surface (2050 cm^2) and 0 to 10 cm and 10 to 20 cm deep. This sampling represents the baseline weed seed bank density. Main plots (burn and no burn) were split into two subplots depending on crop rotation: a) fallow-winter wheat-fallow-winter wheat (F-WW-F-WW) or b) fallow-spring wheat-fallow-winter wheat (F-SW-F-WW). Plots were further divided (subsubplots) into standard and integrated wheat planting strategies whenever winter wheat was sown in the plots.

In the conventional summer-fallow (F-WW-F-WW) plots were initially tilled during Fall 1996, fertilised in June 1997 and planted September 24, 1997. 'Stephens' wheat was planted at 76 kg ha^{-1}, in 35 cm row spacing with no additional fertiliser in the standard treatments. In the integrated treatments, 'Stephens' wheat using large seed, was planted at 118 kg ha^{-1}, in 25 cm rows, with deep-banded nitrogen and starter phosphorous fertiliser added at the time of planting. Large seed varied from year-to-year but was generally selected by screening the largest 30 to 50% of seed contained in a commercial 100 kg bag. In the F-SW-F-WW rotation, plots were fallowed chemically from the fall of 1996 until spring 1998 when 'Penawawa' spring wheat was planted no-till at 90 kg ha^{-1} with deep banded nitrogen and phosphorous with the seed. Plots were harvested in August 1998 and grain yield and dockage (weight/weight basis) were measured.

The entire experimental area was conventionally summer-fallowed from fall 1998 until fall 1999. Standard practice plots were fertilised in June 1999 while integrated plots were fertilised at the time of planting. 'Stephens' winter wheat was planted on October 22, 1999 at 84 kg ha^{-1} and 118 kg ha^{-1} for the standard and integrated treatments respectively. Plots were harvested on July 24, 2000 and grain yield and dockage were measured.

Jointed goatgrass plant density was counted in each plot prior to tillage or herbicide application every year. Final densities were counted March 2001.

Data were analysed using SAS Proc Mixed (SAS, 1999) as a split-split-plot analysis of variance in a randomised block design. Burned/not burned factor was main plot treatment, crop rotations were subplot treatments, and planting practices were sub-subplot treatments. Analysis of residuals was used to check the validity of the statistical assumptions of normality and homogeneity of variances. Where necessary some analyses were conducted on transformed data (natural logarithm) to better satisfy assumptions. Hsu's multiple comparison with the best procedure (Hsu 1984) was used to select treatment combination(s) into a subset such that the best treatment combination (burning status, rotation, planting practice) is included in the subset with a 95% level of confidence. This allows growers to identify the best combination of treatments for optimum production.

RESULTS AND DISCUSSION

Baseline jointed goatgrass spikelet densities in OR averaged 245 spikelets on the soil surface (2050 cm^{-2}), and 34 and 3 spikelets at the 0 to 10 and 10 to 20 cm depths respectively (Young *et al.* 1999). Burning destroyed 30% of the spikelets on the soil surface and reduced seed viability 93% (Young *et al.* 1999).

The first year's crops in this study were harvested in 1998 and contained both spring wheat and winter wheat which followed a chemical fallow and traditional fallow respectively. Based on yield, the best combination of treatments was a one-time burn with integrated planting practices for winter wheat (Table 1). The only treatment comparable to the best treatment was the nonburn, integrated planted winter wheat. All other systems produced at least 17% less grain than either integrated winter wheat system. Spring wheat produced considerably less grain than the top two systems which produced winter wheat. However, in regards to dockage, the burn, spring wheat systems had the lowest percent dockage (Table 1). Neither burn nor nonburn winter wheat produced under standard management practices had grain quality similar (low dockage) to the burn, spring wheat.

In 2000, winter wheat was planted in all plots, and the best combination of treatments, based on yield, was the nonburn, spring wheat, integrated system (Table 2). Similar yielding treatments included all other integrated systems. Over the course of this 5-year study, at a location severely infested with jointed goatgrass, the overall best combination of treatments would have been a one-time burn, fallow-spring wheat-fallow-winter wheat rotation, with integrated winter wheat planting practices. This system, while similar to the best yielding combination system the second year, was the best system for reducing dockage both years (Table 1 and 2) and final weed density (data not shown). In the burn, F-SW-F-WW, integrated planting system, 25 jointed goatgrass plants m^{-2} were present February 2001. All other systems which included SW had similar weed populations in 2001. In contrast, weed densities in winter wheat production systems ranged from 75 to 175 plants m^{-2}.

Table 1. Best combination of treatments for optimum yield and reduced dockage in 1998[a].

Treatments[b]				
Burn	Rotation	Practice	Yield (kg ha^{-1})	Dockage (%)
Y	WW	S	3495	1.69
Y	WW	I	4255**	0.36*
N	WW	S	3190	3.07
N	WW	I	4190*	0.48*
Y	SW	S	3225	0.18*
Y	SW	I[c]	3135	0.04**
N	SW	S	2655	0.32*
N	SW	I[c]	2905	0.67*

[a] **Denotes best combination of treatments; *denotes treatments similar to best combination at 95% confidence level.
[b] Burn, Y = yes, N = no; Rotation, WW = F-WW-F-WW; SW = F-SW-F-WW; Practice, S = standard, I = integrated.
[c] Integrated refers to planting practices for the subsequent 2000 winter wheat crop.

Table 2. Best combination of treatments for optimum yield and reduced dockage in 2000[a].

Treatments[b]				
Burn	Rotation	Practice	Yield (kg ha^{-1})	Dockage (%)
Y	WW-F-WW	S	2505	8.5
Y	WW-F-WW	I	3005*	4.1*
N	WW-F-WW	S	2250	19.5
N	WW-F-WW	I	2905*	6.3
Y	SW-F-WW	S	2585	4.0*
Y	SW-F-WW	I	2840*	1.4**
N	SW-F-WW	S	2705	8.3
N	SW-F-WW	I	3110**	4.3*

[a] **Denotes best combination of treatments; *denotes treatments similar to best combination at 95% confidence level.
[b] Burn, Y = yes, N = no; Practice, S = standard, I = integrated.

ACKNOWLEDGEMENTS

The scientists would like to thank the National Jointed Goatgrass Research Initiative for providing support and funding for this long-term, multi-state research project.

REFERENCES

Ball, D.A., Young, F.L. and Ogg Jr., A.G. (1999). Selective control of jointed goatgrass, with imazamox in herbicide-resistant wheat. *Weed Technology* 13, 77-82.

Batie, S. (1993). 'Soil erosion: Crisis in America's croplands', 136 pages. (The Conservation Foundation, Washington DC).

Hsu, J.C. (1984). Constrained simultaneous confidence intervals for multiple comparisons with the best. *Annals of Statistics* 12, 1136-1144.

Mesbah, A.O. and Miller, S.D. (1998). Influence of fertilizer placement on jointed goatgrass competition in winter wheat. Proceedings of the Western Society Weed Science 51, 23.

Ogg Jr., A.G. and Seefeldt, S.S. (1999). Characterizing traits which enhance the competitiveness of winter wheat (*Triticum aestivum*) against jointed goatgrass (*Aegilops cylindrica*). *Weed Science* 47, 74-80.

Papendick, R., and Veseth, R. (1996). Northwest Columbia Plateau wind erosion air quality project. Washington State University, No. MISC0184, 63 pp.

SAS (1999). SAS/STAT user's guide, version 8. Cary, NC: SAS Institute, Inc., 3384 pp.

Seefeldt, S.S., Zemetra, R., Young, F.L. and Jones, S.S. (1998). Production of herbicide-resistant jointed goatgrass (*Aegilops cylindrica*) × wheat (*Triticum aestivum*) hybrids in the field by natural hybridization. *Weed Science* 46, 632-634.

Young, F.L., Gallandt, E.R. and Alldredge, J.R. (2000). Predicting winter wheat (*Triticum aestivum*) yield loss based on jointed goatgrass (*Aegilops cylindrica*) populations from the previous season. *Weed Technology* 14, 423-427.

Young, F.L., Seefeldt, S.S., Yenish, J.P., Thill, D. and Ball, D.A. (1999). Strategies for integrated jointed goatgrass management in the Pacific Northwest. Proceedings of the Western Society Weed Science 52, 153-155.