

IMPACT OF CULTURAL PRACTICES ON JOINTED
GOATGRASS (*Aegilops cylindrica*) IN
WHEAT (*Triticum aestivum*)

By

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Bachelor of Science

Kansas State University


Manhattan, Kansas

1994

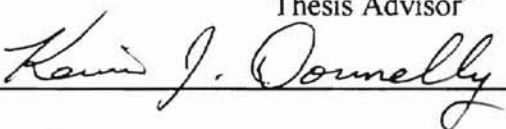
Submitted to the faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirement for
the Degree of
MASTER OF SCIENCE
May, 1998

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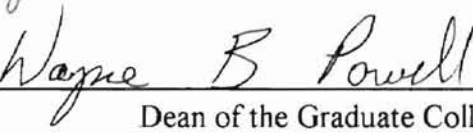
Thesis Approved:



Thesis Advisor







Dean of the Graduate College

ACKNOWLEDGMENTS

I express sincere appreciation to my major advisor, Dr. Thomas F. Peeper, Professor of Plant and Soil Sciences, for his time, advice, and constructive criticism during the course of this research. Appreciation is also extended to my committee members Dr. Kevin Donnelly and Dr. John Solie for their time and input.

I would like to thank my supportive and understanding wife Melissa for her encouragement during the course of this research. Thanks also to my parents, Kenneth and Helen Kelley for their support.

Appreciation is also extended to the members of the Small Grains Weed Science project, Jeff, Case, Brandi, Michelle, Todd, Amanda, John, Chad, Mike, and Johnny for the many hours of field work that they spent assisting me in this research.

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INTRODUCTION

Each chapter of this thesis is a manuscript to be submitted for publication in Weed Technology, a Weed Science Society of America publication.

CHAPTER I

Effects of Grazing Jointed Goatgrass (*Aegilops cylindrica*) Infested Wheat (*Triticum aestivum*).

**Effects of Grazing Jointed Goatgrass (*Aegilops cylindrica*) Infested
Wheat (*Triticum aestivum*).¹**

JASON P. KELLEY and THOMAS F. PEEPER²

Abstract: Replicated field experiments were conducted at two locations and repeated the next season to evaluate the effects of winter grazing by cattle on jointed goatgrass and hard red winter wheat. Grazing had no effect on wheat yield at one location and increased wheat yield at the second location during the 1994-1995 crop year when averaged over jointed goatgrass presence or absence. In 1995-1996, grazing reduced wheat yield at one location, and had no effect at the other location when averaged over jointed goatgrass presence or absence. Grazing increased jointed goatgrass spikelets with harvested wheat 967 and 189% in the 1994-1995 experiments but did not increase spikelets in the 1995-1996 experiments. Increases in spikelet production in grazed wheat was caused by increases in jointed goatgrass heads per plant and spikelets per head. Jointed goatgrass reduced wheat yield 20 and 22% in the 1994-1995 experiments and 69 and 62% at the same locations in 1995-1996.

Nomenclature: Jointed goatgrass, *Aegilops cylindrica* L.^{#3}, AEGCY; winter wheat,

¹Received for publication _____ and in revised form _____.

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³Letters followed by this symbol are WSSA-approved computer codes, Available from WSSA.

Triticum aestivum L., '2180'; Cattle, *Bos* sp.

Additional index words: Grazing, spikelet, AEGCY.

INTRODUCTION

Grazing of winter wheat during the vegetative growth stage is a common practice in the Southern Great Plains (Winter and Thompson 1987). In Oklahoma, wheat is often a dual purpose crop grazed from November to March, then grain is harvested in June. The earnings from grazing the wheat can often exceed the value of the grain crop (Cuperus et al. 1983; Denman and Arnold 1970; Harper 1961). About half of the wheat in Oklahoma is grazed.

In Oklahoma, grazing cheat (*Bromus secalinus* L.)-infested wheat by cattle defoliated wheat plants more than cheat plants and increased cheat biomass at harvest by 24 % (Koscelny and Peeper 1990a). This suggests that grazing favors cheat over wheat (Koscelny and Peeper 1990b).

Jointed goatgrass, a winter annual with phenology similar to cheat and wheat, is rapidly becoming a serious threat to winter wheat production in the Great Plains and in the western United States (Donald and Goo 1991). As few as 10 jointed goatgrass plants/m² reduced wheat yield 27% in Oklahoma (Hill 1977). In Oregon, 54 to 86 jointed goatgrass plants/m² reduced wheat yield 25 to 29% (Rydrych 1983). There are currently no herbicides that selectively control jointed goatgrass in wheat. Thus, cultural controls are the only way to reduce the impact of jointed goatgrass. Little if any research has been conducted on the effects of seasonal grazing of jointed goatgrass infested wheat. The

objective of this research was to evaluate the effects of grazing wheat infested with jointed goatgrass on wheat yield and jointed goatgrass reproduction.

MATERIALS AND METHODS

Field experiments were conducted during the 1994-1995 crop year and repeated on adjacent land during the 1995-1996 crop year on Agronomy Research Stations near Perkins and Stillwater, in north central Oklahoma, to examine the influence of winter grazing by cattle on jointed goatgrass and wheat during the winter months. The experimental design for each year and location was a split-plot. The main plot treatments were grazed versus ungrazed wheat and the subplot treatments were the presence or absence of jointed goatgrass. The treatments were replicated four times and plot size was 2.4 m by 7.6 m.

The hard red winter wheat cultivar '2180' was planted between September 20 and September 29 at 67 kg/ha in 23-cm wide rows using a double disk grain drill with press wheels. All plots received 168 kg/ha of 18-46-0 fertilizer and 110 kg/ha of nitrogen broadcast and incorporated approximately two weeks before seeding.

To ensure a uniform stand of jointed goatgrass, 90 kg/ha of spikelets were hand broadcast onto appropriate plots and incorporated 2 to 4 cm deep using a light field cultivator with double rolling baskets immediately prior to seeding. Moisture at planting was sufficient to ensure rapid wheat emergence. Rainfall of 1.25 cm or greater fell 11 and 1 days after planting at Perkins and Stillwater in 1994-1995 and 3 and 1 days after planting in 1995-1996 at Perkins and Stillwater.

Cattle (*Bos sp.*) were allowed to graze appropriate plots beginning November 14, 1994, and December 4 or 6 in 1995. In 1995 grazing initiation was delayed by slow wheat

cornal root development due to extremely dry soil conditions. Earlier grazing would have uprooted wheat plants. Grazing was continuous throughout the winter except when fields became too wet to support the weight of the cattle or when the forage supply was depleted. Wire panels excluded cattle from ungrazed plots. Grazing was terminated February 17, and March 3, 1995 for Perkins and Stillwater and February 20, 1996 at both locations. Cattle used for grazing consisted of two mature animals (770 and 545 kg) at Stillwater, and six stocker calves (270 kg) at Perkins each year. The stocking density was approximately 525 and 650 kg of beef per ha at Stillwater and Perkins each year. After grazing was terminated, wheat forage removed by grazing was estimated by hand clipping forage at ground level from one meter of row from grazed and ungrazed plots.

The soils were Teller sandy loam (fine-loamy, mixed, thermic Udic Argiustoll) with pH 5.9 and 0.9% organic matter at Perkins, and a Zaneis sandy clay loam (fine-loamy, mixed, thermic Udic Haplustoll) with pH 5.3 and 1% organic matter at Stillwater. Precipitation from planting until harvest during the 1994-1995 season was 926 and 800 mm for Perkins and Stillwater and 200 and 154 mm for Perkins and Stillwater in 1995-1996.

A treatment was included in each experiment wherein jointed goatgrass was hand seeded to examine the response of jointed goatgrass to grazing. In this treatment individual jointed goatgrass spikelets were hand planted in a zigzag pattern, with individual spikelets offset 4 cm from the row middle, and 7.5cm apart. Thus, 100 spikelets were seeded in each appropriate wheat row middle in plots 7.6 m long. Jointed goatgrass and wheat emergence was quantified in early October.

Seven to ten days before the wheat was harvested, all hand planted jointed goatgrass plants were individually removed. Seed heads per plant were counted on every plant and

spikelets per head were counted on every tenth plant. Jointed goatgrass survival was determined by comparing emergence with presence at maturity. Three wheat rows from plots with hand-seeded jointed goatgrass were harvested at maturity. One harvested row had experienced interference from jointed goatgrass in both adjacent row middles, one harvested row had experienced interference from jointed goatgrass in one adjacent row middle and one harvested row had no interference from jointed goatgrass on either side. Data from these wheat rows included wheat yield and thousand seed weights.

The remaining plots were harvested with a small plot combine in late May or early June. The air flow from the separator fan on the combine was reduced to help retain the jointed goatgrass spikelets with the harvested wheat grain. Since this adjustment increased the chaff and straw in the grain, samples were cleaned with a small commercial seed cleaner to remove excess straw and chaff. After cleaning, the jointed goatgrass spikelets were manually removed from a 100-gram sample of the wheat-jointed goatgrass mixture from each plot. Wheat yields were adjusted for jointed goatgrass content.

RESULTS AND DISCUSSION

There were no grazing by presence of jointed goatgrass interactions in wheat yield at any location or year. In combined data analysis, year and location effects were significant. Therefore data are presented separately for each year and location.

Wheat Yield. Wheat yields were 85 and 83% of the county average at Perkins and 83 and 59% of the county average at Stillwater in 1994-1995 and 1995-1996. Lower than average yields were attributed to stresses on the wheat that developed as a result of early seeding for grazing, including increased moisture depletion.

Averaged over jointed goatgrass presence or absence, grazing did not affect wheat yield at Stillwater during the 1994-1995 crop year ($P=0.13$), but reduced wheat yield 33% ($P=0.0004$) during the 1995-1996 crop year. The decrease in wheat yield was attributed to very dry conditions during the 1995-1996 growing season, which limited wheat growth and the ability of the wheat to recover from defoliation by grazing. At Perkins, grazing increased wheat yield 11% ($P=0.023$) during the 1994-1995 crop year and had no effect ($P=0.915$) during the 1995-1996 crop year, when averaged over presence or absence of jointed goatgrass.

Averaged over grazed and ungrazed plots, jointed goatgrass reduced wheat yield 20 and 22% at Perkins and Stillwater in 1994-1995 and 69% and 62% at Perkins and Stillwater in 1995-1996. The yield greater yield reduction from jointed goatgrass in 1995-1996 was attributed to higher densities of jointed goatgrass and very dry conditions in much of the 1995-1996 crop year. Densities of jointed goatgrass were 104 (s.d.= 9) and 112 (s.d. = 14) plants/m² at Perkins and Stillwater in 1994-1995, and 177 (s.d. = 21) and 207 (s.d.= 39) plants/m² at Perkins and Stillwater in 1995-1996.

Grazing Effects on Jointed Goatgrass Spikelet Production. Jointed goatgrass spikelet yield was increased by grazing 967% and 189% at Perkins and Stillwater in 1994-1995.

In 1995-1996, grazing did not affect jointed goatgrass spikelet yield (Table 1).

Differences between years were attributed to low wheat forage production during the 1995-1996 crop year due to extremely dry conditions. In 1995-1996, ungrazed wheat failed to canopy over the area between wheat rows, allowing the jointed goatgrass to receive more direct sunlight. Grazing removed 4350 and 1630 kg/ha of dry matter at Perkins and Stillwater in 1994-1995, and 1230 and 1090 kg/ha at Perkins and Stillwater in

1995-1996 (Table 3). Visually, it appeared that grazing had removed more forage from wheat than from jointed goatgrass. The prostrate growth habit of jointed goatgrass appeared to reduce the amount of jointed goatgrass forage removed by grazing.

Grazing had little or no effect on individual jointed goatgrass plant survival. Survival at Perkins in 1994-1995 was 65% in ungrazed plots and 78% ($P=0.25$) in grazed plots. At Stillwater in 1994-1995 survival of jointed goatgrass plants was 78% and 79% ($P=0.78$) for grazed and ungrazed plots. At Perkins in 1995-1996 plant survival was 97% in grazed wheat and 99% in ungrazed wheat ($P=0.88$) and 100% in grazed wheat and 97% in ungrazed wheat ($P=0.10$) at Stillwater. Jointed goatgrass survival was much higher in 1995-1996, suggesting that jointed goatgrass is adapted to dry conditions or conditions where wheat is less competitive.

At Perkins in 1994-1995, grazing increased mean jointed goatgrass seed heads from 3.0 to 14.8 ($P=0.0001$) and spikelets per head from 5.6 to 7.8 ($P=0.001$). In 1995-1996 grazing increased spikelets per head from 7.2 to 7.6 ($P=0.03$) (Table 4). Results were similar at Stillwater in 1994-1995 where grazing increased the number of seed heads from 4.5 to 8.8 ($P=0.0001$) per plant and spikelets per head from 5.8 to 7.4 ($P=0.0001$).

Jointed Goatgrass Interference Effects on Wheat. Wheat yield and thousand seed weight from wheat rows from which individual jointed goatgrass data were obtained, were affected by the level of jointed goatgrass interference. At Perkins there was a grazing by jointed goatgrass level interaction for wheat yield for both years (Table 5). In 1994-1995 grazed wheat with no interference from jointed goatgrass produced 680 kg/ha. Wheat yield was reduced 26% by jointed goatgrass growing in one adjacent row middle (one sided interference, approximately one jointed goatgrass plant per 3.0 wheat plants), and

50% by jointed goatgrass growing in both row middles (two sided interference, approximately one jointed goatgrass plant per 1.5 wheat plants). With no grazing, wheat yields were not reduced by jointed goatgrass. In 1995-1996, yield of grazed wheat declined 30 and 61% with jointed goatgrass interference in one and two adjacent row middles, but was not affected with no grazing. At Stillwater there was not an interaction of grazing treatment and interference level on wheat yield either year. Averaged over grazed and ungrazed treatments, increasing levels of jointed goatgrass did not effect wheat yield in 1994-1995 (Table 5), but in 1995-1996 wheat yields were reduced 30 and 37% by one sided and two sided interference.

Wheat thousand seed weight not reduced by grazing but was reduced by jointed goatgrass interference level at Perkins both years. In 1994-1995, two-sided interference, averaged over grazed and ungrazed plots, reduced thousand seed weight 4.8% ($P=0.04$). In 1995-1996, two-sided interference reduced wheat thousand seed weight 7% ($P=0.02$). At Stillwater, averaged over jointed goatgrass interference level, grazing did not reduce wheat thousand seed weight in 1994-1995 ($P=0.39$), but reduced seed weight 11% in 1995-1996 ($P=0.035$). Wheat thousand seed weight was not affected by jointed goatgrass interference level either year.

These data indicate that grazing jointed goatgrass infested winter wheat during the winter months can increase the negative impact of jointed goatgrass on wheat and may increase jointed goatgrass spikelet production. These results are similar to the effects of grazing cheat infested wheat by cattle which increased the ability of cheat to compete with wheat (Koscelny and Peeper, 1990b). Not grazing wheat to suppress jointed goatgrass

can be a supplement to other cultural control practices, although, as with many cultural control practices, results are often variable from year to year.

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Table 1. Effect of grazing, averaged over jointed goatgrass presence, on wheat yield and effect of grazing on jointed goatgrass spikelet yield at two locations and two years.

Crop year	Grazing	Perkins		Stillwater	
		Wheat	Jointed goatgrass	Wheat	Jointed goatgrass
		kg/ha			
1994-1995	Grazed	930	320	680	260
	Ungrazed	830	30	750	90
LSD (0.05)		80	40	NS	120
1995-1996	Grazed	1000	790	560	970
	Ungrazed	1000	870	840	740
LSD (0.05)		NS	NS	240	NS

Table 2. Effect of jointed goatgrass pooled over grazing treatments, on wheat yield at two locations and two crop years.

Crop year	Jointed goatgrass	Wheat yield	
		Perkins	Stillwater
		————— Kg/ha —————	—————
1994-1995	Absent	980	800
	Present	780	630
LSD (0.05)		110	60
1995-1996	Absent	1530	1020
	Present	470	390
LSD (0.05)		250	100

Table 3. Wheat forage present when grazing was terminated at two locations in two crop years.

Crop year	Treatment	Perkins	Stillwater
		kg/ha	
1994-1995	Grazed	220	2350
	Ungrazed	4580	3970
LSD (0.05)		610	410
1995-1996	Grazed	590	600
	Ungrazed	1830	1690
LSD (0.05)		920	630

Table 4. Effect of grazing on jointed goatgrass heads per plant and spikelets per head at two locations and two crop years.

Crop year	Treatment	Perkins		Stillwater	
		Heads/plant	Spikelets/head	Heads/plant	Spikelets/head
1994-1995	Grazed	14.8	7.8	8.8	7.4
	Ungrazed	3.0	5.6	4.5	5.8
LSD (0.05)		1.0	0.4	0.6	0.4
1995-1996	Grazed	12.7	7.6	8.7	7.8
	Ungrazed	12.0	7.2	8.5	7.8
LSD (0.05)		NS	0.3	NS	NS

Table 5. Interaction between grazing and jointed goatgrass interference levels on wheat yield at Perkins for two crop years and effect of interference levels on wheat yield, averaged over grazed and ungrazed wheat, at Stillwater.

Interference level	Perkins				Stillwater	
	1994-1995		1995-1996		1994-1995	1995-1996
	Grazed	Ungrazed	Grazed	Ungrazed	Mean	Mean
	kg/ha					
No interference	680	810	990	810	570	490
Jointed goatgrass in one adjacent row middle	500	740	690	670	490	340
Jointed goatgrass in two adjacent row middles	340	730	380	720	510	310
LSD (0.05)	130		230		NSD	70

Table 6. Effect of three jointed goatgrass interference levels, averaged over grazing pressure, on wheat thousand seed weight at two locations for two crop years.

Crop year	Interference level	Seed weight (g) per 1000 kernels	
		Perkins	Stillwater
1994-1995	No interference	26.3	24.4
	Jointed goatgrass in one adjacent row middle	26.1	23.4
	Jointed goatgrass in two adjacent row middles	25.1	23.7
LSD (0.05)		1.1	NSD
1995-1996	No interference	22.1	17.7
	Jointed goatgrass in one adjacent row middle	21.1	16.9
	Jointed goatgrass in two adjacent row middles	20.6	17.3
LSD (0.05)		0.8	NSD

CHAPTER II

Effect of Wheat (*Triticum aestivum*) Row Spacing and Seeding Rate on Competitiveness of Jointed Goatgrass (*Aegilops cylindrica*)

**Effect of Wheat (*Triticum aestivum*) Row Spacing and Seeding Rate on
Competitiveness of Jointed Goatgrass (*Aegilops cylindrica*)¹**

JASON P. KELLEY, THOMAS F. PEEPER, and JOHN B. SOLIE²

Abstract: Field experiments were conducted in Oklahoma to determine the effects of wheat row spacing and wheat seeding rate on the competitiveness of hard red winter wheat with jointed goatgrass. Decreasing wheat row spacing from 30 or 20 to 10-cm reduced jointed goatgrass spikelet yield at two of three locations. Increasing wheat seeding rate from 34 kg/ha to 134 kg/ha decreased jointed goatgrass spikelet yield at all three locations. Averaged over wheat row spacings and seeding rates, jointed goatgrass reduced wheat yield by 12.5 to 26.5 percent. Averaged over seeding rates and presence or absence of jointed goatgrass, wheat yield was increased by narrowing row spacing from 30 to 10-cm. Increasing wheat seeding rates from 34 to 134 kg/ha increased wheat yield when averaged over wheat row spacing and presence or absence of jointed goatgrass at two of three locations.

¹Received for publication _____ and in revised form _____.

Approved for publication by the Director, Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater, OK 74078.

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Nomenclature: *Aegilops cylindrica* L. #³, AEGCY; wheat *Triticum aestivum* L. '2163'.

Additional index words: Winter wheat, AEGCY

INTRODUCTION

Jointed goatgrass is an introduced, difficult-to-manage winter annual grass weed in the western United States and the Great Plains (Donald and Goo 1991; Wiese et al. 1995). A 1993 survey revealed about 1.9 million ha of cropland infested with jointed goatgrass in 14 central and western states. The area infested is increasing by 20,000 ha/year (Anonymous 1995). In Colorado, 18 jointed goatgrass plants/m² reduced winter wheat yields 27 % when the jointed goatgrass emerged simultaneously with wheat (Anderson 1993). In Oklahoma, 10 jointed goatgrass plants/m² reduced wheat yield about 30 % (Hill 1977) and in Oregon 54 to 86 jointed goatgrass plants/m² reduced wheat yield 25 to 29 % (Rydrych 1983). No herbicides are currently available to selectively control jointed goatgrass in wheat (Anderson 1993). Therefore producers are seeking effective cultural control techniques to suppress this weed in wheat.

One potential means to suppress jointed goatgrass in wheat is to narrow wheat row spacing and/or increase wheat seeding rate. These methods have proved effective with other weed species but variable results have also been reported.

³ Letters following this symbol are WSSA-approved computer codes from Composite List of Weeds, Revised 1989. Available from WSSA.

Decreasing wheat row spacing from 23 cm to 8 cm increased wheat yields in cheat (*Bromus secalinus* L.) infested wheat by 11% in Oklahoma (Solie et al. 1991; Koscelny et al. 1990). In contrast, narrowing row spacing from 20 cm to 10 cm in barley had no effect on barley (*Hordeum vulgare* L.) yield in the presence or absence of quackgrass (*Agropyron repens* L.) (Pageau and Tremblay 1995). Cheat seed yield was reduced in wheat by narrowing wheat row spacing from 23cm to 7.5cm (Justice et al. 1993).

Increasing wheat seeding rates above 150 plants/m² decreased wild oat (*Avena fatua* L.) seed production, especially when density was low (Radford et al. 1980). In weed-free soft red winter wheat, with a constant seeding rate, reducing wheat row spacing from 20 to 10 cm increased wheat yield 7 to 8% (Johnson et al. 1988). Increasing wheat seeding rates from 265 to 530 seeds/m² decreased cheat seed production by 25% (Koscelny et al. 1990). However, increased wheat seeding rates and reduced row spacing were not economically viable substitutes for herbicides for Italian ryegrass (*Lolium multiflorum* Lam.) control (Justice et al. 1994).

The objective of this research was to determine the effect of reducing wheat row spacing and increasing wheat seeding rate on jointed goatgrass spikelet production and wheat yield.

MATERIALS AND METHODS

Replicated field experiments were conducted at three locations in Oklahoma during the 1994-1995 winter wheat growing season to determine the effect of hard red winter wheat row spacing and seeding rate on yield of jointed goatgrass infested wheat, and the ability of wheat to suppress jointed goatgrass spikelet production. Characteristics of the soil at each location are in Table 1.

The experimental design for each location was a randomized complete block with a factorial arrangement of treatments with six replications. Factors included wheat row spacing of 10, 20, and 30-cm, wheat seeding rates of 34, 67, 101, or 134 kg/ha, and the presence or absence of jointed goatgrass. A treatment of jointed goatgrass with no wheat seeded was included to estimate jointed goatgrass spikelet production potential at each site. Plot size was 3- by 7.6-m. To ensure a uniform density of jointed goatgrass, jointed goatgrass spikelets were hand broadcast on appropriate plots at 67 kg/ha (approximately 210 spikelets/m²) and incorporated 2 to 4 cm deep with an s-tine harrow with double rolling baskets immediately prior to wheat seeding. In a laboratory germinator, a seedling emerged from 85 % of the jointed goatgrass spikelets.

The hard red winter wheat cultivar '2163' was seeded into a conventionally tilled seedbed with a double disk drill with press wheels, with 10-cm row spacing. To seed 20-cm and 30-cm rows, seed dispensing cups were covered and wheat seeding rate of the active metering units were adjusted to compensate for the change in row spacing. Wheat was seeded October 6, 11, and 26, 1994 on Agronomy Research Stations near Perkins, Lahoma, and Orlando, respectively. Soil moisture at planting was adequate to ensure rapid wheat emergence. Rainfall of at least 1.25-cm or more fell 6, 5, and 1 days after

planting at Lahoma, Orlando, and Perkins, respectively, after which jointed goatgrass emerged. Jointed goatgrass densities, counted in December, were 122 (s.d. =40), 88 (s.d.=16), and 103 (s.d.=37) plants/m² at Lahoma, Orlando, and Perkins, respectively. Experiments were fertilized according to soil tests recommendations for a 4000 kg/ha wheat yield goal (Johnson and Tucker 1988).

Wheat yield and jointed goatgrass spikelet yield were obtained by harvesting plots in early June with a small plot combine adjusted to retain jointed goatgrass spikelets in harvested grain. Since these settings retained above normal amounts of chaff and straw in the harvested sample, harvested samples were scalped with a small commercial seed cleaner. Jointed goatgrass spikelet production was estimated by hand separation of a 100 gram scalped grain sample from each plot. Wheat yield was adjusted for jointed goatgrass content and adjusted to 13.5% moisture content.

All data were subjected to analysis of variance, and regression analysis as appropriate. Means were separated using protected LSD's at the 0.05 level.

RESULTS AND DISCUSSION

No wheat row spacing by wheat seeding rate interactions were detected in jointed goatgrass spikelet yield data, however there were location by row spacing and location by seeding rate interactions. Therefore data are presented by location.

Effect of Wheat Row Spacing on Jointed Goatgrass. When averaged over wheat seeding rate there was a linear relationship between wheat row spacing and jointed goatgrass spikelet yield at Lahoma ($y = 15.48x + 141.61$, $R^2 = 0.98$). As row spacing decreased from 30-cm to 10-cm jointed goatgrass spikelet yield decreased from 189 to

158 kg/ha (Figure 1). At Orlando, there was also a linear relationship between wheat row spacing and jointed goatgrass spikelet yield ($y = 29.77x + 308.15$, $R^2=0.47$) (Figure 1).

As wheat row spacing decreased from 30-cm to 10-cm, jointed spikelet yield decreased from 379 to 320 kg/ha. At Perkins, narrowing row spacing from 30-cm to 10-cm had little effect on jointed goatgrass spikelet yield with jointed goatgrass yield of 33 kg/ha in 30-cm rows and 36 kg/ha in 10-cm rows ($Y = -1.19x + 37.77$, $R^2=0.29$). Most of the jointed goatgrass growing with wheat shattered during a severe thunderstorm prior to mechanical harvest at this site, which made differences between row spacings difficult to detect.

These data indicate that seeding wheat in narrow rows can suppress jointed goatgrass, but the amount of suppression obtained from adoption of narrow wheat row spacing would not be adequate. In practicality, seeding wheat in rows less than 10-cm would not be feasible, especially in no-till or reduced tillage cropping systems.

Effect of Wheat Seeding Rate on Jointed Goatgrass. Jointed goatgrass spikelet production with the zero wheat seeding rate was 980, 1350, and 900 kg/ha at Lahoma, Orlando, and Perkins, respectively. Increasing the wheat seeding rate from 0 to 34 kg/ha (34 kg/ha rate averaged over row spacing) decreased jointed goatgrass spikelet production 60, 72, and 94% at Orlando, Lahoma, and Perkins, respectively. The 34 kg/ha wheat seeding rate resulted in approximately a 2:1 ratio (210:120 per m^2) of jointed goatgrass spikelets broadcast prior to planting to wheat seeds planted. This clearly shows that wheat is a strong competitor with jointed goatgrass in central Oklahoma.

There was a quadratic response between wheat seeding rate and jointed goatgrass spikelet yield compared to percent of the zero wheat seeding rate at Lahoma and Orlando, and a linear response at Perkins (Figure 2). At Lahoma, increasing wheat seeding rate

from 34 to 134 kg/ha decreased jointed goatgrass spikelet yield from 28.6 to 11.2% of the spikelet yield with the zero seeding rate ($Y=0.0019x^2 - 0.4806x + 41.964$, $R^2=0.68$). At Orlando, increasing wheat seeding rate from 34 to 134 kg/ha decreased jointed goatgrass spikelet yield 46.8 to 19.6% of the yield with the zero wheat seeding rate ($Y=0.0021x^2 - 0.5591x + 56.62$, $R^2=0.60$). At Perkins, increasing wheat seeding rate from 34 to 134 kg/ha decreased jointed goatgrass spikelet yield 6.1 to 2.4% of the yield of the zero wheat seeding rate ($Y= -0.041x + 7.4482$, $R^2=0.45$). These results are similar to those of Kappler et al. (1997) who found that jointed goatgrass spikelet production, in Wyoming, decreased as wheat seeding rate increased from 33 to 101 kg/ha.

Wheat Yield. There were no row spacing by seeding rate by presence or absence of jointed goatgrass interactions on wheat yield at any location. There were location by row spacing and location by seeding rate interactions. Averaged over wheat row spacing and presence or absence of jointed goatgrass, increasing wheat seeding rate from 34 kg/ha to 134 kg/ha, increased wheat yield from 1745 to 2130 kg/ha at Lahoma, from 1955 to 2360 kg/ha at Orlando, and from 1515 to 1580 kg/ha at Perkins (Figure 3). The optimum wheat seeding rate for maximum wheat yield at Lahoma and Orlando appears to be greater than 134 kg/ha. Wheat yield would not be further increased by increasing wheat seeding rates beyond 134 kg/ha at Perkins.

When averaged over seeding rates and presence or absence of jointed goatgrass, narrowing wheat row spacing from 30-cm to 10-cm increased wheat yield at all locations (Figure 4). Narrowing wheat row spacing from 30-cm to 10-cm increased wheat yield from 1755 to 2019 kg/ha at Lahoma, 2033 to 2287 kg/ha at Orlando, and 1570 to 1645

kg/ha at Perkins. Narrowing wheat row spacing to less than 10-cm would likely further increase wheat yields at Lahoma and Orlando, but not at Perkins.

Effect of Jointed Goatgrass on Wheat Yield. There were no jointed goatgrass presence by wheat row spacing or wheat seeding rate by jointed goatgrass presence interactions. When averaged over all wheat row spacing and wheat seeding rates, jointed goatgrass reduced wheat yield 590 kg/ha at Lahoma, 348 kg/ha at Orlando, and 211 kg/ha at Perkins (26.5%, 14.8%, and 12.5% at Lahoma, Orlando, and Perkins, respectively) (Table 2).

These results are similar to reported effects of wheat row spacing and seeding rate on cheat (Koscelny et al. 1991). Although seeding rates of 134 kg/ha may not be the maximum seeding rate required for maximum suppression of jointed goatgrass, this rate is the highest level that a producer would likely employ for suppression. Optimum wheat row spacing for jointed goatgrass suppression appears to be less than 10-cm but, row spacing less than 10-cm would not be practical in many instances, especially reduced tillage systems. Also, limitations to narrowing rows occur when row spacing approaches wheat seed spacing within a row.

These data indicate that wheat row spacing and wheat seeding rate can have an impact on jointed goatgrass spikelet production, but only suppression can be expected. As with many cultural control practices results are often variable. Narrowing wheat row spacing and increasing seeding rates are practices that producers could use to reduce the impact of jointed goatgrass in winter wheat.

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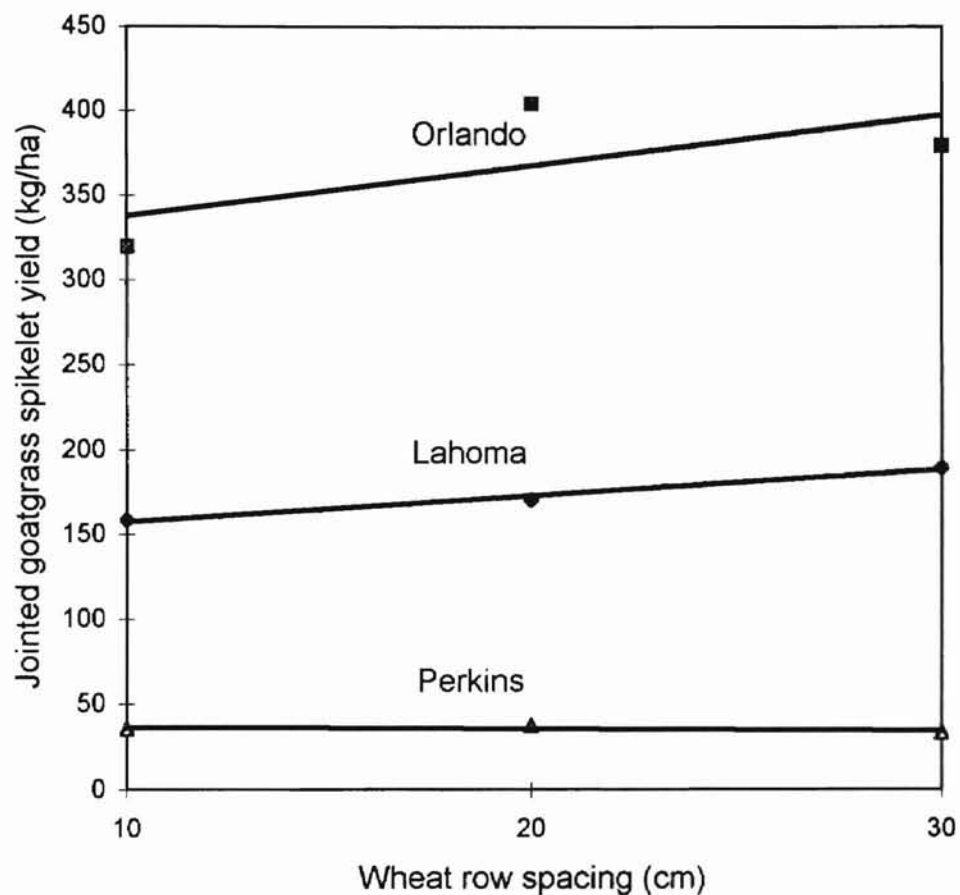


Figure 1. Effect of wheat row spacing on jointed goatgrass spikelet yield averaged over wheat seeding rate at Lahoma ($Y = 15.48x + 141.61$, $R^2 = 0.98$), Orlando ($Y = 29.77x + 308.15$, $R^2 = 0.47$), and Perkins ($Y = -1.19x + 37.77$, $R^2 = 0.29$).

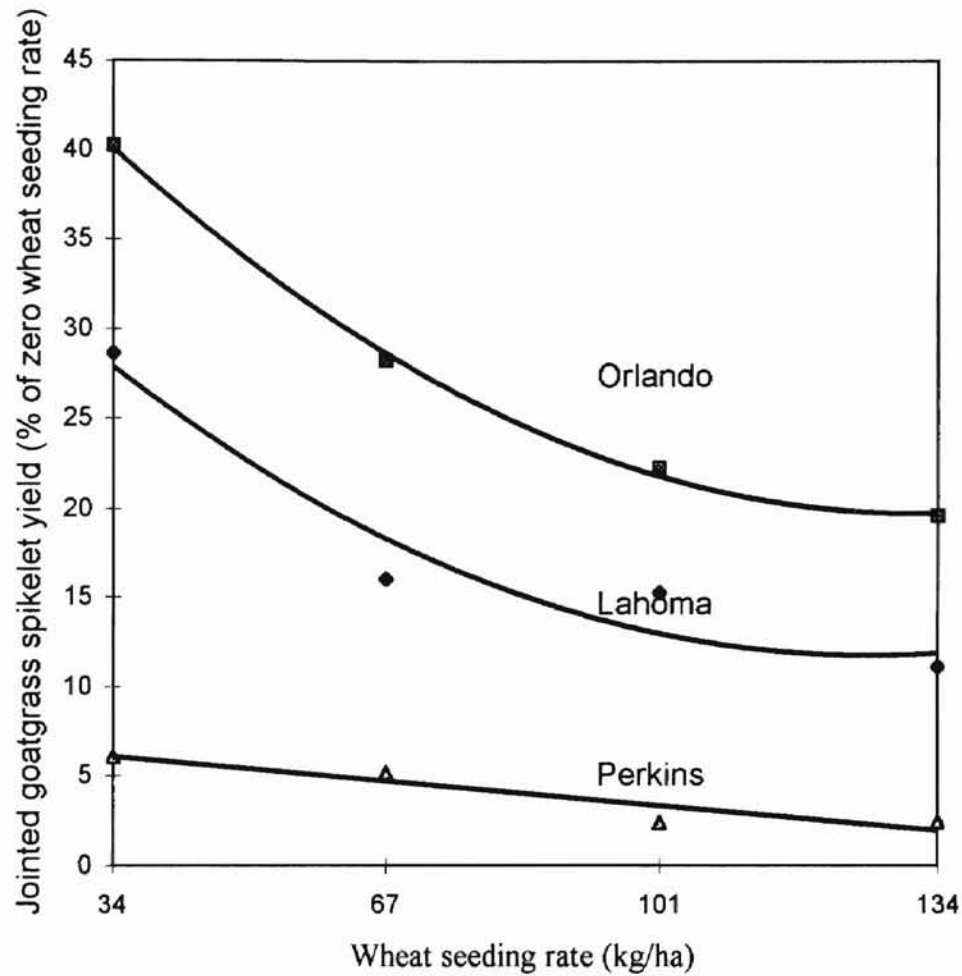


Figure 2. Effect of wheat seeding rate on jointed goatgrass spikelet yield (% of zero wheat seeding rate) at Lahoma ($Y = 0.0019x^2 - 0.4806x + 41.96$, $R^2 = 0.68$), Orlando ($Y = 0.0021x^2 - 0.5591x + 56.62$, $R^2 = 0.60$), and Perkins ($Y = -0.041x + 7.4482$, $R^2 = 0.45$).

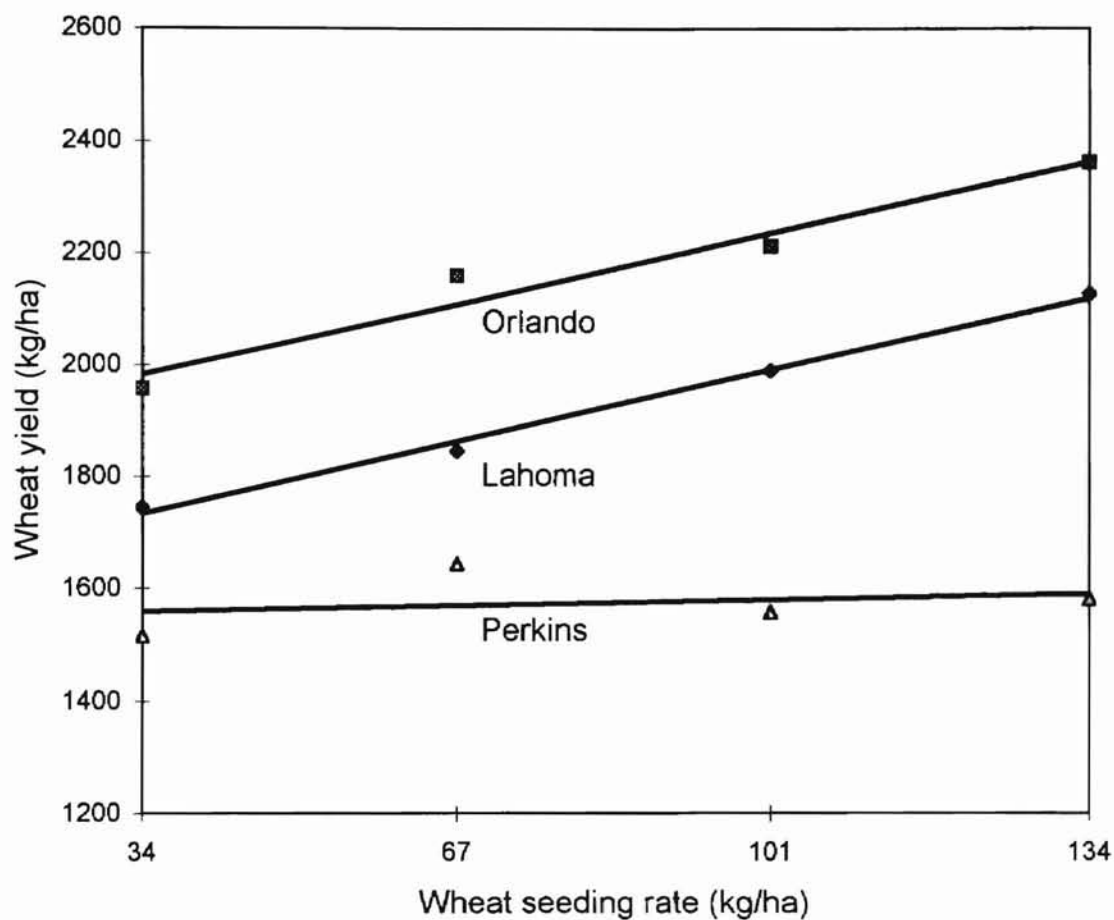


Figure 3. Effect of wheat seeding rate averaged over wheat row spacing and presence or absence of jointed goatgrass on wheat yield at Lahoma ($Y = 126.76x + 1604.8$, $R^2 = 0.99$), Orlando ($Y = 126.46x + 1855.4$, $R^2 = 0.95$), and Perkins ($Y = 10.59x + 1547.5$, $R^2 = 0.07$)

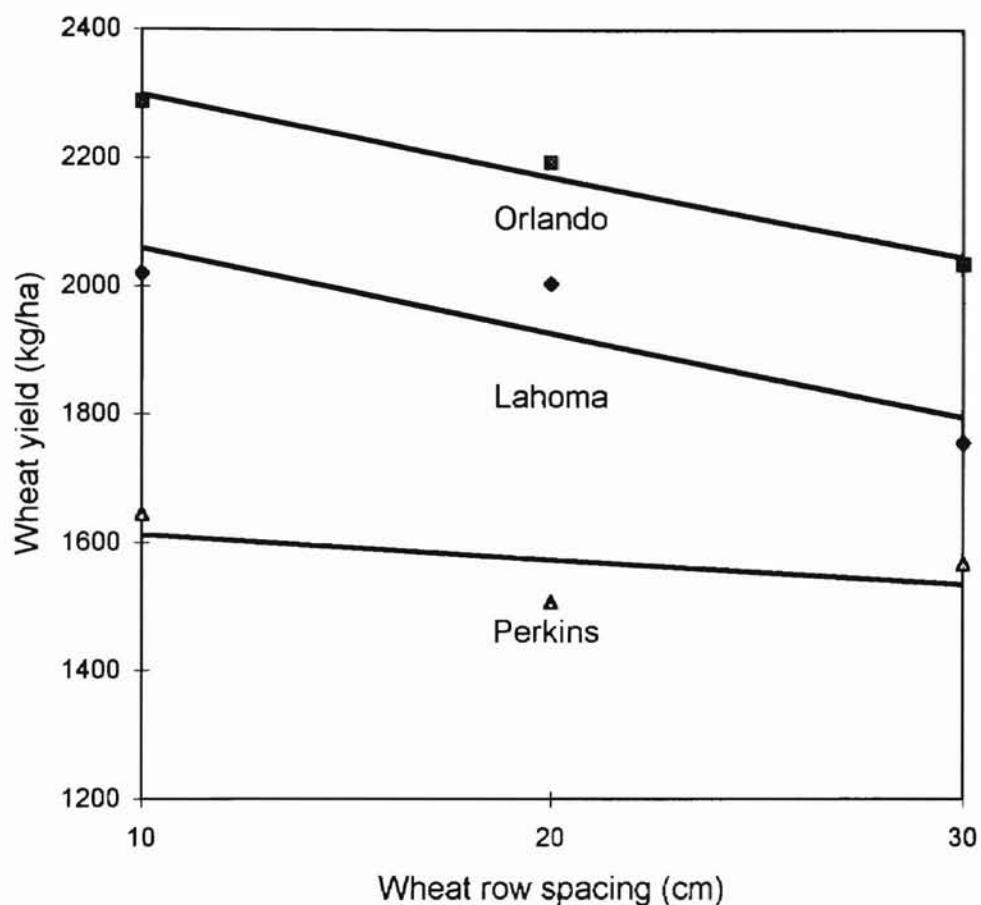


Figure 4. Effect of wheat row spacing on wheat yield averaged over wheat seeding rate and presence or absence of jointed goatgrass at Lahoma ($Y = -132.23x + 2191.2$, $R^2 = 0.79$), Orlando ($Y = -126.7x + 2424.9$, $R^2 = 0.97$), and Perkins ($Y = -38.4x + 1650.6$, $R^2 = 0.31$).

Table 1. Soil information, precipitation, and planting dates at Lahoma, Orlando, and Perkins.

	Lahoma	Orlando	Perkins
Series	Pond Creek	Port	Teller
Texture	Loam	Loam	Sandy loam
Classification	fine-silty, mixed, thermic Pachic	fine-silty, mixed, thermic Cumulic	fine-loamy, mixed, thermic Udic
	Arguistoll	Haplustoll	Arguistoll
Organic Matter %	1.5	2.7	1.4
pH	6.2	5.8	6.4
Rainfall ^a (mm)	777	828	883
Planting date	Oct. 11, 1994	Oct. 26, 1994	Oct. 6, 1994

^aRainfall from planting until harvest.

Table 2. Effect of jointed goatgrass on wheat yield averaged over wheat row spacing and seeding rate at Lahoma, Orlando, and Perkins.

Jointed goatgrass	Lahoma	Orlando	Perkins
		kg/ha	
Absent	2220	2350	1680
Present	1630	2000	1470
LSD (0.05)	100	90	100

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VITA

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