INFLUENCE OF STARTER FERTILIZER AND HARD RED WINTER WHEAT SEEDING PRACTICES ON INTERFERENCE FROM JOINTED GOATGRASS AND CHEAT

By

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FROM JOINTED GOATGRASS

AND CHEAT

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INTRODUCTION

Chapters I and II of this thesis are manuscripts to be submitted for publication in Weed Technology, a Weed Science Society of America publication.

CHAPTER I

ROW SPACING AND STARTER FERTILIZER EFFECTS ON INTERFERENCE OF JOINTED GOATGRASS (*Aegilops cylindrica*) WITH WHEAT (*Triticum aestivum*)

Row Spacing and Starter Fertilizer Effects on Interference of Jointed Goatgrass (*Aegilops cylindrica*) with Wheat (*Triticum aestivum*)[1]

MICHELLE L. ARMSTRONG, THOMAS F. PEEPER and JOHN B. SOLIE[2]

Abstract: Field experiments were conducted at three sites in north central Oklahoma to determine the effects of wheat row spacing and starter fertilizer treatment on the interference of jointed goatgrass with hard red winter wheat. At two of three sites, banding fertilizer with the wheat seed decreased juvenile wheat plant density. Mean sunlight interception by the vegetative canopy in April varied from 87 to 93% at all sites. At two sites, fertilizer treatment and weed presence did not affect sunlight interception, but sunlight interception increased as row spacing decreased from 30 to 20 cm. Jointed goatgrass mean spikelet production was affected by fertilizer treatment at two sites. Wheat spike density was increased by decreasing wheat row spacing. At two sites, banding 10-34-0 fertilizer at 168 kg/ha reduced wheat yield. Averaged over other factors, reducing row spacing increased wheat yield.

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Nomenclature: Jointed goatgrass, *Aegilops cylindrica* Host #[3], AEGCY; wheat, *Triticum aestivum* L., '2163', or 'Chisholm'.

Additional index words: AEGCY, fertilizer, wheat row spacing.

Abbreviations: PAR, photosynthetically active radiation.

INTRODUCTION

Jointed goatgrass has become a serious weed problem in winter wheat producing areas of the Great Plains and Western United States. It was reported in 1947 as a "weed in wheat fields throughout Oklahoma" (Featherly 1946) and is most common along roadsides and fence rows in central and western Oklahoma. Jointed goatgrass is an annual grass with tall stems and cylindrical terminal spikes (Featherly 1946). The total area infested in 14 western states exceeds 12 million hectares (Ogg 1993) and the total economic loss to U.S. agriculture from jointed goatgrass was estimated to exceed $145,000,000 annually.

No herbicides are available for selective jointed goatgrass control in wheat (Anonymous 1996). Thus, current research has focused on developing cultural control measures.

In Oklahoma, jointed goatgrass infestations are most frequently reported from the Panhandle, where sweep plows are commonly used for tillage. Sweep

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

plowing is less effective in controlling jointed goatgrass than moldboard plowing or disking (Peeper and Koscelny 1993). However, many producers are unable to use inverting tillage due to conservation compliance measures (Peeper and Koscelny 1993).

Recent research with nutrient effects on jointed goatgrass has focused on nitrogen. In Wyoming, nitrogen was applied at 45 kg/ha in a band 5 cm below and 2.5 cm to the side of the wheat row, broadcast on the soil surface or point injected 10 cm deep and 5 cm to the side of the wheat row (Miller and Van Vleet 1996). Jointed goatgrass spikelets per spike was not influenced by fertilizer placement; however, spikes per plant and biomass production were highest when fertilizer was broadcast. In that research, winter wheat was less competitive with jointed goatgrass when fertilizer was broadcast compared to spoke wheel injection or band placement.

Phosphorus banded with wheat seed at planting, alone or with nitrogen, increased winter survival, wheat spikes per unit area, kernel weight, and yields (Knapp and Knapp 1978). Test weight was generally increased by phosphorus but not by nitrogen. Phosphorus also hastened maturity by speeding growth early in the season. In Kansas, fertilizer (10-14.8-0 and 28-0-0) banded with the seed increased wheat tillering and early dry-matter production but did not increase grain yields (Cabrera et al. 1986). The effect of such increases in tillering and early dry-matter production on the competitiveness of wheat with jointed goatgrass was not explored.

Banding phosphate fertilizers in the furrow with wheat seed is recommended in Oklahoma for alleviation of forage and grain yield losses attributed to aluminum toxicity in low pH soils (less than pH = 5.5) even when phosphate soil test values are very high (Johnson et al. 1991). Thus, banding liquid 10-34-0 has become a common practice in Oklahoma (Krenzer et al. 1998).

Increasing the wheat seeding rate from 67 to 101 or 134 kg/ha decreased cheat biomass in wheat seeded in 7.5 cm rows and 22.5 cm rows (Koscelny et al. 1990; Koscelny et al. 1991). Reducing row spacing from 22.5- to 15- or 7.5-cm increased yield of cheat-infested hard red winter wheat in eight of 13 experiments.

In Arkansas, soft red winter wheat seeded in 10 cm rows had more spikes per square meter than wheat in 15- or 20-cm rows (Freeze and Bacon 1990). Marshall and Ohm (1987) found that wheat in 6 cm wide rows averaged 6.8 and 5.3% (1983 and 1984, respectively) more grain than wheat seeded in 19 cm rows and that wheat in narrow rows (6 cm) averaged one spike per plant more than wheat in wider rows (19 cm).

The objective of this research was to determine the effect of wheat row spacing and starter fertilizer treatment on jointed goatgrass growth, reproduction, and interference with hard red winter wheat.

MATERIALS AND METHODS

Field experiments were conducted near Lahoma, Orlando, and Perkins, Oklahoma. The production system at all sites included conventional tillage, dryland, continuous winter wheat. The sites were not previously infested with jointed goatgrass.

The soil was a Pond Creek loam (a fine-silty, mixed, thermic Pachic Argiustoll) with 1.4% organic matter and pH = 6.5, a Port loam (a fine-silty, mixed, thermic Cumulic Haplustoll) with 1.5% organic matter and pH = 6.7, and a Teller sandy loam (a fine-loamy, mixed, thermic Udic Argiustoll) with 1.2% organic matter and pH = 6.0 at Lahoma, Orlando, and Perkins, respectively.

The design for each experiment was a randomized complete block with a three by two by five factorial arrangement of treatments. Factors included wheat row spacing (10, 20, and 30 cm), level of jointed goatgrass (present and absent) and five starter fertilizer treatments i.e., broadcast and banded applications of 10-34-0 (NPK) liquid fertilizer at 84 (low) and 168 (high) kg/ha, plus a no fertilizer treatment,. Experiments had six replicates at Orlando and Perkins, and four at Lahoma. Plot size was 3.1 by 7.6 m.

Locally harvested jointed goatgrass spikelets were broadcast by hand at 34 kg/ha (1,300,000 spikelets/ha) on October 16, 8, and 11, 1996 at Lahoma, Orlando, and Perkins, respectively, with an equal amount on each plot. The starter fertilizer was broadcast onto appropriate plots through capillary tubes spaced 10 cm apart, approximately 15 cm above the soil surface. The jointed goatgrass spikelets for all treatments and starter fertilizer for the broadcast treatments were incorporated approximately 2.5 cm deep with an s-tine harrow with double rolling baskets.

Hard red winter wheat ('2163' at Lahoma and Perkins, and 'Chisholm' at Orlando) was seeded at 67 kg/ha immediately after incorporation of starter fertilizer and jointed goatgrass. The drill used for seeding was a double-run double-disk end wheel drill, with 6-cm wide press wheels, modified to hold 29 double disc openers spaced 10-cm apart. Seed metering gates on the low rate side of each seed metering unit were modified to permit metering the wheat by both the large and small sides of each metering unit. Each plot contained 29 10-cm rows, 15 20-cm rows, or 10 30-cm rows, all 7.6 m long. Seeds were placed about 2.5 cm deep.

The soil test fertilizer recommendations for each site were based on a 4000 kg/ha yield goal. Prior to fertilizing and planting, N, P_2O_5, and K_2O requirements at Lahoma were zero. The N, P_2O_5, and K_2O requirements, at Orlando, were 101, 0, and 22 kg/ha, respectively, and at Perkins were 118, 17, and 0 kg/ha, respectively.

Seedbed moisture at planting was adequate for wheat emergence. At Lahoma, Orlando, and Perkins, 1, 3, and 2 cm of rain fell 4, 12, and 9 days after seeding, respectively.

On February 11 and 13, 1997, experiments at Orlando and Perkins were broadcast fertilized with ammonium nitrate (34-0-0) according to soil test recommendations for maximum expected grain yield of 4000 kg/ha. The amount applied per plot was adjusted for the 10-34-0 starter fertilizer applied at planting.

Wheat plants in two meters of the center row of each plot with 30-cm rows not seeded with jointed goatgrass were counted in November. Jointed goatgrass plants were counted in two randomly selected 0.125 m^2 quadrats in all plots seeded with jointed goatgrass.

Light interception by the wheat and jointed goatgrass canopy was measured in April. The wheat was approximately 80 cm tall at Lahoma and approximately 90 cm tall at Orlando and Perkins and beginning grain fill (Zadoks 50) (Zadoks et al. 1974). Sunlight intensity was determined at midday on cloud free days above the wheat canopy and approximately 7 cm above the soil surface in each plot by inserting a ceptometer[4] between two wheat rows. Interception of photosynthetically active radiation (PAR) was calculated as: [((PAR above canopy – PAR below canopy)/PAR above canopy) * 100].

Mature jointed goatgrass spikes per plant, spikelets per plant, and plant height were counted and measured for 10 randomly selected plants in each plot overseeded with jointed goatgrass prior to wheat harvest. Wheat spike density was determined by counting the spikes in one meter of wheat row from the center row of each plot.

A 1.4 by 7.6 m area from each plot was harvested in June, using a small plot combine adjusted to retain most of the jointed goatgrass spikelets in the wheat grain. Substantial amounts of chaff were collected with each grain sample because the air flow from the separator fan was restricted and the sieve openings increased to minimize jointed goatgrass spikelet loss. Harvested wheat and jointed goatgrass samples were weighed and cleaned using a small commercial type seed cleaner to remove chaff and straw. Jointed goatgrass

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[4]Sunfleck Ceptometer, Decagon Devices, Inc., Pullman, WA.

spikelet production (kg/ha) was determined by weighing the spikelets in 100-g samples of cleaned wheat and jointed goatgrass.

Wheat grain yield, adjusted for both jointed goatgrass content and to 13.5% moisture, was determined after cleaning. Wheat moisture and test weight were determined using standard grain analysis equipment[5]. Juvenile wheat and jointed goatgrass density, jointed goatgrass spikes per plant, spikelets per plant, and mature plant height data were subjected to mixed analysis of variance, using SAS[6]. Sunlight interception, wheat spike density, and wheat grain yield data were subjected to analysis of variance. Juvenile wheat and jointed goatgrass densities were analyzed after square root transformations and means were separated with protected least significant differences for all data.

RESULTS AND DISCUSSION

Wheat stand data from plots with 30-cm row spacing and no jointed goatgrass present, revealed that banding fertilizer with the seed reduced juvenile wheat density compared to the unfertilized treatment at two of three locations (Table 1). Broadcasting fertilizer did not affect the wheat stand. The cause of the reduced density in the banded treatments is not clear.

Jointed goatgrass seedling density, which was counted in plots with 30-cm spacing, varied with location but the ratio of wheat to jointed goatgrass in plots which received no fertilizer was approximately 4:1 at Lahoma and Orlando, and

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[5]Grain Analysis Computer 2000. Dickey John, Corp., Auburn, IL 62615.

[6]Statistical Analysis Systems for Windows 95. The SAS Institute, Cary, NC.

approximately 5:1 at Perkins (Table 1). Fertilizer treatment did not affect jointed goatgrass density except at Orlando, where the jointed goatgrass density in plots which received no fertilizer was higher than in plots that received the band high or broadcast low fertilizer treatments (Table 1). The reasons for these differences were not clear.

Evidence indicating that reducing wheat row spacing and banding starter fertilizer increased the competitive ability of wheat was found in the sunlight interception, jointed goatgrass reproduction, and wheat yield data. However, results varied with location, thus data were not pooled across locations.

Mean sunlight interception by the vegetative canopy varied from 87 to 93% at the three sites. Averaged over other factors, jointed goatgrass presence did not affect sunlight interception by the canopy except at Orlando, where jointed goatgrass infested plots intercepted 0.9% more sunlight ($p = 0.11$) than plots without jointed goatgrass. Since the total sunlight intercepted varied little whether or not jointed goatgrass was present, sunlight interception by jointed goatgrass would appear to have directly reduced that intercepted by wheat.

At Lahoma, a row spacing by jointed goatgrass presence interaction occurred in the sunlight interception data (Table 2). With no jointed goatgrass present, light interception increased when row spacing decreased from 30- to 10-cm (Table 2). With jointed goatgrass present, row spacing did not affect sunlight interception. This indicates that relatively mature weed free wheat intercepts more sunlight when planted in 10-cm rows than in 30-cm rows, and that jointed goatgrass filled in the inter-row space when wheat was seeded in 30-cm rows.

No interactions were found at Orlando and Perkins. At these sites, sunlight interception by the vegetative canopy, averaged over fertilizer treatment and jointed goatgrass presence, increased as row spacing decreased from 30- to 20-cm (Table 2). At Perkins, sunlight interception was increased further by decreasing row spacing from 20- to 10-cm.

Averaged over row spacing, fertilizer treatment did not affect sunlight penetration at two locations. At Orlando, sunlight interception increased from 91.9% in the unfertilized check to 93.3% or more in all fertilized plots (LSD 0.05 = 1.2).

Treatment effects on mean jointed goatgrass spikes per plant varied with location. Jointed goatgrass spikes per plant, averaged over fertilizer treatments, was not affected by row spacing at Lahoma (p = 0.16) (Table 2). Spike production was decreased by decreasing row spacing from 30- to 20- cm at Perkins (Table 2). Mean jointed goatgrass spikes per plant, averaged over row spacing, were greater in the broadcast low rate fertilizer treatment than any other fertilized treatment at Lahoma (Table 3).

Banding fertilizer with the wheat did not decrease jointed goatgrass spikes per plant at Lahoma or Perkins (Table 3). A fertilizer by row spacing interaction occurred at Orlando, where jointed goatgrass spikes per plant decreased with decreasing row spacing in the unfertilized check. Also, within the 10- and 30-cm row spacings, the broadcast high rate fertilizer treatment decreased jointed goatgrass spikes per plant compared to the unfertilized check (Table 3). In the 30-cm rows, all fertilizer treatments reduced jointed goatgrass spikes per plant compared to the unfertilized check. These data do not consistently support the hypothesis that banding starter fertilizer in the wheat row while seeding can suppress jointed goatgrass spike production compared with broadcasting the fertilizer.

Averaged over row spacing, broadcasting the lower rate of fertilizer increased jointed goatgrass spikelets per plant at Lahoma (Table 3). The increase in jointed goatgrass spikelets per plant can be attributed to the greater number of spikes per plant (Table 3) in that treatment. Jointed goatgrass spikelets per plant was unaffected by treatment at Perkins. At Orlando, a fertilizer treatment by row spacing interaction occurred. Jointed goatgrass spikelets per plant decreased with decreasing row spacing in the unfertilized check (Table 3). In the 10-cm rows, the banded high rate treatment increased the number of spikelets per plant compared to the unfertilized check, the broadcast high rate and banded low rate treatments. In the 20-cm row spacing, the broadcast low rate treatment and the banded high rate fertilizer treatments reduced jointed goatgrass spikelets per plant compared to the unfertilized check. In the 30-cm rows, all fertilizer treatments reduced jointed goatgrass spikelets per plant compared to the unfertilized check (Table 3). Thus, as row spacing decreased, the suppressive effects of fertilizer treatments on jointed goatgrass spikelets per plant was harder to discern.

Jointed goatgrass mean spikelet yield at Lahoma and Orlando was 78 and 35 kg/ha and was not affected by fertilizer treatment ($p = 0.23$ and $p = 0.12$) nor were interactions with row spacing found at these sites. At Lahoma, averaged over fertilizer treatment, decreasing row spacing from 30- to 10-cm decreased jointed goatgrass spikelet yield from 98.4 to 57.8 kg/ha (Table 2). The high spikelet production at Lahoma can be attributed to the high jointed goatgrass density (Table 1), spikes per plant (Table 3) and spikelets per plant (Table 3) compared to the other two locations.

At Perkins, a row spacing by fertilizer treatment interaction was found in spikelet yield. Some fertilizer treatments increased spikelet production, but no consistent pattern was found. No fertilizer treatments decreased spikelet production (Table 3). Unlike the jointed goatgrass spikes per plant and spikelets per plant data, spikelet production was not decreased by decreasing row spacing in the unfertilized check (Table 3). Therefore, the manipulation of fertilizer rates and application method does not appear to be a viable approach to suppressing jointed goatgrass spikelet yield in wheat fields where initial P_2O_5 is not deficient.

Mean jointed goatgrass mature plant height also varied with location. The mean jointed goatgrass height at Lahoma was 95-cm and was unaffected by row spacing (p = 0.51) or fertilizer treatment (p = 0.67). A fertilizer by row spacing interaction occurred in mature jointed goatgrass height data from Orlando and Perkins. With no starter fertilizer applied, jointed goatgrass responded to reductions in wheat row spacing from 30- to 10-cm by growing taller. At Orlando, when wheat was seeded in 30-cm rows, jointed goatgrass was shorter in both banded fertilizer treatments and the broadcast high rate fertilizer treatment than in the unfertilized check (Table 3). In the 10-cm rows, both broadcast fertilizer treatments and the banded high rate fertilizer treatment reduced jointed goatgrass plant height compared to the unfertilized check. In plots with 20-cm row spacing, the high rate broadcast or banded increased jointed goatgrass height (Table 3). There was little evidence to suggest that fertilizer treatment could be used to suppress jointed goatgrass height.

Wheat spike density varied with location. A fertilizer by row spacing by jointed goatgrass presence interaction occurred at Lahoma and Orlando (Table 4). At Perkins, jointed goatgrass did not affect wheat spike density, but a fertilizer treatment by row spacing interaction was found. At Lahoma, within a row spacing, with jointed goatgrass absent, all banded fertilizer treatments increased wheat spike density. Within a row spacing and with jointed goatgrass present, fertilizer increased wheat spike density only in the banded low rate 20-cm row spacing treatment (Table 4). Thus, in the presence of jointed goatgrass, banding the starter fertilizer did not appear beneficial in terms of wheat spike density.

At Orlando, as at Lahoma, wheat spike density in unfertilized wheat in 10-cm rows was greater when jointed goatgrass was present (Table 4). This phenomenon did not occur when wheat was seeded in 20- or 30-cm rows. As at Lahoma, there was no strong evidence that starter fertilizer treatments increased spike numbers of jointed goatgrass infested wheat. At Perkins, there was not a major response to fertilizer in the wheat spike density data (Table 4). At all sites, the major factor affecting spike density was row spacing. It was clear that decreasing row spacing increased wheat tillering, which agrees with the response of soft red winter wheat to decreased row spacing in Arkansas (Freeze and Bacon 1990).

Mean wheat yield at Orlando and Perkins was 3015 and 2618 kg/ha, respectively, and was not affected by jointed goatgrass presence (p =0.13 and p = 0.40, respectively). Thus, jointed goatgrass at 20 to 40 weeds/m^2 did not compete aggressively enough against wheat to decrease wheat yield. Our results contrast with those of Hill (1976), who found that in northwestern Oklahoma jointed goatgrass densities of one and two weeds per m^2 did not reduce wheat yield, but densities of 10 and 20 weeds per m^2 significantly reduced yield. At Lahoma, averaged over fertilizer treatment and row spacing, jointed goatgrass reduced mean wheat yield from 3301 to 3085 kg/ha (p = 0.05). This difference was attributed to higher jointed goatgrass density (60 to 80 plants/m^2) at Lahoma compared to Orlando and Perkins (Table 1).

The effect of fertilizer treatment on wheat yield varied with location. Averaged over row spacing and jointed goatgrass presence, wheat yield was increased by banding starter fertilizer at Lahoma, even though the soil test recommended no fertilizer. At the other sites, the banded high rate fertilizer treatment reduced yield, which may be attributed to affects on wheat stand establishment.

The relatively minor influence of jointed goatgrass on wheat yield explains the lack of interactions with jointed goatgrass presence in the yield data. At Lahoma and Perkins, each decrease in row spacing increased wheat yield (Table 5). Averaged over fertilizer treatment and jointed goatgrass presence, at Orlando, the effect of row spacing on yield was not as large as at the other sites. These results agree with earlier research conducted in Oklahoma with cheat infested wheat (Koscelny et al. 1990; Koscelny et al. 1991).

In our research, the lack of a row spacing by jointed goatgrass presence interaction at two locations indicates that jointed goatgrass may not be able to capture sunlight or other resources as effectively as wheat. Our research also indicates that banding 10-34-0 starter fertilizer in the seed furrow decreases wheat stand density, which can result in lower wheat yields. Reducing wheat row spacing can also reduce jointed goatgrass spikes per plant and spikelets per plant.

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Table 1. The effect of fertilizer treatment on juvenile wheat and jointed goatgrass density in the fall in plots with wheat seeded in 30-cm rows at three locations.

Starter fertilizer	Wheat Lahoma	Wheat Orlando	Wheat Perkins	Jointed goatgrass Lahoma	Jointed goatgrass Orlando	Jointed goatgrass Perkins
	plants/m^2					
Broadcast low	241	156	208	84	18	53
Broadcast high	229	131	213	63	33	39
Band low	201	137	178	59	33	47
Band high	221	120	184	78	23	39
None	258	147	209	63	34	38
LSD (0.05)	29[a]	NS	11	NS	4	NS

[a]Wheat at Lahoma (LSD 0.10).

Table 2. Interaction of jointed goatgrass presence and wheat row spacing, averaged over fertilizer treatment, on sunlight interception by the vegetative canopy in April (Zadoks 50), and the effect of row spacing averaged over fertilizer treatment on jointed goatgrass spikes per plant and spikelet production.

		Sunlight interception			Jointed goatgrass	
		Jointed goatgrass				
Site	Row spacing	Present	Absent	Mean	Spikes	Spikelet production
	cm	%			no./plant	kg/ha
Lahoma	10	87	90	--	6.5	58
	20	89	87	--	6.4	78
	30	90	84	--	7.9	98
LSD (0.05)		4		--	NS	30
Orlando	10	--	--	94	4.8	33
	20	--	--	94	5.7	47
	30	--	--	92	5.4	27

Table 2. Con't.

LSD (0.05)		--	--	1	0.4	10
Perkins	10	--	--	91	3.1	--[a]
	20	--	--	88	3.4	--
	30	--	--	83	4.3	--
LSD (0.05)		--	--	2	0.3	--

[a]Interaction present, see Table 3.

Table 3. Interaction of fertilizer treatment and row spacing on jointed goatgrass spikes per plant, spikelets per plant, spikelet production, and mature plant height at three locations.

		Lahoma	Orlando				Perkins			
	Starter	Row spacing (cm)								
Parameter	fertilizer	Mean	10	20	30	Mean	10	20	30	Mean
		no./plant								
Spikes	Broadcast low	9.2	5.3	4.6	4.5	--	--	--	--	3.7
	Broadcast high	6.8	3.3	5.5	4.1	--	--	--	--	3.5
	Band low	5.5	4.6	7.3	5.6	--	--	--	--	3.5
	Band high	6.3	6.0	5.5	5.4	--	--	--	--	3.7
	None	6.9	4.9	6.0	7.6	--	--	--	--	3.5
LSD (0.05)		1.9	------	0.91	------	--	--	--	--	NS
		no./plant								
Spikelets	Broadcast low	68	43	30	37	--	--	--	--	24

Table 3. Con't.

	Broadcast high	51	25	40	27	--	--	--	--	23
	Band low	40	32	54	39	--	--	--	--	23
	Band high	47	46	39	41	--	--	--	--	24
	None	52	31	47	56	--	--	--	--	23
LSD (0.05)		15	------ 7.2 ------			--	--	--	--	NS
		kg/ha								
Spikelets	Broadcast low	97	--	--	--	28	47	25	32	--
	Broadcast high	76	--	--	--	35	29	20	20	--
	Band low	87	--	--	--	38	18	61	21	--
	Band high	58	--	--	--	46	36	37	16	--
	None	72	--	--	--	30	14	22	11	--
LSD (0.05)		NS	--	--	--	NS	------ 16.6 -------			--
		cm								

Table 3. Con't.

Plant height	Broadcast low	94	89	90	94	--	79.5	77.6	68.9	--
	Broadcast high	95	90	96	86	--	77.4	68.2	67.3	--
	Band low	95	97	91	87	--	83.2	75.6	62.9	--
	Band high	96	88	97	89	--	74.6	73.7	77.0	--
	None	93	99	93	95	--	72.8	69.9	67.3	--
LSD (0.05)		NS	------	2.2	------	--	------	2.7	-------	--

Table 4. Interaction of fertilizer treatment, row spacing, and jointed goatgrass presence on mature wheat spike density at three locations.

		Jointed goatgrass presence								
		Present			Absent			Mean		
	Starter	Row spacing (cm)								
Site	fertilizer	10	20	30	10	20	30	10	20	30
		spikes/m^2								
Lahoma	Broadcast low	1600	640	470	1350	750	570	--	--	--
	Broadcast high	1690	680	430	1340	750	420	--	--	--
	Band low	1480	760	430	1670	750	530	--	--	--
	Band high	1500	640	450	1650	720	570	--	--	--
	None	1770	590	400	1470	600	410	--	--	--
LSD (0.10)		100						--	--	--
Orlando	Broadcast low	1110	500	260	1140	490	420	--	--	--

Table 4. Con't

	Broadcast high	1050	400	390	1400	460	420	--	--	--
	Band low	1100	470	310	1100	440	310	--	--	--
	Band high	1050	450	350	1120	610	390	--	--	--
	None	1290	510	390	1130	490	320	--	--	--
LSD (0.05)		----------	----------	---------- 90 ----------	----------	----------	----------	--	--	--
Perkins	Broadcast low	--	--	--	--	--	--	1380	580	410
	Broadcast high	--	--	--	--	--	--	1160	610	400
	Band low	--	--	--	--	--	--	1280	550	370
	Band high	--	--	--	--	--	--	1280	560	380
	None	--	--	--	--	--	--	1260	640	440
LSD (0.05)		--	--	--	--	--	--	---------	70	---------

Table 5. The effect of fertilizer treatment, averaged over row spacing and jointed goatgrass presence, and the effect of row spacing, averaged over fertilizer treatment and jointed goatgrass presence, on wheat grain yield at three locations.

Parameter	Level	Lahoma	Orlando	Perkins
			kg/ha	
Starter fertilizer	Broadcast low	3060	3130	2730
	Broadcast high	3100	3040	2590
	Band low	3380	2940	2590
	Band high	3440	2910	2410
	None	3130	3070	2770
LSD (0.05)		240	150	170
Row spacing (cm)	10	3500	3070	2980
	20	3290	3040	2700
	30	2870	2940	2170
LSD (0.05)		190	120	130

CHAPTER II

ROW SPACING AND STARTER FERTILIZER EFFECTS ON INTERFERENCE OF CHEAT (*Bromus secalinus*) WITH WHEAT (*Triticum aestivum*)

CHAPTER II

Row Spacing and Starter Fertilizer Effects on Interference of Cheat (*Bromus secalinus*) with Wheat (*Triticum aestivum*)[1]

MICHELLE L. ARMSTRONG, THOMAS F. PEEPER, JOHN B. SOLIE, and CARLA L. GOAD[2]

Abstract: Field experiments were conducted at two sites for two years in north central Oklahoma to determine the effects of row spacing and starter fertilizer treatment on the interference of cheat with hard red winter wheat. Mean sunlight interception by the vegetative canopy was not increased by starter fertilizer treatments either year at one site. Averaged over cheat presence, banded fertilizer treatments increased sunlight interception at a second site one year. In 1997-98 fertilizer treatment effects on sunlight interception occurred only in the absence of cheat. Sunlight interception was less in wheat seeded in 30- than in

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10- or 20-cm rows both years at one site and neither year at the other. Cheat consistently reduced wheat yield but interactions with fertilizer treatment and row spacing were absent. In one of four experiments, reducing row spacing reduced dockage.

Nomenclature: Cheat, *Bromus secalinus* L. #[3] BROSE; wheat, *Triticum aestivum* L., 'Chisholm', '2163'.

Additional index words: BROSE, starter fertilizer, wheat row spacing.

Abbreviations: PAR, photosynthetically active radiation.

INTRODUCTION

Cheat, a winter annual with erect stems (Featherly 1946), is a serious problem for winter wheat production in Oklahoma and the central Great Plains. Cheat was reported as one of the most troublesome weeds in Oklahoma wheat fields as early as 1947 (Chaffin 1947).

Losses in grain and forage yield, delayed harvesting, additional cleaning expenses, and dockage are all caused by cheat infestations (Ratliff and Peeper 1987). Cheat dockage in harvested grain can exceed 40% in heavily infested fields (Ratliff 1985).

In Oklahoma, reducing row spacing from 22.5 to 7.5 cm increased grain yield of cheat-free hard red winter wheat in two of three experiments and of cheat-

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[3]Letter following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA; 810 East 10th Street, Lawrence, KS 66044-8897.

infested wheat in six of 10 (Koscelny et al. 1990). Reduced row spacing and increased seeding rate suppressed cheat to a greater extent in wheat planted in September, than in wheat planted later (Koscelny et al. 1991). Also, fewer cheat plants were noted in narrow-row wheat seeded in October at 134 kg/ha than at 67 kg/ha. In Indiana, wheat seeded in narrow rows (6 cm) yielded on the average 6.8 and 5.3% (1983 and 1984, respectively) more grain than wheat in wider rows (19 cm) (Marshall and Ohm 1987).

In Indiana, wheat in 6 cm rows produced 47% more spikes/m^2 than wheat in 19 cm rows (Marshall and Ohm 1987). Wheat in 19 cm rows averaged one less spike per plant than wheat seeded in 6 cm rows. In Arkansas, spring wheat in 10-cm rows had more spikes/m^2 than wheat in 15- and 20-cm rows (Freeze and Bacon 1990).

In research conducted to determine the effects of wheat cultivar selection on cheat suppression, '2163' was ranked in the middle of the eight cultivars for competitive ability (Kelley et al. 1998). The relative competitive ability of 'Chisholm' has not been investigated. In earlier research, Koscelny et al. (1990) were unable to detect consistent cheat seed suppression differences among seven wheat cultivars at five locations.

The influence of fertility practice on cheat infestations has not been thoroughly investigated. Webb (1986) in Oklahoma found that fertilizing with diammonium phosphate banded with the wheat seed at 20-52-0 kg/ha followed by a spring application of ammonium nitrate at 55-0-0 kg/ha, reduced cheat dockage 14% compared with the unfertilized check.

Maxwell et al. (1984) in Kansas reported that wheat plants atop fertilizer bands produced more tillers than plants at some distance from the bands. However, tillers were not actually counted to verify that observation. The most desirable fertilizer band spacing may also depend on the row spacing of wheat since both affect the degree of shielding of some wheat rows by others. Knapp and Knapp (1978) and Alessi and Power (1980) reported that banding P_2O_5 with wheat seed provided early availability of that nutrient and, in many cases, increased dry matter and grain production even in soils with medium-to-high levels of available P_2O_5. Fiedler et al. (1989) concluded that in small grains P_2O_5 is more effective when applied in the crop row than when broadcast. Maxwell et al. (1984) found that the closer the preplant band of P_2O_5 was to the wheat seedling, the greater the early-season uptake.

The objectives of this research were to determine the effects of wheat row spacing and starter fertilizer treatment on the interference of cheat with hard red winter wheat.

MATERIALS AND METHODS

Field experiments were conducted at the Agronomy Research Stations near Orlando and Perkins, Oklahoma, in the 1996-97 crop year and repeated in adjacent fields in 1997-98. The production system at all sites included conventional tillage and dryland, continuous winter wheat. The sites were not previously infested with cheat.

The soil was a Pulaski loam (a course-loamy, mixed, nonacid, thermic Udic Ustifluvent) with 1.5% organic matter and pH = 6.7. and a Port loam (a fine-silty, mixed, thermic Cumulic Haphistoll) with 1.3% organic matter and pH = 5.2, at Orlando in 1996-97 and 1997-98. The soil at Perkins was a Teller sandy loam (a fine-loamy, mixed, thermic Udic Argiustoll) with 1.2% organic matter and pH = 6.0, in 1996-97 and 0.8% organic matter and pH = 5.7 in 1997-98.

The design for all experiments was a randomized complete-block with a three by two by five factorial arrangement of treatments. Factors included wheat row spacings (10-, 20-, and 30-cm), two levels of cheat (present and absent) and five starter fertilizer treatments i.e., broadcast and banded applications of 10-34-0 (NPK) liquid fertilizer at 84 (low) and 168 (high) kg/ha, plus a no fertilizer treatment. Experiments had six replicates except that four replicates were used at Orlando in 1996-97. Plot size was 3.1 by 7.6 m.

Locally harvested cheat seed was broadcast by hand at 34 kg/ha on October 8 and 11, 1996, and October 12 and 10, 1997, at Orlando and Perkins, respectively, with an equal amount on each plot. The liquid starter fertilizer was broadcast onto appropriate plots through capillary tubes spaced 10-cm apart, released approximately 15 cm above the soil surface. The cheat seed and starter fertilizer for the broadcast treatments were incorporated approximately 2.5-cm deep with an s-tine harrow with double rolling baskets.

Hard red winter wheat ('Chisholm' at Orlando and '2163' at Perkins) was seeded at 67 kg/ha immediately after the incorporation of starter fertilizer and cheat. The drill used for seeding was a double-run double-disk end wheel drill, with 6-cm wide press wheels, modified to hold 29 double disc openers spaced 10-cm apart. Seed metering gates on the low rate side of each seed metering unit were modified to permit metering wheat by both the large and small sides of each unit. Each plot contained 29 10-cm rows, 15 20-cm rows, or 10 30-cm rows, all 7.6 m long. Seeds were placed about 2.5 cm deep.

The soil test fertilizer recommendations for each site were based on a 4,000 kg/ha yield goal. Prior to fertilizing and planting, N, P_2O_5, and K_2O requirements, at Orlando, were 100, 35, and 0 kg/ha and 85, 0, and 20 kg/ha in 1996-97 and 1997-98, respectively, and at Perkins were 100, 0, and 0 kg/ha and 105, 25, and 20 kg/ha, in 1996-97 and 1997-98, respectively.

Seedbed moisture at planting was adequate for wheat emergence. At Orlando in 1996-97 and in 1997-98, 3 and 2 cm of rain fell 12 and 9 days after seeding. At Perkins in 1996-97 and 1997-98, 3 cm of rain fell one day after seeding each year.

On February 12 +/- 2 days, experiments were fertilized with ammonium nitrate (34-0-0) broadcast according to soil test recommendations. The amount applied per plot was adjusted for the 10-34-0 starter fertilizer applied.

Wheat plants in two m of the center row of each plot seeded in 30-cm rows and not seeded with cheat were counted at both sites in mid-November, 1996 and at Perkins on February 4, 1998. Cheat plants were counted in two randomly selected 0.125 m^2 quadrats in all plots overseeded with cheat, on December 1 $\pm$ 2 weeks in 1996 and at Perkins on February 4, 1998. Wheat and cheat densities were not counted at Orlando in 1997-98.

Light interception by the wheat and cheat canopy was determined on April 19 ± 4 days when the wheat was approximately 90-cm tall (Zadoks 50) (Zadoks et al., 1974) and beginning grain fill. Sunlight intensity was determined at midday on cloud free days above the wheat canopy and then approximately 7-cm above the soil surface in each plot by inserting a ceptometer[4] between two wheat rows. Interception of photosynthetically active radiation (PAR) was calculated as: {[(PAR above canopy – PAR below canopy)/PAR above canopy]*100}.

At wheat maturity, a 1.4 by 7.6 m area from each plot was harvested using a small plot combine adjusted to retain most of the cheat seed in the wheat grain. Thus, substantial amounts of chaff were collected with each grain sample because the air flow from the separator fan was restricted and the sieve openings increases to minimize cheat seed loss. Grain from each plot was weighed and cleaned using a small commercial type seed cleaner to remove chaff and straw. Samples were reweighed and recleaned to remove cheat seed from the harvested wheat grain. Weight lost during the second cleaning was considered dockage. It consisted primarily of cheat seed and shriveled wheat seed and was expressed as a percentage of the initial sample weight.

Wheat grain yield, adjusted to 13.5% moisture, was determined after recleaning. Wheat moisture and test weight were determined by a grain analysis computer[5]. Wheat and cheat stand counts, dockage, and wheat yield data were

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[4]Sunfleck Ceptometer. Decagon Devices, Inc., Pullman, WA.

[5]Grain Analysis Computer 2000. Dickey John Corp., Auburn, IL, 62615.

subjected to analyses of variance; and means were separated using protected least significant differences.

RESULTS AND DISCUSSION

Wheat stand data from plots with 30-cm row spacing and no cheat present, revealed that juvenile wheat density was unaffected by fertilizer treatment (p = 0.14) at Orlando in 1996-97 (Table 1). Three of four starter fertilizer treatments increased wheat stand density at Perkins in 1996-97, but banding starter fertilizer with the seed at the high rate, slightly reduced juvenile wheat density compared to the unfertilized treatment at Perkins in 1996, but not in 1997.

Cheat seedling density, which was counted in plots with 30-cm wheat row spacing, was somewhat similar to wheat density in most treatments (Table 1). Banding starter fertilizer increased cheat seedling density at Orlando. Cheat seedling density varied with fertilizer treatment at Perkins in 1996-97, however, fertilizer treatment did not affect cheat density at Perkins in 1997-98. The reasons for these differences were not clear.

No fertilizer by row spacing interactions were present in the sunlight interception data, however, fertilizer by cheat presence and row spacing by cheat presence interactions were observed. Due to other interactions, the data were not pooled across experiments.

At Orlando, both years, sunlight interception was less in broadcast fertilizer plots than in the unfertilized check (Table 2). Banding starter fertilizer did not affect sunlight interception.

At Perkins in 1996-97, no interaction between cheat presence and starter fertilizer treatment was found in the sunlight interception data. Both banded fertilizer treatments, and neither broadcast fertilizer treatment increased sunlight interception (Table 2).

At Perkins in 1997-98, pooled across row spacing, and within a cheat level fertilizer treatments did not affect sunlight interception (Table 2). In unfertilized plots, cheat presence increased sunlight interception from 72 to 85%.

At Perkins, both years, wheat in 30-cm rows intercepted less sunlight that wheat in 10- or 20-cm rows (Table 2), whereas no effect of row spacing was found at Orlando ($p = 0.14$ or greater). At Perkins, cheat increased sunlight interception by the vegetative canopy both years when wheat was seeded in 30-cm rows, and in 1997-98 when wheat was seeded in 20-cm rows. However, this was not evident when wheat was seeded in 10-cm rows. The difference between locations may be a result of row direction. Wheat was seeded in north-south rows at Perkins and in east-west rows at Orlando. At midday in April, more sunlight could penetrate to the soil in tall wheat seeded in north-south rows.

Averaged over other factors, mean sunlight interception by the vegetative canopy was increased ($p = 0.01$) by cheat from 91 to 96% at Orlando in 1996-97 and from 91 to 93% ($p = 0.04$) in 1997-98. No interactions were found at Orlando either year. Thus, starter fertilizer applications affected sunlight interception in all experiments, but the effects varied among experiments. With the exception of wheat seeded in 10-cm rows at Perkins, cheat infested wheat consistently intercepted more sunlight than weed free wheat, indicating that the weed free wheat was unable to utilize all available sunlight as a resource.

Wheat grain yield at Orlando, in 1996-97 and 1997-98, was unaffected by starter fertilizer treatment (p = 0.16 and 0.44) or row spacing (p = 0.74 and 0.91). No interactions were found. Averaged over other factors, cheat reduced wheat yields 31 and 28% in 1996-97 and 1997-98 (Table 3).

At Perkins in 1996-97, averaged over other factors, wheat grain yield was reduced from 2460 kg/ha in 10-cm rows to 2120 and 1920 in 20- and 30-cm row [LSD (0.05) = 130] and unaffected in 1997-98. No interactions with fertilizer treatment or cheat presence were found. Averaged over other factors, cheat reduced wheat yields at Perkins 14 and 21% in 1996-97 and 1997-98 (Table 3). Fertilizer treatment did not affect wheat yield at Perkins in 1996 (p = 0.21) but in 1997 averaged over other factors, banding the low rate of starter fertilizer resulted in 6.5% higher grain yield than broadcasting fertilizer at the same rate and a 6% increase in yield compared with applying no fertilizer (P = 0.054).

Dockage was not affected by fertilizer treatment except at Perkins in 1997-98 where, averaged over other factors, both banded fertilizer treatments reduced (P = 0.02) dockage from 17% in the unfertilized check to 13%. Averaged over other factors, cheat presence increased (P = 0.01) dockage at Orlando from 4 to 26% in 1996-97 and from 13 to 23% in 1997-98.

At Perkins in 1996-97, each decrease in row spacing decreased dockage of cheat infested wheat (Table 4). This was the only situation where narrowing the wheat rows reduced dockage.

Our research indicates that banding the high rate of 10-34-0 starter fertilizer "in-furrow" did not affect grain yield at three of four locations. Reducing wheat row spacing from 30-cm to 10-cm may help to reduce cheat dockage in harvested grain. No fertilizer treatment by row spacing combination substantially suppressed cheat.

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Table 1. The effect of fertilizer treatments on juvenile wheat and cheat density in the fall in plots with wheat seeded in 30-cm rows in three experiments.

Starter fertilizer	Wheat Orlando 1996-97	Wheat Perkins 1996-97	Wheat Perkins 1997-98	Cheat Orlando 1996-97	Cheat Perkins 1996-97	Cheat Perkins 1997-98
	plants/m^2					
Broadcast low	120	160	140	160	170	130
Broadcast high	120	170	120	100	160	130
Band low	100	170	120	160	150	130
Band high	90	140	130	180	190	130
None	110	150	120	130	190	130
LSD (0.05)	NS	9	9	24	19	NS

Table 2. Interactions of fertilizer treatment and cheat presence and row spacing and cheat presence on sunlight intercepted by the vegetative canopy at Orlando and Perkins in 1996-97 and 1997-98.

		Orlando		Perkins				
		1996-97	1997-98	1996-97			1997-98	
Factor	Level	Mean	Mean	Present	Absent	Mean	Present	Absent
		%						
Fertilizer treatment	Broadcast low	90	90	--	--	76	82	74
	Broadcast high	91	89	--	--	75	82	79
	Band low	95	93	--	--	79	79	79
	Band high	95	93	--	--	81	83	76
	None	96	93	--	--	73	85	72
LSD (0.05)		4	3	--	--	6	----- 7 -----	
Row spacing	10	94	93	88	85	--	84	85
	20	93	92	85	82	--	87	80

Table 2. Con't.

30	94	91	72	49	--	74	63
LSD (0.05)	NS	NS	------ 7 -----		--	----- 6 -----	

Table 3. The effect of cheat presence, averaged over fertilizer treatment and row spacing on wheat grain yield in three experiments.

Location	Crop Year	Cheat presence Present	Absent	*P* value
		kg/ha		
Orlando	1996-97	2200	3190	0.0001
	1997-98	2590	3600	0.0001
Perkins	1996-97	2010	2330	0.0001
	1997-98	3130	3960	0.0001

Table 4. Interactions of row spacing and cheat presence on dockage[a] at Perkins in 1996-97 and 1997-98.

Factor	Level	1996-97 Present	1996-97 Absent	1996-97 Mean	1997-98 Present	1997-98 Absent	1997-98 Mean
		%					
Row spacing	10	22	6	--	23	7	--
	20	25	7	--	22	6	--
	30	28	7	--	21	8	--
LSD (0.05)		----- 2 -----		--	----- 3 -----		--
Cheat[b]		26	4	--	23	13	--
LSD (0.05)		--- 2 ---		--	----- 6 ------		--

[a]Dockage consisted of cheat, chaff, shriveled wheat, and wheat straw.

[b]At Orlando.

VITA

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