Wheat Cultivar Response to Grazed and Ungrazed Production Systems

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ABSTRACT

Wheat grown on the Southern Great Plains is frequently utilized for both grazing and grain. The effects of grazing on grain yield are controversial. Semidwarf and tall cultivars were compared in grazed and ungrazed production systems where the major variables were wheat planting date and grazing duration. Semidwarf cultivars outyielded tall cultivars regardless of wheat planting date or duration of grazing. The grain yield advantage of semidwarf cultivars was greatest (up to 58%) in the most productive environment (late planted ungrazed) and least (5%) in the early planted wheat with longer grazing duration. Lodging resistance and grain yield potential were important cultivar attributes correlated with response to production system. Grazing induced reduction in height and lodging potential is more likely to benefit tall cultivars than semidwarf, lodging-resistant cultivars.

Wheat grown on the Southern Great Plains is frequently utilized for grazing prior to floral initiation and, after cattle removal, for grain production. The effects of grazing on wheat grain yield are poorly defined and have been the subject of controversy for many years. Both positive and negative effects of grazing on wheat grain yield have been summarized in two major reviews on the subject (Holliday, 1956; Redmon et al., 1995).

Grazing generally reduces plant height and lodging (Winter and Thompson, 1987). Thus, in productive environments with cultivars prone to lodge, grazing may increase grain yield by reducing lodging (Holliday, 1956; Redmon et al., 1995; Winter and Thompson, 1987; Winter and Thompson, 1990). Semidwarf lodging-resistant cultivars may offer higher grain yield potential than tall cultivars in productive environments (Winter et al., 1990; Winter and Musick, 1991). However, semidwarf cultivars may be more sensitive to the negative aspects (reduced height and leaf area) of excessive grazing (Pumphrey, 1970; Redmon et al., 1995; Winter and Musick, 1991).

The objective of this research was to compare tall and semidwarf wheat cultivar responses to a range of grazed and ungrazed wheat production systems. A wide range of treatments was considered essential to delineate the full range of responses and interactions that can occur.

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MATERIALS AND METHODS

Wheat grazing systems research was conducted on Pullman clay loam soil (fine, mixed, thermic Torrertic Paleustoll) with furrow irrigation at Bushland, Texas for the 1989-90 and 1990-91 wheat growing seasons. The independent variables evaluated were: date of planting, date of grazing, grazing management, and cultivar.

Planting date was the main plot, or whole pasture, variable with each pasture 5.5 acres in size (200 x 1200 ft). Each year there were four planting dates plus a duplicate of the earliest planting date with intensive, early-season grazing. This provided five main effect variables referred to as production systems 1 to 5 (Table 1).

The main effect treatments are systems as contrasted to single variable treatments. Each system was managed individually to maximize net return using best management practices. Thus, multiple variable effects may be confounded in main plots (systems) and results must be interpreted accordingly. The confounding of planting date, irrigation, grazing dates, etc. is appropriate for systems research where it is needed to optimize management of each system.

The grazing treatments (subplots) within each pasture were an ungrazed check plot plus cattle removal dates of 1 February, 1 March, and 21 March. Subplot areas were 50 ft x 70 ft blocks near the south end of each pasture. Each block consisted of seven cultivars as sub-subplots each 10 ft x 50 ft in size. Cattle water tanks and mineral supplement were on the north end of each pasture to avoid excessive trampling in the plot area and to maintain suitable beds and furrows in the critical water input area (south end). This method provided representative grazing pressure in the plot area without destroying beds and furrows.

The seven cultivars were randomized as strips each 10 ft wide (four 30-inch beds) that ran the entire 1200 ft length of each pasture. The remaining 130 ft width of each pasture was planted to TAM 107. Drill rows were spaced 6 inches apart (five rows per bed) in the cultivar strips and 10 inches in the bulk area of TAM 107. Seeding rate was 90 to 100 lbs acre^{-1} on all areas.

The cultivars used included four modern semidwarf cultivars: TAM 107, Quantum 588 (Q588, a hybrid), TAM 200, and Mesa. The taller cultivars were Quantum 554 (Q554, a beardless hybrid), Siouxland, and Triumph 64. Cultivar plots were harvested with a small plot combine. Total harvest area of each cultivar plot within each pull-off date was 5 ft by 40 ft. Grain yields were adjusted to 13% moisture.

The pastures of systems 2 to 5 were initially stocked with 450 to 500 lb stocker cattle at the rate estimated to fully consume available forage prior to rapid spring growth without over or undergrazing. Adjustments in stocking rates were made when it became apparent that a pasture was over or understocked. No more than one or two adjustments were needed in each pasture each year. Initial stocking rates varied from 300 to 900 lbs live weight acre^{-1} depending on available forage and length of grazing season remaining. This process reduced forage height to approximately 3 inches in late winter as growth resumed. After rapid spring growth began in mid to late February, green leaf area generally increased because growth rate exceeded consumption. Stocking rates from late February until 21 March were usually 500 to 1200 lbs acre^{-1} because the cattle had grown and forage availability was high. System 1 was managed somewhat differently than systems 2 to 5 in that a high initial stocking rate (2.7 to 4.0 head acre^{-1}) was used in October to rapidly remove most of the available forage. After irrigation, a lower stocking rate (1.0 head acre^{-1}) was used to utilize regrowth.

Planting dates and irrigation amounts are listed in Table 1. All grazing treatments within a production system were irrigated the same including the ungrazed check plots. All pastures were fertilized the same. The only fertilizer needed according to soil testing was nitrogen. Each year the total of nitrate nitrogen in the 0-4 ft soil profile plus preplant applied nitrogen from anhydrous ammonia equaled at least 250 lbs acre^{-1}. No fertilizer was applied during the growing season. These fertilization practices equal or exceed standard recommendations for Pullman soil (Pennington et al., 1981).

Table 1. Planting dates and irrigation amounts for 2 years at Bushland, Texas.

Production system	Planting date		Irrigation			
			1989-1990		1990-1991	
	1989	1990	Fall	Spring	Fall	Spring
			- - - - - - - - - inches	- - - - - - - - -		
1	24 Aug	21 Aug	4.6	8.0	7.5	12.0
2	24 Aug	21 Aug	7.4	8.0	7.3	12.0
3	5 Sep	10 Sep	3.8	8.0	6.9	12.0
4	18 Sep	21 Sep	3.9	8.0	3.4	12.0
5	5 Oct	7 Oct	4.1	8.0	0.0	12.0

Lodging was rated visually during grain filling as the percentage of the plot area that was leaning significantly (usually 45° or greater from vertical). In some cases, plants that lodged soon after heading later partially recovered. An attempt was made to rate lodging at its maximum occurrence.

Data were analyzed as a split-split plot with three replications the first year and four the second. Production systems were main plots, grazing pull-off date treatments were subplots, and cultivars were sub-sub plots.

RESULTS AND DISCUSSION

System, grazing treatment, and cultivar mean effects averaged over all levels of the other factors are given in Table 2. Wheat in the later planted systems had higher grain yield. This is in agreement with previously reported results (Petr and Doughtrey, 1978; Winter and Musick, 1993). The early October (system 5) planting date was intended to be the optimum for grain yield. One must, however, remember that the results for systems presented in Table 2 could be affected by much more than planting date. Water, fertility, weather patterns, or other factors could contribute to yield differences. The higher yield and greater height of system 2 wheat compared to system 1 (same planting date) in 1990 illustrates the effect that factors other than planting date can have on system performance. System 2 wheat received more fall irrigation in 1989 than system 1, which probably accounts for much of the yield and height difference.

Moderate grazing until early spring increased grain yield compared to the same planting date (system) that was ungrazed (Table 2). However, grazing past 1 March 1990, or 1 February 1991, tended to reverse that effect such that grazing until 21 March provided a similar or only slightly greater grain yield than ungrazed. The effects of late grazing on wheat grain yield are similiar to earlier results when one takes into consideration that the earlier studies were more severely grazed (Winter and Thompson, 1987).

Grazing reduced plant height and lodging compared to the ungrazed check (Table 2). Lodging may be reduced as much by the soil firming attributable to grazing as to the slight height reduction. None of the cultivars lodged significantly when grazed. Lodging was severe only in the ungrazed wheat of system 5 in 1990.

The cultivars could be divided into two groups based on height. TAM 107, TAM 200, Q588, and Mesa averaged about 8 inches shorter than Q554, Siouxland, and Triumph 64 (Table 2). The four shorter cultivars averaged about 80% as tall as the three taller cultivars.

On average, TAM 107 was the highest yielding cultivar both years (Table 2). TAM 200 and Q588 were next highest yielding. Triumph 64 was consistently low in yield and lodged the most.

Detailed results of cultivar grain yield by system and treatment are presented in Tables 3 and 4. The positive response of early planted wheat to moderate grazing appears to hold true for all cultivars. Significant interactions of cultivars with system or treatment occurred in some cases (eg., system x cultivar was significant for yield and lodging in 1990 and 1991) but otherwise was not consistently obtained. The interactions that occurred are not easily explained. One interaction occurred in 1990 when Q588 yielded relatively much better compared to TAM 107 in system 5, where yield potential was high, than in systems 1 to 3 where yields were lower (Table 3).

A significant interaction of cultivar with system and treatment in 1989-90 is illustrated in Figure 1 where the data are presented by height class. The four semidwarf cultivars yielded significantly more in system 5 ungrazed than the three tall cultivars. Reference to Table 3 indicates that this outperformance was attributable almost exclusively to TAM 107, Q588, and Mesa with yields of 82.6, 86.8, and 72.0 bu $acre^{-1}$, respectively. TAM 200 yielded only 61.4 bu $acre^{-1}$ in system 5 while the three tall cultivars averaged only 50.8 bu $acre^{-1}$. These results are partially attributable to lodging which was 57, 43, 32, 13, 10, 7, and 6% for Triumph 64, TAM 200, TAM 107, Siouxland, Q554, Q588, and Mesa, respectively. The poor yield of Triumph 64 and the under performance of TAM 200 relative to the other semidwarf cultivars may be partially explained by lodging. TAM 200 has relatively weak straw for a semidwarf wheat. The relatively good performance of Q588 compared to TAM 107 in system 5 compared to systems 1 to 3 may be explained by the greater lodging of TAM 107 in system 5. However, lodging does not explain why the semidwarf cultivars outyielded the tall cultivars Q554 and Siouxland that did not lodge severely. In 1991, with even higher yields and no

Table 2. Mean effect for production systems, grazing treatments, and cultivars averaged over all other factors for wheat harvested in 1990 and 1991 at Bushland, TX.

	Grain yield		Height		Lodging		Heading date	
Factor	1990	1991	1990	1991	1990	1991	1990	1991
PRODUCTION SYSTEM	- - bu acre^{-1} - -		- - - inches - - -		- - - - % - - - -		Day of year	
1	38.5 d	66.5 d	28.4 e	33.6 d	0 b	0 c	120	113
2	48.8 c	63.2 e	33.7 b	32.5 e	0 b	2 bc	121	113
3	54.7 b	77.7 c	29.9 d	34.4 c	0 b	3 ab	120	113
4	63.0 a	82.9 b	30.5 c	36.0 b	1 b	4 a	124	115
5	64.0 a	87.9 a	38.3 a	36.6 a	9 a	1 bc	129	118
GRAZING TREATMENT								
Ungrazed	49.2 c	72.8 c	32.9 a	35.5 a	6 a	4 a	122	113
Feb. 1	56.4 a	79.0 a	32.3 b	35.4 a	2 b	2 b	121	113
Mar. 1	57.0 a	77.3 b	32.0 b	34.5 b	1 b	1 b	124	114
Mar. 21	52.6 b	74.1 c	31.4 c	33.6 c	0 b	1 b	125	117
CULTIVAR								
Semidwarf								
TAM 107	66.7 a	84.1 a	30.7 d	32.3 c	2 b	1 cd	119	112
Quantum 588	57.5 b	79.0 b	29.9 e	30.3 e	0 b	0 d	120	113
TAM 200	54.4 c	79.9 b	29.6 e	31.5 d	3 b	1 cd	124	114
Mesa	51.5 d	73.5 d	26.4 f	30.3 e	0 b	0 d	119	112
Tall								
Quantum 554	50.0 d	76.1 c	37.0 a	41.4 a	1 b	2 bc	129	118
Siouxland	49.8 d	73.6 d	35.1 c	39.0 b	2 b	3 b	128	117
Triumph 64	46.7 e	64.1 e	36.2 b	38.6 b	6 a	6 a	121	113

Table 3. Grain yield response of seven wheat cultivars to production systems and grazing treatments in 1989-90.

Production system	Grazing dates		Cultivar						
	Date on	Date off	TAM 107	TAM 200	Q588	Mesa	Siouxland	Triumph 64	Q554
			bu acre^{-1}						
1	Ungrazed	Ungrazed	41.1 a†	32.7 ab	22.1 c	18.8 c	27.5 bc	21.5 c	28.4 bc
	4 Oct	1 Feb	58.1 a	42.9 b	41.8 b	32.7 b	35.4 b	34.3 b	43.8 b
	4 Oct	1 Mar	57.2 a	43.3 b	44.0 b	36.8 b	43.8 b	40.4 b	41.7 b
	4 Oct	21 Mar	53.4 a	39.8 bc	40.4 bc	34.8 c	43.4 b	38.7 bc	38.0 bc
2	Ungrazed	Ungrazed	56.3 a	54.3 ab	44.4 bc	40.9 c	42.8 bc	33.9 c	45.4 abc
	27 Oct	1 Feb	67.0 a	55.9 b	53.0 b	53.6 b	46.9 c	45.8 c	53.7 b
	27 Oct	1 Mar	57.3 a	51.6 ab	54.3 ab	52.8 ab	47.5 b	49.1 b	47.0 b
	27 Oct	21 Mar	52.7 a	40.6 b	45.3 ab	45.6 ab	45.2 ab	43.9 ab	40.0 b
3	Ungrazed	Ungrazed	67.4 a	60.6ab	47.3 bc	46.5 c	55.1 abc	44.6 c	48.2 bc
	15 Nov	1 Feb	67.7 a	58.0 ab	56.1 ab	48.3 b	57.7 ab	46.3 c	58.7 ab
	15 Nov	1 Mar	67.3 a	52.6 bc	52.3 bc	54.9 bc	61.3 ab	48.9 c	49.8 c
	15 Nov	21 Mar	65.2 a	52.7 b	51.9 b	48.2 b	62.3 a	49.4 b	51.6 b
4	Ungrazed	Ungrazed	66.5 a	63.1 ab	54.8 bc	52.7 c	54.0 bc	42.6 d	52.2 c
	15 Nov	1 Feb	79.8 a	70.6 ab	73.9 ab	60.1 bc	58.4 bc	52.4 c	61.7 bc
	15 Nov	1 Mar	82.4 a	68.5 bc	74.6 ab	62.7 c	66.1 bc	60.8 c	63.8 bc
	15 Nov	21 Mar	78.7 a	58.1 bc	67.1 b	64.5 bc	61.9 bc	53.2 c	58.7 bc
5	Ungrazed	Ungrazed	82.6 a	61.4 bc	86.8 a	72.0 ab	44.7 c	56.6 bc	51.0 c
	11 Jan	1 Feb	83.8 a	64.4 b	83.0 a	68.8 ab	45.0 c	56.9 bc	55.9 b
	11 Jan	1 Mar	81.5 a	63.9 bc	80.6 a	69.5 ab	51.0 d	55.3 cd	61.2 bcd
	11 Jan	21 Mar	67.3 b	53.0 d	75.6 a	66.6 b	45.4 e	58.9 c	50.2 d

†Within a row means are followed by the same letter are not significantly different at P=0.05.

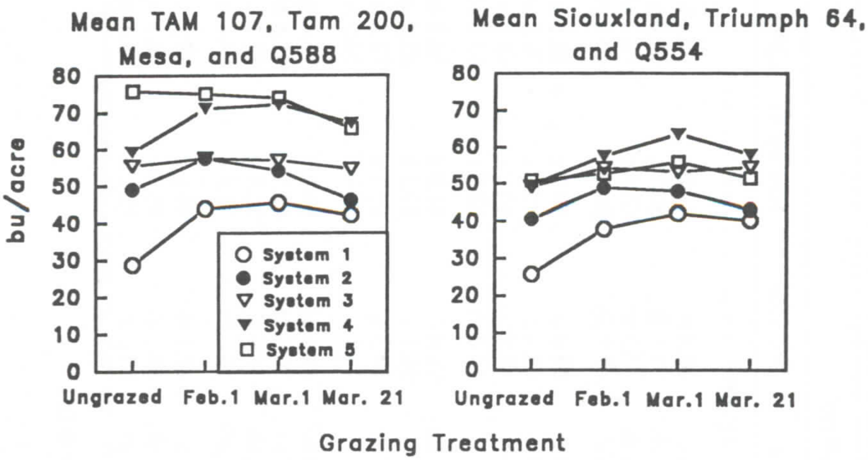

Figure 1. Grain yield response of semidwarf and tall wheat cultivars to five production systems and four grazing treatments for the 1989-90 wheat crop.

significant lodging by any cultivar, the under performance of tall cultivars is about the same in all systems (Table 4 and Figure 2).

Absolute differences in yield between semidwarf cultivars and taller cultivars may not be due to height. Perhaps the difference could be attributed to breeding progress since the shorter cultivars are generally of more recent origin. Relative responses or interactions of cultivars with other factors might be attributable to height differences.

The semidwarf wheats were selected in environments similar to system 5 ungrazed. In such productive environments for grain yield, semidwarf wheats have a significantly higher grain yield potential than the taller cultivars due to higher harvest index and greater seed acre^{-1} (Winter and Musick, 1991). The high potential grain yield of semidwarf wheat cultivars must be considered when comparing the economic potential of various grazed and ungrazed wheat production systems.

Even though most semidwarf wheat cultivars were selected almost exclusively in nongrazed environments, these cultivars equal or exceed the grain yield of taller cultivars in all grazing systems and treatments tested. With early planting and late grazing termination, the grain yield advantage of the semidwarf cultivars was reduced but not eliminated (Figure 1).

The important cultivar attributes for wheat production systems that were identified in this research appear to be lodging resistance and grain yield potential. Tall cultivars never yielded more than the semidwarfs and yielded much less in a high yield environment where lodging became significant and where tall cultivars have reduced ability to convert high biomass to grain. While early planting and heavy grazing may have reduced the grain yield advantage of semidwarf cultivars, they

Table 4. Grain yield response of seven wheat cultivars to production systems and grazing treatments in 1990-91.

Production system	Grazing dates		Cultivar						
	Date on	Date off	TAM 107	TAM 200	Q588	Mesa	Siouxland	Triumph 64	Q544
			bu acre^{-1}						
1	Ungrazed	Ungrazed	71.4 a†	64.1 b	57.3 bc	53.0 c	61.4 b	51.0 c	62.1 b
	10 Oct	1 Feb	79.0 a	73.2 ab	69.1 ab	67.1 ab	71.1 ab	57.7 c	68.0 b
	10 Oct	1 Mar	80.3 a	73.2 ab	71.1 ab	68.6 ab	71.9 ab	63.4 b	70.1 ab
	10 Oct	21 Mar	72.0 a	69.8 ab	66.2 bc	59.8 ab	67.8 ab	54.1 c	69.2 ab
2	Ungrazed	Ungrazed	74.5 a	62.8 b	58.5 bc	53.0 c	63.0 b	54.7 c	62.2 b
	24 Oct	1 Feb	77.7 a	63.8 bc	73.2 a	56.9 c	65.4 b	56.0 c	70.8 ab
	24 Oct	1 Mar	69.5 a	59.8 b	71.4 a	56.4 b	67.5 a	50.9 c	68.6 a
	24 Oct	21 Mar	65.8 ab	61.8 b	69.1 a	55.1 c	63.8 ab	52.9 c	63.8 ab
3	Ungrazed	Ungrazed	92.9 a	83.6 b	82.2 b	76.1 bc	71.4 c	61.8 d	76.9 bc
	15 Nov	1 Feb	90.1 a	85.4 a	87.8 a	83.4 a	82.1 a	67.7 b	83.8 ab
	15 Nov	1 Mar	83.2 a	81.4 a	80.7 a	76.5 ab	80.3 a	67.3 b	77.8 a
	15 Nov	21 Mar	77.1 a	72.8 a	72.1 a	70.7 a	75.1 a	62.3 b	74.5 a
4	Ungrazed	Ungrazed	92.5 a	89.9 a	81.7 b	76.0 bc	68.4 cd	64.4 d	72.4 cd
	26 Nov	1 Feb	99.6 a	93.3 ab	90.0 abc	88.9 bc	76.5 de	68.1 e	81.5 cd
	26 Nov	1 Mar	94.0 ab	90.7 ab	90.8 ab	87.3 ab	76.9 c	70.3 c	85.1 b
	26 Nov	21 Mar	92.6 a	87.5 a	86.4 a	84.2 ab	75.2 bc	71.8 c	84.8 a
5	Ungrazed	Ungrazed	93.5 a	93.3 a	92.5 a	86.1 a	83.1 ab	74.6 b	87.7 a
	20 Feb	1 Mar	93.5 ab	94.2 ab	96.6 a	91.6 ab	88.3 ab	75.2 c	86.1 b
	20 Feb	21 Mar	91.8 a	93.4 a	90.8 ab	90.4 ab	80.1 ab	77.2 b	87.4 ab

†Within a row means are followed by the same letter are not significantly different at $P = 0.05$.

always outperformed tall cultivars. When comparing the economics of various grazed and ungrazed wheat production systems, the high grain yield potential of modern semidwarf cultivars should be considered. Modern, lodging-resistant, wheat cultivars may give a very high grain yield response to productive environments that would have resulted in severe lodging and reduced grain yield with older, taller cultivars. With lodging resistant cultivars, the need for grazing to control lodging is much reduced.

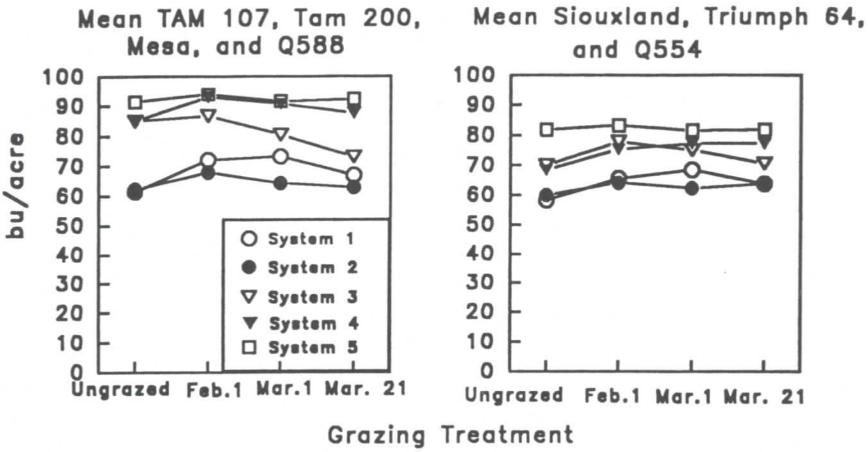

Figure 2. Grain yield response of semidwarf and tall wheat cultivars to five production systems and four grazing treatments for the 1990-91 wheat crop.

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