Wheat Grazing and Planting Date Impacts on Livestock and Grain Production

Steven Winter*

Texas A&M Research & Extension Center, P. O. Drawer 10, Bushland, TX 79012

Norbert Chirase

Stephen Amosson

Texas A&M Research & Extension Center, 6500 Amarillo Blvd. West, Amarillo, TX 79106

ABSTRACT

Wheat (*Triticum aestivum* L.) grazing systems with variable planting dates and cattle pull-off dates were grown with limited furrow irrigation at Bushland, TX. Grain yields averaged 40.4, 53.1, and 66.6 bu/ac for non-grazed check plots with mean planting dates of Aug. 24, Sept. 11, and Oct. 2, respectively. Moderate grazing increased grain yield of wheat planted in August or September. Grain yield averaged 50.9, 55.7, and 46.3 bu/ac for non-grazed, early pull-off, and late pull-off, respectively. However, early-planted, properly grazed wheat still yielded less than a later planted non-grazed control. Adjusted gross return using prevailing costs and returns was maximized with a mean planting date of Sept. 12 and pull-off of Mar. 25. These dates are slightly later than expected. Delaying planting of grazed wheat from late August to mid September increases grain yield and gross return but reduces total grazing and shifts some grazing from fall to spring.

KEYWORDS: economics, grain yield, grazing, stocker cattle

Wheat grown on the Southern High Plains is commonly used as a dual purpose crop, i.e., for grazing and grain. Using wheat in this manner reduces risk by providing two income sources. The wheat crop provides highly nutritious forage at a time of the year when most other forages are dormant. Thus, wheat forage may provide low cost gains for stocker cattle compared to other systems of wintering these animals.

Wheat grazing systems are complex with many management, environmental, and economic variables. Farmer's land and water resources vary considerably. Management styles and abilities may make some producers more inclined to grazed or non-grazed systems for non-economic reasons. This complexity requires a systems approach to study the problem of identifying the best wheat management systems. In these studies treatments are systems of production with best management practices (BMP) identified from previous research and grower experience. Using systems based on BMP as treatments requires confounding of inputs and careful interpretation of results. For example, one can not necessarily conclude anything about planting date effects, per se, from confounded systems; rather one must compare an early planted system to a late planted system. In the case of planting dates, we have included some unconfounded check treatments for clarification and comparison. A key point is that results must be interpreted carefully.

Grazed wheat systems are planted 4 to 6 wk earlier than dates identified as optimum for grain-only production (Fuehring, 1981). Thus, grazed systems require more irrigation and may encounter more disease and insect problems. Early planting can promote more fungal and viral diseases of wheat that may reduce grain yield even when fall forage production is greatly increased.

There has long been controversy over whether grazing reduces grain yield of wheat (Holliday, 1956; Redmon et al., 1995). This has been a difficult question to answer experimentally because of the complexities of the systems involved. Also, researchers have been reluctant to confound variables such as irrigation, planting date, and fertility as would be dictated by established BMP. Thus, grazed and non-grazed systems have often been studied by varying only grazing while attempting to maintain uniform planting dates and other inputs. The results of such research can be misleading or unrealistic. However, results of systems research for grain yield, cattle performance, and economic conclusions will be only as good as the researchers ability to optimize resource utilization in all aspects of each system.

The goal of this research was to provide resource managers with response functions to optimize grazing system management while comparing BMP established for grazing systems and grain-only systems. Understanding the types of responses that can occur should help producers optimize utilization of their resources.

MATERIALS AND METHODS

Wheat grazing systems research was conducted at the Bush research farm which is located 1.5 miles north of Bushland, TX. The research was conducted during five growing seasons between 1990 and 1996. The soil is a Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll) with 0-1% slope and irrigated by graded furrows. This soil, when fully wet, is capable of supplying about 8 inches of plant available water for wheat. A complete description of this soil has been published (Unger and Pringle, 1981).

The climate is semi-arid with highly variable rainfall and temperature. Spring freezes and hail are serious hazards for wheat grain production. Weather during the wheat growing seasons of these studies is summarized in Table 1.

Treatments were wheat grazing systems planted with cv. 'Tam 107' with variable planting dates and cattle pull-off dates. Each system was managed using a set of best management practices in an attempt to maximize return to available resources (Winter, 1994). Since treatments were systems, some factors are purposefully confounded. For instance, earlier planted systems were commonly irrigated more in the fall than later planted systems. A non-grazed check plot was included for each planting date.

Pastures (planting dates) were 5.5 acres in size and were stocked with 3 to 12 head of 350 to 400 lb. stocker calves of mixed breeds at times appropriate for each planting date (see Tables 2-6 for grazing dates). A put and take system was used to maximize utilization of forage without severe overgrazing. This system used tester animals that remained on the pastures at all times. Tester animals were used to determine average daily gain. Other animals were added or removed to achieve uniform, desired forage removal levels. The wheat was grazed to a 2 or 3 inch stubble height at pull-off. Grazing was probably somewhat less severe than common commercial practice but adequate to utilize available forage. Head counts were taken daily. Total beef production was determined by multiplying average daily gain times total head-days for a given grazing period.

Pastures were 5.5 acres in size (200 ft by 1200 ft) and pull-off dates were achieved by moving an electric fence. Both non-grazed plots and pull-off date plots were 20 ft by 1200 ft in size and were harvested with a commercial combine. Cattle were weighed at each pull-off date after overnight shrinkage (18 hr with no feed or water). Pasture area was adjusted with each pull-off date for calculations of cattle gain and head-days/acre.

Cattle pull-off dates were by calendar dates the first two years and by first hollow

Table 1. Precipitation and temperature record at the Bush research farm during the grazing trials.

Wheat crop year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
						inches						
1989-90	4.24	0.00	3.57	0.00	0.56	0.10	1.17	0.34	0.59	0.78	0.30	11.65
1990-91	2.53	3.28	0.31	0.77	0.24	1.02	0.02	0.38	0.09	2.20	3.38	14.22
1993-94	2.18	0.58	0.87	0.81	0.74	0.27	0.03	0.81	1.62	2.32	3.25	13.48
1994-95	4.27	1.89	1.93	0.22	0.33	0.48	0.02	0.86	0.43	4.47	2.60	17.50
1995-96	2.47	3.94	0.70	0.06	0.79	0.10	0.19	0.12	0.00	0.60	2.98	11.95
Normal †	2.81	1.93	1.53	0.73	0.58	0.50	0.51	0.78	1.01	2.67	3.00	16.05
						Mean ^0F						
1989-90	73.4	63.6	57.6	46.2	29.1	35.8	39.5	44.6	54.1	61.6	79.4	
1990-91	74.0	70.1	55.0	47.1	31.0	30.5	43.6	47.9	55.9	66.6	72.7	
1993-94	74.5	66.4	53.7	40.2	37.7	34.6	35.2	47.1	53.4	63.0	77.4	
1994-95	74.6	67.9	57.1	45.0	40.2	37.5	42.5	46.4	52.0	60.5	69.3	
1995-96	76.2	66.6	56.2	47.4	37.6	34.0	40.9	42.6	55.4	70.2	75.4	
Normal †	74.6	67.1	56.0	43.8	35.3	34.9	39.1	46.0	55.4	64.0	73.1	

stem observation the last three years (Krenzer et al., 1995). Where possible, one pull-off date was before, at, and after first hollow stem. This system worked as planned in 1993-94 and 1994-95; however, in 1995-96 poor weather for establishment and growth of wheat delayed onset of grazing and limited choice of pull-off dates. The first pull-off date in 1995-96 was at first hollow stem for both planting dates. The second pull-off date was at mid-jointing and early-jointing for the early and late planting dates, respectively.

Planting dates (pastures of 5.5 acres) were replicated 3 or 4 times in a randomized block design. Non-grazed checks each 20 ft by 1200 ft of every planting date were included in each replicate. The latest planted non-grazed check, usually planted in the first week of October, was intended to provide a grain-only check treatment.

Irrigation was by graded furrow. Gross irrigation application is given in Tables 2 to 6. Usually spring applications were similar but fall applications were generally larger on earlier planted wheat. Tail water was not measured and probably averaged 10 to 20% of gross applications. Irrigation was seldom adequate to maximize forage yield or grain yield due to inadequate pumping capacity. This was particularly true in the spring when wheat water use rates can be very high. Rates applied ranged from 30 to 60% of potential crop evapotranspiration. Thus, wheat grain yields were generally limited by drought stress in these studies. The irrigation levels used are common in commercial practice because water is usually limited.

Soil tests indicated that nitrogen and phosphorus were the only deficient elements. Nitrogen was all applied preplant at levels equal to or exceeding the recommended rate. Phosphate was broadcast and incorporated with sweeps and by listing.

An economic analysis of all treatment combinations including non-grazed checks was conducted using average prices and costs observed during the study period. An adjusted gross return was calculated for each treatment. The adjustments to gross return were deductions for excess inputs such as extra tillage, chemicals, or irrigation above the lowest input treatment. Wheat grain yields, livestock gains, and adjusted gross return were statistically analyzed each year as a randomized complete block design with planting dates as main plots and grazing treatments as subplots. This treatment framework was not always valid because subplot treatments were not always the same for every planting date. Another analysis using the general linear models procedure of the Statistical Analysis System compared each planting date/grazing date combination as a separate treatment. This analysis was used to calculate Duncan's multiple range test at P =0.05. T-tests were used to compare adjusted gross returns of grazed and non-grazed systems within each year.

RESULTS AND DISCUSSION

Generally good wheat stands were achieved in these studies despite variability in precipitation and temperatures (Table 1). Dry weather necessitated irrigation for emergence with about 40% of the planting date treatments. Dry weather during the winter and spring reduced grain yield in 1989-90 and 1995-96. Severe freezes in the fall and spring plus greenbugs (*Schizaphis graminum*, Rond.) and hail reduced yields in 1993-94. Spring freezes and severe disease and insect pressure reduced grain yields in 1994-95. Untimely rains delayed planting in 1995-96 and the drought and spring freeze that followed reduced forage and grain yields. In general, the first two growing seasons were more favorable for grain production than grazing. During the last three growing seasons mild, generally dry winters, favored cattle gains over grain production.

Table 2. Cattle performance and wheat grain yield with several wheat grazing systems in 1989-90 at Bushland, TX.

Planting	Irrigation		Grazing dates		Cumulative grazing		
date	Fall	Spring	Date on	Pull-off	Head-days	Beef gain	Grain yield
	inches				d/ac	lb/ac	bu/ac
Aug. 24	7.4	8.0	Non-grazed	Non-grazed	0	0 f	56.3 c
			Oct. 27	Feb. 1	124	178 b	67.0 b
			Oct. 27	Mar. 1	163	224 a	57.3 c
			Oct. 27	Mar. 21	189	245 a	52.7 c
Sept. 5	3.8	8.0	Non-grazed	Non-grazed	0	0 f	67.4 b
			Nov. 15	Feb. 1	90	130 c	67.7 b
			Nov. 15	Mar. 1	128	177 b	67.3 b
			Nov. 15	Mar. 21	154	195 ab	65.2 b
Sept. 18	3.9	8.0	Non-grazed	Non-grazed	0	0 f	66.5 b
			Nov. 15	Feb. 1	74	94 d	79.8 a
			Nov. 15	Mar. 1	95	129 c	82.4 a
			Nov. 15	Mar. 21	121	197 ab	78.7 a
Oct. 5	4.1	8.0	Non-grazed	Non-grazed	0	0 f	82.6 a
			Jan. 11	Feb. 1	13	18 f	83.8 a
			Jan. 11	Mar. 1	30	45 e	81.5 a
			Jan. 11	Mar. 21	56	97 d	67.3 b

Table 3. Cattle performance and wheat grain yield with several wheat grazing systems in 1990-91 at Bushland, TX.

Planting date	Irrigation		Grazing dates		Cumulative grazing		Grain yield
	Fall	Spring	Date on	Pull-off	Head-days	Beef gain	
	inches				d/ac	lb/ac	bu/ac
Aug. 21	7.3	12.0	Non-grazed	Non-grazed	0	0 d	74.5 de
			Oct. 24	Feb. 1	131	154 a	77.7 cd
			Oct. 24	Mar. 1	131	154 a	69.5 e
			Oct. 24	Mar. 21	152	180 a	65.8 e
Sept. 10	6.9	12.0	Non-grazed	Non-grazed	0	0 d	92.9 a
			Nov. 15	Feb. 1	137	90 b	90.1 ab
			Nov. 15	Mar. 1	165	112 b	83.2 bc
			Nov. 15	Mar. 21	186	176 a	77.1 cd
Sept. 21	3.4	12.0	Non-grazed	Non-grazed	0	0 d	92.5 a
			Nov. 26	Feb. 1	61	74 bc	99.6 a
			Nov. 26	Mar. 1	80	104 b	94.0 a
			Nov. 26	Mar. 21	101	161 a	92.6 a
Oct. 7	0	12.0	Non-grazed	Non-grazed	0	0 d	93.5 a
			Feb. 20	Mar. 1	8	16 d	93.5 a
			Feb. 20	Mar. 21	29	70 c	91.8 a

The 1989-90 and 1990-91 Seasons

The first two growing seasons had similar treatments and similar wheat and cattle responses (Tables 2 and 3). Planting dates and grazing dates were similar across the two years. These dates were near the desired dates to test planting date effects and to properly utilize the resulting forage production. Beef gain per acre was increased by earlier planting of wheat and by later cattle pull-off. Total cattle gains were rather modest both years. A severe winter with heavy snowfall and severe wind-chills stressed the cattle. Average daily gain (beef gain/head-days) was rather low as a result.

Wheat grain yields were generally high these two years and treatment responses were similar (Tables 2 and 3). Yield was higher with later planted systems as compared to earlier planted systems. Mean yields for the earliest to latest of the four planting date systems were 65.1, 76.4, 85.8, and 85.9 bu/ac, respectively. Dry spring weather and inadequate spring irrigation limited yields in 1989-90.

Grain yield responses to pull-off date show a clear pattern. Mean yields across the two seasons of the first three planting dates for the non-grazed, Feb. 1, Mar. 1, and Mar. 21 pull-off dates were 75.0, 80.3, 75.6, and 72.0 bu/ac, respectively. The historically recommended pull-off date has been about Mar. 15 (Winter and Thompson, 1987). The mean date of first hollow stem was not recorded these years but probably averages early March in this climate. These data indicate that grain yield of grazed wheat would be maximized with a pull-off no later than March 1. This, however, is not the economically optimum date for the system as a whole because cattle gains are usually quite good during the spring after wheat begins to grow rapidly.

Last Three Growing Seasons

The last three years are discussed separately because growing conditions, cattle, and wheat performance were similar those years but different in some respects from the first two years. Available plot area was less the last three years so planting dates were reduced to three dates rather than four. The dates were as similar across these three years as planting conditions allowed.

The 1993-94 season had unfavorable fall and spring freezes, greenbugs, and hail. These factors reduced both forage and grain yields. Total cattle gain was significantly improved by early planting (Table 4). First hollow stem occurred near Feb. 25 to 28 for both the Aug. and Sept. planting dates. Forage yields of the Sept. 14 planting and early growth of the Oct. 1 planting were restricted by a severe cold spell lasting 7 days in late Oct. and early Nov. The temperature fell to near 0°F during this period. This prolonged period of excessive cold weather reduced forage yield in the fall of 1993. Wheat grain yields were limited by inadequate irrigation in the spring of 1994. These production problems limited both cattle performance and grain yield in 1993-94.

The 1994-95 growing season was another difficult year for wheat production (Table 5). A spring freeze, high insect populations (aphids), and disease pressure (barley yellow dwarf) caused severe damage especially to the system planted Aug. 23. Fall growth was good and mild weather favored good cattle performance. First hollow stem dates were about Feb. 20 and 26 for the Aug. 23 and Sept. 13 systems, respectively. Cattle gains were good with both planting date systems and for all grazing termination dates.

Severe disease and insect pressure damaged wheat in the Aug. 23 planting date system in Mar. and Apr. of 1995. Barley yellow dwarf was particularly severe. Grain yields were nearly zero with the early planted system. Because the wheat looked so poor in Mar. the final pull-off date was extended to give a graze-out treatment that terminated Apr. 1. For the Aug. 23 planting this only sacrificed 7.0 bu/ac wheat for 202 lb/ac beef gain (Table 5). The

Table 4. Cattle performance and wheat grain yield with several wheat grazing systems in 1993-94 at Bushland, TX.

Planting date	Irrigation		Grazing dates		Cumulative grazing		Grain yield
	Fall	Spring	Date on	Pull-off	Head-days	Beef gain	
	inches				d/ac	lb/ac	bu/ac
Aug. 27	8.0	4.4	Non-grazed	Non-grazed	0	0 d	29.5 d
			Nov. 2	Feb. 2	108	251 b	33.2 cd
			Nov. 2	Feb. 28	135	311 ab	36.2 b
			Nov. 2	Mar. 21	163	351 a	32.8 cd
Sept. 14	3.6	4.4	Non-grazed	Non-grazed	0	0 d	36.6 bc
			Dec. 7	Feb. 2	17	45 d	40.0 ab
			Dec. 7	Feb. 28	45	88 cd	42.8 a
			Dec. 7	Mar. 21	75	138 c	40.0 ab
Oct. 1	3.6	4.4	Non-grazed	Non-grazed	0	0 d	46.2 a

Table 5. Cattle performance and wheat grain yield with several wheat grazing systems in 1994-95 at Bushland, TX.

Planting date	Irrigation		Grazing dates		Cumulative grazing		Grain yield
	Fall	Spring	Date on	Pull-off	Head-days	Beef gain	
	Inches				d/ac	lb/ac	bu/ac
Aug. 23	3.0	8.0	Non-grazed	Non-grazed	0	0 c	1.1 d
			Nov. 15	Feb. 6	144	388 b	5.1 d
			Nov. 15	Feb. 21	158	416 b	7.0 d
			Nov. 15	Apr. 1	223	618 a	0.0 d
Sept. 13	3.0	7.0	Non-grazed	Non-grazed	0	0 c	15.5 c
			Nov. 15	Feb. 6	109	300 b	29.0 b
			Nov. 15	Feb. 28	131	335 b	32.7 b
			Nov. 15	Apr. 1	228	700 a	0.0 d
Sept. 26	3.0	7.0	Non-grazed	Non-grazed	0	0 c	44.0 a

Sept. 13 planting gave up 32.7 bu/ac of wheat for 365 lb/ac of beef gain when comparing Feb. 28 to Apr. 1 pull-off.

In 1994-95, the non-grazed treatments yielded 1.1, 15.5, and 44.0 bu/ac for the Aug. 23, Sept. 13, and Sept. 26 planting date systems, respectively. This is a rather dramatic example of the detrimental effects of early planting under severe disease and insect pressure. For the Sept. 13 planting, grazing until Feb. 28 more than doubled yield compared to the non-grazed check (Table 5). Both yields, however, were quite low.

The 1995-96 season was also poor for wheat production (Table 6). Inadequate fall irrigation followed by a record dry winter severely stressed the September planted wheat by February. A freeze March 26 on some of this dry wheat appeared to reduce the stand. This was particularly true for the Sept. 29 planting. Extremely hot, dry weather in May made it impossible to satisfy ET demand. First hollow stem dates were near Mar. 1 and 15 for the Sept. 13 and 29 planting date systems, respectively.

Both cattle performance and wheat yields were better with the earlier of the two September planting date systems in 1995-96. Dry weather and late planting caused the September 29 planting to be nearly ungrazeable. This wheat did not have grazeable forage until nearly Mar. 1, just 2 wk before first hollow stem. Grazing dates were extended somewhat with this treatment but grain yield was substantially reduced when grazing was extended to Apr. 1.

Grain Yield Responses

Production systems which were planted early, particularly in August, had lower grain yield than later planted systems (Tables 2-5). During the first four growing seasons, average grain yields for the first, second, and last planting dates of the non-grazed check were 40.4, 53.1, and 66.6 bu/ac, respectively. Average planting dates of these production systems were Aug. 24, Sept. 11, and Oct. 2 for this comparison. There was no August planting in 1995-96 and yield of the Sept. 29 planting was severely damaged by a late spring freeze. Still in 1995-96, the highest yield was with the Oct. 9 planting (Table 6). Planting date response of these systems are consistent with most prior responses where both very early and late planting dates reduced wheat grain yields (Fuehring, 1981; Winter and Musick, 1991).

Moderate grazing increased grain yield but late grazing reversed this effect. Average grain yields over 12 comparisons for non-grazed, first pull-off, and last pull-off were 50.9, 55.7 and 46.3 bu/ac, respectively. Thus, moderate grazing increased grain yield about 5 bu/ac whereas late grazing reduced it by an equal amount compared to the non-grazed check. The grain yield reduction due to late grazing is easy to understand and has been documented (Winter and Thompson, 1987; Worrell et al., 1992). The increased grain yield of early planted wheat with moderate grazing is a common occurrence at this location but to the authors knowledge has not been reported elsewhere.

There are several factors which might help explain why moderate grazing increases grain yield of early planted wheat. The excessive mass of vegetative growth typical of early planted wheat that occurs in the fall without grazing may play a role. This vegetative material can lodge during the winter due to compaction from snow or freeze damage. In the spring, this mat of dead vegetation reduces light interception, potentially inhibiting tiller emergence, photosynthesis, and growth. The mat of excess vegetation associated with early planted non-grazed wheat is an excellent incubator of foliar fungal pathogens. It is also habitat for insects which can vector viral diseases. Grazing removes this excessive vegetation and may promote improved growth of old, and possibly, new tillers in the spring. Due to irrigation and a productive environment, fall forage yields can be as high

Table 6. Cattle performance and wheat grain yield with several wheat grazing systems in 1995-96 at Bushland, TX.

Planting date	Irrigation		Grazing dates		Cumulative grazing		Grain yield
	Fall	Spring	Date on	Pull-off	Head-days	Beef gain	
	Inches				d/ac	lb/ac	bu/ac
Sept. 13	4.4	14.2	Non-grazed	Non-grazed	0	0 c	44.1 b
		14.2	Dec. 11	Feb. 28	57	165 b	44.2 b
		14.2	Dec. 11	Apr. 1	155	375 a	33.7 c
Sept. 29	4.0	11.2	Non-grazed	Non-grazed	0	0 c	34.0 c
		11.2	Feb. 28	Mar. 20	33	62 c	35.1 c
		10.1	Feb. 28	Apr. 1	95	155 b	17.3 d
Oct. 9	4.0	12.5	Non-grazed	Non-grazed	0	0 c	54.7 a

as 5,000 lb/ac of dry matter in this environment. In areas with less fall growth, later planting, or other overriding factors, the positive effect of moderate grazing may be less or nonexistant.

Severe or late grazing can reduce grain yield. Severe defoliation can increase winterkill. Severe or late grazing delays reproductive growth, kills tillers or delays tiller development, delays heading, and reduces grain yield (Winter and Thompson, 1987). This effect is especially damaging to semi-dwarf, high grain producing wheat cultivars that may not regain sufficient leaf area to maximize grain yield (Winter and Thompson, 1990; Winter, et al., 1990; Winter and Musick, 1991). Delayed heading is known to reduce grain yield in the absence of late spring freezes.

Grazing can increase grain yield in the event of a late spring freeze by delaying the onset of reproductive growth. The improvement in yield is probably no more than would occur if delayed planting were employed to delay heading an equal amount. Grazing that delays the onset of reproductive growth by a significant amount is probably reducing grain yield compared to an earlier termination of grazing. However, the loss of grain yield may be partially or fully offset by animal weight gains with the added benefit of some freeze protection. One benefit of spring grazing is that the first spring irrigation is often delayed. This delay in irrigation and resultant moderate drought stress imparts significant freeze tolerance to the wheat crop. On the other hand, severe drought stress and dry soil can increase winterkill and spring freeze damage. Damaging spring freezes usually occur in late March or early April in this environment.

Economic Analysis

An economic analysis was conducted to integrate, compare, and evaluate return from the varying production systems. The non-grazed treatment in the last planting date was used as a check treatment. This was a well managed, non-grazed check. Mean planting date for this treatment was Oct. 3 and yield averaged 62.2 bu /ac. Mean adjusted gross return was $189/ac (Table 7).

The optimum grazed system to maximize adjusted gross return each year at prevailing commodity prices is presented in Table 8. The optimum planting date ranged from Aug. 27 in 1994 to Sept. 21 in 1991 with a mean date of Sept. 12. However, in four of the five years the optimum date was Sept. 13 to 21. In commercial practice, since all wheat can not be planted on one date, a range of Sept. 10 to 20 or somewhat earlier is a recommended target date. If planting date is delayed much past Sept. 20, there will be a large loss in fall grazing as occurred in 1995-96 (Table 6). Planting will need to start earlier if all wheat acreage can not be planted in 7 to 10 days.

The optimum cattle pull-off date was Mar. 21 to Apr. 1 with an average of Mar. 25. This is later than previously recommended indicating that the cattle gains in early March more than offset the loss in grain yield. A factor in later than expected pull-off date is that later than normal planting dates were recommended. With later planting, grazing can continue somewhat longer in the spring without excessive grain yield loss. Mean grain yield for the optimum grazed system was 43.2 bu/ac, a decrease of 19 bu/ac compared to the non-grazed check. The cattle gain of 357 lb/ac associated with the optimum dates more than offset the loss of grain yield. Mean adjusted gross return was $224/ac, an increase of $35/ac compared to the non-grazed check. This, however, is not a fair comparison because it is comparing the best of several grazed systems to one standard non-grazed check. One does not know in advance what the optimum grazed system will be. A standard grazed system, with planting and pull-off dates as near as possible to optimum, gives return nearly equal to the non-grazed check (Table 9).

Table 7. Planting date, grain yield, and adjusted gross return for the late planted non-grazed check treatment at Bushland, TX.

Harvest Year	Planting date	Grain yield	Adjusted gross return at $3.00/bu
		bu/ac	$/ac
1990	Oct. 5	82.6	243
1991	Oct. 7	93.5	280
1994	Oct. 1	46.2	134
1995	Sept. 26	44.0	132
1996	Oct. 7	54.7	155
Mean	Oct. 3	62.2	189

Table 8. Optimum grazed systems to maximize adjusted gross return over 5 yr for semi-irrigated grazed wheat at Bushland, TX. Wheat $3.00/bu and cattle gain at $0.30/lb.

Harvest Year	Wheat planting date	Cattle pull-off date	Grain Yield	Beef Gain	Adjusted gross return
			bu/ac	lb/ac	$/ac
1990	Sept. 18	Mar. 21	78.7	197	296
1991	Sept. 21	Mar. 21	92.6	161	309
1994	Aug. 27	Mar. 21	32.8	351	186
1995	Sept. 13	Apr. 1	0.0	700	202
1996	Sept. 13	Apr. 1	33.7	375	192
Mean	Sept. 12	Mar. 25	43.2	357	224

Table 9. Adjusted gross returns with $3.00 wheat and $0.30 cattle for a standard grazing system compared to a standard non-grazed check over 5 yr at Bushland, TX.

Harvest year	Adjusted gross return	
	Grazed[a/]	Grain-only[b/]
	$/ac	
1990	213 B[c/]	243 A
1991	243 B	280 A
1994	155 A	134 A
1995	191 A	132 B
1996	160 A	155 A
Mean	192 A	189 A

a/ Planting dates between Sept. 5 and 13 and pull off date of Feb. 28

b/ See data in Table 7.

c/ Comparison of grazed vs. grain-only means for each year, P = 0.05.

Optimum management obviously depends on prevailing prices of wheat and cattle. If wheat grain prices increase relative to cattle prices, planting should be delayed and cattle removed earlier from wheat. If cattle prices are more favorable, earlier planting, higher stocking rates, or later pull-off might be advisable management responses. Variability in all aspects of production systems as complex as these makes economic analysis a difficult task.

In summary, these data suggest that gross return at prevailing prices for a grazed wheat production system would be maximized by planting and grazing somewhat later than common practice. Average optimum dates of planting and pull-off were Sept. 12 and Mar. 25. Later planting helps maintain grain yield with only a modest reduction in total cattle gain. Some of the grazing would, however, be moved from the fall to the spring. This may be unacceptable for some producers.

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