BENEFITS OF FERTILIZATION TO BEEF PRODUCTION FROM FORAGE WHEAT

J. W. Sij, W. E. Pinchak, S. J. Bevers, D. P. Malinowski, R. J. Gill,
T. A. Baughman, and D. L. Robinson
Texas Agricultural Research and Extension Center, Vernon, TX
jsij@ag.tamu.edu (940-552-9941 ext 232)

ABSTRACT

Wheat (*Triticum aestivum* L. em. Thell) production in the southern Great Plains is a unique enterprise that provides both high quality forage and a grain crop within the same growing season. However, information on nitrogen and phosphorous management programs to maximize forage and beef production in a winter-active, dual-use wheat production system is lacking. Field-scale production studies were initiated on a Tillman clay loam near Vernon, TX in 1999 to determine if increased forage production of 'Lockett' wheat from surface or subsurface injected P application could be captured in additional beef gains and increased profitability. Two production systems were evaluated: graze plus grain and graze-out. Applying 20 lb P per acre each year increased forage production 18 to 54% and animal gains per acre 27 to 29% compared with N alone. With respect to forage and subsequent beef production, surface-applied P was generally equal to or better than injected P. Data analysis showed that average returns among fertilizer treatments were not significant ($P = 0.26$), although surface applied P resulted in numerically higher returns each year. However, the graze-plus-grain system was clearly superior to the graze-out system ($38 vs. $12 /ac, $P < 0.0001$) in generating higher net returns over the study period. Nitrogen fertility management in dual-use wheat is complex due to the inclusion of cattle, and the need to maximize both forage and grain. Forage production had a near linear response to pre-plant N application. However, excess N can result in a serious animal health issue, bloat. Bloat was most pronounced in a pasture that received a pre-plant application of 120 lb N/ac and appears to be correlated with soluble plant proteins. The development of bloat is a very complex issue that involves the animal, weather, forage allowance, and N fertility.

INTRODUCTION

Nearly 20 million acres of hard red winter wheat are grown in the semiarid southern Great Plains. Dryland wheat production in this winter-active agricultural system is unique and versatile compared with other wheat-producing regions in the U.S. because of the common practice of utilizing wheat forage in stocker cattle grazing systems, with the option to terminate wheat grazing and still produce a grain crop. The use of winter wheat as a dual-use crop is a vital component of the agricultural economies of Texas, southern Kansas, eastern New Mexico, Oklahoma, and southeastern Colorado. Up to 80% of the wheat planted in the southern Great Plains is grazed annually. If cattle are removed from wheat in late winter at the first-hollow-stem stage of development, wheat will produce grain.

Dual-use wheat production is more complex and requires a higher level of management than wheat grown strictly for grain or forage. Cultivar selection, tillage, planting date, seeding rate, soil fertility management, and pull-off date are crucial to successful implementation of a dual-use winter wheat system. For example, factors to consider when choosing a cultivar include seedling emergence under early planting dates, grazing tolerance, vegetative regrowth, grazing duration, and timing of first-hollow-stem.

Nitrogen (N) and phosphorus (P) are essential in maximizing forage and grain production in nutrient-deficient soils. A soil deficiency in either or both nutrients can result in significantly less forage and grain yield. Unfortunately, there is little information on N and P fertilizer management under different tillage and fertilizer placement systems in dual-use wheat.

In wheat trials in the southern Great Plains of Texas, it has been reported that in five of eight site-year comparisons, deep placement of P increased forage yields 50% more than surface-applied P and 45% more than wheat fertilized with the same rate of N but no P fertilizer.

Our research hypothesis was that application of P to P-deficient soils would increase both wheat grain and forage yield, and subsequently, animal gain per unit area, and deep-placed P would provide additional efficiency and economic returns to wheat/stocker operations. The objectives of this study were to (1) determine the influence of P fertilizer and P fertilizer placement on forage, beef, and grain production from dual-use wheat, and (2) identify economic costs and returns associated with P fertilizer and P placement methods in dual-use wheat production in the Texas Rolling Plains.

A high research priority has been placed on no-till and reduced-till systems in a dual-use wheat/stocker enterprise, particularly development of efficient N and P fertility programs. Information on N fertility response of wheat in a no-till grazing system does not exist, although this knowledge is vital to successful implementation of no-till grazing systems.

Although N is essential for wheat forage production, excess N can be detrimental to cattle grazing wheat. The major source of death loss and depressed stocker cattle performance on wheat pasture is bloat, which is correlated with soluble plant protein. Nitrogen fertilization affects soluble protein in wheat. Manipulating and managing the amount and/or timing of N application may reduce the incidence of bloat and enhance returns in wheat/stocker operations.

The primary objective of this research is to identify N fertility levels that maximize forage and beef yields as well as maintaining grain yield and quality in no-till and conventional-till wheat/stocker production systems. A second objective is to document and quantify the effects of N fertility management on bloat potential.

MATERIALS AND METHODS

The winter wheat pasture study was conducted from mid-September through May during the growing seasons of 1999-2000, 2001-2002 and 2002-2003 on the Smith/Walker Research Unit of the Texas Agricultural Experiment Station approximately near Vernon, Texas.

The soil in the pastures is predominately Tillman clay loam (fine, mixed, superactive, thermic Vertic Paleustolls) of 0 to 2% slope. This soil has high water-holding capacity but low infiltration rates and slowly permeable subsoils that cause them to be drought prone or retain surface moisture during winter when there is low evaporative demand. Soils were sampled for nutrient analysis prior to fertilizer applications in August each year.

Fertilizers were applied in liquid formulations each year between 01 and 20 September. Three P fertilizer treatments were employed: 0 P, 20 lb P/ac broadcast on the soil surface, and 20 lb P/ac injected about 6 inches deep with 20 inches between injection points. Treatments were replicated three times in a randomized complete block design using nine, 25-acre pastures as experimental units. Fertilizer treatments were randomly assigned to pastures within blocks the first year of research in 1999 and maintained in the same pastures for the duration of the experiment. Nitrogen and sulfur (S) fertilizers were applied uniformly to all pastures at rates of 65 lb N and 20 lb S/ac in the same solutions with P fertilizer. Where no P was applied, the N and S solution was broadcast on the surface. All pastures were lightly tilled with a field cultivator immediately after fertilizer applications to incorporate the fertilizer and prepare a seedbed for planting wheat. "Lockett" wheat was planted between 18 and 30 September each year at the rate of 75 lb seed/ac.

Forage samples were dried in a forced-air oven and dry weights recorded. Grazing was initiated on 13 and 17 December and 15 January during the three years of the study. Animals were added to pastures to provide forage allowances of 11 to 16 lb dry matter per 90 lb body weight per day in each 25-acre pasture, based on forage weights taken during the prior week. Initial stocking rates were 8 to 15 head per pasture. Animals were weighed and forage yields were measured on approximately 28-d intervals throughout each season. At weigh dates, cattle were added or removed to re-establish the desired forage allowances.

At first-hollow-stem (around 1 March) two grazing exclosures (8 x 16 ft) were installed in each pasture for the remainder of the season to allow grain production, and thereby simulate a dual-use, graze-plus-grain system. Grazing was terminated in early May each year, creating a full-season graze-out system. Grain was harvested within the two randomly-placed cages using a small plot combine.

The experimental design comprised repeated measures and pastures as experimental units. Year was considered a random variable when comparing the two production systems. Data were analyzed using the Proc Mixed model procedure of SAS Institute (1996).

An economic analysis was completed for each treatment based upon grain yield and cattle gain for each experimental unit in order to compare economic costs and returns within each grazing management system. The economic results are reported as returns to indirect costs, land, and management. Direct expenses or typical costs associated with each production practice were used to determine total expenses per treatment and grazing system. Cattle expenses included labor, feed, minerals, hay, and veterinarian costs. All cattle expenses were recorded separately for the two grazing systems. Consequently, the cattle expense was a function of the treatment and the number of cattle that grazed each pasture.

The N fertility study was nested in a larger 35-acre pasture with free-ranging stocker cattle. Plots size was 20 ft by 100 ft. All fertilizer was surfaced applied as liquid material. Fertilizer treatments in each tillage system (no-till and conventional-till) included 0, 30, 60, 90, and 120 lb N/ac, with and without 45 lbs N/ac top-dressed in January in a randomized complete block design with 4 replications. "Cutter" wheat was planted mid-September at 60 lbs seed/ac. Plots were clipped periodically to determine forage production. Cattle were removed from pastures at the 'first hollow stem' growth stage to allow grain production.

In the bloat study beginning in November, cattle were observed weekly in production-size pastures (35+ ac) to assess the effect of three pre-plant N fertility treatments (30, 60, and 120 lbs N/ac) on bloat. Bloat severity was scored on a scale of 0 (no bloat) to 3 (severe bloat). Soluble and total crude protein in wheat forage was also determined.

RESULTS AND DISCUSSION

Phosphorus fertilizer applications increased wheat forage production each year of the study, with the greatest percentage increases occurring during the first grazing phase or prior to 1 March. Compared with no P application, forage production increased an average of 54% (620 lb/ac) and 18% (512 lbs/ac) before and after 1 March, respectively, due to P applications (Table

1). On an annual basis, P application increased forage production an average of 29% or 1135 lb/ac. Compared with N alone, the magnitude of the response to P increased each year of the study from 16% in 2000 to 47% in 2003. It was apparent that deep placement of fertilizers gave no advantage over surface application followed by incorporation, except in the fall of the first year.

Table 1. Mean forage production in grazed pastures of 'Lockett' wheat receiving three fertility practices in three management systems during 3 yr at Vernon, TX.

Fertilizer placement	Forage production through February				Annual Mean	Residue Mean
	2000	2002	2003	Mean		
	----------lb/ac----------					
N surface	1415 [b]	1180 [b]	835 [b]	1150 [b]	—	—
NP surface	1645 [b]	1905 [a]	1780 [a]	1770 [a]	—	—
NP deep	2090 [a]	1440 [b]	1790 [a]	1770 [a]	—	—
	Forage production from March - May					
N surface	2850	2635	3010 [b]	2830 [b]	3980 [b]	1790
NP surface	3350	3045	4210 [a]	3570 [a]	5340 [a]	2000
NP deep	2810	2980	3550 [ab]	3115 [a]	4890 [a]	1890

Phosphorus applications (deep- and surface-applied) increased average 3-yr animal gain per acre by 20 lb or 27% in the grazing phase prior to 1 March. Animal gain per acre was increased each year of the study, ranging from 21 to 39% higher with applied P. The forage allowance stocking strategy facilitated the capture of 93% (average 27% increase in beef production divided by an average 29% increase in forage production) of increased forage production in additional beef gain. Increased animal gains were statistically significant in only one year (2001-2002) because of the high degree of variability among replicates within treatments.

Greatest revenue was generated from surface-applied NP in the graze-plus-grain system (Table 2). In the graze-out management program, revenues were lower than those in the graze-plus-grain production system (Table 3). Again, revenues were highest with surface-applied NP, exceeding values for injected NP and N alone by \$7.45/ac and \$23.19/ac, respectively. Expenses were also greatest with surface-applied NP due to the higher stocking rate afforded by increased forage production. Net returns were highest with surface-applied NP, exceeding \$16/ac and nearly double those from N alone.

Table 2. Economic costs and returns from three soil fertility practices in a **graze-plus-grain** management system during 3 yr at Vernon, TX.

	Fertility placement		
	N Surface	NP Surface	NP Deep
	------------------------ $/ac-------------------------		
Revenue			
Grain	74.29	92.81	84.64
Cattle	23.81	29.50	30.81
FSA Payment	17.31	17.31	17.31
Total Revenue	115.41	139.62	132.76
Expenses	82.96	95.12	95.70
Net returns	32.45	44.50	37.06

Table 3. Economic costs and returns from three fertility practices in a **graze-out** management system during 3 yr at Vernon, TX.

	Fertility placement		
	N Surface	NP Surface	NP Deep
	------------------------$/ac--------------------------		
Revenue			
Cattle	69.15	92.33	84.88
FSA	17.31	17.31	17.31
Total Revenue	86.45	109.64	102.19
Expenses	77.91	93.07	91.85
Net returns	8.55	16.57	10.34

Increases in forage and beef production due to surface-applied P improved income sufficiently to exceed the cost of P fertilizer by nearly $8 (graze-out) to $12 (graze-plus-grain) per acre per year. The graze-plus-grain system was clearly superior ($P < 0.0001$) to the graze-out system in generating higher net returns over the study period. There was no significant difference ($P \geq 0.05$) in forage production to March 1, 2005 between conventional tillage and no-till production systems (Fig. 1). However, increasing amounts of pre-plant N resulted ($P \geq 0.05$) in increasing amounts of forage (Fig. 1).

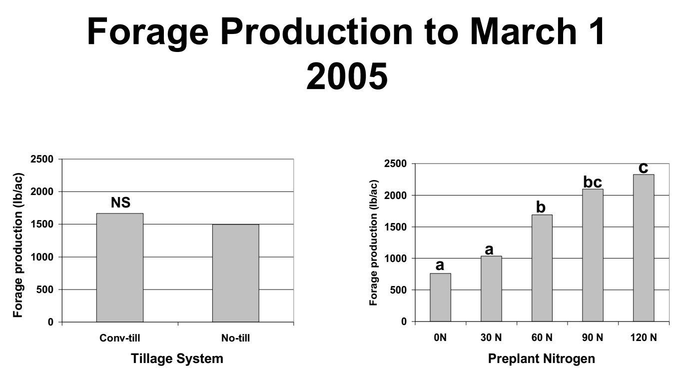

Figure 1. Wheat forage response to tillage and preplant N.

Unfortunately, with increasing N rate and subsequent lush forage, bloat can develop during the rapid vegetative growth stage of wheat in late winter and early spring. Results showed that increasing levels of pre-plant N resulted in increasing levels of bloat (Fig. 2).

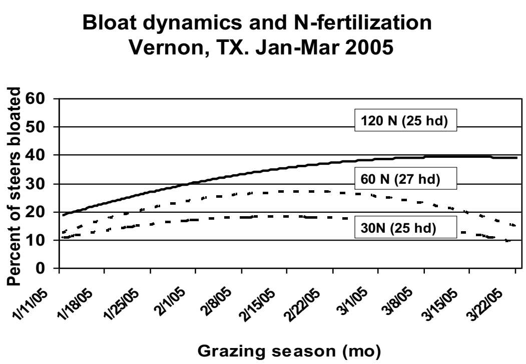

Figure 2. Effect of N fertility on bloat dynamics.

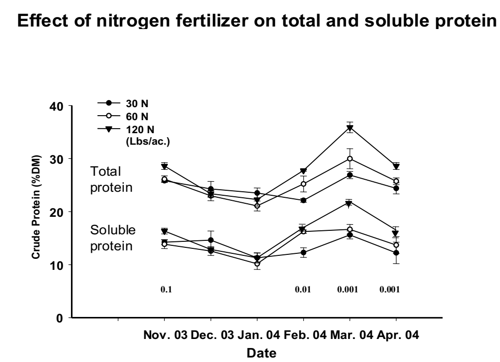

Figure 3. Time-course of N effects on total and soluble plant protein.

Bloat has been reported to be correlated with soluble plant protein levels. Figure 3 shows the relationship between soluble protein and pre-plant N during the time when bloat is observed.

Bloat was most pronounced in the pasture that received a pre-plant application of 120 lb N/ac. The development of bloat is a very complex issue that involves the animal, weather, forage allowance, and N fertility. We are developing management programs that attempt to find the optimum economic balance between forage production, grain yield, beef production, and reduced animal health risk.

ACKNOWLEDGEMENTS

The authors wish to thank the Fluid Fertilizer Foundation, the Potash and Phosphate Institute, and the Texas Wheat Producers Board for financial and in-kind support of this research.