PHOSPHORUS FERTILIZER EFFECTS ON FORAGE, BEEF AND GRAIN PRODUCTION FROM WINTER WHEAT

D.L. Robinson, J.W. Sij, W.E. Pinchak, R.J. Gill, S.J. Bevers, D.P. Malinowski, and T.A. Baughman
Texas A&M University System, Vernon, TX
dl-robinson@tamu.edu (940)-552-9941

ABSTRACT

Phosphorus fertilizer was surface applied or injected in a NPS solution and compared to a surface-applied NS solution to determine if fall forage production could be increased by P applications and to determine if the additional forage could be captured through beef production to make the P applications profitable. The experimental units were nine 25-acre pastures in which the three treatments were replicated three times and grazed with yearling stocker calves in two management systems: 1) graze from late fall through February and remove cattle to produce a grain crop, and 2) graze season-long from late fall through early May. During four years, forage was produced for grazing in three years and grain was produced each year. Four annual applications of 40 lb/A of P_2O_5 raised surface soil-test P levels from 9 or 10 ppm to 23 ppm; did not significantly increase grain yields; increased forage production by 35%, more dramatically prior to 1 March; and increased beef production by 32% in the graze-plus-grain system and by 34% in the graze-out system. There was no advantage to deep-placement of the fertilizers. Economic returns to land and management in the graze-plus-grain system averaged \$40 and \$32/A with surface applied and injected NPS fertilizer, respectively, and \$28/A with the NS fertilizer. The graze-out system was consistently less profitable, returning only \$12 and \$2/A with surface applied and injected NPS and \$4/A with no P in the fertilizers. Although both forage and beef production were increased by one-third and increased income sufficiently to exceed the cost of added P, the profit margin was very narrow in the graze-plus grain system and negative in the graze-out system. The study confirms our belief that grain production is still extremely important in Rolling Plains wheat-stocker cattle production programs.

INTRODUCTION

Nearly 20 million acres of hard red winter wheat are grown in the semiarid Southern Great Plains. The use of winter wheat as a dual-use crop is an extremely important component of the agricultural economies of Texas, southern Kansas, eastern New Mexico, western Oklahoma, and southeastern Colorado (Pinchak et al., 1996; Ralphs et al., 1997; Redmon et al., 1995; Shroyer et al., 1993).

The grazing value of winter wheat forage has been known since the 1930's (Schlehuber and Tucker, 1967). More recently, it has been estimated that 30 to 80% of the wheat planted is grazed to some degree (Krenzer et al., 1992; Pinchak et al., 1996; True et al., 2001). Depending on cattle and grain prices, farmers and ranchers have the option to either graze out wheat if cattle prices are high relative to wheat grain, or remove cattle and allow the wheat to develop grain if wheat prices are high relative to cattle.

Dual-use wheat production is more complex and requires a higher level of management than permanent pastures, wheat for pasture only, or grain only. Fertilizers, particularly N and P, are essential in maximizing forage and grain production in nutrient-deficient soils (Schlehuber and Tucker, 1967). A deficiency in either element or both can result in significantly reduced forage and grain yields. Unfortunately, there is little information on fertilizer management in dual-use wheat/stocker systems. Nitrogen requirements for forage, grain, and that removed by cattle can be estimated. However, the amount of P to be applied is less readily determined. Kaitibie et al. (2002) showed that for acid soils in the southern plains of Oklahoma, a broadcast application of lime before the initial season and 65 lb/ac of diammonium phosphate in the seed furrow *each year* was the most economically optimum strategy for dual-use wheat production over a 5-yr period (to amortize the cost of lime). In wheat trials in the southern Great Plains of Texas, Miller (1998) reported that in five of eight site-year comparisons, deep placement of P increased wheat forage yields 50% more than surface-applied P and 45% more than the same rate of N but no P fertilizer.

There is little question that application of P to P-deficient soils will increase both grain and forage yields. The question is "Can this increase in forage be captured in additional animal gain per unit area and would deep-placed P provide additional efficiency and economic return 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-purpose wheat, 2) Determine grazing termination date effects of grain yield and animal performance, and 3) Identify economic costs and returns associated with P fertilizer and P placement methods and length of grazing period of winter wheat in the Texas Rolling Plains.

MATERIALS AND METHODS

The winter wheat pasture study was conducted 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 eight miles south of Vernon, TX. Three P fertilizer variables; 0 P, 40 lb/A P_2O_5 broadcast, and 40 lb/A P_2O_5 injected 6 inches deep with 20 inches between knives, were replicated three times in a randomized complete block design using nine 25-acre pastures as experimental units. Fertilizers variables were applied to the same pastures each year between 01 and 20 September. Nitrogen and S fertilizers were applied uniformly to all pastures at rates of 62 lb N and 20 lb S/A in the same solutions with P fertilizers. 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 application to incorporate the fertilizer, control weeds, and prepare a seedbed for planting wheat.

Grazing was initiated on 17 and 13 December and 15 January during the three years, utilizing steers and heifers that initially weighed 430 to 490 lb and were approximately 10 months of age. During the 1999-2000 season, all animals were heifers. Animals were added to provide forage allowances of 12 to 18 lb DM/100 lb BW/day in each 25-acre pasture, based on forage weights taken during the prior week. Animals were weighed and forage yields were measured on approximately 28-day intervals. The data were used to adjust cattle numbers so that fairly uniform forage allowance was maintained among all treatments. At first hollow stem (ca. 1 March) two cages of 8 x 16 ft were installed in each pasture for the remainder of the season to prevent grazing and allow grain production inside the cages, simulating a dual-purpose graze-plus-grain system. Grazing was terminated in early May each year, creating a full-season-graze-out system. Grain was harvested with a small combine within the caged areas when the grain was mature and yields were determined.

RESULTS AND DISCUSSIONS

Although fertilizers were applied for four consecutive years, wheat planting was delayed by continuous rain until December in 2000, so no forage was available for grazing that year and only grain was harvested in spring of 2001. As shown in Table 1, the fertilizer applications of 40 lb/A P_2O_5 per year increased soil-test P levels in the soil surface from 9 or 10 ppm P to 23 ppm P during the four years. These data indicate that soil test P levels increased by one ppm for every 12 lb/A of P_2O_5 applied, consistent with values reported in the literature. However, the values reported here refer only to the top two inches of soil. The rapid increase in soil test P indicates that 40 lb/A of P_2O_5 exceeded the long-term fertilizer requirement for this cropping system.

Table 1. Soil test P levels at two soil depths and three fertilizer practices during four years on Tillman clay loam at Vernon, TX.

Fertilizer Applied	Soil Depth	Year 1999	2000	2001	2002	2003
	Inches	- - - - ppm Soil Test P[1/] - - - -				
NS surface	0-2	8	—	7	8	9
	2-6	2	—	4	2	4
NPS surface	0-2	10	—	18	21	23
	2-6	3	—	8	6	8
NPS Deep	0-2	9	—	16	17	23
	2-6	3	—	9	5	10

[1/] Values are means of 12 samples extracted with sodium bicarbonate. Critical level = 10 ppm P.

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. Data in Table 2 indicate that forage production increased 55% (630 lb/A) and 26% (740 lb/A) before and after 1 March 1, respectively, due to P applications. On an annual basis, P application increased forage production 35% or nearly 1400 lb/A. Furthermore, the response to P increased each year of the study. Although fall forage production is especially important to stocker cattle programs in the Southern Great Plains, the season-long increase in production is also very valuable and less recognized. It is apparent that deep placement of fertilizers gave no advantage over surface applications followed by incorporation. However, the location of knife rows could be identified visually by the larger, darker green wheat plants in late fall.

Because we attempted to keep forage allowance uniform among all pastures in the experiment, animal gain per head per day (ADG) and gain per head would be expected to be the same in all pastures. Animal gain per acre should reflect the differences in forage production among pastures through higher stocking rates and thus more gain per acre in pastures with more

Table 2. Mean forage production in grazed pastures of 'Lockett' wheat receiving three soil fertility practices in two management programs during three years at Vernon, TX.

Fertilizer Applied	Forage[1/] production through February 2000	2002	2003	Mean	Residual	Annual
	- - - - - - - -	- - - - - -	lb/A	- - - - - -	- - - - - -	- - - - - -
N surface	1420[b]	1190[b]	835[b]	1150[b]	—	—
NP surface	1650[b]	1910[a]	1785[a]	1780[a] (55%)	—	—
NP deep	2095[a]	1450[b]	1795[a]	1780[a]	—	—
	Forage[1/] production from March through May					
N surface	2860	2640	3015[b]	2840[b]	1795	3985[b]
NP surface	3360	3155	4220[a]	3580[a] (26%)	2010	5360[a] (35%)
NP deep	2825	2995	3565[ab]	3125[a]	1890	4905[a]

[1/] Forage yields were estimated as the difference between forage weights in caged and uncaged areas taken one month apart.

forage production. The data in Table 3 show that ADG and gain per head were very similar among treatments. Phosphorus applications increased average animal gain per acre by 23 pounds or 32% during three years in the grazing phase prior to 1 March. Increased gains per acre were statistically significant in only one year, 2001-2002. During the three years, grain yields were not significantly increased by P fertilization although yields increased by as much as nine bushels per acre in 2003.

Table 3. Beef and grain production from 'Lockett' wheat grown with three soil fertility practices for three years in a **graze-plus-grain** management system at Vernon, TX.

Fertilizer Applied	Beef Gain Per: Head/Day Mean	Head Mean	Acre: 1999-2000	2001-2002	2002-2003	Mean	Grain Yield 2003	Grain Yield Mean
	- - - - - -	- - - - - -	pounds	- - - - - -	- - - - - -	- - - - - -	-----Bu/A-----	
N surface	2.2	161	85	70[b]	62	72	32	26
NP surface	2.3	170	102	103[a]	81	95 (32%)	38	28
NP deep	2.4	175	108	78[b]	90	92	41	31

[1/] Means from three years of data.

Under the graze-out management system (Table 4), ADG and gain per head were both unaffected by P applications. Gain per acre increased each year of the study but was significantly increased only in 2002-2003 and as an average of the three years. Three-year average values for animal gain per acre increased by 71 lb/A or by 34%.

Table 4. Beef production from ‘Lockett’ wheat grown with three soil fertility practices for three years in a **graze-out** management system at Vernon, TX.

	Beef Gain Per					
			Acre			
Fertilizer Applied	Head/Day Mean	Head Mean	1999-2000	2001-2002	2002-2003	Mean
	- - - - - - - - - - - - - - - - - - - -pounds -					
N surface	2.7	203	180	219	229[b]	209[b]
NP surface	2.5	188	250	265	324[a]	280[a] 34%)
NP deep	2.7	201	231	230	310[a]	257[a]

An enterprise budget was created for each replication of each fertilizer treatment in order to compare economic returns within each grazing management system. Table 5 contains income, direct expenses, and returns for the three fertilizer practices in the graze-plus-grain system. Three-year means show that where no P was applied, income averaged $111 per year while income averaged $135 and $128 per year where P was surface applied and knifed, respectively. Direct expenses were similar among treatments except that P application increased costs by roughly $12/A. Returns of $32 to $40/A where P was applied, compared to $28/A without P, largely reflect the increased income resulting from applied P. In 2003 the returns were more favorable but trends were similar. The returns do not include indirect expenses or the costs of land and management.

Table 5, Economic returns from three soil fertility practices on ‘Lockett’ wheat in a **graze-plus-grain** management program during three years at Vernon, TX.

	N surface		NP surface		NP deep	
	2003	Mean[1/]	2003	Mean	2003	Mean
	- dollars/acre -					
Income						
Grain	92	72	120	91	109	83
Cattle	20	22	27	27	30	28
FSA	12	17	12	17	12	17
Total	124	111	159	135	151	128
Expenses	92	83	106	95	107	96
Returns[2/]	33	**28**	53	**40**	44	**32**

[1/]Means from three years of data. [2/]Returns to indirect costs, land and management.

Economic components of the graze-out management system are contained in Table 6. Again, income in the presence of P applications averaged roughly $20/A more than where no P was applied. Direct expenses averaged about $15/A more with applied P than without. Resulting returns were considerably lower in the graze-out-system, averaging only $4/A without

P and $2 to $12 with P application. Again, the trends were similar in 2003, although the returns were more favorable.

Table 6. Economic returns from three soil fertility practices on 'Lockett' wheat in a **graze-out** management program during three years at Vernon, TX.

	N surface		NP surface		NP deep	
	2003	Mean[1/]	2003	Mean	2003	Mean
	- - - - - - - -	- - - - - - - -	- - - - - - - -	dollars/acre - - - -	- - - - - - - -	- - - - - - - -
Income						
Cattle	76	65	107	88	102	77
FSA	12	17	12	17	12	17
Total	88	82	119	105	114	94
Expenses	86	77	102	93	103	92
Returns[2/]	2	**4**	17	**12**	11	**2**

[1/]Means from three years of data. [2/]Returns to indirect expenses, land and management.

CONCLUSIONS

Phosphorus applications of 40 lb/A P_2O_5 per year for four consecutive years increased soil test P levels of the soil surface from 9 or 10 ppm to 23 ppm P, indicating that the long-term fertilizer requirement was exceeded and resulting in a valuable soil P reserve that would influence crop yields for several more years. Increases in forage and beef production by roughly one-third increased income sufficiently to exceed the cost of P fertilizer applications by as much as $12/A during three years. Economic returns to indirect expenses, land and management were marginal in the graze-plus-grain system, which generated income from both cattle and grain. Returns would not cover land costs in the graze-out system, which derived all income from cattle gains. In the Rolling Plains it appears that profitable wheat/stocker operations are closely tied to grain harvest as well as effective utilization of wheat as a forage crop.

REFERENCES

Kaitibie, S., F.M. Epplin, E.G. Krenzer, Jr., and H. Zhang. 2002. Agron. J. 94:1139-1145.

Krenzer, E.G., Jr., J.D. Thompson, and B.F. Carver. 1992. Crop Sci. 32:1143-1147.

Miller, T. 1998. Better Crops 82:26-28.

Pinchak, W.E., W.D. Worrall, S.P. Caldwell, L.J. Hunt, H.J. Worrall, and M. Conoly. 1996. J. Range Manage. 49:126-130.

Ralphs, M.H., D. Graham, M.L. Galyean, and L.F. James. 1997. J. Range Manage. 50:250-252.

Redmon, L.A., G.W. Horn, E.G. Krenzer, Jr., and D.J. Bernardo. 1995. Agron. J. 87:137-147.

Schlehuber, A.M., and B.B. Tucker. 1967. Wheat and Wheat Improvement. ASA, CSSA, SSSA, Madison, WI.

Shroyer, J.R., K.C. Dhuyvetter, G.L. Kuhl, D.L. Fjell, L.N. Langemeier, and J.O. Fritz. 1993. Cooperative Ext. Ser. Rpt. C-713 KSU, Manhattan, KS.

True, R.R., F.M. Epplin, E.G. Krenzer, Jr., and G.W. Horn. 2001. Oklahoma Agric. Exp. Sta. B-815, OSU.