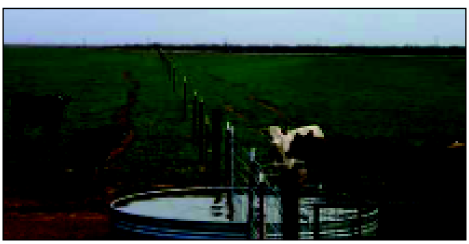
Phosphorus Fertilizer Impacts Forage, Beef, and Grain Production from Wheat

By D.L. Robinson, W.E. Pinchak, J.W. Sij, S.J. Bevers, R.J. Gill, D.P. Malinowski, and T.A. Baughman

Phosphorus (P) fertilizer increased 3-year average winter wheat forage yield in the Texas Rolling Plains by 55% during early production from planting to March. Season-long forage yield was increased 35% by P fertilizer. Additionally, stocker cattle gain was significantly affected by P fertilizer...beef gain increased over the no P control by 25% in the early season and 34% during the entire season. Surface applied P was consistently as good as or better than deep banded P fertilizer. Economic analyses indicated that the graze-plus-grain system was more profitable than the graze-out system. Net return to P fertilizer in the graze-plus-grain system was as high as $12/A.

Hard red winter wheat is grown on nearly 20 million acres in the Southern Great Plains, with about 6 million acres grown in Texas. The crop is uniquely used in the region as forage for winter grazing of stocker cattle, with the option of also producing a grain crop if grazing is terminated prior to jointing (graze-plus-grain system). Some producers utilize the crop entirely as forage by grazing until maturity (graze-out system). Estimates indicate that about 70% of the crop is grazed prior to jointing and 40 to 45% is grazed season-long. Regardless of how wheat is utilized, it is extremely important to the economy of the Southern Great Plains.



Four annual applications of P increased early-season wheat forage production by 55% and beef production by 25% in the graze-plus-grain system. The study confirms that grain production is still important in Rolling Plains wheat-stocker production systems.

Nitrogen (N) and P are the two most widely recognized nutrient deficiencies in soils of the Texas Rolling Plains. Unfortunately, there is very little data available to form the basis of fertilizer management practices in dual-use wheat programs. Previous work in the Rolling Plains showed that knifed NP fertilizer increased fall forage yields 50% over surface applied NP and 45% over N alone in 5 of 8 site-years. Deep-placed NP increased grain yields over surface-applied NP and N alone in 6 site-years by 2.0 and 9.9 bu/A, respectively.

Our study was conducted in the Rolling Plains on the Texas Agricultural Experiment Station's Smith/Walker Research Unit near Vernon to determine if increased forage production from P applications could be captured as additional beef gains and increased profitability. The study was on a Tillman clay loam soil. The initial average soil pH (0 to 6 in. depth) of the pastures was 7.1 (range 6.4 to 7.9), and the average organic matter content (0 to 6 in. depth) was 1.7% (range 1.2 to 2.3%). Soil potassium (K) level was very high to high in all pastures. The three fertilizers were applied pre-plant as solutions that supplied 20 lb S/A. Tillage with a field cultivator immediately followed fertilizer applications. The N rate was 65 lb/A and the P_2O_5

rate 40 lb/A applied to the same pastures each year for 4 years. Forage was available early enough to graze in 3 of the 4 years. Statistical differences were evaluated at the 5% level of significance.

Soil Test Phosphorus Effects

Like many soils in the Rolling Plains, most of the P in the soil at the experimental site was in the surface 2 in. (**Figure 1**). Original values averaged 8 to 10 parts per million (ppm) P at the 0- to 2-in. depth and 2 to 3 ppm at the 2- to 6-in. depth. Values at both depths increased during the 4 years where P was applied, reaching 24 ppm P in the top 2 in. and 8 to 10 ppm in the 2- to 6-in. layer. Method of P application did not affect soil test results. The 2- to 3-fold increase in soil P values in 4 years indicates that 40 lb P_2O_5/A/year exceeded the long-term P requirement of this soil and crop management program. Values exceeding about 15 ppm P are considered sufficient. The higher soil test values are an asset but are not accounted for in the economic analysis at this time.

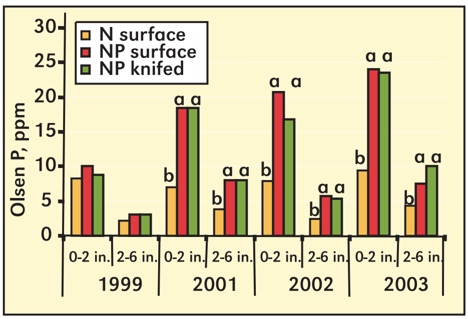


Figure 1. Phosphorus fertilizer influences on soil test P at two depths. Phosphorus was applied at 40 lb P_2O_5/A/year.

Forage Yield Responses

Forage yields consistently increased in response to P applications during the 3 years (**Table 1**), but there was no apparent advantage to deep placement of the P fertilizer. Forage production from planting until March 1, the average date of jointing, increased by 630 lb/A, or 55% where P fertilizer was applied. During the graze-out phase, from March 1 to early May, surface-applied NP increased average forage yields 740 lb/A, or 26% over N alone. Annual forage yields for the 3 years were 3,985 lb/A for N alone, 5,360 lb/A for surface-applied NP, and 4,905 lb/A for knifed NP…an increase in forage yield of 1,375 lb/A, or 35% due to surface-applied P.

Table 1. Forage production in grazed wheat pastures receiving three fertilizer treatments during 3 years.

Fertilizer	Planting to March 1	March 1 to May	Total
	- - - - - - - - - - lb forage/A	- - - - - - - - - -	
N Surface	1,150[b]	2,840[b]	3,985[c]
NP Surface	1,780[a]	3,580[a]	5,360[a]
NP Knifed	1,780[a]	3,125[ab]	4,905[b]

Increases in fall forage production were clearly visible in the pastures. The higher level of forage production that continued into spring, although at a reduced rate, is a further benefit from P applications that has not been fully recognized.

Beef Gains

In the graze-plus-grain system, stocker calves (initial weight 400 to 500 lb) grazed from early December through February, when grazing was terminated to allow the wheat to produce a grain crop. In the graze-out system, stocker calves grazed wheat from early December into May, utilizing the crop entirely for forage.

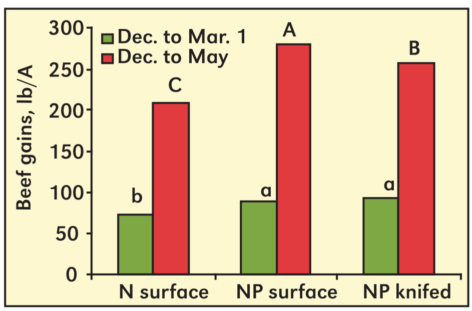


Figure 2. Phosphorus fertilizer influence on beef gain from wheat pasture during three years. December to March represents the graze-plus-grain system, while December to May is the graze-out system.

Figure 2 shows that P fertilizer increased average beef production per acre in both grazing systems during the 3 years regardless of how it was applied. In the graze-plus-grain system, there was no difference in beef gain between surface-applied or knifed NP fertilizer, with beef production increasing by 17 to 21 lb/A, or about 25% over N alone. In the graze-out system, surface-applied NP produced over 70 lb/A, or 34% more beef than N alone and 23 lb/A, or 9% more beef than knifed NP. The knifed NP treatment produced 48 lb/A more beef gain than surface-applied N alone.

Table 2. Costs and returns associated with three fertilizer treatments within two wheat management systems.

	Graze + Grain			Graze-out		
	N Surface	N+P Surface	N+P Knifed	N Surface	N+P Surface	N+P Knifed
Revenue	$/A					
Grain	74	93	85	–	–	–
Cattle	24	29	31	69	92	85
FSA [1]	17	17	17	17	17	17
Total	115	139	133	86	109	102
Expenses	83	95	96	78	93	92
Net returns [2]	32	44	37	8	16	10

[1] Land payments from USDA-Farm Services Administration (FSA).
[2] Net returns to indirect costs, land, and management.

Grain Yields

Grain yields subsequent to grazing in the graze-plus-grain system during the 3 years averaged 26 bu/A with N alone, 32 bu/A with surface-applied NP and 29 bu/A with knifed NP. Yields were not statistically different, although they trended higher where P was applied.

Economic Costs and Returns

A summary of costs and returns associated with each fertilizer treatment within each wheat management system is presented in **Table 2**. In the graze-plus-grain system, most of the income came from grain sales, which was $11 to $19/A higher where P was applied. Income from cattle was $5 to $7/A more where P was applied, resulting in total revenues of $24 to $18/A more due to P applications. The cost of 40 lb P_2O_5/A was about $12/A, accounting for most of the added expense where P was applied. Net returns to land, management, and other indirect costs from surface-applied P during the 3 years averaged $44/A, or $12/A more than where no P was applied. These returns show that surface-applied P returned $12/A above the cost of P fertilizer. No statistical differences in net returns could be detected among fertilizer treatments.

In the graze-out system, beef gains generated about three times more income than in the graze-plus-grain system, but was insufficient to compensate for the loss of income from grain. Total income from beef gains was $16 to $23/A more where NP was applied than where N was applied alone. Expenses were about $15/A higher where P was applied, due to P fertilizer costs plus additional labor costs for handling more cattle at the higher stocking rates. Net returns were lower from all fertilizer practices in the graze-out than in the graze-plus-grain system. Net returns from surface-applied P exceeded the cost of the P fertilizer and paid an additional $8/A over net returns where no P was applied. Although net returns trended higher with P application, no statistical differences were identified in the economic data.

In this Texas Rolling Plains study, application of P fertilizer to winter wheat on a Tillman clay loam soil increased soil test levels 2- to 3-fold. Phosphorus fertilizer increased forage production over 55% during fall and winter, and over 26% during spring. Beef gain per acre increased about 25% due to P applications in the graze-plus-grain system where wheat was grazed from early December until March 1. Wheat grain yields following grazing trended higher with P applications, but increases averaging as much as 6 bu/A were not significant. Beef gains in the graze-out system, where the wheat was utilized entirely as a forage crop, increased 34% where P was surface-applied and 23% where P was knifed into the soil. In all cases, surface-applied P fertilizer was equal to or better than P knifed into the soil. A greater advantage to knifed P would be expected at very low soil test P levels and very low P application rates.

Although results from economic analyses of each treatment were not statistically different, surface-applied P produced the highest net returns in each system, averaging $44/A in the graze-plus-grain system and $16/A in the graze-out system. In addition to paying for the P fertilizer, surface-applied P returned $12/A and $8/A in the two management systems.

Net returns to land, management, and other indirect costs were consistently higher in the graze-plus-grain than in the graze-out system, indicating that grain production is a major factor in profitability of wheat/stocker programs in the Texas Rolling Plains. BC

Dr. Robinson is Professor and Resident Director; Dr. Pinchak is Associate Professor; Dr. Sij is Professor; and Dr. Malinowski is Assistant Professor, all in the Texas Agricultural Experiment Station, Vernon. Mr. Bevers is Associate Professor and Dr. Baughman is Associate Professor, Texas Cooperative Extension at Vernon. Dr. Gill is Professor in Texas Cooperative Extension at Dallas.
PPI/FAR Research Project TX-44F.

Straw Management… *(continued from page 7)*

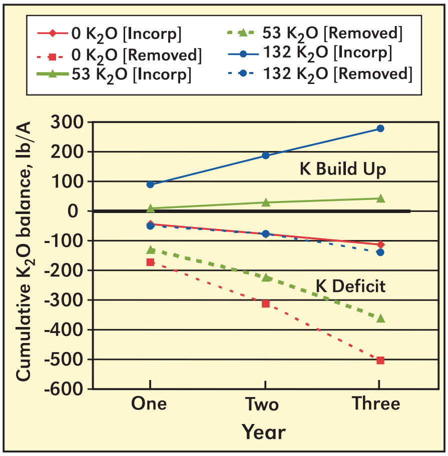


Figure 3. Potassium balance for 3 years of rice production, as affected by straw management (incorporated or removed) and K fertilizer addition (0, 53, or 132 lb K_2O/A).

Changes in straw management practices have an impact on a number of related issues. For example, an increase in methane production (a greenhouse gas) from rice fields occurs when straw is left in the field under flooded conditions. However, increases in soil carbon that follow from straw incorporation may reduce the amount of carbon dioxide emitted to the atmosphere. Additionally, winter flooding which increases the decomposition of rice straw also creates valuable habitat for millions of migratory and wetland-dependent birds along the Pacific Flyway in northern California.

Rice straw is a valuable source of plant nutrients and its management can make a significant impact on the following crop. The rice industry is working to develop off-field uses for rice straw with the goal of converting crop residues to a profitable resource. Current research shows that straw removal removes large amounts of nutrients which must be replaced to sustain yields. Careful management of rice straw will slow the export of nutrients from the soil, reduce production costs, and eliminate air quality concerns associated with burning…all while maintaining a high level of grain production. BC

Mr. Byous and Mr. Jones were graduate students, and Dr. Horwath is Associate Professor in the Department Land, Air & Water Res., Univ. of Calif., Davis. Mr. Williams (retired) was Univ. of Calif. Coop. Extension Director and Farm Advisor in Sutter and Yuba counties. Dr. van Kessel is Professor and Chair of the Department of Agronomy & Range Science, Univ. of Calif., Davis; e-mail: cvankessel@ucdavis.edu.

Acknowledgments

The financial support of the Fertilizer Research and Education Program (FREP) of the California Department of Food & Agriculture and PPI/FAR is highly appreciated. PPI/FAR Research Project CA-21F.