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Deep Phosphorus Banding in Winter Wheat
A Risk Management Tool for the Southern Great Plains

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Introduction

The southern Great Plains is home to approximately sixteen million acres of winter wheat. Wheat is widely planted in this region because of its great ability to compensate for extremes in weather. Rainfall in this wheat growing region may range from 10 to 50 inches per year, and distribution of that rainfall may place to crop in jeopardy of injury from both flood and drought conditions in one growing season. In much of Texas, Oklahoma and portions of New Mexico, Kansas and Colorado, wheat is an dual purpose crop, with winter pasture and grain production both being of great importance to farmers and ranchers. It is estimated that Texas wheat growers graze more than 70 per cent of the crop, and that 40 to 45 per cent is grazed the entire season with no grain harvested. In wheat production systems such as this, fertilizer management to enhance early forage production is of near equal importance to practices which optimize grain yield. Early forage production is the key to utilizing fall rains and to enhancing stocking rates of cattle through the winter.

Late August through early October is typically a high rainfall period, as the first cold fronts from the north collide with Gulf moisture, resulting in long bands of thundershowers which drift from northwest to southeast across the region resulting in rainfall accumulations of 3 to 4 inches per month. The October through March period tends to be a very dry time of the year, with monthly averages below one inch per month or lower accumulations than is utilized by the wheat crop, resulting in a deficit moisture condition. Wheat for grazing is planted early to optimize vegetative growth, which is the forage that carries cattle through the winter. This rapid early growth tends to deplete surface moisture. If we look at mobile fertilizer elements such as N, this does not pose a problem as active roots in the lower soil profile continue to supply the crop with N. With P, we begin to quickly see a yield limiting situation with conventional fertilizer application techniques.

The P deficiency condition results from stratification of nutrients in the soil. Farmers in the southern Great Plains use few tillage operations which invert soil, so that applied fertilizer P tends to accumulate in the top two to three inches of the soil profile. When the soil is moist, and wheat roots are active, this P is taken up and used by the crop to good effect, but as the crop reaches deficit moisture conditions in the fall and winter, this P enriched zone reaches moisture deficits which prevent active root uptake of fertilizer. Although the wheat continues to grow and make good use of water from lower in the soil profile, the crop is nutrient deficient with respect to immobile elements which are were either placed on the soil surface or subjected to shallow incorporation prior the drilling of the wheat crop.

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Based upon studies reported in this article and numerous others, phosphorus is of great importance in establishing tillers, a deep, massive root system, and the fall vegetative growth that is the basis of the stocker cattle enterprises of farmers and ranchers. These studies clearly indicate that when lack of fall moisture limits activity of roots near the surface, and P is incorporated by conventional P fertility programs, forage yields are greatly increased by deep P application. It is theorized that these dramatic responses in forage growth are associated with better moisture availability associated with the location of the fertilizer band in the soil profile and the subsequent increased availability of fertilizer P over a greater percentage of the growing season. It is clear that lower wheat forage yields can be largely attributed to P deficiency, particularly early season P deficiency, and that conventional P incorporation technology results in fertilizer which is not readily available during the dry fall weather common to much of the southern Great Plains.

Beef cattle is the largest agricultural enterprise in the Southern Great Plains. The potential for enhanced forage yields and the resultant increase carrying capacity under drought conditions has very large implications. Drought and the fear of drought weighs heavily in the management plans of most farmers and ranchers in this production region. In good (wet) conditions, properly managed wheat pastures can generate 3000 to 4500 pounds per acre dry weight forage, which, when judiciously grazed can result in 200 to 400 lbs/ acre weight gain in light weight stocker calves. In dry years, forage yield might be realistically reduced to 750 to 1500 pounds of dry matter. In fields such as these, farmers may deem forage supplies inadequate to turn cattle into the fields. As wheat pasture is commonly leased on a gain basis, and \$35/ cwt gain is a widely used contract price, gross income from wheat pasture leases can vary from zero to \$150 per acre. As approximately 10 million acres of wheat are grazed annually in this production region, the economic potential for a system to improve yields on the high risk or dry years in enormous with respect to farmers, ranchers and the agricultural industry as a whole. Those years with zero return for fertilizer dollars invested are a great deterrent to further investment in fertilizer by farmers, and certainly a drain on the financial bottom line. This article highlights research conducted in the Texas Rolling Plains evaluating the effect of P fertility and its placement on wheat forage and grain yields. The results clearly indicated that P fertilizer is a key component in forage and grain yields in dry years in wheat production systems in the Southern Great Plains and that wheat farmers are at less risk of a crop failure due to drought when P is deep banded preplant than with conventional fertilizer application techniques or when no P fertilizer is applied.

Materials and Methods

In each trial, plots were planted early relative to the optimum date for grain production in winter wheat. This is common in the wheat-stocker cattle production system, as early heat units drive the forage production upon which the stocker cattle component of the system depends. Fertilizer was applied in all trials except those at Abilene as a fluid ammonium polyphosphate (10-34-0). Trials at Abilene compared 11-52-0 (MAP) banded at the 6 inch depth with an air seeder at the same rate surface applied with air boom and incorporated prior to planting. The Abilene trials used anhydrous ammonia as the N source, while UAN was the N source on the other trials. The Abilene trial was treated with 80 lbs N/ac, the other sites with 50 lbs N/ac. Other banded applications were injected on 10 inch centers at a depth of 8 inches preplant. Surface incorporated treatments were dribbled on the surface and then incorporated either with a disc or field cultivator. Rate of application was 40 lbs/acre of P_2O_5, with the exception of the Abilene site where the rate was 50 lbs/ac. Wheat was sewn on planting dates from mid-September to early October with a plot drill on 10 inch centers. Forage was hand clipped using a small frame; oven dried and weighed. Grain yield was determined with a machine harvest by a Hege plot combine. Plot design was a Randomized Complete Block with either 3 or 4 replications.

Results and Discussion

In these trials, forage dry matter yield response was greatest to deep, banded P relative to surface incorporated P or the untreated check in dry years (Table 1). In 5 of 8 site-year comparisons in the Texas Rolling Plains, deep banded P resulted in forage yields 50% greater (850 lbs/acre forage) than wheat treated with the same rate of surface incorporated P and 45% greater (796 lbs/acre forage) than wheat treated with the same rate of N but no P fertilizer. In 4 of the 5 sites, fall weather was abnormally dry while at the fifth site, weather would be considered average. From this we can see two clear effects. The first is that P placement significantly improved forage yield; the second is that P use efficiency with respect to forage yield with surface incorporated P in dry fall weather was nil.

In six trials where valid comparisons of grain yield were made between P placement techniques, three yielded significantly higher with deep placed P, with the yield average of deep banded P being 8.4 and 10.5 bu/acre greater than the surface incorporated treatment and the untreated check, respectively (Table 2). This represents a yield increase of 57 and 83 percent under very dry growing conditions. In two trials, there was no difference between P placement techniques with respect to grain yield. In one trial during a very wet growing season, wheat fertilized with the surface incorporated P yielded more than the deep, banded P treatment. Averaged over six sites, deep banded P resulted in grain yields of 2.0 and 9.9 bu/ac greater than the surface incorporated P and untreated check, respectively. In two sites (Wichita '95 and Abilene '96) where drought drastically limited grain yield, no response was obtained to N fertilizer alone or N fertilizer with surface incorporated P, but significant yield response was obtained with deep, banded P and N.

Conclusions

There has been a widespread perception among wheat farmers that fertility applied in drought conditions was risky, and that fertilizer dollars were better spent elsewhere when the weather did not cooperate. This article proves them both correct and highly in error. When P fertilizer was applied in the traditional manner by surface application followed by incorporation, no effect was visible with respect to forage yield in average to dry fall weather, and in years where dry weather continued through grain fill, little effect was noted in grain yield. In two trials, neither grain nor forage yield was effected by P or N fertilizer when surface applied and shallow incorporated. In these same trials significant and economic yield responses were observed in both grain and forage yield when P fertilizer was deep banded. In short, it appears that reevaluating P application technology may well be one of the more important risk management tools that can be used by wheat farmers who rely on income from grazing and grain production in the southern Great Plains.

Table 1. Response of Wheat Forage to Fertilizer Placement — Texas Rolling Plains

Location	Year	Forage Yield[1], lbs/acre			
		Deep P + N	Surface P + N	N Only	Check
Runnels	1988	2583 a	1595 b	1482 b	
Wichita	1995	2357 a	1238 b	1257 b	1199 b
Baylor	1994	2552 a	1248 b	1568 b	
Baylor	1995	4295 a	3757 b	3615 b	3607 b
Abilene	1995	2598 b	4770 a	2200 c	
Abilene	1997	580 a	483 a	477 a	259 b
Young	1997	1050 a	749 bc	935 b	598 c
Wichita	1997	1003 a	929 a	912 a	
Average		**2290**	**1846**	**1556**	

[1]Yields in the same row followed by the same letter are not different according to L.S.D. test at 95% level of confidence.

Table 2. Response of Wheat Grain Yield to Fertilizer Placement — Texas Rolling Plains

Location	Year	Forage Yield[1], lbs/acre			
		Deep P + N	Surface P + N	N Only	Check
Runnels	1988	31.0 a	25.8 b	20.8 c	
Baylor	1984	46.0 a	47.0 a	35.0 b	
Baylor	1995	41.4 a	39.2 a	39.1 a	27.9 a
Wichita	1995	16.4 a	5.1 b	4.8 b	3.5 b
Abilene	1995	34.0 b	48.5 a	19.5 c	
Abilene	1996	22.0 a	13.2 b	12.21 b	7.7 d

[1]Yields in the same row followed by the same letter are not different according to L.S.D. test at 95% level of confidence.

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