PHOSPHORUS MANAGEMENT ON EXTREMELY ACID SOILS IN SOUTH CENTRAL KANSAS

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ABSTRACT

Research was conducted to evaluate the effectiveness of phosphate fertilizer in reducing the toxicity of soluble aluminum (Al) on very acidic soil for production of winter wheat. Banded P fertilizer increased wheat grain yields significantly with the response being greater on unlimed compared to lime conditions. Based on the findings of this research coupled with Oklahoma State University research, banded P is an alternative to liming for wheat production on extremely acidic soils with considerable soluble Al. Results also confirm variety selection is important on acidic, high soluble Al soils.

INTRODUCTION

Acidic soils have existed in southcentral Kansas for many years, but lime rate studies conducted in the past on sites with water pH's in the low 5's have not resulted in grain yield responses on wheat or grain sorghum, the dominate crops in the area. In spite of this lack of response liming has been recommended to farmers on soils with pH's below 5.5. In most cases, however, producers have ignored lime recommendations because research and on-farm trials had not proven liming to be profitable for short-term economics, especially considering that lime is not readily available in the area making it relatively expensive. Lack of lime response has been attributed to growing crops relatively tolerant of low pH's and to subsoil pH's being neutral to calcareous.

The situation has changed in recent years. Farmers have observed poor emergence and poor early season growth of wheat. Further investigation of these fields revealed soil pH's in the poor growth areas are below 5.0 and a significant amount of KCl extractable aluminum (Al) exists. In most cases soil test results also show high to very high Bray and Kurtz-1 extractable P. Lime rate studies with wheat have resulted in tremendous grain yield responses. As an example, the Kingman County location in Table 1 shows that four-year average grain yields were more than doubled by liming. The full rate of lime is the rate of effective $CaCO_3$ (ECC) to neutralize two million pounds of soil. One fourth the full rate of recommended lime (1.5 tons ECC/a) was as effective as the full rate. After 4-years the 1/4 rate of lime had not increased soil pH much, but had markedly lowered the KCl-extractable Al. Concurrent research has shown a marked difference among wheat varieties in their tolerance to these very acid soils. Farmers are using aluminum tolerance as one of the factors in their selection of wheat varieties especially in cases where the landlord is reluctant to lime.

With lime quarries more than a 100 miles from some of acidic fields, farmers have looked for alternatives to ag-lime. Phosphate fertilizer is known to react with Al in soil solution and could be used to reduce Al toxicity. With P soil test results showing high to very high available P levels, on many of these extremely acid soils, response to P application

seemed unlikely, however, farmers have reported responses to starter-bands of P fertilizer. Their visual observations are based on the malfunction of the fertilizer applicator on the drill leaving a check strip for comparison. Recently, Oklahoma State University researchers (Johnson et. al., 1991) have reported excellent response to banded P on wheat in north central Oklahoma on extremely low pH soils. Their research has shown phosphate fertilizer applied with the seed to be effective in increasing early season growth and grain yields. Their research confirms that the phosphate fertilizer reacts with the soluble Al in the seed zone to reduce the Al toxicity to the seedlings resulting in good early growth of the wheat allowing roots to reach much higher pH subsoils. Their research has been conducted on extremely acidic soils without a lime application variable to ascertain if the phosphate is as effective as liming.

OBJECTIVES

In the summer of 1991 research was initiated in southcentral Kansas to evaluate the effectiveness of phosphate fertilizer as an alternative to ag-lime in overcoming the toxic effects of extremely acidic soils for wheat production. We also wanted to compare wheat varieties of different Al tolerance because variety selection has proven to be effective for moderately acidic soils.

METHODS

Two locations in southcentral Kansas in Sedgwick and Saline Counties on cooperator fields were found for us by the county extension agricultural agents. The Sedgwick County site is on a Farnum silt loam (Fine-loamy, mixed, thermic Pachic Argiustolls) and Saline County site is on a Crete silt loam (Fine, montmorillonitic, mesic Pachic Argiustolls). Selected chemical characteristics of these sites are shown in Table 2. The studies, initiated in the fall of 1991, consisted of three lime rates (0, 3750 and 7500 lb ECC/a), three P treatments (none, 40 lb P_2O_5/a broadcast and 40 lb P_2O_5/a banded with the seed) and two varieties (Karl, fairly sensitive to Al; and 2163, somewhat tolerate to Al) in a split-plot design with lime rates being the main plots and the P rates and varieties as the subplots. The lime and broadcast P treatment were applied in late July with incorporation by the cooperator. Little precipitation was received at either location from the time of lime application to wheat seeding on September 18. Sufficient rain was received after planting for good stand establishment.

RESULTS AND DISCUSSION

Shortly after emergence, visual differences were evident at the Sedgwick County location. The visual growth differences were more dramatic in the spring with the most dramatic visual growth difference being to banded P, regardless of lime rate or variety. Visual growth response to lime was not as evident as expected from previous experiments with soil of similar pH and KCl-extractable Al levels. This poorer visual response to lime was thought to be in part to slow reaction of lime because of the relatively dry conditions that existed after lime application. Soil samples taken in March, however, showed that the lime had been effective by then in raising soil pH and lowering KCl-extractable Al in the surface three inches of soil, but had little impact on pH or KCl-Al below the three inch layer, Table 3.

Excellent grain yields were harvested at both locations in spite of below normal growing season precipitation. Analysis of the data at the Sedgwick County location revealed a highly significant variety by lime and P interaction. The Al-sensitive Karl responded to both lime and P application, whereas, the Al-tolerate 2163 did not respond to either lime or P application, Table 4. With Karl, the banded P application was very effective in increasing yields at all levels of lime application over no P or broadcast P. Broadcast P was not effective in increasing yields. The respond to banded P was greater when no lime was applied compared to the 3750 and 7500 lb ECC/a lime rates. Liming was effective in increasing yields when no banded P was applied, but did not increase yields if banded P was applied. The yield results do not show any additive effect from the application of the combination of lime and banded P. In this year the banded P was the most effective treatment in increasing wheat yields. The study is being continued to assess the long-term economics of liming compared to annual banded P application on this extremely acidic, relatively high available P soil.

The Saline County location, with slightly higher pH and lower KCl-extractable Al, did not show a response to lime or P for either variety, Table 5. The lack of response was not unexpected based on the authors previous experiment with liming studies in the area where sites with pH's of 5.0 or less and 20 ppm or more of KCl-extractable Al responded to liming, but only a few of the sites with less than 20 ppm Al responded.

In summary, our results coupled with those from Oklahoma State researchers, would suggest that banded P is an alternative to liming for wheat production on extremely acidic soils. Our recommendation to farmers is that they lime when possible, but if liming is not possible, then variety selection for Al tolerance and banded P are alternatives to consider on extremely acidic soils in southcentral Kansas.

REFERENCES

Johnson, Gordon V., Robert L. Westerman and Randy Bowman. 1991. Phosphorus: An alternative to liming acid wheatland soils. Solutions Vol. 35:30-34.

Table 1. Effect of Ag-Lime Rate on Hard Red Winter Wheat Yields, pH and KCl-Extractable Al Four Years After Application in Kingman Co., KS

Lime Rate	Four-Year Average Yield	0-6" pH	KCl-Extractable Al
lb ECC/a	bu/a		ppm
0	15	4.6	102
3,000	39	5.1	26
6,000	38	5.9	0
12,000	36	6.4	0

Initial pH-4.7, KCl-Extractable Al-94 ppm
Source: Unruh, et. al., KS Fert. Res Report of Prog., 1986 thru 1989

Table 2. Selected Chemical Characteristics of Study Locations in Saline and Sedgwick Counties

Chemical Analysis	Location	
	Saline Co.	Sedgwick Co.
Soil pH	5.1	4.7
SMP Lime, lb ECC/a	5250	7500
Bray-1 P, ppm	17	53
Exch. K, ppm	264	135
KCl-Ext. Al, ppm	9	47

0-6" soil samples

Table 3. Effect of Lime Rate on soil pH and KCl-Extractable Al Six Months after Application, Sedgwick Co.

Lime Rate	Soil pH		KCl-Extractable Al	
	0-3"	3-6"	0-3"	3-6"
lb ECC/a			- - ppm - -	
0	4.9	4.9	72	71
3750	5.7	4.9	5	66
7500	6.2	5.0	0	70

Incorporation by field cultivator

Table 4. Effect of Lime Rate, Phosphorus Rate and Application Method and Hard Red Winter Wheat Variety on Grain Yield in Sedgwick Co., KS, 1992

Variety	Lime Rate	P_2O_5 Rate (lb/a)		
		None	40 B'cast	40 Band
	lb ECC/a	- - - bu/a - - -		
Karl	0	44.3	45.3	58.4
	3750	50.9	49.1	58.5
	7500	48.2	49.1	57.3
2163	0	56.3	58.7	58.6
	3750	60.8	61.4	61.9
	7500	60.6	52.4	62.1

LSD (.05) = 6.9

Table 5. Effect of Lime Rate, Phosphorus Rate and Application Method and Hard Red Winter Wheat Variety on Grain Yield in Saline Co., KS, 1992

Variety	Lime Rate	P_2O_5 Rate (lb/a)		
		None	40 B'cast	40 Band
	lb ECC/a	- - - bu/a - - -		
Karl	0	40.5	43.7	37.9
	3750	43.4	44.5	37.6
	7500	38.9	41.6	43.4
2163	0	35.3	41.7	40.6
	3750	36.8	45.6	41.3
	7500	35.6	40.0	36.8

LSD (.05) = NS

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