DO WE REALLY NEED A SOIL TEST FOR SULFUR?

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The importance of sulfur (S) in a fertilizer program for crop production has been recognized for over 50 years. The need for fertilizer S was not universal. Measured responses were limited to special or localized situations. Since S in a fertilizer program was not needed for all crops and all soils, it was only logical to attempt to develop a soil test that would accurately predict the need for the addition of this essential nutrient.

Development of a soil test for S that would accurately predict the amount of fertilizer S needed and, at the same time, could be used on a routine basis has been the focus of various research projects for over 50 years. The extractants evaluated ranged from water to neutral salts to bicarbonate solutions.

Alfalfa Production

Currently, the majority of the soil testing laboratories in the Midwest which analyze soil samples for S use a solution of calcium phosphate in water with the P concentration at 500 ppm [Ca $(H_2PO_4)_2$]. Measuring the response of alfalfa to fertilizer S at 49 sites, Hoeft et al., (1973) concluded that this extractant was one of the best predictors of the need for S fertilization. Soils used for the study were neutral to slightly acid and the accuracy of prediction increased with decreasing soil pH.

If the calcium phosphate extractant was used, Hoeft et al., suggested that a response of alfalfa to S fertilization could be expected if SO_4-S was less than 6 ppm. Soils testing greater than 10 ppm would not be expected to respond.

The use of the calcium phosphate extracting solution was reasonably successful in predicting the need for fertilizer S if a substantial increase in alfalfa yield (about .9 ton/acre) could be expected, the soil pH was neutral to slightly acid, and soil texture was coarse to medium. The predictive ability of this extractant for a wide range of soil properties was questioned.

Therefore, studies were conducted in Minnesota in the early 1980's in an effort to evaluate the effect of S fertilization on alfalfa production and to relate any response to soil properties. These studies were conducted at several sites. The information provided in Tables 1 and 2 is representative of the data collected.

The amount of SO_4-S extracted from soils at three sites by the calcium phosphate extractant is summarized in Table 1. The soil at the WS2 site was an acid sandy loam and collection of a good representative sample below a depth of 6 inches was difficult. The soil at the GO site was slightly acid silt loam while the soil at the GJ site was a calcareous silty clay loam. The SO_4-S extracted with the calcium phosphate solution either remained constant or decreased slightly with depth.

The application of fertilizer S increased alfalfa yield at one of three sites (Table 2). Use of fertilizer S for alfalfa grown on an irrigated sandy soil nearly doubled yield. However, yields were not affected by S fertilization when the soil texture was a silt loam or silty clay loam. Using the generally accepted critical value of 6 ppm, a response to S fertilization would have been anticipated at the GJ site. The lack of a response at these two sites can best be explained by the release of SO_4-S from soil organic matter. Approximately 90 to 95% of the total amount of sulfur in soils is contained in the soil organic matter. This S becomes available for plant use as the organic matter is broken down (mineralized) throughout the growing season.

The information from growing alfalfa at these three sites suggests that the widely used soil test for S is not a good predictor of the need for S in a fertilizer program. It is important to note that this statement applies to soil in the Midwest.

Corn Production

There is also general agreement that addition of S to a fertilizer program can increase corn yields in certain situations. As with alfalfa, the challenge was to develop a soil test for S that would accurately predict the need for this nutrient in a fertilizer program. Results have been mixed.

Working in Illinois, Hoeft et al., (1985) measured the effect of fertilizer S on corn yield at 81 sites over a period of 3 years. Sulfur fertilization increased yields at 5 of these sites. The soil test for S reliably predicted the need at 4 of the 5 sites which responded. However, the soil test (calcium phosphate extraction) did not reliably predict those sites which did not respond to fertilizer S at 14 of the non-responding sites. In this extensive study, the use of the calcium phosphate procedure for S would have produced a recommendation for fertilizer S that was not needed.

The soil test for sulfur needed for corn production was also evaluated for a period of 3 years in Nebraska. The results are summarized in Table 3. With the research conducted on irrigated sandy soils, there was a response to fertilizer S when the soil have a texture of a loamy fine sand and soil organic matter content was less than 1.0% (Rehm, 1976). The soils with the loamy fine sand texture also had a low soil organic matter content.

Fine-textured soils were not included in this study. However, results of this study show that if soils have a texture of loamy fine sand or sandy loam, there is some indication that the procedure used to measure S in soils may predict the need for SO_4-S with some accuracy.

In an effort to develop a more solidified base to support S recommendations for corn production, additional trials were conducted with irrigated corn in Nebraska from 1978 through 1981. The results are summarized in Figure 1. The sulfur was applied in a starter fertilizer.

The use of a calcium phosphate soil test for S accurately predicted the response to fertilizer S at 3 of the 4 sandy sites. The amount of SO_4-S measured to a depth of 72 inches at these sites is summarized in Table 4. In 1978 and 1979 with low levels of SO_4-S, there was a positive response to the use of fertilizer S. In 1980, measured SO_4-S was substantially higher and there was no response to fertilizer S. In 1981, however, the SO_4-S measured at 0 to 6 inches was high. Yet, there was an increase in yield when S was added to the fertilizer program.

While field research in the Midwest had clearly demonstrated the beneficial effect of S in a fertilizer program for corn production, there were questions about the use of fertilizer S for corn production on medium and fine-textured soils. Sulfur, supplied as potassium sulfate, was applied at numerous locations throughout Minnesota. The information summarized in Table 5 is typical of the results that were gathered.

Amounts of SO_4-S extracted by the calcium phosphate procedure were high and no response to S, as expected, was measured (Table 5). There was also some question about the ability of the calcium phosphate extractant to measure any change in SO_4-S in soils as a result of the application of fertilizer S. A comparison of values recorded in the spring of 1971 with those measured in the spring of 1972 shows no change. Since SO_4-S is mobile in soil, major changes should not be anticipated.

In Minnesota, the evaluation of the calcium phosphate extractant initiated in the 1970's was continued in the 1980's. The study was conducted at 10 sites over a period of three years. Results from three sites were typical of results from throughout the three years (Table 6). The various rates of S were broadcast and incorporated before planting.

The application of S in a fertilizer program increased yield only where the corn was grown on a coarse textured (sandy loam) soil. Although the amount of SO_4-S extracted by the calcium phosphate procedure was similar at all sites, there was no response to fertilizer S when the soil had a silt loam texture (Table 7).

When searching for a soil property that will predict a need for fertilizer S for corn, results from several field evaluations from around Minnesota lead to the conclusion that soil texture is as good as, if not better than, a laboratory measurement of sulfate-sulfur in the soil. In Minnesota, a positive response to the use of fertilizer S for both corn and alfalfa can be expected if soils are sandy (loamy sands, sandy loams). A measurement of SO_4-S extracted by calcium phosphate (the most frequently used extract) can lead to recommendations for use of fertilizer S where none is needed.

Summary

In contrast to the major nutrients, the need for S in a fertilizer program is not universal across the North-Central states. The use of this nutrient, however has been economically important in some situations. The calcium phosphate extract now used to measure SO_4-S in soils by many soil testing laboratories was developed to predict the situations where fertilizer S might be needed.

Numerous trials with both corn and alfalfa were conducted to evaluate the predictive ability of this extractant. Results from several years showed that the test using calcium phosphate could predict S needs with some reliability when soils were sandy. This testing procedure, however, tended to produce S recommendations when S fertilizers were not improving production on fine-textured soils. This is especially true for calcareous soils.

Even though the S test could predict a need for S when soils were sandy, a relationship between the results of the test and the rate of S needed for optimum production has not been developed. In most states, recommendations for S usage do not take yield goals of the intended crop into consideration.

After reviewing data collected from various studies conducted over several years, it appears that soil texture is as reliable, if not more reliable, as the soil test for S in predicting the need for fertilizer S. The soil test procedure using the calcium phosphate extractant does not usually add to the confidence needed for making fertilizer recommendations for sulfur.

It should be noted that the previous discussion has focused on sulfur use for alfalfa and corn production. There are exceptions for the canola crop. Research (primarily from Canada) has shown that this crop will respond positively to S applied to fine-textured soils. Therefore, a soil test for S may be needed for cropping systems where canola is included.

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Table 1. Sulfate sulfur extracted by the calcium phosphate extractant from three soils in Minnesota where S was applied to alfalfa.

Depth	Location WS2	GO	GJ
in.	------------ ppm SO_4-s ------------		
0 to 6	5	8	5
6 to 12	-	9	3
12 to 24	-	9	2
24 to 36	-	7	2
36 to 48	-	6	1
48 to 60	-	8	2

Table 2. Alfalfa yield at three locations in Minnesota as affected by the application of fertilizer S.

S Applied	Location WS2	GO	GJ
lb./acre	------------ ton dry matter/acre ------------		
0	2.6 a*	5.2 a	4.1 a
25	4.5 b	5.4 a	4.2 a
50	4.6 b	5.0 a	4.3 a
75	4.8 b	5.5 a	4.3 a
100	4.7 b	5.3 a	4.0 a

* Treatment means in each column followed by the same letter are not significantly different at the .05 confidence level.

Table 3. Soil properties and the response of irrigated corn to sulfur fertilizer.

Site I.D.	Texture	O.M.[1]	SO_4-S[1]	Yield No 3	S Applied[2]
		%	Ppm	----- bu./acre -----	
P (74)	loamy fine sand	0.89	4.7	161	180
P (75)	loamy fine sand	0.97	4.6	141	163
P (76)	loamy fine sand	0.85	2.7	109	129
H (74)	sandy loam	1.40	5.6	161	152
H (75)	sandy loam	3.77	12.1	97	105
H (76)	sandy loam	2.15	7.9	183	184

[1] 0 to 6 inches

[2] averaged over 4 rates of applied sulfur

Table 4. Sulfate-sulfur to a depth of 72 inches at four irrigated sites in Nebraska.

Depth	Year 1978	1979	1980	1981
in.	ppm SO_4-S			
0 to 6	3.0	3.9	11.3	16.1
6 to 12	4.0	3.1	8.2	7.3
12 to 24	4.3	3.4	10.4	7.1
24 to 36	3.7	2.7	9.0	8.6
36 to 48	3.6	5.3	10.5	7.5
48 to 60	4.7	6.4	10.6	8.8
60 to 72	3.9	6.2	9.3	8.0

Table 5. Effect of the application of SO_4-S on corn yield and associated measurements of SO_4-S at a dept of 0 to 6 inches.

Soil Type	SO_4-S Spring (71)	Spring (72)[1/]	S Applied (lb./acre) 0	25	50[2/]
	ppm SO_4-S		bu./acre		
Borup loam	17	18	90	89	90
Fayette silt loam	17	18	142	144	146

[1/] 50 lb. S/acre applied in spring of 1971.

[2/] Potassium Sulfate was broadcast and incorporated.

Table 6. The effect of the application of fertilizer S on corn yield.

S Applied	Site S 84	JS 86	K 86
lb./acre	bu./acre		
0	122	161	168
10	132	159	169
20	137	167	173
40	128	164	172
Texture:	sandy loam	silt loam	silt loam

Table 7. Sulfate sulfur extracted by the calcium phosphate procedure for sites where fertilizer S was applied to corn

Depth	S 84	JS 86	K 86
		Year	
in.		ppm SO4-S	
0 to 6	4	3	6
6 to 12	3	2	7
12 to 24	-	4	6
24 to 36	-	3	7
36 to 48	-	2	7
48 to 60	-	2	8

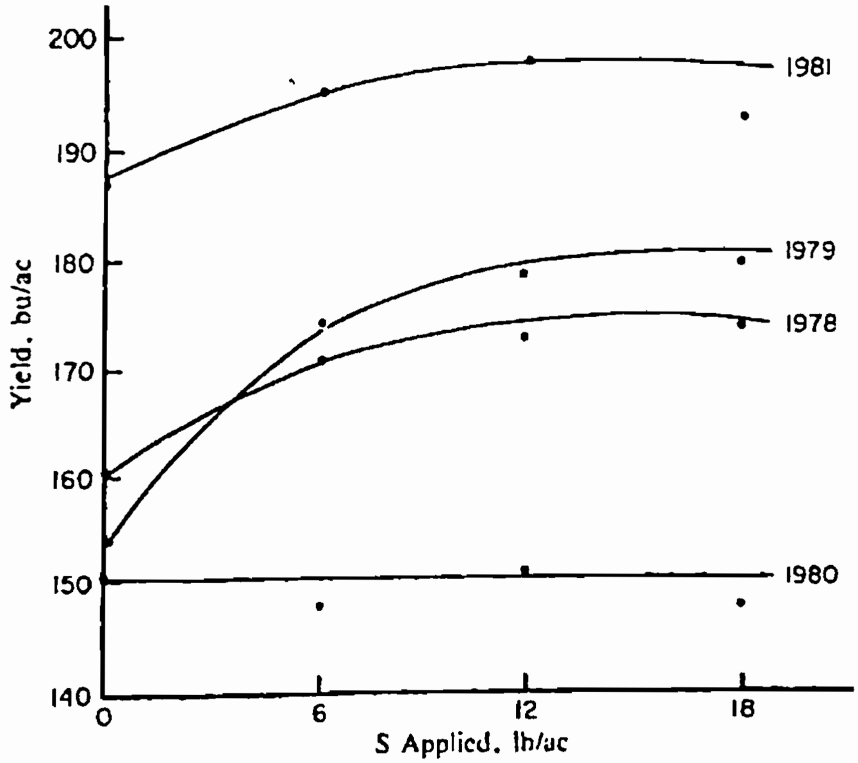

Figure 1. Effect of rate of S applied in a starter fertilizer on yield of corn grown on irrigated sandy soil.

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