EVALUATION OF SOIL TEST METHODS AND PLANT TISSUE ANALYSIS TO ASSESS SULFUR RESPONSE TO FERTILIZER SOURCES IN WHEAT

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ABSTRACT

Identifying how winter wheat responds to sulfur (S) fertilization through the use of soil test S (STS) methods has been a challenge across Kansas soils. The objective of this study was to evaluate soil test extraction methods for S as well as plant S nutritional status using different S fertilizer sources and rates. Sulfur response trials were established at 24 Kansas locations during two years (2019 and 2020). Fertilizer rate treatments included a control, 10 and 40 lbs S/ acre applied using ammonium sulfate AMS (21-0-0-24S); a blanket application of 100 lbs of nitrogen (N) ac-1 and 40 lbs of P2O5 (P) ac-1 using urea and mono ammonium phosphate. Adding to the control treatment and balancing N fertilizer accordingly. Results indicate STS methods varied in their correlation with one another. The highest correlating methods to one another included the calcium phosphate extraction and the ammonium acetate extraction, which resulted in an R2 of 0.96. While yield and Feekes 6 NDVI showed little impact to S fertilizer rates and sources, most tissues samples saw an increase in S concentration as rates of S increased and a decrease in S concentration when elemental S was used as the source.

INTRODUCTION

Sulfur (S) deficiency in winter wheat has become more common in recent years. Identifying the need for S as fertilizer has typically been done through the use of profile sampling (0-24 in), much like is seen for nitrogen. Since these two nutrients have similar “mobility” in the soil. Applying the correct amount of this nutrient to obtain an economic return is the main driver S fertilization in crops like winter wheat. Identifying how efficiently the crop utilizes this nutrient as well as how effectively the crop can uptake it from the soil is key to understanding how to manage this nutrient. There are many different soil test S (STS) methods being used to identify S deficient soils in Kansas. This makes it a challenge when determining where a response could be seen. This is especially apparent if an STS method has not been well correlated with crop response.

How well a crop responds to sulfur depends largely on which form of sulfur is in the soil at the time of crop S uptake. Sulfur in the sulfate form is readily available to the plant, while other sources such as S in organic matter need to be mineralized to become plant available. This is also relevant for the type of fertilizers that are applied to a growing crop. While many fertilizers contain S in the sulfate form, others contain S in the elemental form, which requires oxidation before becoming plant available. This process depends upon soil moisture and temperature because sulfur oxidation is primarily done by microorganisms. With the transition to no-till, soil temperatures are typically lower in these production practices due to previous crop residue providing a temperature buffer in the spring. In addition to this, wheat is grown during the colder part of the year as well as in drier regions of Kansas. Knowing how much elemental sulfur is converted to the plant-available sulfate form is difficult to tell. The objective of this study was to evaluate soil test extraction methods for S as well as plant S nutritional status using different S fertilizer sources and rates.

MATERIALS AND METHODS

Sulfur response trials were established at 24 Kansas locations during two years (2019 and 2020). Fertilizer rate treatments included a control, 10 and 40 lbs S/ acre applied using ammonium sulfate AMS (21-0-0-24S); a blanket application of 100 lbs of nitrogen (N) ac-1 and 40 lbs of P2O5 (P) ac-1 using urea and mono ammonium phosphate. Adding to the control treatment and balancing N fertilizer accordingly. Fertilizer S source treatments included the application AMS, Micro-Essentials SZ “MESZ” (12-40-0-10S-1Zn), and elemental sulfur (0-0-0-90S). All P and S and 50 lbs N ac-1 of N were broadcast in the fall, followed by 50 lbs N ac-1 topdress application at Feekes 5.

A randomized complete block design was used for the experiment with four replications in this study. Soil samples were taken by replication at depths of 0-6 and 0-24 in and analysis for four different STS methods. At Feekes 6 (jointing), normalized difference vegetation index (NDVI) and tissue samples were taken and analyzed for total S concentration. Soil samples were extracted for S using four methods: calcium phosphate, resin, Mehlich 3, and ammonium acetate. Sulfur was determined with the ICP–OES (Inductively Coupled Plasma Optical Emission Spectrometry) for all extraction methods other soil parameters measured by replication at each site included soil pH, OM, and CEC

RESULTS AND DISCUSSION

When comparing the relationship of the calcium phosphate method (most common;y used) to other methods, the highest R2 (0.96) was with the Ammonium Acetate (AA) extraction (Fig 1). The lowest R2 was with the Mehlich-3 (M3) method with an R2 of 0.31 (Fig 1). The Resin (R) method had an R2 of 0.76 when compared with the calcium phosphate method. The M3 and resin extraction methods showed the lowest R2 and large variability in values.

NDVI measured at jointing showed no significant treatment effects at the α = 0.05 statistical level across locations (Fig 2 and 3). Responsive locations to S fertilizer had tissue S concentrations of 0.24% or lower (Fig 2 and 3). Flag leaf tissue samples were also responsive to S fertilizer application rates Tissue analysis (and yield at responsive locations) indicate that fall-applied elemental sulfur was not available to the plant during the growing season, MESZ was plant-available; however, the plant response seems attributable to the sulfate fraction of the total S content in MESZ (MESZ is composed of 50% sulfate and 50% elemental sulfur) (Fig 2)

Table 1. Soil test information from samples collected before wheat sowing and fertilizer application.

Location	pH	OM	S (0-6 in)	CEC	S (0-24 in)
		%	ppm	(meq/100g)	ppm
1	6.5	2.3	3.4	13	23.1
2	7.7	2.5	4.4	25.9	4.5
3	6.2	3.5	2.7	15.1	4.2
4	6.9	2.5	3.6	18.4	4.8
5	6.7	2.6	3.2	17.5	5.7
6	7.6	2.0	2.6	29.1	5.6
7	6.4	2.5	2.5	15.2	7
8	5.7	3.1	2.2	16.1	3.2
9	7.7	2.0	2	21.2	3.2
10	6.2	2.3	0.7	10.7	1.2
11	5.6	2.3	1.1	9.3	1.5
12	7.2	2.3	2.4	21.6	2.5
13	8.3	2.3	2.4	30.5	2.1
14	7.3	2.5	2	20.4	2.8
15	7.6	2.4	1.8	24.3	2.5
16	6.5	2.5	1.4	21.7	2.5
17	5.4	2.7	1.8	11.9	12.3
18	5.6	3.0	1	14.7	2.1
19	6.2	2.9	1.4	13.3	1.6
20	6.6	2.8	1.8	16.6	3
21	6.7	1.8	12.8	6.3	151.9
22	6.8	2.4	2.3	17.4	3.5
23	6.8	2.4	2.6	19.1	2.6
24	5.6	2.8	1.5	13.4	1.9

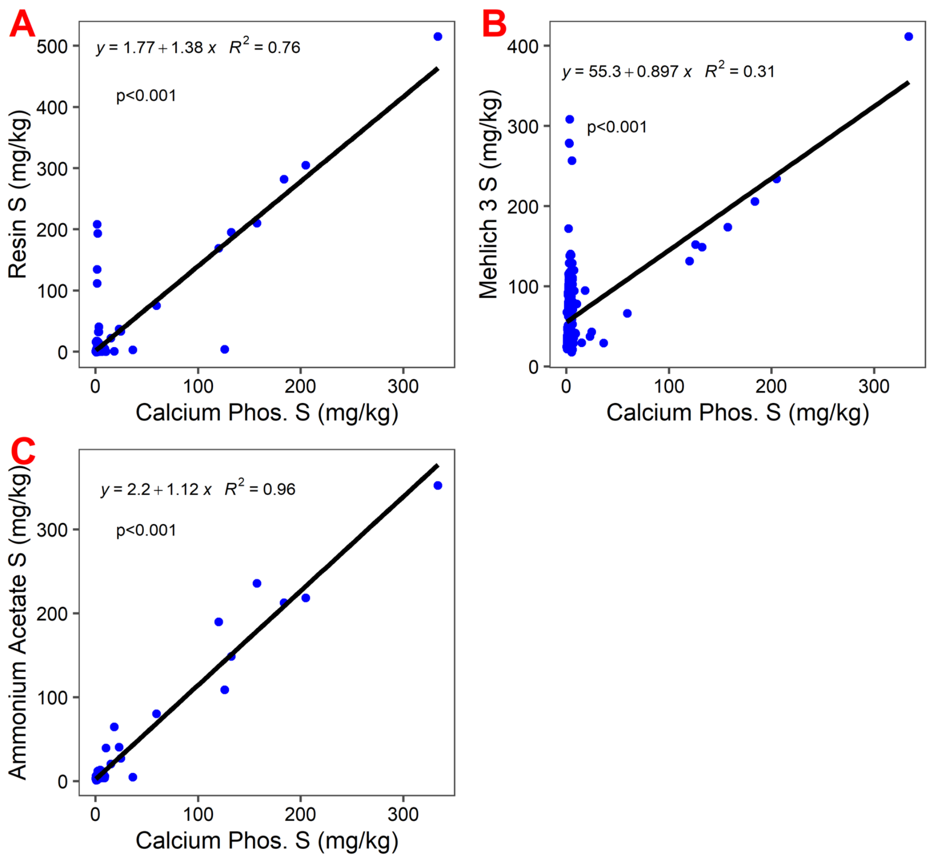

Figure 1. Relationship between four different extraction methods for S.

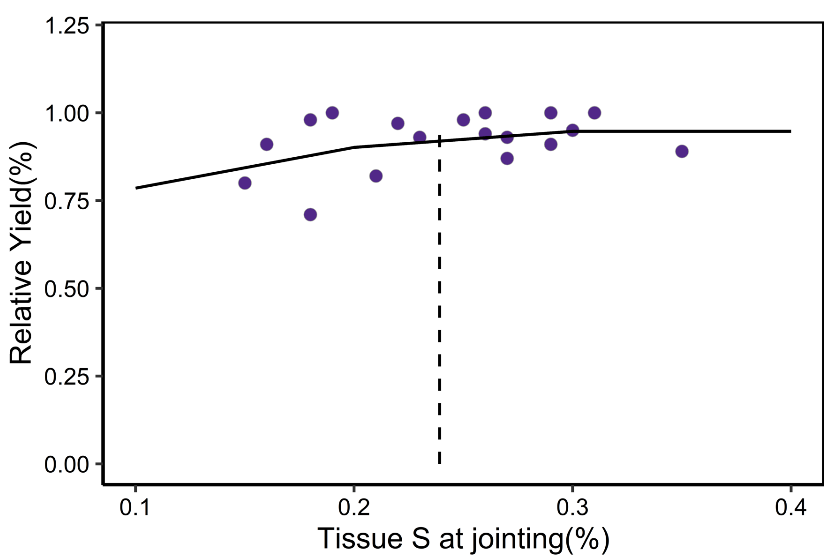

Figure 2. Tissue S concentration at Feekes 6 (jointing) and relative yield response to S fertilization (critical value of 0.24%).

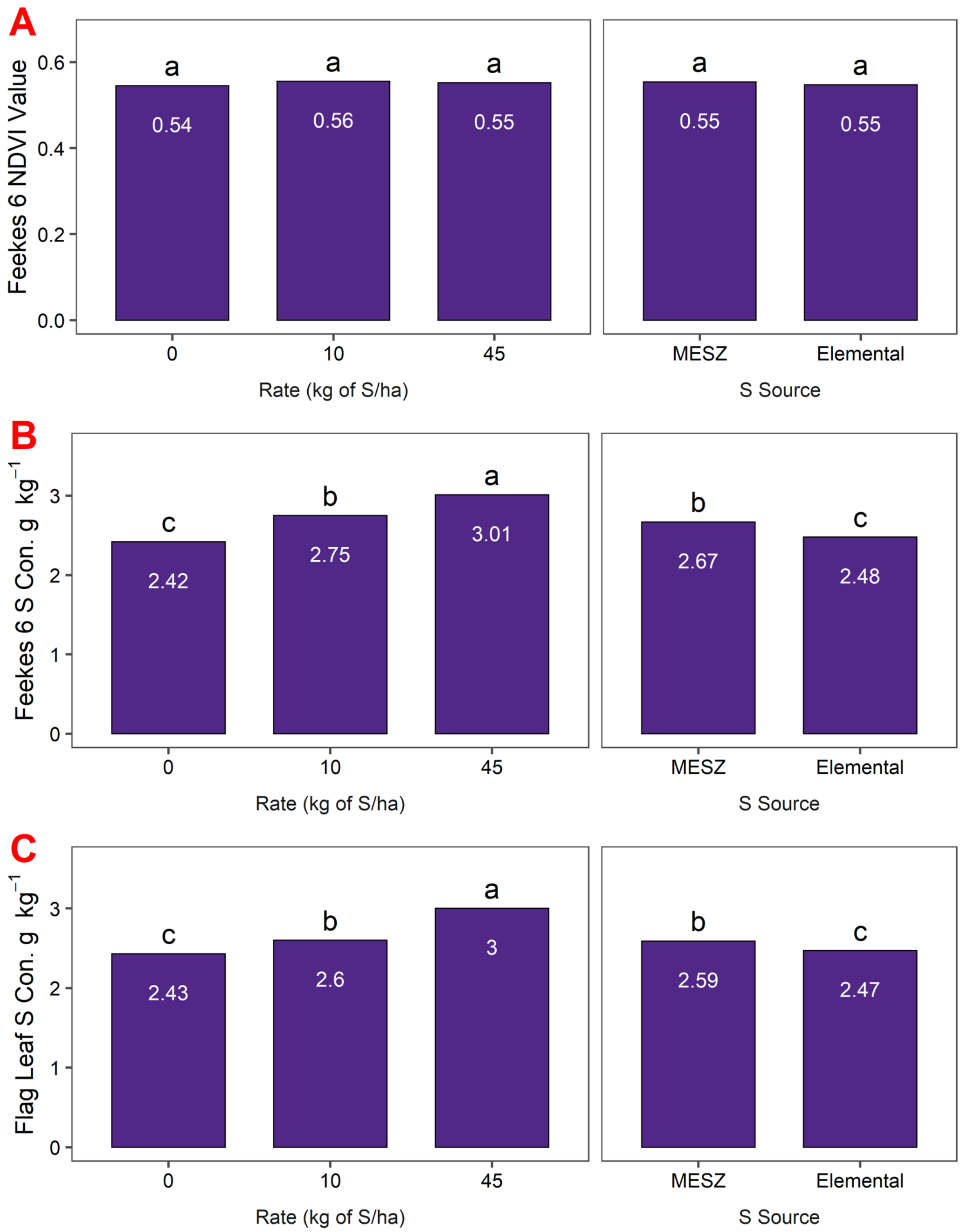

Figure 3. Wheat response to S application rate (as fall ammonium sulfate); and two sources (MESZ and elemental S) with the same application time at 40 lbs S/acre rate (45 kg/ha).