ASSESSING SULFUR RESPONSE, UTILIZATION EFFICIENCY, AND DIAGNOSTIC TOOLS FOR CORN IN KANSAS

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ABSTRACT

Efficient sulfur (S) utilization is crucial for crops' productivity and the sustainability of agricultural systems. This study aims to evaluate the effect of sulfur application on corn production across various Kansas sites and determine how sulfur fertilization affects different growth parameters and diagnostic tools for corn. The study was conducted over the 2021-2022 growing seasons across 26 sites in Kansas. Two different sulfur fertilizer treatment rates were applied. Soil samples were collected and analyzed for pH, organic matter, sulfate content, and soil texture. Plant tissue samples were obtained at different growth stages, and diagnostic tools such as NDVI and SPAD measurements were recorded. A strong positive correlation was found between the total sulfur uptake and yield, indicating the critical role of sulfur in determining crop productivity. The SUE analysis revealed that the mean agronomic efficiency across all sites was 22 lb. lb., indicating the yield achieved for each sulfur unit applied. The average recovery efficiency in the year of application was 6%, the proportion of applied sulfur that the crop successfully utilized. The recovery efficiency value was was high as 20% at some locations. This study highlights the importance of sulfur in corn production in Kansas and its direct influence on crop yield. The positive correlation between total sulfur uptake and yield suggests that optimizing sulfur application can increase productivity.

INTRODUCTION

Sulfur, often referred to as the "fourth major nutrient," plays a crucial role in the growth and yield of corn crops. Its efficient utilization is essential to the sustainability of agricultural systems. The significance of sulfur in agriculture cannot be overstated. It is a constituent of essential amino acids, vitamins, and enzymes crucial to plant growth. Like any nutrient, sulfur's efficient utilization is vital to maximize crop yield while minimizing environmental impacts. Effective use of sulfur directly impacts crop productivity and influences the overall sustainability of agricultural systems. Corn cultivation is a vital part of the Kansas agriculture system, and it's essential to understand the relationship between sulfur application and corn production. This study explores the dynamics between sulfur application and corn production across different sites in the state. By studying soil properties and analyzing plant tissue samples using diagnostic tools such as the Normalized Difference Vegetative Index (NDVI) and Soil Plant Analysis Development (SPAD), this research aims to evaluate sulfur response, utilization efficiency, and diagnostic tool application.

MATERIALS AND METHODS

The study was conducted from 2021-2022; field experiments were carried out in 26 sites throughout Kansas (Table 1). Two different rates were used for the fertilizer treatments - one with sulfur fertilizer (40 lb. of S ac^{-1}) and one without (lb. of S ac^{-1}). Ammonium sulfate (21-0-0-24S) was used as a sulfur fertilizer source. Additionally, a uniform application of phosphorus fertilizer was applied at a rate of 90 lb. of P_2O_5 ac^{-1} using mono-ammonium phosphate (11-52-0). Nitrogen was balanced using urea (46-0-0). All the fertilizer was applied once by broadcast pre-plant. Soil samples were collected by block at 0-6 in depth and 0-24 in depth. Soil samples were analyzed for pH 1:1 (soil:water) (Peters, Nathan, and Laboski 2012), organic matter by loss on ignition (Combs and Nathan 1998), sulfate by the monocalcium phosphate extraction (Franzen 2015) and soil texture (particle size distribution) using a hydrometer. In early season, tissue samples were taken from whole plants in the V6 growth stage (V5-V7). At the same time NDVI using a RapidSCAN CS-45 handheld crop sensor. In the middle season, tissue sampling was done on the ear leaf in the R1 growth stage (range between VT-R2). Additionally, SPAD was also collected using the handheld chlorophyll meter SPAD-502. During the late season, a whole plant at the R6 stage was sampled. The tissue samples were dried and ground. The concentration of sulfur was determined using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The uptake was calculated based on the concentration of sulfur and biomass. The two center rows were harvested to determine grain yield, and grain yield was calculated and adjusted to 15.5% moisture. Sulfur use efficiency (SUE) components were calculated using the agronomic use efficiency (AE) and apparent sulfur recovery efficiency (RE) described by (Fixen et al. 2015). All statistical analyses were performed in R version 4.2 using RStudio version 2022.12.0+353.

RESULTS AND DISCUSSIONS

Correlation for Different Parameters

The correlation analysis conducted in this study has revealed valuable insights into the complex relationship between various parameters and their impact on corn production. One of the findings of this study was that there was no significant correlation between NDVI at V6 and corn yield. This indicates that while NDVI can be a useful tool for monitoring plant health and growth, it may not be able to directly predict corn yield. On the other hand, the correlation between SPAD measurements and corn yield was found to be relatively modest with a coefficient of 0.21. Although the correlation is not strong, it suggests that chlorophyll content, as measured by SPAD, can be used to indicate corn yield to some extent. However, it is important to remember many other factors influence that yield, and NDVI and SPAD readings should only be considered as one part of a broader assessment. The most significant correlation within this study was between corn yield and total sulfur uptake, with a strong and positive relationship with a correlation coefficient of 0.85. This finding is of utmost importance as it highlights the crucial role of sulfur in determining crop productivity. The strong correlation between total sulfur uptake and yield confirms that the efficient application and uptake of sulfur in corn plants significantly contributes to higher grain yields.

Sulfur use efficiency
The agronomic efficiency value calculated from the study stands at 22 lb/lb as an average across 25 sites. This means that for every unit of sulfur applied, an average of 22 pounds of corn is produced. The high agronomic efficiency value indicates that sulfur application significantly impacts corn yield in the study sites. The elevated value reflects the crop's ability to convert the applied sulfur into increased grain yield, highlighting the importance of sulfur in agricultural systems. The average apparent recovery efficiency value was found to be 6% on average across all the sites. The recovery efficiency metric quantifies the proportion of the applied sulfur the crop utilized successfully. A recovery efficiency value of 6% indicates that only a small fraction of the sulfur applied was recovered and utilized by the corn plants the year of application. The low recovery efficiency value suggests the need for further investigation into methods for improving sulfur recovery during the year of application. A significant portion of applied sulfur may be taken up by plants during multiple years (cycling/accumulating in the organic fraction). Strategies for enhancing sulfur utilization, such as optimizing application rates and timing, can be explored to maximize the benefits of sulfur fertilization. Additionally, understanding the factors that affect sulfur uptake by corn plants, such as soil pH and organic matter, can aid in devising more effective sulfur management practices. These findings provide practical insights for farmers and agricultural practitioners to refine nutrient management strategies, boost corn yields, and minimize resource wastage.

REFERENCE

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Table 1: Soil test information from samples collected before fertilizer application. Sampling depth of 0-15 cm for pH, organic matter (OM), Sand, and Clay; and 0-60 cm for SO_4^{-2}.

Site	Year	County	pH	OM %	SO_4^{-2} ppm	Sand %	Clay %
1	2021	Riley	6.2	2.0	2	36	10
2	2021	Shawnee	7.5	1.9	3	46	12
3	2021	Republic	6.0	2.7	4	20	19
4	2021	Republic	6.5	3.3	8	28	15
5	2021	Brown	6.2	3.1	4	18	16
6	2021	Gove	6.6	2.7	4	21	25
7	2021	Gove	7.1	2.5	3	20	21
8	2021	Franklin	5.8	3.4	4	14	24
9	2021	Gove	6.0	3.1	5	21	21
10	2021	Logan	6.4	2.8	4	20	24
11	2021	Dickinson	6.0	3.5	4	22	26
12	2021	Salina	5.3	2.9	5	30	24
13	2022	Jewell	6.8	3.7	3	11	24
14	2022	Jewell	7.1	5.5	3	10	32
15	2022	Jewell	5.2	3.4	3	12	26
16	2022	Shawnee	7.0	2.1	2	46	11
17	2022	Franklin	6.1	3.6	4	12	24
18	2022	Franklin	5.7	3.6	4	11	27
19	2022	Reno	7.4	2.8	14	42	26
20	2022	Reno	6.8	3.2	18	31	28
21	2022	Jefferson	7.2	3.8	4	40	22
22	2022	Republic	6.3	3.5	11	14	20
23	2022	Republic	6.2	3.0	9	14	18
24	2022	Riley	6.4	2.8	4	14	28
25	2022	Smith	6.2	2.9	2	14	34
26	2022	Smith	5.3	3.0	3	8	29

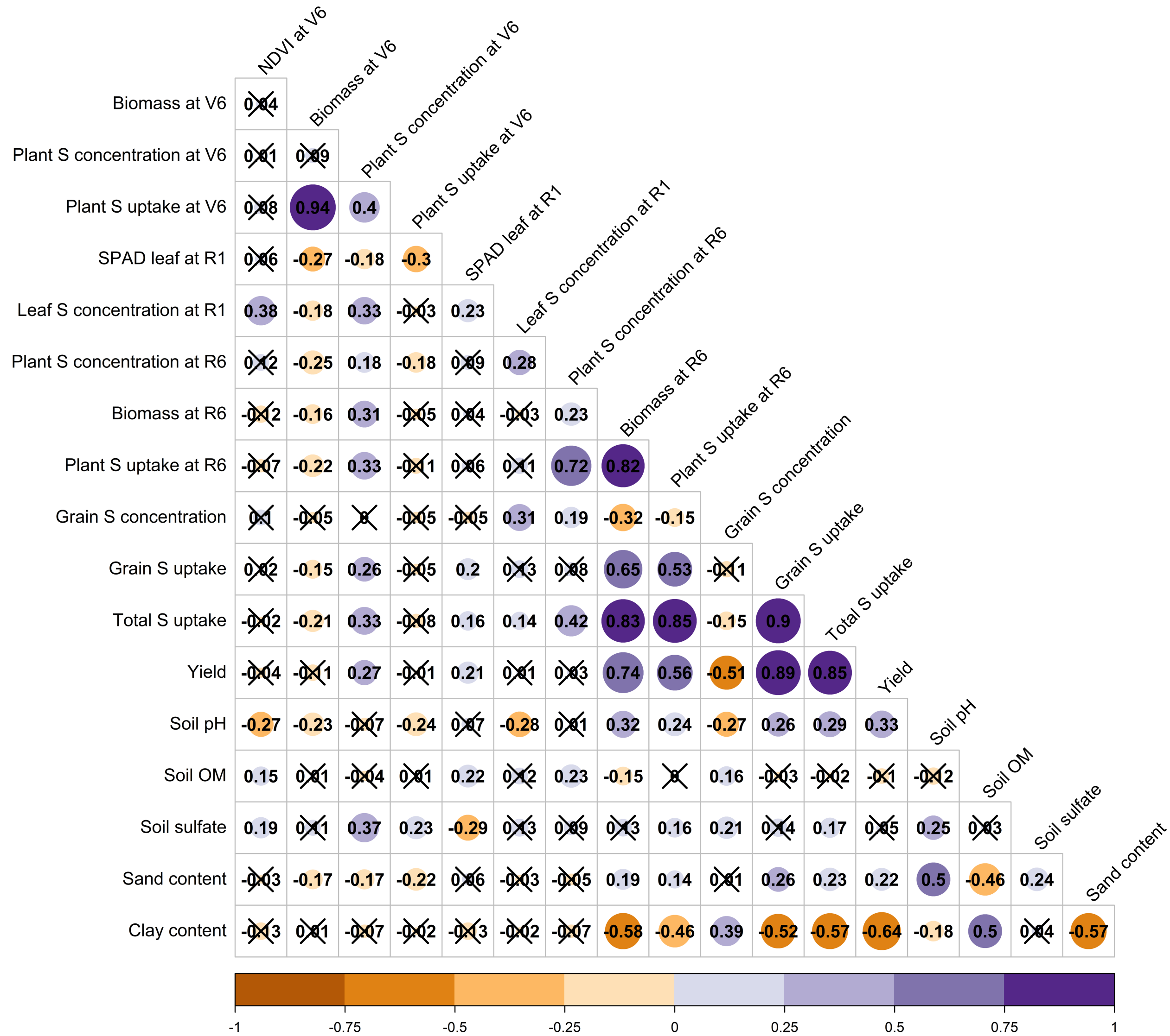

Figure 1. Pearson correlation matrix for different tissue, yield, and soil parameters (p<0.05). Darker colors indicate a higher (positive or negative) correlation coefficient; non-significant correlations are indicated by an “X”.

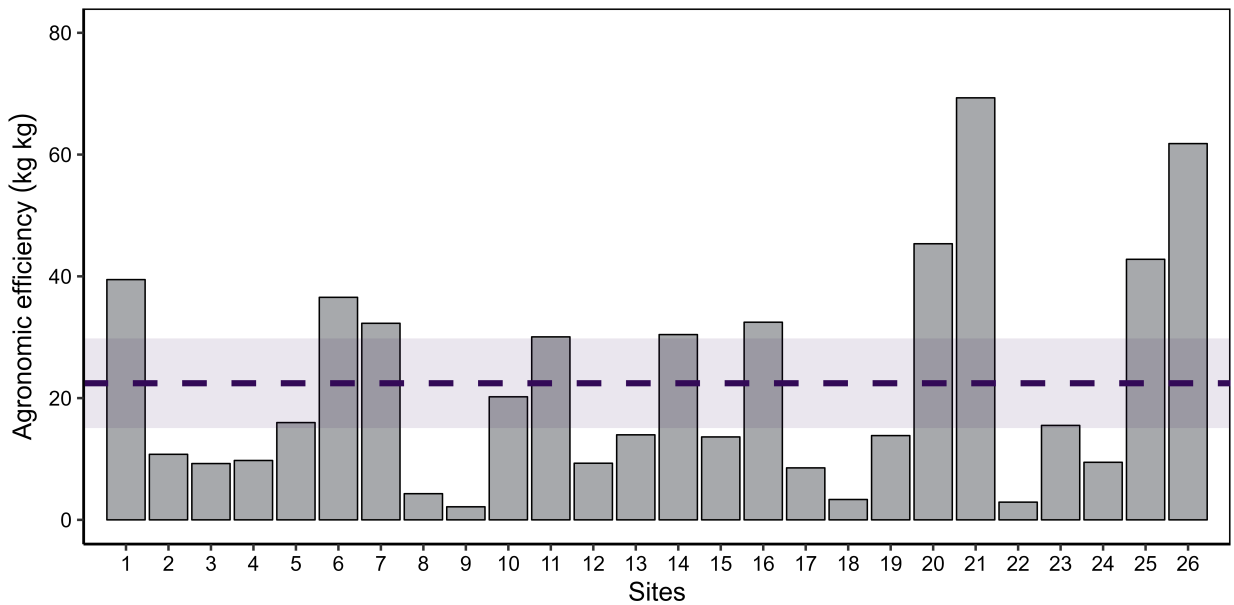

Figure 2. Agronomic sulfur efficiency (lb. of grain per lb. of sulfur applied), the dashed line represents the average across all sites, and the shaded area indicates a 95% CI of the mean.

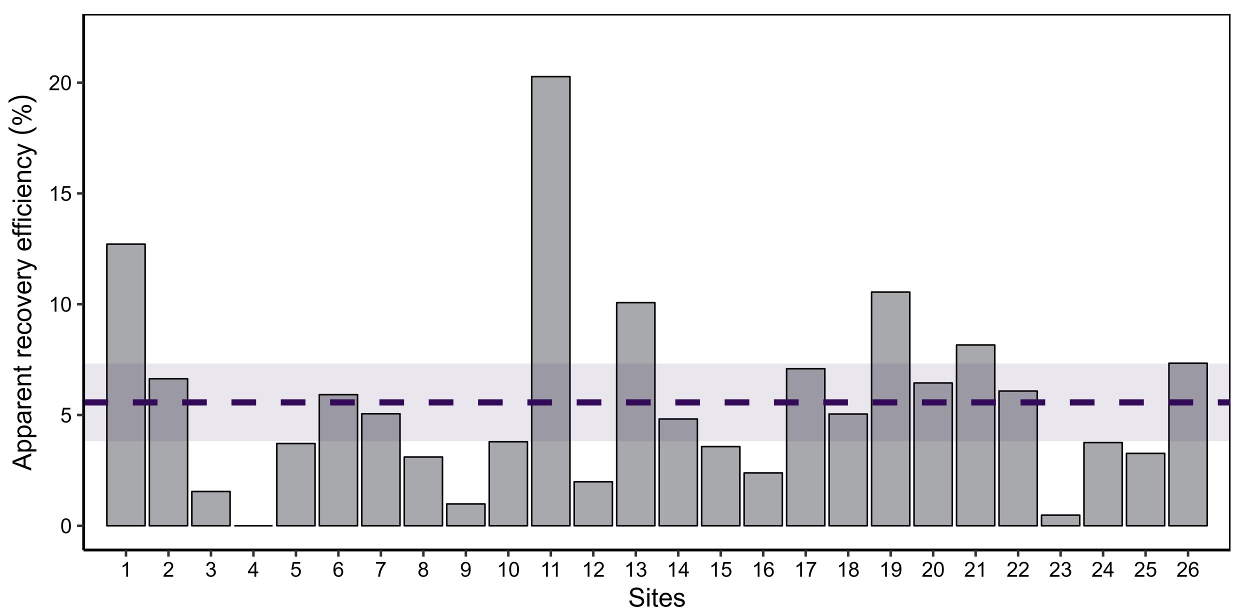

Figure 3. Apparent sulfur recovery efficiency (percent), the dashed line represents the average across all sites, and the shaded area indicates a 95% CI of the mean.