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Performance of second-season maize subjected to elemental sulfur doses

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ABSTRACT: Maize cultivated in succession to soybeans in the second season plays a significant role in grain production in the Midwest region. However, some crucial nutrients, such as sulfur, have been overlooked by rural producers during grain cultivation. This research aims to evaluate the performance of second-season maize subjected to doses of elemental sulfur. It provides practical insights that can be immediately applied to improve maize cultivation practices. The experiment, conducted at Giruá Ypê Farm in Alto Taquari, MT, Brazil, in a Latossolo Vermelho Distrófico (Oxisol) area, used the hybrid Morgan 540 PWU, sown on 03/13/2023. The experiment was conducted in a randomized block design, consisting of one control treatment and five doses of elemental sulfur. The elemental sulfur doses were 0, 30, 60, 90, 120 and 150 kg ha-1. The doses of elemental sulfur influenced the SPAD indices of total chlorophyll and chlorophyll B, plant height, and grain yield. Maximum maize grain yield was obtained with the estimated maximum dose of 135,41 kg ha-1 of elemental S, representing a 13% increase compared to the control. In clayey Latossolo with low sulfur content, the application of elemental sulfur was found to significantly improve the performance of second-season maize in the state of Mato Grosso, providing practical guidance for producers and researchers in the field.
Keywords: fertilization; chlorophyll; nutrition.

Desempenho do milho de segunda safra submetido a doses de enxofres elementar

RESUMO: O milho cultivado em sucessão à soja em segunda safra, desempenha importante papel na produção de grãos da região Centro-Oeste. Durante o cultivo de grãos, alguns nutrientes têm sido ignorados por parte dos produtores rurais, a exemplo do enxofre. Portanto, objetivou-se avaliar o desempenho do milho cultivado em segunda safra submetido a doses de enxofre elementar. O experimento foi realizado na fazenda Giruá Ypê em Alto Taquari-MT, área de latossolo vermelho distrófico. A variedade utilizada foi o híbrido Morgan 540 PWU, semeado em 13/03/2023. O experimento foi conduzido em delineamento de 4 blocos casualizados, constando de um tratamento controle e cinco doses de enxofre elementar. As doses de enxofre elementar foram: 0; 30; 60; 90; 120 e 150 kg ha^{-1}. As doses de enxofre elementar influenciaram os índices SPAD de clorofila total, clorofila B, altura de plantas e produtividade de grãos. A produtividade máxima de grãos de milho, foi obtida com a máxima dose estimada de 135,41 kg ha^{-1} S elementar, incrementando em 13% quando comparado ao controle. Em latossolo argiloso com baixos teores de enxofre, a aplicação de enxofre elementar é capaz de melhorar o desempenho da cultura do milho em segunda safra no estado do Mato Grosso.
Palavras-chave: adubação; clorofila; nutrição.

1. INTRODUCTION

Occupying an estimated area of 204.7 million hectares, the Cerrado biome is located in the central portion of Brazil and is considered a vegetation complex where savanna vegetation predominates (BOLFE et al., 2020). The characteristics of Cerrado soils are unsuitable for agriculture due to the effects of acidity, usually associated with the presence of aluminum and manganese at toxic levels (SOUSA et al., 2007). However, introducing practices such as acidity correction and increased fertility allowed for obtaining high yields of grain crops such as maize, making the Cerrado one of the country's main agricultural regions.

The state of Mato Grosso in the 2022/23 season had a record in sown area and the production of maize grains. In this state, maize grown in the second season predominates. In the 2022/23 season, a total of 50731.2 thousand tons were produced, with an average of 6886 kg ha^{-1} of grains. Such production was 16.6% (approximately 17%) higher than that obtained in the 2021/22 season, with an average yield of 5856 kg ha^{-1} (CONAB, 2023). These favorable results in grain production for the maize crop are due to a combination of favorable climatic conditions, associated with advanced agricultural practices with high-quality seeds and efficient management of fertilizers and pest containment.

Crops are often produced with farmers being mainly concerned with concentrated fertilizers containing mainly nitrogen (N), phosphorus (P) and potassium (K), causing the deficiency of some nutrients such as sulfur (S), in particular, to be limiting for the growth and development of maize (FIORINI et al., 2017). As the soils of the Cerrado region mostly have limited availability of S, this element becomes a limiting factor for agricultural production (MENDONÇA et al., 2023). Therefore, supplying S through fertilizer is necessary for more efficient and sustainable production systems.

Application of fertilizers containing S may or may not favor crop performance (PINHO et al., 2009; FIORINI et al., 2016; MENDONÇA et al., 2023). Application of S to cereals can increase the quality of grains, improving their quality (MALAVOLTA; MORAES, 2007). In maize crops, the application of S associated with N increases chlorophyll concentration (LI et al., 2019). In this same crop, the supply of elemental sulfur promoted an increase in shoot dry matter production when compared to ammonium sulfate and the control treatment, but no differences were observed in the SPAD index for chlorophyll (FIORINI et al., 2017). Due to the different results found in the literature on using elemental sulfur, especially in field experiments, this study aimed to evaluate the performance of maize cultivated in the second season subjected to elemental sulfur doses.

2. MATERIAL AND METHODS

The study was conducted at the Giruá Ypê farm in the municipality of Alto Taquari, MT, Brazil, located at the following geographic coordinates: 17° 50' 29" S and 53° 24' 0" W. The region has an average annual temperature of approximately 24.2 ºC and an average rainfall of 1400 mm. The prevailing climate is hot, semi-humid and notably seasonal, with rainy summers and dry winters classified as "Aw", according to Köppen's classification. The soil used was classified as *Latossolo Vermelho Distrófico* (Oxisol) (Santos et al., 2018) and contains, in the 0-0.20 m layer, 700 g kg^{-1} of clay, 50 g kg^{-1} of silt and 250 g kg^{-1} of sand.

The experimental area has been managed under no-tillage and cultivated with soybeans in the summer crop and maize, sorghum, or millet in the winter crop since 2005. For the chemical characterization of each treatment, a sample was collected from the 0-0.2 m layer (Table 1), and the chemical analyses were performed according to Teixeira et al. (2017).

Table 1. Basic chemical characterization of the experimental area, in the 0-0.2 m layer, municipality of Alto Taquari (MT), 2023.
Tabela 1. Caracterização química básica da área experimental, na camada de 0-0,2 m, município de Alto Taquari (MT), 2023.

pH	OM	P	K	S
Ca Cl$_2$	g dm^{-3}	--------mg dm^{-3}---------		
4.70	4.65	29.05	132.9	2.4

pH	Ca	Mg	Al	H+Al	SB	CEC	V
Ca Cl$_2$	---------------cmol$_c$ dm^{-3}------------------						--%-
4.70	2.63	0.77	0.05	6.49	3.74	10.23	36.6

The experimental design was randomized blocks with 06 treatments and four blocks. Treatments were 01 control treatment and 05 treatments with elemental sulfur doses containing 90% of S, in the amounts of 30, 60, 90, 120 and 150 kg ha^{-1} and four replicates per treatment. Each block in the experimental area was 24 meters long and 2 meters wide. The experimental unit was four linear meters long, spaced 0.5 m apart.

The planting of maize grown in the second season was carried out after harvesting soybean grown in the summer crop, on 03/13/2023. The soybean crop was fertilized with 270 kg ha^{-1} of the 03:21:21 (NPK) formulation and 120 kg ha^{-1} of the KCl fertilizer. The maize variety used was Morgan 540 PWU. Top-dressing fertilization in maize was carried out with 350 kg ha^{-1} of the Yara 30:00:20 (NPK) formulation, in 02 applications. In the first application, 200 kg was applied broadcast when the plants were in the V2 stage, and finally, in the second application, 150 kg was applied in the V8 stage.

On May 09, 2023, the chlorophyll test was performed on maize, in the phenological stage R1. Photosynthetic pigments, chlorophyll A, chlorophyll B, and total chlorophyll, were obtained using the portable chlorophyll meter, ClorofiLOG® (CFL1030; Falker, Porto Alegre, RS, Brazil). With the portable equipment, by pressing the leaves on its sensor, three chlorophyll A and B measurements were taken in each plot, using the leaf below the corncob. On 06/21/23, plant height and stem diameter were evaluated using a digital caliper, by sampling three plants per plot. To determine the yield, the two central rows with 02 meters in length were harvested, the corncob were threshed, and the obtained value then extrapolated to one hectare, with grain moisture corrected to 13%.

To compare the ash bed doses, the data were subjected to analysis of variance and, when significant, polynomial regression analysis was performed. A biplot graph was then constructed to check the overall mutability of the experiment and the trends of the multivariate analysis. A correlation analysis was also performed between the variables obtained in this study. The analyses were conducted using the Rbio program with the interface of the R program (BHERING, 2017).

3. RESULTS

Elemental sulfur doses impacted the SPAD index of total chlorophyll and chlorophyll B (Figures 1 and 3). The maximum estimated dose of 93.18 kg ha^{-1} of elemental S corresponded to the maximum SPAD index of total chlorophyll, which was 87.73. The maximum estimated dose of 93.18 kg ha^{-1} of elemental S increased the SPAD index by 10% compared to the treatment with the application of 30 kg ha^{-1} of elemental S. However, it is possible to observe that the use of elemental S did not cause significant differences in the contents of Chlorophyll A (Figure 2). The maximum estimated dose of 97.1kg ha^{-1} of elemental S corresponded to the maximum SPAD index of chlorophyll B, which was 34.7 (Figure 3).

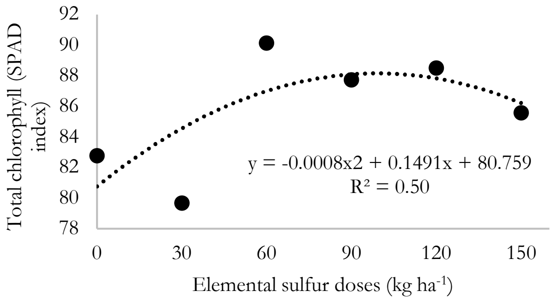

Figure 1. Total chlorophyll in second-season maize subjected to elemental sulfur doses.
Figura 1. Clorofila total em milho segunda safra submetido a doses de enxofre elementar.

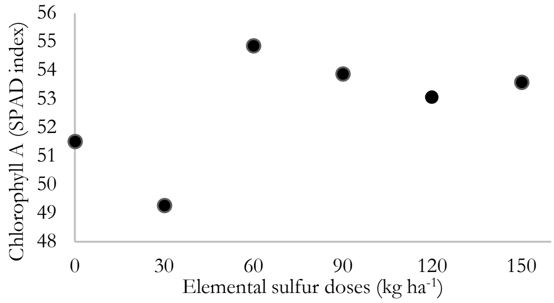

Figure 2. Chlorophyll A in second-season maize subjected to elemental sulfur doses.
Figura 2. Clorofila A em milho segunda safra submetido a doses de enxofre elementar.

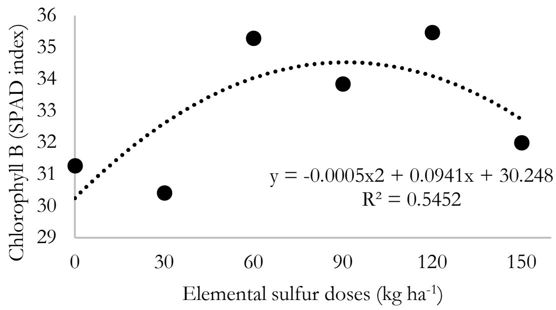

Figure 3. Chlorophyll B in second-season maize subjected to elemental sulfur doses.
Figura 3. Clorofila B em milho de segunda safra submetido a doses de enxofre elementar.

Elemental sulfur doses could not alter maize plants' stem diameter in the second season (Figure 4).

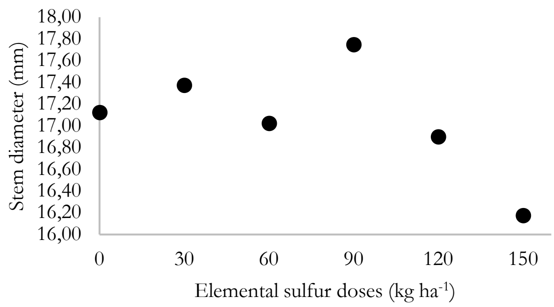

Figure 4. Stem diameter of second-season maize subjected to elemental sulfur doses.
Figura 4. Diâmetro do colmo do milho segunda safra submetido a doses de enxofre elementar.

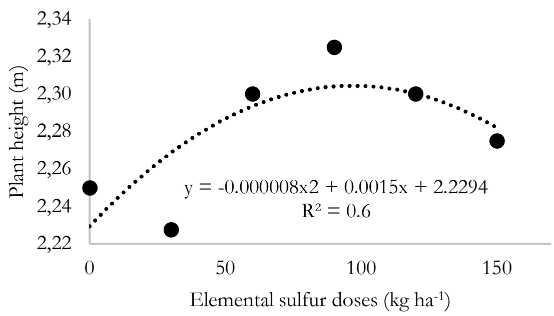

Figure 5. Height of second-season maize plants subjected to elemental sulfur doses.
Figura 5. Altura de plantas de milho segunda safra submetido a doses de enxofre elementar.

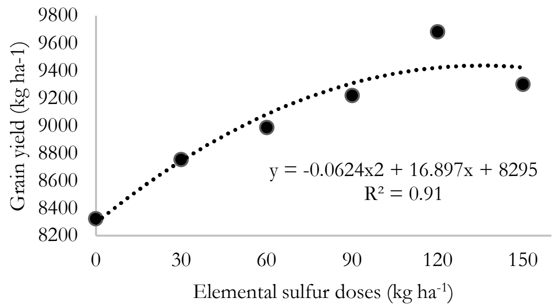

Figure 6. Yield of second-season maize subjected to elemental sulfur doses.
Figura 6. Produtividade do milho de segunda safra submetido a doses de enxofre elementar.

A correlation network was performed to compare the studied variables. A network of comparisons was constructed using Pearson's correlation to visualize all the characteristics measured in this study simultaneously (Figure 7). Positive correlations were expressed in green lines, negative correlations were expressed in red lines, and the intensity of the correlation was proportional to the thickness of the lines. It can be seen that there was a high correlation between the SPAD indices of total chlorophyll, chlorophyll A and chlorophyll B. However, the other variables studied here showed low correlation.

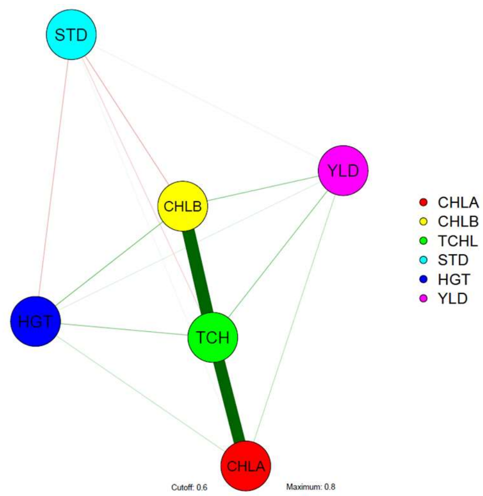

Figure 7. Correlation among variables Total Chlorophyll (TCHL), Chlorophyll A (CHLA), Chlorophyll B (CHLB), plant height (HGT), stem diameter (STD), and yield (YLD) after the application of elemental sulfur doses in second-season maize in the year 2023, from March to August.
Figura 7. Correlação entre variáveis Clorofila total (CLR), Clorofila A (CLA), Clorofila B (CLB), altura de plantas (alt), diâmetro do colmo (dmt) e produtividade (Prd), após a utilização de doses de enxofre elementar em milho cultivado em segunda safra, no ano de 2023 entre os meses de março a agosto.

Analyses of canonical variables were performed to check each variable's contribution (Figure 8). This technique is similar to principal component analysis; however, it should be used when a given study has an experimental design with replicates.

The eigenvectors in Figure 8 show that the elemental sulfur dose of 120 kg ha^{-1} was close to the yield and SPAD indices of total chlorophyll and chlorophyll B. On the other hand, the elemental sulfur dose of 60 kg ha^{-1} was close to plant height and the SPAD index of chlorophyll A. In turn, the control treatment and the elemental sulfur dose of 30 kg ha^{-1} were close to each other and were not close to any variable evaluated in this study.

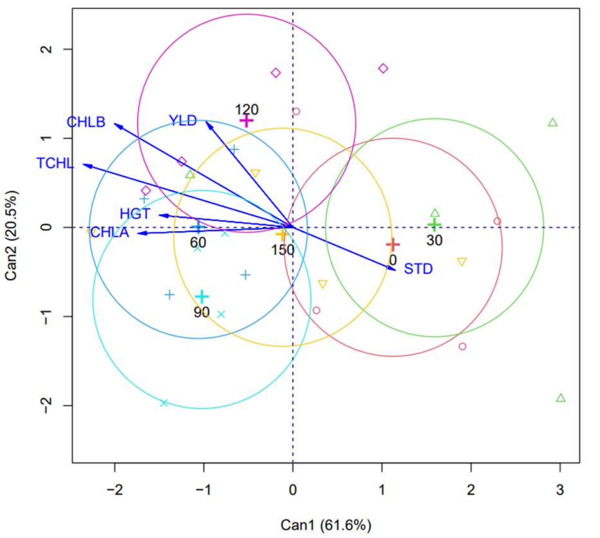

Figure 8. Canonical variable analysis between yield (YLD), SPAD index of total chlorophyll (TCHL), SPAD index of chlorophyll A (CHLA), SPAD index of chlorophyll B (CHLB), height (HGT) and stem diameter (STD). Treatments: 0, 30, 60, 90, 120 and 150 kg ha^{-1} of elemental sulfur.
Figura 8. Análise de variáveis canônicas entre produtividade (Prod), índice SPAD de clorofila total (Clortotal), índice SPAD de clorofila A (ClorA), índice SPAD de clorofila B (ClorB), altura (altura) e diâmetro do colmo (diâmetro). Tratamentos: 0; 30; 60; 90; 120 e 150 kg ha^{-1} de enxofre elementar.

4. DISCUSSION

The maximum estimated dose of 93.18 kg ha^{-1} of elemental S increased the SPAD index by 10%. However, using elemental S did not cause significant differences in the contents of Chlorophyll A. The increase in elemental S promoted an increase in the intensity of the green color of the leaves. It may be related to the influence of S on chlorophyll synthesis and photosynthesis, being an important component of ferredoxins and thioredoxins (MALAVOLTA, 2006), hence being able to increase chlorophyll content in plants. The increase in leaf chlorophyll content in maize is important due to its linear relationship with grain yield and plant biomass (LIet al., 2019). The supply of S doses can even be indicated to increase the green color in leafy crops such as arugula (SOARES et al., 2017). However, the results found in the present study differ from those reported by Fiorini et al. (2016), who evaluated different sources of S and found no statistical differences in different phenological stages of maize grown in greenhouses.

The maximum estimated dose of elemental S corresponded to the maximum SPAD index of chlorophyll B. The maximum estimated dose of 97.1 allowed an increase of approximately 11% in the SPAD index of chlorophyll B. The increments in chlorophyll B contents are important due to the capture of a greater amount of incident light to the site of action of the photosystems, which leads to a greater formation of ATP and NADPH, which will be used by the plant in the photosynthetic process, increasing yield (WHATLEY; WHATLEY, 1982).

In the present study, plant height was influenced by increasing doses of elemental S. Similar results were found by Mendonça et al. (2023) when evaluating the morphological characteristics of maize subjected to different sources of S. These authors observed that foliar application of elemental S, associated with gypsum applied to the soil, increased the height of maize plants by 0.2 m, when compared to the control treatment without S application.

There was an influence of elemental S doses on grain yield. The possible increase in yield in the maize crop grown in the second season may be related to the low availability of S in the soil of the experimental area, which is 2.4 mg dm^{-3} (Table 1), being less than 4 mg dm^{-3}, thus considered as low content (SOUSA; LOBATO, 2004). In addition, the gradual availability of sulfate in *Latossolo* (Oxisol), when elemental S is applied, may have favored maize yield, due to the gradual conversion of S to sulfate, with a higher conversion intensity between 22 and 70 days after its application to the soil (HOROWITZ: MEURER, 2006). This gradual availability of S in the soil associated with maximum accumulation of S in maize hybrids occurs 125 days after planting (Pinho et al., 2009), which may have favored the yield of maize grown in the second season. The results in the present study corroborate those reported by Fiori et al. (2016), who observed an increase in maize dry matter production when using the elemental S source compared to other S sources.

The increase in grain yield with the improvement of the management adopted, such as the management of fertilization carried out in the maize crop, is important because it can increase the sustainability of agricultural systems, as it increases the production per unit of area. Therefore, improving the increments in maize yield with the supply of elemental S was possible. In addition to increasing yield, the application of S in cereals and increasing the quality of grains, as this element increases the methionine content in cereal proteins, also improves their nutritional quality (MALAVOLTA: MORAES, 2007). However, caution is required with excessive applications of elemental S to the soil, due to reduced soil pH. In this context, when studying different soils in southern Brazil, Dall'Orsoletta et al. (2022) observed that the application of elemental S at a dose of 50 kg ha^{-1} was able to reduce pH in H_2O by one unit. Therefore, elemental S application should be carefully practiced, especially in soils with lower pH.

About the analyses of canonical variables, the accumulation of variances in the first two variables corresponded to 82%, which is higher than the recommended level of at least 80% (MINGOTI, 2005). Therefore, the canonical variables in this study can be used for a precise interpretation.

5. CONCLUSIONS

Based on the results obtained, it is possible to affirm that the present study achieved the intended objective, which was to evaluate the performance of maize cultivated in the second season subjected to elemental sulfur doses. The main findings of the study are presented below.

The maximum estimated doses of 93.18 and 97.1 kg ha^{-1} of elemental S promoted the highest increments in the SPAD indices of total chlorophyll and chlorophyll B, equal to 87.7 and 34.7, respectively.

The maximum grain yield was 9438.86 kg ha^{-1}, obtained with the maximum estimated dose of 135.41 kg ha^{-1} of elemental S. In a clayey *Latossolo* (Oxisol) with low S contents, the application of elemental S can improve the performance of the maize crop grown in the second season in Mato Grosso, Brazil.

6. REFERENCES

BHERING, L. L. Rbio: A tool for biometric and statistical analysis using the R platform. **Crop Breeding and Applied Biotechnology**, v. 17, p. 187-190, 2017.

BOLFE, E. L.; SANO, E. E.; CAMPOS, S. K. **Dinâmica agrícola no cerrado: análises e projeções.** Vol.1. Brasília, DF: Embrapa, 2020.

CONAB_Companhia nacional de abastecimento. **Acompanhamento da safra brasileira**. 12. ed. Brasilia: Conab, 2023. 110 p.

DALL'ORSOLETTA, D. J.; MUMBACH, G. L.; BRIGNOLI, F. M.; GATIBONI, L. C. Elemental sulfur recommendation for pH reduction in soils from Southern Brazil. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 26, n. 3, p. 212-218, 2022. https://doi.org/10.1590/1807-1929/agriambi.v26n3p212-218

DOMINGUES, L. A. S. **Milho em plantio direto sobre Brachiaria brizantha no sistema integração agricultura-pecuária**. 2004. 55f. Dissertação (Mestrado em Sistemas de Produção) - Faculdade de Engenharia de Ilha Solteira, Universidade Estadual Paulista, Ilha Solteira, 2006.

DORIGATTI, G. **Você sabia que o Brasil faz uma 3a safra de milho? Cultivo na região Nordeste está crescendo e aumentando oferta do cereal**. 2021. Available on:https://www.noticiasagricolas.com.br/videos/milho/265015-voce-sabia-que-o-brasil-faz-uma-3-safra-de-milho-cultivo-na-regiao-nordeste-esta-crescendo-e-aumentando.html. Acessed at: 30 Jul. 2024.

FIORINI, I. V. A.; VON PINHO, R. G.; PIRES, L. P. M.; SANTOS, A. O.; FIORINI, F. V. A.; CANCELLIER, L. L.; RESENDE, E. L. Evaluation of sulfur sources and forms of micronutrients coated onto NPK fertilizer in maize. **Revista Brasileira de Milho e Sorgo**, v. 15, n. 1, p. 20-29, 2016. https://doi.org/10.18512/1980-6477/rbms.v15n1p20-29

HOROWITZ, N.; MEURER, E. J. Oxidation of elemental sulfur in tropical soils. **Ciência Rural**, v. 36, p. 822-828, 2006. https://doi.org/10.1590/S0103-84782006000300015

LI, N.; YANG, Y.; WANG, L.; ZHOU, C.; JING, J.; SUN, X.; TIAN, X. Combined effects of nitrogen and sulfur fertilization on maize growth, physiological traits, N and S uptake, and their diagnosis. **Field crops research**, v. 242, e107593, 2019. https://doi.org/10.1016/j.fcr.2019.107593

MALAVOLTA, E. **Manual de nutrição mineral de plantas**. São Paulo-SP: Editora Agronômica Ceres, 2006. 638p.

MALAVOLTA, E.; MORAES, M. F. Fundamentos do nitrogênio e do enxofre na nutrição mineral das plantas cultivas. In: YAMADA, T.; ABDALLA, S. R. S.; VITTI, G. C. **Nitrogênio e enxofre na agricultura brasileira**. Piracicaba: Ipni, 2007. p. 1-722.

MENDONÇA, D. L. S.; CASTRO, R. G.; REZENDE, C. F. A. Morphological and productive response of corn with sulfur supply in different sources Respuesta morfológica y productiva del maíz con suministro de azufre de distintas fuentes. **Research, Society and Development**, v. 12, n. 3, e11112340516, 2023. https://doi.org/10.33448/rsd-v12i3.40516

MINGOTI, S. A. **Análise de dados através de métodos de estatística multivariada**. Belo Horizonte: UFMG, 2005. 297p.

VON PINHO, R. G.; BORGES, I. D.; PEREIRA, J. L. de A. R.; REIS, M. C. dos. Macronutrients absorption and dry matter accumulation in maize. **Revista Brasileira de Milho e Sorgo**, v. 8, n. 2, p. 157-173, 2009. https://doi.org/10.18512/1980-6477/rbms.v8n02p%25p

SANTOS, H. G.; JACOMINE, P. K. T.; ANJOS, L. H. C. dos; OLIVEIRA, V. A. de; LUMBRERAS, J. F.; COELHO, M. R.; ALMEIDA, J. A. de; ARAÚJO FILHO, J. C. de; OLIVEIRA, J. B. de; CUNHA, T. J. F. **Sistema brasileiro de classificação de solos**. Brasília: EMBRAPA, 2018. 356p.

SOARES, M. M.; BARDIVIESSO, D. M.; BARBOSA, W. F. S.; BARCELOS, M. N. Topdressing arugula crop with sulfur. **Revista de Agricultura Neotropical**, v. 4, n. 1, p. 49-52, 2017.

SOUSA, D. M. G.; MIRANDA, L. N.; OLIVEIRA, S. A. Acidez do solo e sua correção. In: NOVAIS, R. F.; ALVAREZ V, V. H.; BARROS, N. F.; FONTES, R. L.; CANTARUTTI, R. B.; NEVES, J. C. L. (Eds.). **Fertilidade do solo**. Viçosa: Sociedade Brasileira de Ciência do Solo, 2007. p. 205-274.

SOUSA, D. M. G.; LOBATO, E. **Cerrado: correção do solo e adubação**. Embrapa Cerrados, 2004. 416p.

TEIXEIRA, P. C.; DONAGEMA, G. K.; ADEMIR, F.; TEIXEIRA, W. G. **Manual de métodos de análise de solo**. 3 ed. Rio de Janeiro: Embrapa Solos, 2017. 573p.

VIANA, J. L.; ZOLIN, C. A.; BACCIN, G. N.; SANTOS, R. Infiltração de água do solo em latossolo vermelho-amarelo distrófico sob diferentes sistemas de manejos. In: V JORNADA CIENTÍFICA, **Anais...** 2018. sINOP: p. 48-51. Available on: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1065675/infiltracao-de-agua-do-solo-em-latossolo-vermelho-amarelo-distrofico-sob-diferentes-sistemas-de-manejos. Acessed at: 30 Jul. 2024.

WHATLEY, J. M.; WHATLEY, F. R. **A luz e a vida das plantas**. São Paulo: EPU-EDUSP, 1982. 101p.

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Data availability: The data of this research can be obtained by request from the corresponding author via e-mail.

Conflict of interest: The authors declare no conflict of interest. Supporting entities had no role in the study's design, in the collection, analysis, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.