SULFUR SUPPLEMENTATION MITIGATES DROUGHT DELETERIOUS EFFECTS IN SOYBEAN PLANTS

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1 – INTRODUCTION

Soybean is as leguminous crop cultivated in several countries in the world, to be used for various purposes, such as oil production and animal feed. In Brazil, the soybean crop is keeping to increase throughout the year the expected production is 123.2 million tons, a milestone in history. Nonetheless, the climatic conditions may negatively impact on plant performance, especially in several producing Brazilian states, mainly due to low rainfall (CONAB, 2019). Currently, one of the limitations of Brazilian agriculture is the scarcity of water, a limiting factor for the production and development of culture. The effect of water deficit on soybean production is influenced by several factors, such as the time of occurrence and time of exposure, stage of germination, emergence and flowering, as well as during grain filling (TEXEIRA et al., 2008).

Prolonged water restriction during the stages of plant development causes numerous complications for the plant, including physiological changes, the decline in symbiotic fixation of atmospheric nitrogen, reduction of leaf area, short internodes, closure of leaflets, reduction of phytomass, abortions and flower falls, impaired seed germination, reduced number of pods, increased susceptibility to pathogens and pests, stomatal closure and, consequently, declined production (BARBOSA, 2017).

Numerous studies have been conducted in order to identify strategies for maintaining soybean production. Fertilization with mineral nutrients emerges as a promising strategy, once it can be an important research target, seeking to minimize the effects of water scarcity on the plant. According to Richart and Kotz (2017), S is a constituent of the amino acids that form plant cell proteins, being also an activator of enzymes and vitamins that promote nodulation for nitrogen fixation by legumes, assisting in the production of seeds and being necessary for the formation chlorophyll, and several organic compounds.

Considering the socio-economic importance of soybean for Piaui State, studies focusing strategies for increase the plant tolerance are fundamental to develop new cultivation techniques and new genotypes/cultivars capable to grown under adverse environmental conditions, in order to produce economically. Our study aimed to investigate the role of supplementation with sulfur (S) on soybean tolerance to water stress, analyzing aspects related to plant growth, relative tolerance and sulfur accumulation in plants tissues.

2 - MATERIAL AND METHODS

This study was conducted in the experimental area of the Federal University of Piauí (UFPI), in Bom Jesus city, Piauí State, Brazil (Latitude: 9°04'South / Longitude: 44°21' West /Altitude: 650 m). The environmental conditions in the region include a photoperiod of approximately 12 h; and maximum and minimum temperatures of 36 and 22 ° C, respectively.

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The trials were carried out using completely randomized blocks (DBC), in a 3 × 2 × 2 factorial arrangement, consisting of three levels of drought stress (control, moderate drought, and severe drought), two doses of sulfur (S) (40 and 80 kg ha^{-1}) and two soybean genotypes (BÔNUS 8579 and M8808), with four replications.

During the sowing, the seeds were treated with fungicide and then sown in a row at 0.01 m deep, with irrigation at 60% of the field capacity (FC), conducted by drip hoses with 0.02 m dripper spacing and 1.5 L h^{-1} flow.

The application of sulfur treatments (S) was done by adding agricultural plaster. For water stress treatments, the soil humidity was daily monitored using tensiometers, which measured the tension of the water retained by the soil particles. Whenever there was a need for water replacement, a volume based on the evapotranspiration of the culture was applied. Drought treatments were imposed after 28 days of sowing, by decreasing the water level for 45% (moderated drought) and 30% FC (severe drought). A block was irrigated with 60% FC, consisting of the control treatment.

Harvests were done 28 days after drought treatments imposition. In this case, the following parameters were analyzed: fresh and dry mass; relative tolerance to water stress; and sulfur content in plant tissues.

The results were subjected to analysis of variance (ANOVA) and the means were compared by using Tukey test ($P \leq 0.05$). Statistical analyzes were performed using the SISVAR program, and the figures were made using the SigmaPlot software (Version 11).

3 - RESULTS AND DISCUSSION

The data of fresh shoot weight (FSW) and dry shoot weight (DSW) was reduced by water stress, a response depending on soybean genotype and drought level (Figure 1). However, the S supplementation partially reverted the water stress damage on the growth medium. The data demonstrated that plants of the M8808 genotype under severe stress resulted in better growth with an increased dose of S (80 kg ha^{-1}) compared to the recommended dose for the crop (40 kg ha^{-1}). Interestingly, the plants of this genotype subjected to severe drought, and under a high S dose, displayed identical values of FSW and DSW to those of the control treatment (Figure 1). In addition, the growth of M8808 plants under severe drought was higher than that of plants of the genotype BÔNUS.

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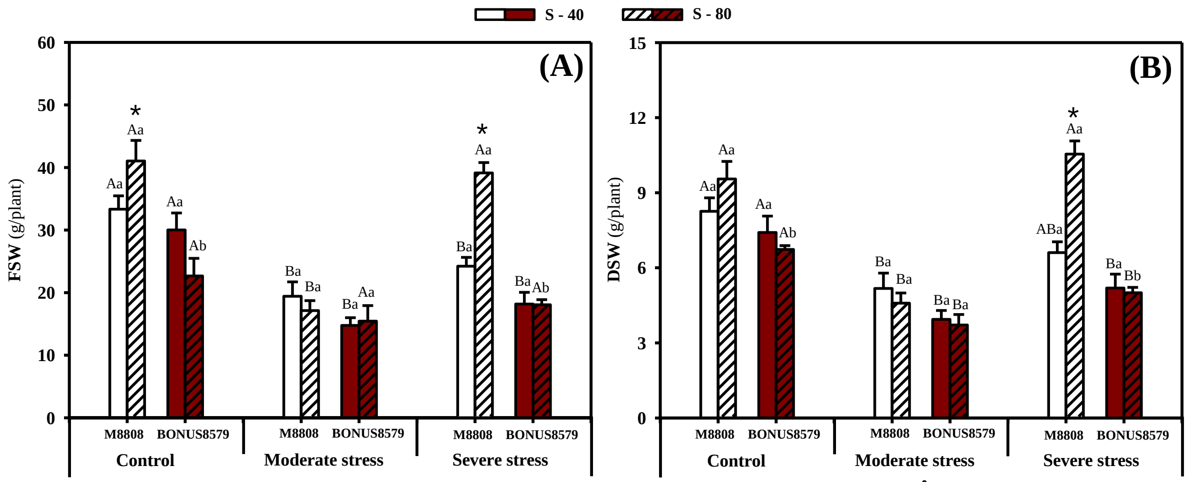

Figure 1: Fresh (MFPA, A) and dry mass (MSPA, B) from shoot of soybean plants, genotypes M8808 and BÔNUS8579, after 28 days of water stress treatments, under differentiated sulfur supplementation (S). The water stress was caused by the reduction of the water level in the soil to 45% (moderate stress) and 30% (severe stress) of the field capacity, with the treatment of 60% as control. The sulfur treatments consisted of fertilization with 40 (recommended dose) and 80 kg ha-1 (supplementation). In the same genotype and stress level, asterisks represent a significant difference due to sulfur fertilization; whereas, at the same level of stress and fertilization with S, different lowercase letters denote significant differences between genotypes; and, in the same genotype and dose of S, different capital letters represent differences due to the treatment of water stress, according to the Tukey test ($p \leq 0.05$).

The regulation of biomass production as a result of stress treatments directly reflected in the relative tolerance of plants to water deficit (Figure 2). In this case, at the recommended dose for the crop (40 kg ha^{-1}), both soybean genotypes studied (M8808 and BÔNUS8579) dissipated drastic reductions in water deficit tolerance. On the other hand, the data clearly demonstrate that increases in the dose of S (80 kg ha^{-1}) increased the tolerance of plants of the M8808 genotype to severe water stress, compared to a recommended dose. This response was dependent on the genotype and stress level, since the increase S level further reduced the M8808 tolerance to moderate water stress.

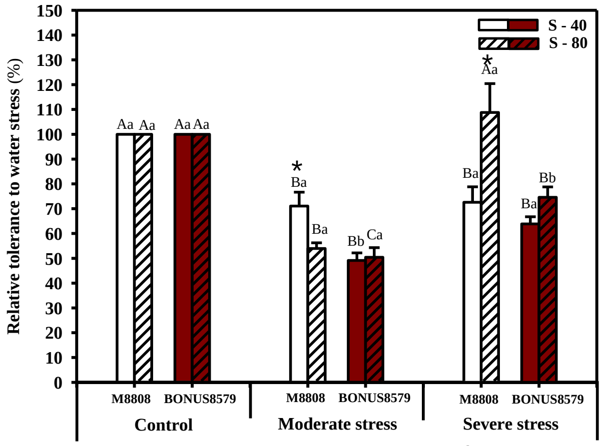

Figure 2: Relative tolerance to water stress of soybean plants, genotypes M8808 and BÔNUS8579, after 28 days of water stress treatments, under differentiated sulfur supplementation (S). The water stress was caused by the reduction of the water level in the soil to 45% (moderate stress) and 30% (severe stress) of the field capacity, with the treatment of 60% as control. The sulfur treatments consisted of fertilization with 40 (recommended dose) and 80 kg ha-1 (supplementation). Statistical details are similar to those in figure 1.

To establish a relationship between the role of S supplementation in modulating responses to water deficit and its accumulation in the tissues of soybean plants, the S levels from shoot and roots were measured (Figure 3). In absolute terms, soybean plants showed higher S accumulation in root tissues compared to aerial tissues. In shoot, the S supplementation promoted increases in the levels of this element in the M8808 genotype under control condition, and in the BÔNUS8579 plants under moderate stress (Figure 3A). On the other hand, in the roots, plants growing in the highest dose of S (80 kg ha^{-1}) showed significant increases in the S levels, regardless of genotype and water stress, except for the BÔNUS8579 genotype growing under control condition (Figure 3B).

The water stress promoted reductions in shoot S content from plants subjected to supplementation treatments, a response intensified by the level of stress (Figure 3A). In contrast, in roots, plants M8808 and BÔNUS8579 submitted to severe water deficit showed increases in the levels of S when supplemented with this element, in comparison to the respective controls (Figure 3B). The results clearly show that the accumulation of sulfur occurs mainly in the root tissues and that this response depends on the level of stress to which the plants are exposed. In all cases, supplementation with this nutrient in the growth medium intensifies its accumulation in plant tissues and induces differential responses to water stress, including modulation of growth processes.

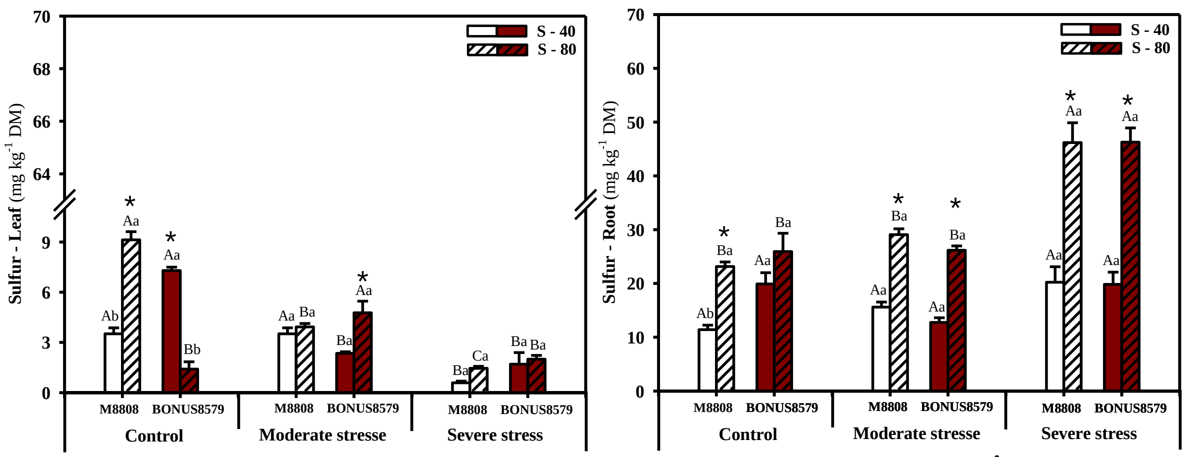

Figure 3: Sulfur contents in the aerial part (A) and in the roots (B) of soybean plants of the genotypes M8808 and BÔNUS8579, after 28 days after the submission of the water stress treatments, under differentiated sulfur supplementation (S). Water stress was imposed by reducing the water level in the soil to 45% (moderate stress) and 30% (severe stress) of field capacity, with 60% treatment as control. The sulfur treatments consisted of fertilization with 40 (recommended dose) and 80 kg ha-1 (supplementation). Statistical details are similar to those in figure 1.

4 – CONCLUSION

Supplementation with S at 80 kg ha^{-1} emerges as a promising strategy for growing soybean plants of the M8808 genotype in soils with low water availability, being a viable alternative to mitigate the deleterious effects of water deficit.

5 – BIBLIOGRAPHY

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