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Response of the Weight of A Thousand Seed With Inoculation With Nitrogen-Fixing Bacteria In Soybean Cultivated in Soil Contaminated With Copper

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Abstract: Copper is a heavy metal that occurs naturally in soil and is an essential micronutrient for plant development, but high levels of copper in soil can harm agricultural production due to its toxicity, posing risks to the entire anthropogenic chain, including animals and animals. humans. Soy production has reached global relevance, manifested in domestic and export markets due to the socioeconomic value of its products and by-products in numerous applications, producing a variety of food products such as oils, milk, margarine, cheeses, sauces, proteins from texture. of soy, soy flour and meal for animal feed. The insertion of the bacterium *Bradyrhizobium joponicum* promotes biological nitrogen fixation and is one of the main factors in large-scale soybean cultivation in Brazil.

Key words: copper, heavy metal, Bradyrhizobium joponicum

1. Introduction

Copper (Cu), a heavy metal that occurs naturally in soils, is a fundamental micronutrient for plant development [1], which plays an important role in nutrition, participates in metabolism and is a structural part of some enzymes [2].

High levels of Cu in the soil can harm crop production due to its toxicity, posing risks to the entire anthropic chain, including animals and humans [3]. The main anthropogenic sources of copper in the soil are arbitrary use of pesticides, fungicides, industrialization, urbanization, mineralization [4].

Plants grown in soils with high copper content can heavily accumulate these heavy metals in their tissues and develop symptoms of toxicity [5].

Soy production has reached worldwide relevance, due to the socioeconomic value of the numerous applications of its products and by-products, with expression in the domestic and export market [6], several foods such as oil, milk, margarine are produced from soy, cheeses, sauces, textured protein, flour and soybean meal used in animal feed [7].

Soybean is a nodular plant, as the roots can establish a symbiotic relationship with species of bacteria capable of fixing molecular nitrogen N2 from the atmosphere into nitrogenous compounds. The functionality of N2 fixation is guaranteed by the establishment of an efficient vascular system inside the nodule, which supplies the fixing bacteria with nutrients [8].

The insertion of bacteria of the genus *Bradyrhizobium joponicum*, promoters of biological nitrogen fixation (BNF), was one of the major agents of large-scale soybean cultivation in Brazil [9].

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The use of inoculants with the bacterium *Bradyrhizobium joponicum*, led to annual savings equivalent to US$ 3.2 billion in nitrogen fertilizers [10]. The share of nitrogen fixed by soybeans via biological nitrogen fixation is proportional to up to 300 kg N ha^{-1}, supplying about 94% of the crop's needs [11].

The objective of this work was to evaluate the response of the thousand seed weight to the inoculation with *Bradyrhizobium joponicum* in soybean cultivated in soil contaminated with copper.

2. Material and Methods

The experiment was carried out in a greenhouse at the Federal University of Santa Maria, campus Frederico Westphalen – RS. The experimental design was completely randomized, with a 7 × 2 sampling grid, with seven doses of copper (0, 80, 120, 240, 320, 400 and 480 mg of copper kg^{-1} of soil) with inoculation *Bradyrhizobium joponicum* and control (TEST) without inoculation. The inoculant used was provided by the company Simbiose located in the city of Cruz Alta, RS, Brazil. The liquid inoculant Symbiose® composed of bacteria of the genus *Bradyrhizobium joponicum* (SEMIA 5079 and SEMIA 5080) was used at a concentration of 5.0 × 109 cells per mL, at a dose of 2 ml kg^{-1} of seed, which resulted in a concentration of 2,000,000 CFU per seed, inoculates were homogenized with the seeds at the time of sowing, performing 8 replications.

The seeds used in the experiment were soybean cultivar 5917 ipro, supplied by Cooperativa Agroindustrial Alfa, Chapecó, SC. The soil used was Red Latosol according to SANTOS (2013) [12], collected in an agricultural production area in the Alto Uruguai region, in the 0-20 cm layer, 70% clay texture.

Plastic pots with a capacity of five liters were used, filled with 4.5 kg of soil. In each pot, 5 seeds were sown, which were disinfected with 2% sodium hypochlorite for 15 minutes and then washed in running water. Thinning was performed eight days after germination, using only one plant per pot. Irrigation was performed daily using a drip irrigation system.

The results were submitted to analysis of variance and when they expressed considerable interaction, they were submitted to regression analysis of the quantitative variation factor (doses) within each level of the qualitative factor (inoculation). For the parameters that did not show interaction, the simple effects were unfolded, and the means of the qualitative factor were compared by the Tukey test at 5% error probability and the means of the quantitative factor submitted to polynomial regression analysis by the SISVAR program [13].

3. Results and Discussion

There were significant interactions between *Bradyrhizobium joponicum* inoculation and doses of copper applied to the soil for the variables analyzed, Peso de Mil Sementes (PMS) (Fig. 1).

For the weight of a thousand seeds, without inoculation, there was a linear decrease with the dose of copper applied to the soil, with the inoculation it obtained a quadratic curve, the best response was achieved at the dose of 161 mg kg^{-1} of copper applied to the soil, where it reached the maximum point of weight of a thousand seed of 182 g. above this value, decreasing the weight of a thousand seed as the copper dose in the soil increases.

This result corroborates the work carried out by Kamicker and Brill (1986) [14] who, evaluating the effect of inoculation, found that the application of inoculant allowed an increase in the weight of a thousand seeds. In agreement with the results obtained by Braccini (2016) [15] in which he observed that the mass of a thousand soybean grains had a positive effect on the use of Bradyrhizobium. In the same way, results found by Pardinho and Primieri (2015) [16], found an increase in the values of weight of a thousand seed and in soybean productivity.

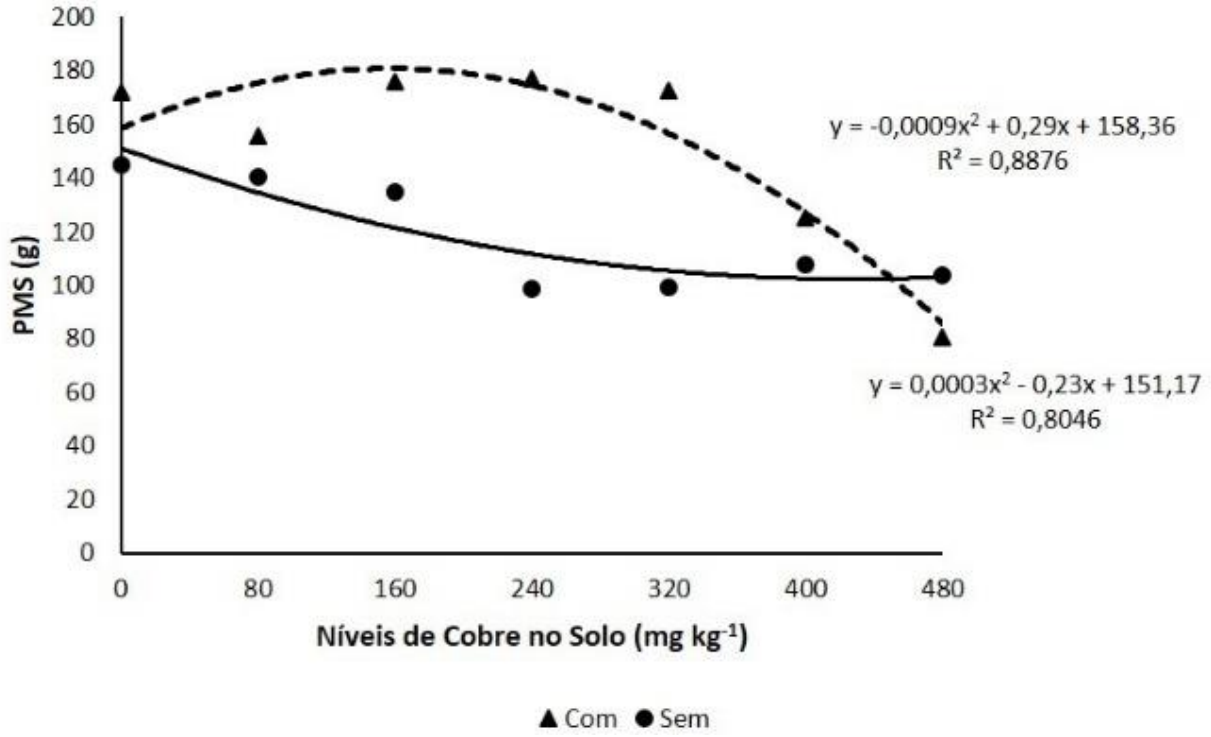

Fig. 1 Weight of a thousand seeds of soybean plants subjected to copper dose in the soil with and without inoculation with *Bradyrhizobium Japonicum.*

According to Silva et al. (2010), nitrogen is an essential nutrient for plant development, this result is justified because biological nitrogen fixation occurred. According to Hungary (2011), when the nutritional balance is maintained in plants, the results will be reflected in their productivity, enhancing soybean yield.

The increase in the concentration of copper in the soil provided a greater decrease in the development factor of soybean plants in the non-inoculated treatments [17].

When there is an increase in the concentration of Cu, the development of the plant decreases, demonstrating that the plant activates defense mechanisms by which it limits the absorption of the metal. Restriction in the flow of the toxic element is seen as an important defense mechanism of shoot structures, since excess Cu can inhibit important physiological processes [18].

4. Conclusion

Inoculation in seed treatments with Bradyrhizobium japonicum provides increments in the weight of a thousand seeds.

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