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Citrate exudation in *Glycine max* as a response to drought under different semi-arid soil microbiomes

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Drylands face increasing challenges due to climate change, making the search for natural adaptation mechanisms in crops like soybean (*Glycine max*) essential. This study investigates a multifactorial approach to the interactions between different microbiomes (Caatinga and Atlantic Forest), soil water availability (60%, 40%, and 20% Water Holding Capacity), and plant genotypes (drought-susceptible and drought-tolerant), to evaluate how these factors influence plant growth and rhizosphere metabolic responses, particularly citrate exudation. The experiment was conducted using a 3x4x2 factorial scheme, involving microbial coalescence between soils in the microbiome factor to assess synergistic effects. Data were analyzed via ANOVA and Tukey's test ($p < 0.05$) . Results for agronomic traits and rhizosphere soil showed that plant shoot fresh weight, P-DGT (labile phosphorus) and citrate levels were significantly influenced through different microbiomes. The biochemical response in the rhizosphere suggests that citrate exudation is a key metabolic strategy for phosphorus mobilization, as soils with less P-DGT presented higher citrate concentration, indicating a negative correlation between these variables and a potential plant mechanism to improve phosphorus availability. Microbiomes related to more conserved enviroments, as Atlantic Forest and Native Caatinga, had higher P-DGT values in the rhizosphere compared to secondary and degraded Caatinga. Regarding plant shoot biomass, higher values were observed in soils with microbial coalescence compared to Atlantic Forest soils, additionally, drought-tolerant genotypes showed greater shoot biomass, except in degraded Caatinga soils, and biomass decreased from 60 % WHC to 20 % WHC. Overall, the integration of adapted semi-arid microbiomes through coalescence presents a promising strategy to study how different microbiomes mitigate water stress effects in soybean by promoting increase in growth parameters and change in nutrient availability at the rhizosphere. This synergy between citrate, phosphorus availability, and shoot fresh mass underscores the role of soil biology in agricultural science and soil health.

KEYWORDS: Organic acid, nutrient acquisition, osmotic stress.

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