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AGRONOMIC EVALUATION OF A GLASS FERTILIZER IN *Urochloa brizantha* CROP GROWING

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Abstract: Considering the challenges related to the low efficiency of fertilizer use and Brazil's dependence on imports, vitreous fertilizers (VF) emerge as a promising alternative, as they are sources of multiple nutrients with slow release for plants. The laboratory of inorganic and vitreous materials(LAMIV, IQSC/USP) synthesized the GF with a final composition (%) of: 11% N; 7.0% MgO; 15.9% SiO_2; 38.2% P_2O_5; 11.1% K_2O; 14.2% CaO; 1.4% MnO; 8.5% ZnO; 0.7% MoO_3; and 2.9% B_2O_3, was evaluated on the cultivation of Brachiaria Brizantha (*Urochloa brizantha*) to understand the dynamics of nutrient release and uptake by the plant. The experiment was conducted in a greenhouse at Embrapa Pecuária Sudeste, São Carlos, SP, using three types of soil and three treatments. Cuts were made every 35 days to assess the production in each pot, analyzing the shoot dry matter production, agronomic efficiency, and nutrient extraction for each soil type. The results showed that the GF when compared to inorganic salts, achieved higher dry matter production, agronomic efficiency, and nitrogen extraction in clay, followed by sandy and medium soils, demonstrating its potential to meet the nutritional needs of the plants.

Keywords: enhanced efficiency fertilizer (EEF), *urochloa brizantha*, vitreous fertilizer

AVALIAÇÃO AGRONÔMICA DE UM FERTILIZANTE VÍTREO NO CULTIVO DE UROCHLOA BRIZANTHA

Resumo: Diante dos desafios relacionados à baixa eficiência do uso de fertilizantes e à dependência de importações do Brasil, os fertilizantes vítreos (FV) surgem como uma alternativa promissora, por serem fontes de múltiplos nutrientes com liberação lenta para as plantas. O fertilizante vítreo foi sintetizado pelo Laboratório de materiais inorgânicos e vítreos (LAMIV, IQSC/USP), com uma composição final (%) de: 11 N; 7,0 MgO; 15,9 SiO_2; 38,2 P_2O_5; 11,1 K_2O; 14,2 CaO; 1,4 MnO; 8,5 ZnO; 0,7 MoO_3; 2,9 B_2O_3, sendo avaliado no cultivo da Brachiaria Brizantha (Urochloa Brizantha) visando compreender a dinâmica de liberação e aproveitamento de nutrientes pela planta. O trabalho foi conduzido em casa de vegetação na Embrapa Pecuária Sudeste, São Carlos-SP com três tipos de solos e três tratamentos. Cortes foram realizados a cada 35 dias para avaliar a produção em cada vaso, sendo determinado a produção de matéria seca da parte aérea, eficiência agronômica e extração dos nutrientes em relação a cada solo. Os resultados obtidos indicaram que o emprego do Fv quando comparado aos sais inorgânicos proporcionou maiores produção de Ms, eficiência agronômica e extração de nitrogênio no solo argiloso, seguido de arenoso e médio, indicando a potencialidade para atender às necessidades nutricionais das plantas.

Palavras-chave: fertilizante de eficiência aumentada (EEF), *urochloa brizantha*, fertilizante vítreo

1. Introduction

Brazil is currently the fourth-largest consumer of fertilizers in the world, importing more than 70% of these nutrient sources, a significant portion from non-renewable sources (Farias et al., 2020; Galembeck et al., 2019). In addition, the efficiency of using NPK fertilizers is often very low, with less than 50% efficiency for nitrogen, less than 10% for phosphorus, and approximately 40% for potassium (Baligar et al., 2001; Cunha et al., 2023). These low efficiencies are due to the losses that these nutrients can suffer in the agricultural environment, making it necessary to improve the adoption of good practices for fertilizer use. Within good management practices (Reetz, 2016), one alternative to reduce the potential for loss is the use of more efficient nutrient sources. Slow- or controlled-release fertilizers utilize technologies that alter nutrient release patterns, resulting in slower nutrient release than conventional sources (Trenkel, 2010). Increased efficiency fertilizers can enhance nutrient use efficiency by reducing losses through leaching, volatilization, fixation, and the emission of nitrous oxide (depending on the N, P, or K source), thereby increasing plant absorption through a gradual supply, according to plant demand (Reetz, 2016).

Among EEF technologies, glassy fertilizers (GF) stand out, as they are non-crystalline and multi-element materials that can release nutrients in a slow and controlled manner (Soares et al., 2025). Despite their composition with macro- and micronutrients, nitrogen cannot be incorporated into the composition due to the high temperatures required in the synthesis process by fusion (800-1200 °C) and cooling. The impact of GF urea has already been reported by Sayed & Ouis (2022). Another alternative that is being explored is, coating of the glassy fertilizer with hydrogel (Soares, 2024). The present study aimed to evaluate the impact of a composite of glassy fertilizer in a hydrogel on the growth and dynamics of nutrient release and use by the plant.

2. Materials and Methods

2.1 Glass Fertilizer Synthesis

The glass fertilizer (GF) was developed at Laboratory of inorganic and vitreous materials (LAMIV,IQSC/USP (São Carlos, SP) to provide essential macro- and micronutrients for plant growth. Its composition follows the proportion (mol %): 38.3 P_2O_5; 14.2 CaO; 11.2 K_2O; 2.5 B_2O_3; 16 SiO_2; 7.1 MgO; 0.7 MoO_3; 8.6 ZnO; 1.4 MnO.

2.2 Greenhouse Trial

The experiment was conducted in a greenhouse at Embrapa Pecuária Sudeste, using three types of soils previously characterized by chemical and granulometric analyses, as described by Raij et al. (2001). The soils presented the following characteristics: (i) clay soil (60.6% clay), (ii) sandy soil (18.9% clay), and (iii) medium soil (35.4% clay).

The experimental design was completely randomized, with the soils (clay, medium, and sandy), treatments (control, soluble salts (at levels similar to the fertilizer), and GF

composite), and four replicates, resulting in a total of 36 pots with 3 kg of each soil type. The test plant chosen was the forage Piatã grass (*Urochloa brizantha*). The soils received limestone to increase basis saturation (V) to 70%, and the fertilizer doses were adjusted to 300 mg kg^{-1} P_2O_5. Two seedlings were planted per pot, and the cuts were made successively every 35 days after planting. Samples of the collected material will be taken to the greenhouse with forced air circulation at 65 °C until a constant weight is achieved, allowing for the determination of dry matter. In these samples, the levels of macro- and micronutrients were determined: by inductively coupled plasma optical spectrometry (ICP-OES) after microwase acid digestion and total by sulfuric digestion and distillation in a micro-Kjeldahl system, as described by Nogueira & Souza (2005).
Based on dry matter production and nutrient content in the aerial part, the agronomic efficiency (AE, Equation 1), and nitrogen use efficiency (NUE, Equation 2), were determined,

$$AE = \frac{(DMP\ GF) - (DMP\ control)}{(DMP\ SS) - (DMP\ control)} X\ 100 \qquad \text{(Equation 1)}$$

Where DMP GF is the dry matter production with the glassy fertilizer, DMP control is the dry matter production without nutrients (control), and DMP SS is the dry matter production with soluble salts.

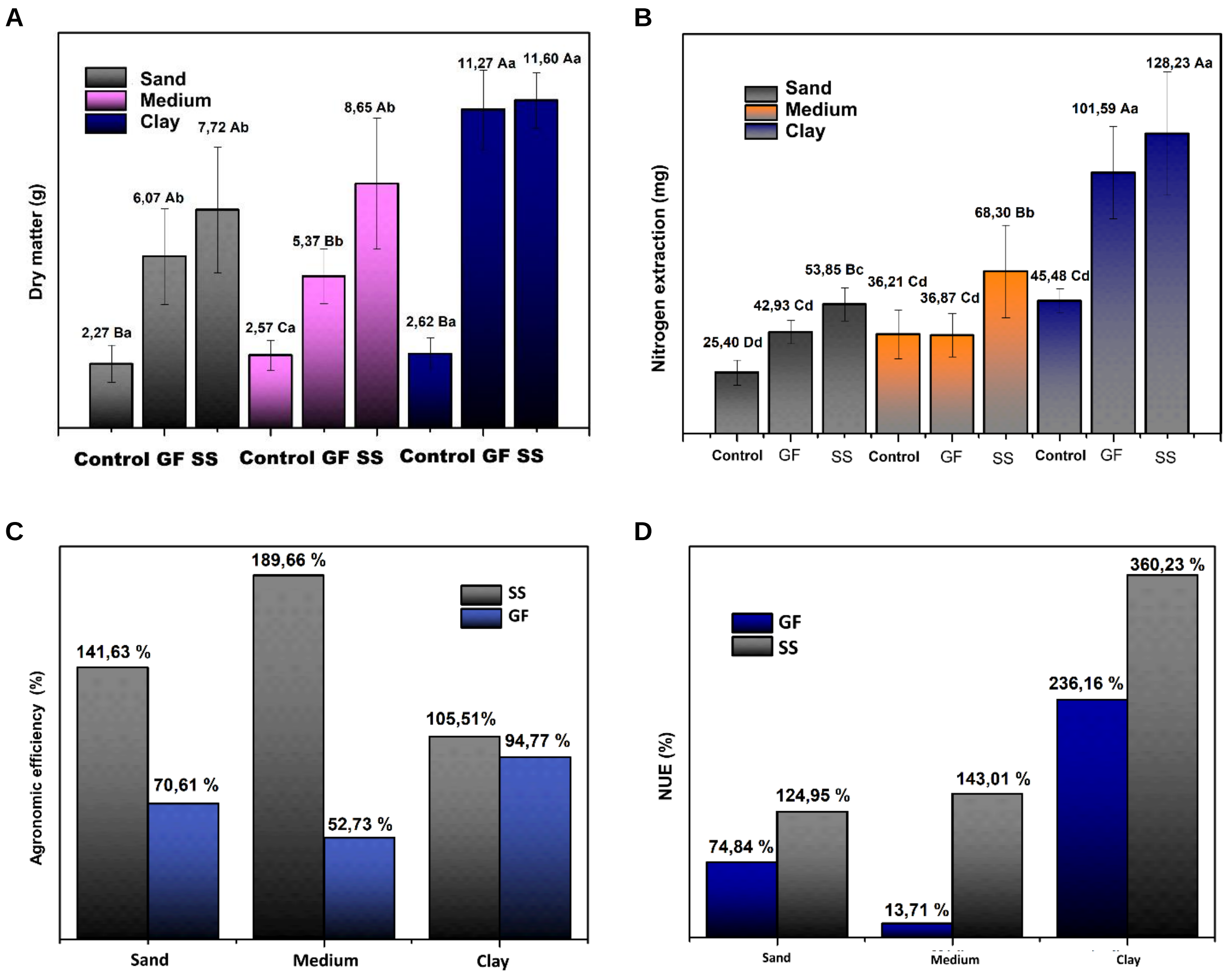
$$NUE = \frac{(DMP\ GF) - (DMP\ control)}{Nut} X\ 100 \qquad \text{(Equation 2)}$$

Where DMP trat is the dry matter production with the glassy fertilizer (g); DMS control is the dry matter production without nutrients (control - g); and Nut is the amount of applied nutrient (g).
Statistical analyses were performed using the SAS 9.4 program by analysis of variance (ANOVA), with $p < 0.05$. The Tukey test was used to analyze the means of the treatments.

3. Results and Discussion

In clay- and medium-texture soils, the treatments with GF and SS showed significantly higher dry matter (DM) production than the control (Figure A), confirming the importance of adequate nutrient supply for forage development. However, there was no statistical difference between them, indicating that the glass fertilizer, even with its controlled release, was equally effective in supplying the nutritional needs of *Brachiaria brizantha* (Soares et al., 2025). Costa et al. (2010) emphasize that nitrogen fertilization significantly increases the biomass of *Brachiaria brizantha*, especially in clay soils, due to its greater cation exchange capacity (CEC), improved moisture retention, and reduced nutrient leaching. The agronomic efficiency of GF (Figure C) was higher in clay soil (94.77%), followed by sandy (70.61%) and medium (52.73%) soils, but similar to SS in clay soil, indicating a viable and efficient alternative source, even with controlled release, when compared to conventional sources. There was no statistical difference in nitrogen extraction between the sandy and medium soils, which presented lower values than the clay soil, which exhibited a greater extraction of both GF and SS.
Nitrogen use efficiency (NUE) was also more pronounced in clay soil (Figure D), confirming that, in this type of soil, the applied N is better utilized, both with GF and SS. This result reinforces the role of soil texture in the dynamics of nutrient absorption, where, in sandy and medium-textured soils, the lower nitrogen retention capacity compromises

fertilization efficiency (Wang et al., 2022).



**Means followed by distinct letters differ from each other by the Tukey test (p<0.05). Capital letters refer to soil type, and lowercase letters refer to treatment.*

Figure 1: Dry matter production (A - g), nitrogen extraction (B - mg), Agronomic efficiency (C - %), and NUE (D - %).

4. Conclusions

The results showed that the GF achieved higher dry matter production, agronomic efficiency, and nitrogen extraction in clay soil, followed by sandy and medium soils, demonstrating its potential to meet the nutritional needs of the plants. These results confirm the potential for developing glass fertilizers facilitating controlled nutrient release.

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