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BACHARELADO EM AGRONOMIA

GIZELLE BARBOSA GONÇALVES

Aplicação de diferentes concentrações de biofertilizante líquido tratado magneticamente para produção de mudas de tomate

CRISTALINA-GO
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Trabalho de conclusão de curso apresentado ao curso de Bacharelado em Agronomia do Instituto Federal Goiano – Campus Cristalina, como requisito parcial para a obtenção do título de Bacharelado em Agronomia.
Orientador: Dr. Álvaro Henrique Cândido de Souza
Coorientador(a): Dr. Wolff Camargo Marques Filho

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APLICAÇÃO DE DIFERENTES CONCENTRAÇÕES DE BIOFERTILIZANTE LÍQUIDO TRATADO MAGNETICAMENTE PARA PRODUÇÃO DE MUDAS DE TOMATE

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Application of different concentrations of liquid biofertilizer magnetically treated for production of tomato seedlings

Aplicação de diferentes concentrações de biofertilizante líquido tratado magneticamente para produção de mudas de tomate

Aplicación de diferentes concentraciones de biofertilizante líquido tratado magnéticamente para la producción de plántulas de tomate

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ABSTRACT
The use of biofertilizers in agriculture has proven to be an effective alternative for cost reduction, sustainable waste disposal, and mitigation of exposure to fluctuations in fertilizer prices. Additionally, the quality of irrigation water is a crucial factor for the production of tomato seedlings; in this context, magnetic treatment emerges as an innovative approach to stimulate growth. The objective of this study was to evaluate the growth of tomato seedlings subjected to four concentrations of liquid biofertilizer (0; 1/30; 1/20; 1/10 v. biofertilizer/v. water) and magnetic treatment of the biofertilizer (with and without). The results indicated that the increasing concentration of liquid biofertilizer promoted a quadratic effect on height, stem diameter, shoot fresh matter and shoot dry matter. This suggests that the use of biofertilizers, especially when combined with magnetic treatment, can be a promising alternative to enhance the growth of tomato seedlings. The biofertilizer concentration between 0.050 and 0.072 (v. biofertilizer/v. water) can be considered for practical application of producers.

Keywords: wastewater, magnetized water, different doses, *Solanum lycopersicum L.*

RESUMO
O uso de biofertilizantes na agricultura tem se mostrado uma alternativa eficaz para a redução de custos, disposição sustentável de resíduos e mitigação da exposição a flutuações nos preços de fertilizantes. Além disso, a qualidade da água de irrigação é um fator crucial para a produção de mudas de tomate; nesse contexto, o tratamento magnético surge como uma abordagem inovadora para estimular o crescimento. O objetivo deste estudo foi avaliar o crescimento de mudas de tomate submetidas a quatro concentrações de biofertilizante líquido (0; 1/30; 1/20; 1/10 v. biofertilizante/v. água) e ao tratamento magnético do biofertilizante (com e sem). Os resultados indicaram que o aumento da concentração de biofertilizante líquido promoveu um efeito quadrático na altura, diâmetro do caule, massa fresca da parte aérea e massa seca da parte aérea. Isso sugere que o uso de biofertilizantes, especialmente quando combinado com tratamento magnético, pode ser uma alternativa promissora para potencializar o crescimento de mudas de

tomate. A concentração de biofertilizante entre 0,050 e 0,072 (v. biofertilizante/v. água) pode ser considerada para aplicação prática dos produtores.

Palavras-chave: água residual, água magnetizada, diferentes doses, *Solanum lycopersicum L.*

RESUMEN
El uso de biofertilizantes en la agricultura ha demostrado ser una alternativa efectiva para la reducción de costos, la disposición sostenible de residuos y la mitigación de la exposición a fluctuaciones en los precios de los fertilizantes. Además, la calidad del agua de riego es un factor crucial para la producción de plántulas de tomate; en este contexto, el tratamiento magnético surge como un enfoque innovador para estimular el crecimiento. El objetivo de este estudio fue evaluar el crecimiento de plántulas de tomate sometidas a cuatro concentraciones de biofertilizante líquido (0; 1/30; 1/20; 1/10 v. biofertilizante/v. agua) y al tratamiento magnético del biofertilizante (con y sin). Los resultados indicaron que el aumento de la concentración de biofertilizante líquido promovió un efecto cuadrático en la altura, el diámetro del tallo, la masa fresca de la parte aérea y la masa seca de la parte aérea. Esto sugiere que el uso de biofertilizantes, especialmente cuando se combina con el tratamiento magnético, puede ser una alternativa prometedora para potenciar el crecimiento de plántulas de tomate. La concentración de biofertilizante entre 0.050 y 0.072 (v. biofertilizante/v. agua) puede ser considerada para aplicación práctica de los productores.

Palabras clave: agua residual, agua magnetizada, diferentes dosis, *Solanum lycopersicum L.*

1 INTRODUCTION

This research aligns with the 2030 Agenda for Sustainable Development, focusing on wastewater treatment from the dairy industry to promote reuse and improve environmental management by preventing detrimental discharges into water systems. Tomatoes are economically vital in Brazil, producing around 1.5 million tons annually, ranking as the third most cultivated vegetable. Goiás is the leading region for industrial tomato production (Korn, 2017; IBGE 2019). Organic fertilizers, such as cattle manure, are increasingly used to support this crop, providing necessary nutrients and beneficial microbes (Gambarini, 2022).

Incentives for more sustainable agricultural practices, particularly organic farming, are becoming more prevalent in Brazil. The Plano Safra 2023/2024, the main agricultural financing policy, allocates resources totaling R$ 364.22 billion and rewards producers who adopt sustainable practices (Brazil, 2023). Therefore, when assessing the viability of these techniques, it is crucial to consider the potential for accessing lower interest rates for financing production costs or investments.

Previous studies have highlighted the effectiveness of biofertilizers. For example, Cavalcante (2009) found that higher concentrations of fermented liquid biofertilizer positively influenced the growth parameters of yellow passion fruit seedlings, including height, leaf area, root length, stem diameter, root area, and phytomass. Furthermore, the use of fermented bovine manure may mitigate the adverse effects of water salinity on seedling growth (Medeiros, 2016).

In addition to organic fertilizers, innovative techniques such as magnetization are gaining attention in agricultural research. Studies have explored the application of magnetic fields on seeds, seedlings, and plants, as well as the effects of passing water through a magnetic field (Souza, 2019). For instance, Abedinpour and Rohani (2017) reported that the germination of corn seeds was accelerated by magnetization, resulting in a 10.9% increase in seedling mass compared to non-magnetized seeds. Similarly, Aguilera and Martin (2016) concluded that magnetically treated water enhances seed germination and stimulates tomato plant development.

Fattah and Aoda (2008) emphasized the importance of considering water magnetization among physical and chemical treatment methods due to its reliability, simplicity, and minimal environmental risk. Hence, the objective of this study was to evaluate the effects of various concentrations of magnetically treated liquid biofertilizer on the growth of tomato seedlings, combining both organic and innovative agricultural practices for optimal results.

2 METHODOLOGY

Two experiments were conducted in a protected environment: the first from April 12 to May 13, 2022, and the second from November 11 to December 13, 2022, at the Instituto Federal Goiano, Campus Cristalina, located in the municipality of Cristalina-GO, Brazil (16° 46’ 18’’ S; 47° 37’ 06’’ W; 1,228 m above sea level). According to Köppen's classification, the climate of the region is of the Aw type (Cardoso *et al.* 2014). The protected environment used featured an arched roof covered with a 150 µm polyethylene film, measuring 18 m in length, 16 m in width, and 5.55 m in height. The experimental design was completely randomized, in a 4 x 2 factorial scheme with four replicates, totaling 32 experimental plots. Four concentrations of liquid biofertilizer, 0; 1/30 (0.033); 1/20 (0.05); 1/10 (0.1) volume of biofertilizer/volume of water and magnetic treatment of biofertilizer, with (M) and without (A).

The biofertilizer consisted of a mixture of 70 kg of green manure of cows in lactation (free stall) and 120 liters of water into a low-cost-anaerobic biodigester of 240 liters with diameter 50 cm and 1,10 m hight during 40 days, these proportions were used by Andrade *et al.* (2017). The mixture filled 175 liters, but 65 liters was empt of the biodigester. There was a tube connected between the top of the biodigester and a bottle full of water with lid open that allowed the expanded gas in biodigester can to escape, but prevented the external air from entering into the biodigester. After the process of anaerobic biodigestion the biofertilizer was brewed and after more ten days was used as treatment.

The costs to build the low-cost-anaerobic biodigester was US$ 65.15, being composed of the sum: plastic barrel with lid (US$ 48.63), silicone glue (US$ 4.86), epoxy glue (US$ 5.83) and plastic shower hose (US$ 5.83). The costs to buy the magnetizing device was US$ 573.92. All the collected quotations considered real as the currency with commercial exchange rate Real(R$)/Dollar(US$) of 5.14, that is, US$ 1.0 purchase R$ 5.14 (Brazil, 2024).

The green manure of cows and biofertilizer originated from the process of anaerobic biodigestion were evaluated chemically (Table 1).

Table 1. Chemical composition of green manure of cows and biofertilizer after the process of anaerobic biodigestion.

Parameter	Green manure of cows	Biofertilizer
pH in CaCl2	6.11	8.22
Organic Matter (%)	29.9	7.6
Total Organic Carbon (%)	17.35	4.41
Total Nitrogen (%)	4.42	< 0.50
C/N Ratio	11.12	> 8.82
Total Phosphorus (P2O5) (%)	< 1.0	< 1.0
Total Potassium (K2O) (%)	< 1.0	< 1.0
Total Magnesium (Mg) (%)	< 0.5	< 0.5
Sodium (Na) (%)	< 0.1	-
Total Boron (B) (%)	< 1.0	< 0.1
Total Copper (Cu) (%)	< 0.05	< 0.05
Total Manganese (Mn) (%)	< 0.05	< 0.05

Total Calcium (Ca) (%)	0.78	-
Iron (Fe) (%)	0.45	-
Fertilizer Sulfur (SO4) (%)	< 1.0	< 1.0
Total Zinc (Zn) (%)	< 0.05	< 0.05
Insoluble Mineral Residue Fertilizer	9.26	-
Moisture at 65°C	36.5	-

Source: Prepared by the authors themselves.

Experimental plot was composed by 128-cell polyethyleve tray filled with commercial substrate composed of NPK, peat, vermiculite and organic residues (Carolina Soil ®) and only one tomate (Santa Clara cultivar, Isla®) seed per cell.

The magnetic treatment of biofertilizer was conducted by a kept the magnetizing device for one hour inside a plastic bucket containing 8 liters of biofertilizer. The magnetizing device comprises a piece with a diameter of 0.10 m and height of 0.168 m.

The application of treatment consisted by daily application of two liters of biofertilizer treatment per tray with a watering can approximately 8 to 11 am.

At the end of the experiment were evaluated speed of germination index, final emergence percentage, shoot fresh matter, shoot dry matter, root dry matter, height and stem diameter. The final emergence percentage (FEP) was calculated using Equation 1, which was proposed by Abendinpour and Rohani (2017):

$$FEP = \left(\frac{Total\ number\ of\ seedlings\ emerged}{Total\ number\ of\ seeds\ planted}\right) x\ 100 \qquad (1)$$

The speed of the germination index was determined according to Maguire's methodology (1962) using Equation 2.

$$SGI = \frac{NE_i}{D_i} + \frac{NE_{i+1}}{D_{i+1}} + \cdots \qquad (2)$$

Where SGI represents speed of germination index; NEi , NEi +1 denotes the number of seedlings emerged on the first day of counting, number of seedlings emerged on the second day

of counting, respectively; Di , Di +1 represents first count day = 1, second count day = 2, respectively.

The shoot fresh matter per seedling (SFM) was determined on the last day of the experiment and weighing them on a semianalytical balance with a precision of 0.001 g. Shoot dry matter per seedling (SDM) was determined by oven-drying the SFM in a forced-oven at 60ºC until it reached a constant level. The root dry matter per seedling (RDM) was determined by a washing of root and oven-drying until it reached a constant level. The height and stem diameter of seedling were determined by using a digital caliper.

The data were subjected to Tukey's test and regression model at a significance level of 1%, 5%, and 10% using the Sisvar Software (Ferreira 2014).

3 RESULTS AND DISCUSSIONS

Table 1 shows the analysis of variance for the different concentrations of liquid biofertilizer (CB), magnetic treatment of biofertilizer (MT) and the interaction between these two factors (CB x TM).

The different CB provided significant differences for all variables studied in the two experiments, except for FEP and RDM in the experiment I. On the other hand, MT had differences only for the variables SDM, SFM and height of seedlings in experiment II.

There was significant interaction between the factors studied, CB and MT for the variables SDM, SFM, height and stem diameter in the experiment I and SDM, RDM, height and stem diameter in experiment II. Thus, the analysis was unfolded for these variables.

Table 2. F values from analysis of variance for the variables of growth of tomatoes seedlings as function of different concentrations of liquid biofertilizer (CB) and magnetic treatment of biofertilizer (MT).

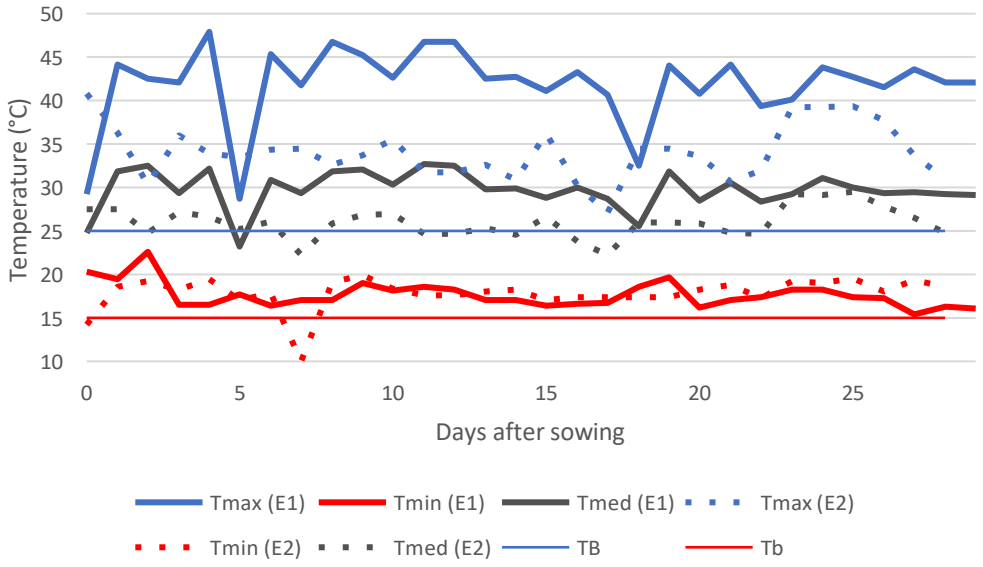
Variables	Source of variation			C.V. (%)	General mean
	CB	MT	CB x MT		
1st experimente					
Shoot fresh matter per seedling (g)	38.668***	0.134ns	3.154**	18.32	0.66
Shoot dry matter per seedling (g)	13.500***	0.154ns	3.054**	24.05	0.073
Root dry matter per seedling (g)	0.638ns	0.068ns	1.682ns	35.30	0.021
Final emergence percentage (%)	1.772ns	0.002ns	0.533ns	10.22	68.40
Speed of germination index	6.792***	0.015ns	1.374ns	14.06	109.21
Height (cm)	12.221***	1.051ns	2.652*	11.93	7.50

Stem diameter (mm)	27.767***	0.925ns	4.481**	7.24	2.28
2nd experiment					
Shoot fresh matter per seedling (g)	47.950***	4.920**	1.582ns	13.25	1.042
Shoot dry matter per seedling (g)	13.221***	4.543**	4.231**	15.19	0.103
Root dry matter per seedling (g)	2.448*	2.019ns	3.026**	17.75	0.035
Final emergence percentage (%)	6.656***	0.002ns	1.187ns	5.34	63.20
Speed of germination index	19.613***	0.667ns	1.326ns	6.02	107.47
Height (cm)	29.458***	3.085*	2.603*	7.77	10.76
Stem diameter (mm)	17.788***	2.417ns	2.507*	7.43	2.52

Note: *** Significant at 0.01 of probability; ** significant at 0.05 of probability; ** significant at 0.10 of probability; ns not significant ($p > 0.05$) according to the F-test.
Source: Prepared by the authors themselves.

It is observed that the growth variables have higher mean values for experiment II, with an increase of 36.6%, 29.1%, 40.0%, 30.3% and 9.5%, respectively for the variables SFM, SDM, RDM, height and stem diameter. Experiment 1 obtained the average maximum temperatures of 41.89 °C, while in Experiment 2 the value was 34.05 °C. The second experiment was most compatible with the requirements of the culture. According to EMBRAPA (2023), the temperature range of 15 to 25 °C is favorable for germination while the production of this range is increased from 10 to 34 °C.

Figure 1. Maximum, minimum and average temperature of air and crop basal temperature for experiment 1 and 2 (Cristalina-GO).



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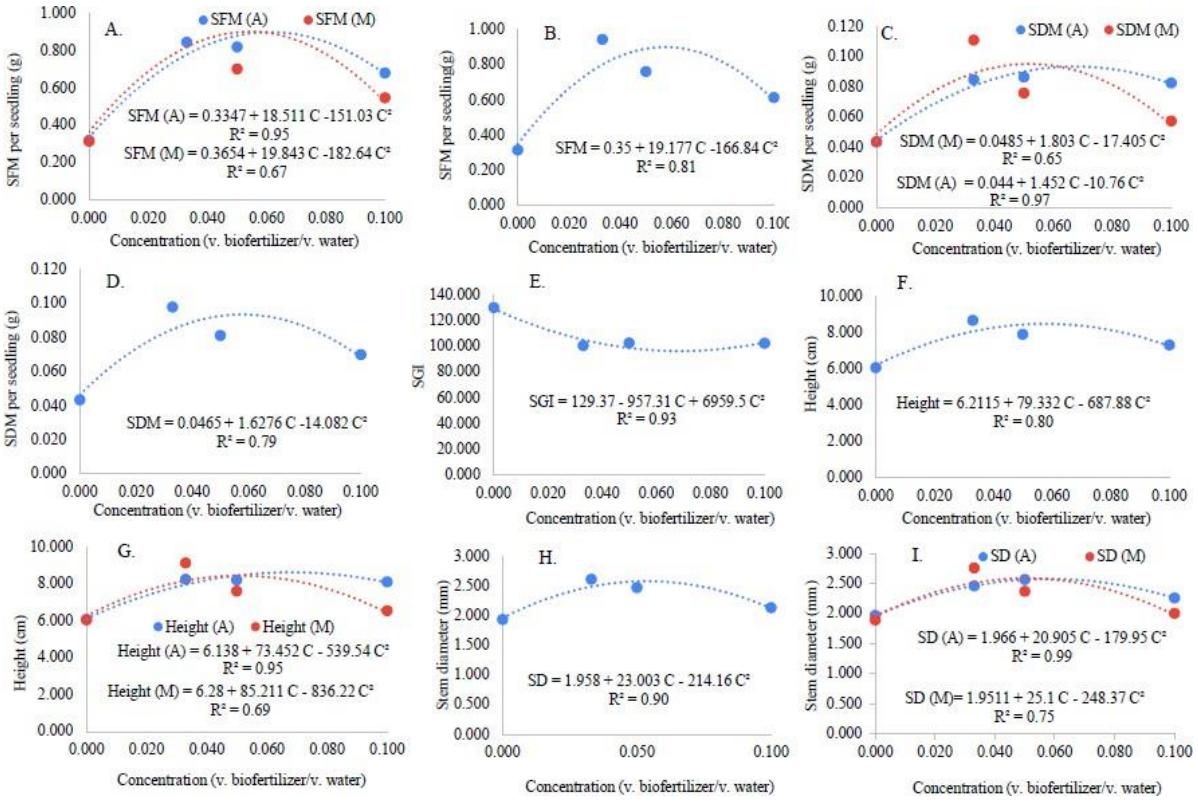
In Figure 2 are presented regression models adjusted for the dependent variables as a function of biofertilizer concentrations for experiment I. For the significant interactions, the general effect and the unfolding of the effect of biofertilizer concentrations were presented magnetically treated and not magnetically treated (SFM, SDM, height and stem diameter). For the non-significant interactions was presented only the general effect of the concentrations for the dependent variable (SGI).

The increase in biofertilizer concentration resulted in a quadratic increase for the variables SFM, SDM, height and diameter, and the optimum concentration was between 0.050 and 0.068 (v. biofetilizante/v. water). Application of the biofertilizer increase 157%, 100.6%, 36% and 31.5% compared to the control, respectively for SFM, SDM, height and stem diameter (Figure 2B, 2D, 2F and 2H). The only variable that presented reduction with the application of biofertilizer was the SGI (Figure 2E).

Lima-Neto *et al.* (2016) found an increase of 276% for total dry matter and 407% of root dry matter of papaya seedlings that received biofertilizer from anaerobic fermentation of fresh manure of lactating cows in a ratio of 200 ml to 2 liters of soil. The addition of manure increased germination, fresh and dry mass, chlorophyll A and B and carotenoids in rice seedlings (Rajasekaran *et al.*, 2015).

Figure 2. Shoot fresh matter (A-B), shoot dry matter (C-D), speed of germination index (E), height (F-G) and stem diameter (H-I) of seedlings of tomato in function of different concentrations of liquid biofertilizer with (M) and without (A) magnetic treatment. 1st experiment. Cristalina-GO.

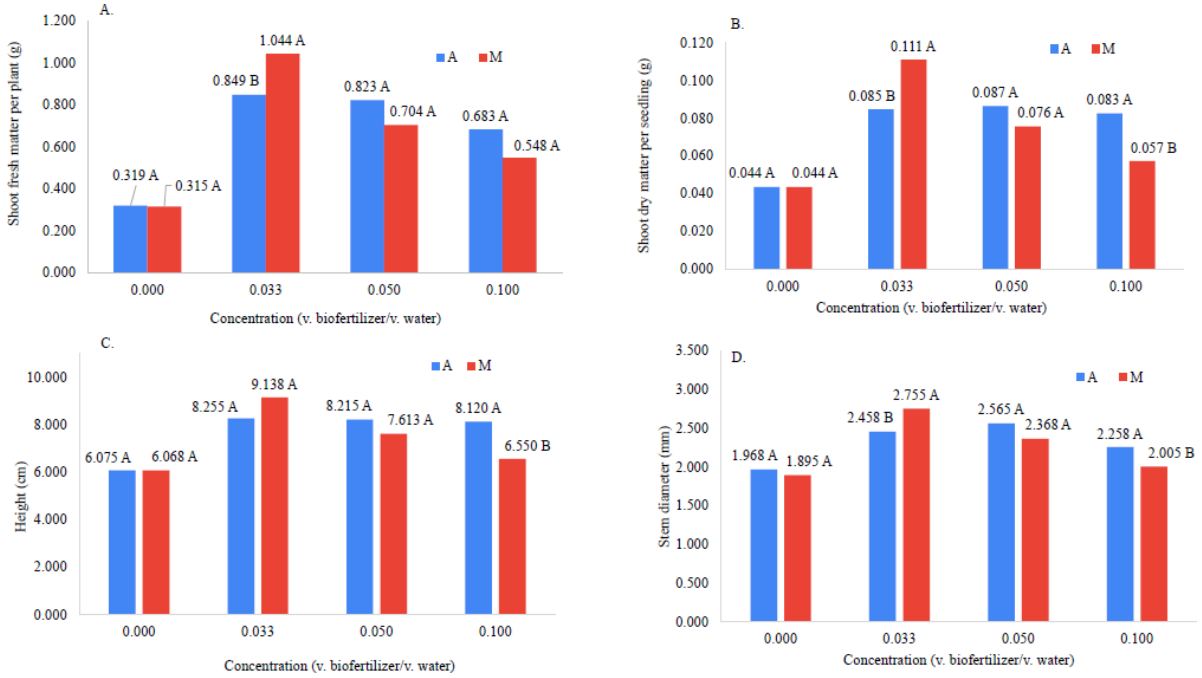


Source: Prepared by the authors themselves.

Figure 3 presents the mean test for the unfolding performed for the significant interactions for experiment I. The variables SFM, SDM, height and stem diameter showed no significant differences for the magnetic treatment at concentration 0 and 0.05 (v. biofertilizer/v. water), but the concentration 0.033 (v. biofertilizer/v. water) showed an increase of 22.96%, 30.58% and 12% with magnetic treatment, respectively for SFM, SDM and stem diameter. The concentration 0.1 (v. biofetilizer/v. water) indicates that the magnetic treatment compared to untreated reduced by 31.32%, 19.33% and 11.20%, respectively for the variables SDM, height and stem diameter.

The effect of the magnetic treatment was not significant for dry and fresh mass of the shoot, differing from the results found by Pradela *et al.* (2018) that verified a positive effect on dry mass of the shoot and root in lettuce seedlings. Fernandes *et al.* (2022) found a beneficial effect on germination speed, fresh and dry mass of shoot, and PEF of tomato seedlings and UH Haq *et al.* (2016) obtained increased germination and speed of turnip emergence, however Pradela *et al.* (2018) did not verify significant differences in the height of lettuce plants that received the magnetic treatment corroborating with the result obtained.

Figure 3. Shoot fresh matter per plant (A), shoot dry matter per seedling (B), height (C) and stem diameter (D) in function of magnetic treatment and different concentrations of liquid biofertilizer. 1st experiment. Cristalina-GO.



Source: Prepared by the authors themselves.

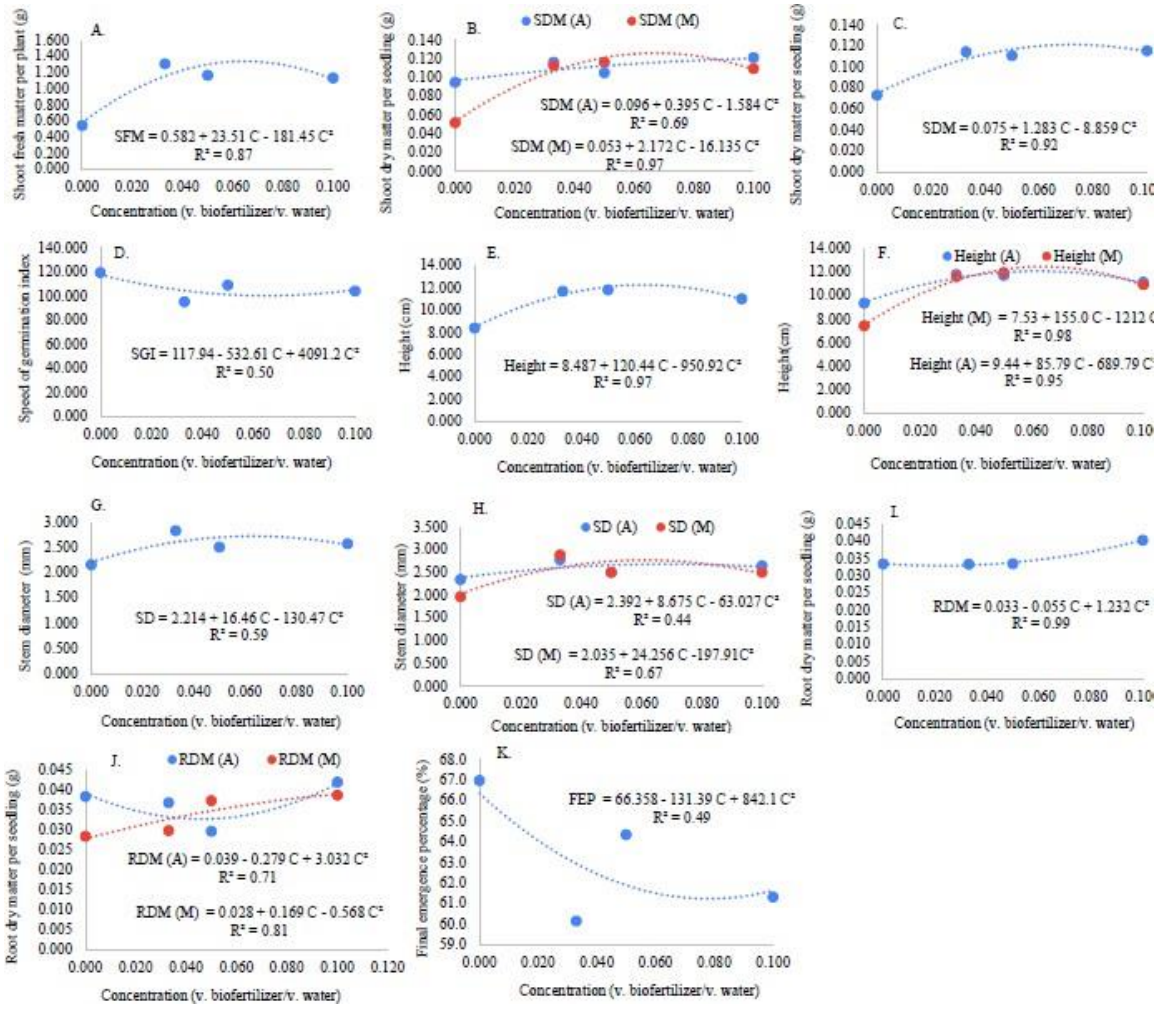
In Figure 4 it is verified that the application of the biofertilizer allowed the increase of 130.75%, 60%, 44.92% and 23.44% compared to the control, respectively for SFM, SDM, height and stem diameter in experiment II corroborating with experiment I (Figure 4A, 4C, 4E, 4G). The optimum concentration was between 0.063 and 0.072 (v. biofertilizer/v. water). The SGI presented reduction with the application of biofertilizer corroborating with the results of the experiment I. The final percentage of emergence was reduced with the application of biofertilizer compared to the control.

Angadi *et al.* (2017) compared the application of manure (12 t/ha) with the control and found increase in height, number of leaves, germination and dry mass of tomato seedlings. The beneficial effect is that biofertilizer is a source of nutrients and microorganisms for plants (Moroccos *et al.*, 2012).

Figure 5 shows that the magnetic treatment did not provide significant differences for growth variables for the treatments that received biofertilizer with the exception of the variable RDM at concentration 0.50 (v. biofertilizer/v. water) that obtained benefit with magnetic treatment of biofertilizer. In the 2nd experiment the magnetic treatment reduced RDM, SDM, high and stem diameter only with treatment that did not receive biofertilizer, differing from the results obtained in experiment I.

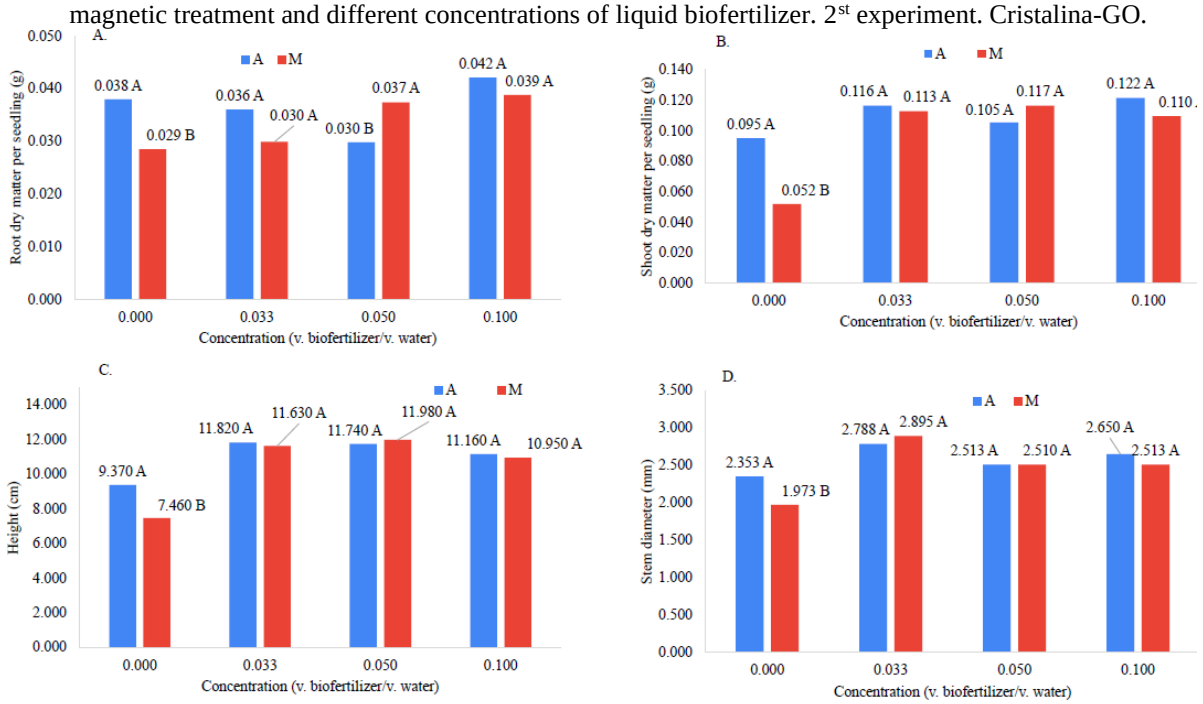
Magnetic treatment can reduce the total soluble solid, total available solid and sodium adsorption ratio and increase the pH compared to non-magnetic treatment, this effect was verified by Uh Haq *et al.* (2016).

Figure 4. Shoot fresh matter (A), shoot dry matter (B-C), speed of germination index (D), height (E-F), stem diameter (G-H), root dry matter (I-J) and final emergence percentage (K) of seedlings of tomato in function of different concentrations of liquid biofertilizer with (M) and without (A) magnetic treatment. 2st experiment. Cristalina-GO.



Source: Prepared by the authors themselves.

Figure 5. Root dry matter (A), shoot dry matter per seedling (B), height (C) and stem diameter (D) in function of magnetic treatment and different concentrations of liquid biofertilizer. 2st experiment. Cristalina-GO.



Source: Prepared by the authors themselves.

Lorenzoni *et al.* (2021) did not verify significant differences for height, stem diameter, fresh and dry mass of sweet pepper seedlings when grown in soil and substrate and soil receiving magnetic treatment. However, Aguilera *et al.* (2016) observed an increase in germination and development of tomato plants during the entire period evaluated, concluding that the magnetic treatment increased quality of tomato seedlings.

4 CONCLUSION

The growth variables, shoot and dry fresh matter, height and stem diameter had benefits with biofertilizer concentration between 0.050 and 0.072 (v. biofertilizer/v. water), can be considered for practical application of producers the average value of 0.061 (v. biofertilizer/ v. water).

The magnetic treatment of biofertilizer promoted a growth trend of tomato seedlings for concentrations 0.033 and 0.50 (v. biofertilizer/ v. water) respectively.

It is recommended that further studies be carried out on the magnetic treatment technique for liquid biofertilizer to consolidate the results obtained in this study, taking into account that it

is a low-cost, easy-to-use and maintenance-free technology and that there are still few studies related to these tests.

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