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EVALUATION OF THE INITIAL GROWTH OF UMBUZEIRO ROOTSTOCKS

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ABSTRACT

Objective: The objective of this study is to investigate the growth of umbuzeiro rootstocks after the application of rock dust and biofertilizer.

Theoretical Framewor: In this topic, the main concepts that underpin the research are presented. Techniques to improve the productivity of species native to the Brazilian Semiarid region stand out, providing a solid basis for understanding the context of the investigation.

Method: *Spondias tuberosa* Arruda fruit seeds were germinated in a seedbed and 30 days after emergence, they were transplanted into polyethylene pots. The experiment was carried out in differentiated randomized blocks, with four levels of rock dust and the presence and absence of biofertilizer, distributed in 3 blocks, evaluating the variables of plant height (AP) and stem diameter (DC).

Results and Discussion: The results revealed that for AP, treatments were significant for 30 and 60 days, while for DC they were significant for 30, 120 and 150 days. In the discussion section, these results are contextualized in light of the theoretical framework.

Research Implications: Practical and theoretical implications are discussed, providing insights into how the results can be applied or practical influences in the field of plant physiology. These implications could encompass the use of rock dust and biofertilizer in agriculture.

Originality/Value: This study contributes to the literature on a native fruit species with economic and environmental potential, which still has gaps in knowledge about its nutritional requirements. The relevance of this research is evidenced by the increase in productivity and local social and economic development.

Keywords: Grafting, *Spondias tuberosa* Arruda, Semi-arid, Fruticulture.

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AVALIAÇÃO DO CRESCIMENTO INICIAL EM PORTA-ENXERTOS DE PLANTAS DE UMBUZEIRO, SOB NÍVEIS DE PÓ DE ROCHA E BIOFERTILIZANTE

RESUMO

Objetivo: O objetivo deste estudo é investigar o crescimento de porta enxertos de umbuzeiros após a aplicação de pó de rocha e biofertilizante.

Referencial Teórico: Neste tópico, são apresentados os principais conceitos que fundamentam a pesquisa. Destacam-se técnicas para melhorar a produtividade de espécie nativa do Semiárido brasileiro, fornecendo uma base sólida para a compreensão do contexto da investigação.

Método: Sementes de frutos de *Spondias tuberosa* Arruda foram germinadas em canteiro e 30 dias após a emergência, foram transplantadas para vasos de polietileno. O experimento foi realizado em blocos casualizados diferenciados, com quatro níveis de pó de rocha e a presença e a ausência de biofertilizante, distribuídos em 3 blocos, avaliando-se as variáveis altura da planta (AP) e diâmetro do caule (DC).

Resultados e Discussão: Os resultados revelaram que para a AP, os tratamentos foram significativos para 30 e 60 dias, enquanto para DC foram significativos para 30, 120 e 150 dias. Na seção de discussão, esses resultados são contextualizados à luz do referencial teórico.

Implicações da Pesquisa: As implicações práticas e teóricas são discutidas, fornecendo insights sobre como os resultados podem ser aplicados ou influenciar práticas no campo da fisiologia vegetal. Essas implicações podem abranger o uso de pó de rocha e biofertilizante na agricultura.

Originalidade/Valor: Este estudo contribui para a literatura sobre uma espécie frutífera nativa com potencial econômico e ambiental, que ainda possui lacunas de conhecimento sobre suas exigências nutricionais. A relevância desta pesquisa é evidenciada pelo aumento da produtividade e desenvolvimento social e econômico local.

Palavras-chave: Enxertia, *Spondias tuberosa* Arruda, Semiárido, Fruticultura.

EVALUACIÓN DEL CRECIMIENTO INICIAL DE PORTAINJERTOS DE UMBUZEIRO BAJO NIVELES DE POLVO DE ROCA Y BIOFERTILIZANTE

RESUMEN

Objetivo: El objetivo de este estudio es investigar el crecimiento de portainjertos de umbuzeiro después de la aplicación de polvo de roca y biofertilizante.

Marco Teórico: En este tema se presentan los principales conceptos que sustentan la investigación. Se destacan técnicas para mejorar la productividad de especies nativas, proporcionando una base sólida para comprender el contexto de la investigación.

Método: Se germinaron semillas del fruto de *Spondias tuberosa* Arruda y 30 días después de la emergencia se trasplantaron a macetas de polietileno. El experimento se realizó en bloques al azar, con cuatro niveles de polvo de roca y presencia y ausencia de biofertilizante, distribuidos en 3 bloques, evaluándose las variables altura de planta (AP) y diámetro de tallo (DC).

Resultados y Discusión: Los resultados revelaron que para AP los tratamientos fueron significativos a los 30 y 60 días, mientras que para DC lo fueron a los 30, 120 y 150 días. En la sección de discusión, estos resultados se contextualizan a la luz del marco teórico.

Implicaciones de la investigación: Se discuten las implicaciones prácticas y teóricas, proporcionando información sobre cómo se pueden aplicar los resultados o las influencias prácticas en el campo de la fisiología vegetal. Estas implicaciones podrían abarcar el uso de polvo de roca y biofertilizantes en la agricultura.

Originalidad/Valor: Este estudio contribuye a la literatura sobre una espécie nativa con potencial económico, que aún presenta vacíos en el conocimiento. La relevancia de esta investigación se evidencia en el aumento de la productividad y el desarrollo económico.

Palabras clave: Injerto, Semiárido, Umbú, Fruticultura.

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1 THEORETICAL FRAME

In Brazil, fruit growing is a prominent segment, being the third largest producer of fruit in the world, where it accounts for 27% of all the work force destined to agriculture, concentrated mainly in globally exploited exotic fruits, such as oranges, apples, mangoes, among others and in very few native species such as cashew, umbu and caja (ABF, 2021). The fruit of umbu sold at free trade fairs in several states and consumed *in natura* or in the form of umbuzada, jams, jellies, popsicles and ice creams, has aroused the emerging industrial interest of pulp processing and interested in fostering the generation of a new source of income for family farming (Rios *et al*., 2012; Paodjuenas et al., 2019).

The umbuzeiro (*Spondias tuberosa* Arruda), a fruit plant belonging to the Anacardiaceae family and originating from the semi-arid regions of the Brazilian northeast, has good development in areas of little rainfall (400 to 800 mm/year), where it can reach tree size at a height of approximately 7 meters with 12 meters of canopy.

However, the scarcity of commercial plantations and the large part of the production obtained in an extractive way (Costa et al., 2015), increases the need for searches for alternatives that will meet the low number of supply, since the trend of consumption is imminent in contrast to the number of plantlets cultivated, mainly in the agreste Paraiba, still beyond what was expected (Torres et al., 2019). As a plant symbol of the Brazilian Northeast, and this region is the one that presents the greatest soil and climatic conditions to fruit growing (Silva et al., 2023), the demand for umbuzeiro fruits is great in the regional context.

Xerophilous and deciduous, the species is fully adapted to the hot climate and to land with varying levels of fertility and agricultural aptitude, where it has as its main means of propagation the endozoic zoocoria that acts in the breaking of seed dormancy by wild and/or domestic captive animals, these frequently used for the collection of grains present in the manure, mainly bovine, for planting and dissemination (Fonseca, 2019; Mertens et al., 2015; Silva-Luz et al., 2023).

Grafting is an agricultural technique used to join parts of two different plants so that they grow as one, combining the rootstock (bottom) and the graft (top). The rootstock provides the root system and the graft is chosen for its desirable qualities, in this sense, the multiplication

of varieties of giant umbu. It is important that the grafted cuttings are acquired from suitable producers. The branches used in the grafting must be of mother plants with proof of access, with vigorous characteristics. The planting of grafted seedlings at least one year old should be carried out in the rainy season (Pires, 2024).

Biofertilizers are liquid preparations rich in nutrients and microorganisms that promote plant growth and help soil health in a sustainable way. These products are prepared from natural ingredients such as dung, milk or whey and honeydew, which after a fermentation process, result in a highly nutritious substance (Rivera, 2014). However, the use of growth regulators, such as phytohormones in native species, has also been studied with the purpose of anticipating phenological phases or improving plant health (Amaro et al.; Taiz et al. (2017)).

The remineralization process with the use of rock powders, in which ground rocks can be used to fertilize the soil, in a process known as rock, presents agronomic efficiency depending on factors such as mineralogy, chemical composition and particle size of ground rocks, climate and soil conditions and microbial activity (Swoboda et al., 2022).

In this context, aiming to increase the supply of fruit to the market, currently some producers, mainly in the southwest region of Bahia, has opted to cultivate the popularly known as "Umbus Gigante", native accesses identified in the caatinga biome and improved by Embrapa Semi-arid, which has as its main characteristic the significant increase of average weight of the fruit, in many cases above 70 grams. This average weight input and the outstanding commercial potential of access, promptly justifies the dissemination to the other regions and the increase of studies that can provide more information about the plant and its characteristics, both systematic and cultivation (Pires, 2024).

The umbuzeiro culture has bioeconomic potential, however, it is vital to adopt innovative handling practices that contribute to precocity, without failing to increase production. Thus, fostering the generation of knowledge guided by diverse commercial interests with strategic information crucial for the development of culture for the Brazilian Semi-Arid is of utmost importance for this promising economic resource.

Based on this context, with the aim of reducing vegetation time in plants of biocommercial interest, the objective of this work was to evaluate the initial growth of umbuzeiro seedlings (*Spondias tuberosa* Arruda), in the future used as rootstocks for "giant umbu", submitted to different doses of dolomite rock powder in substrates with absence and presence of biofertilizer, commercial formula, often used as optimizers of soil fertility and availability of nutrients.

2 METHODOLOGY

2.1 CHARACTERIZATION OF THE EXPERIMENTAL AREA

The survey was carried out between the months of July to December 2023 in the municipality of Campina Grande, in the state of Paraíba, in a greenhouse built with black sombrite screen 40 %, located in the Experimental Station Ignácio Salcedo, at the National Institute of the Semi-Arid (INSA), under the coordinates 7°16'35"S and 35°57'53"W. The region has an average altitude of 550 m and average rainfall of approximately 790 mm a year and warm and humid climate with winter and autumn rains (As), according to Köppen classification, with average temperature of 23,5 °C (Francisco et al. 2018).

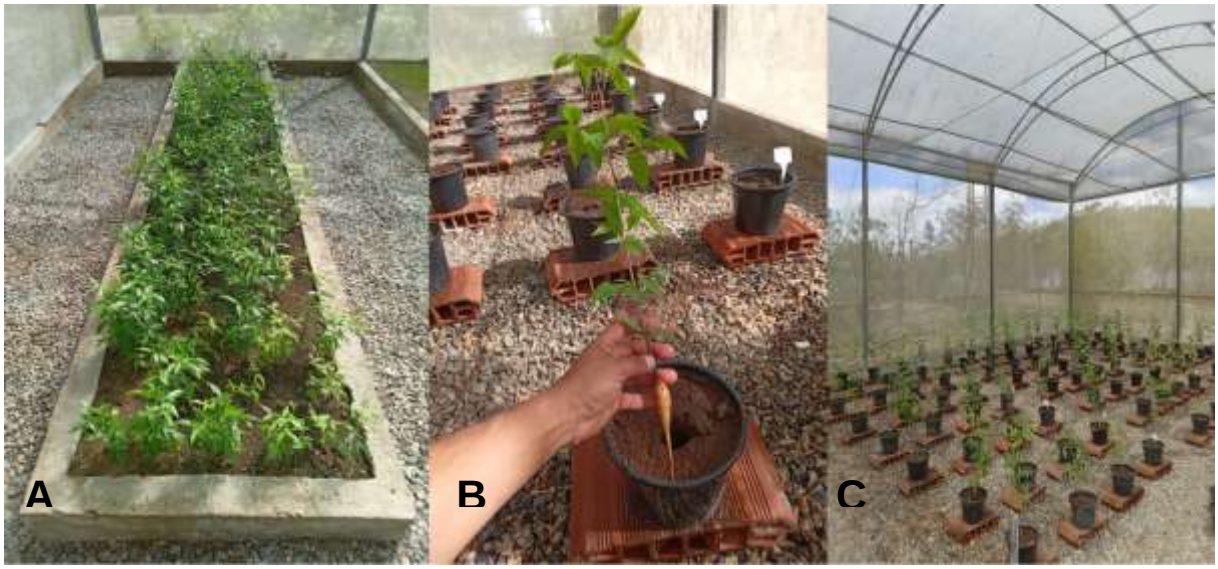
2.2 EXPERIMENTAL DESIGN

The seedlings were produced from commercial fruit seeds of *S. tuberosa* originating from industrial processing carried out in an unpulp mill. The soaking technique was used in 48 hours in the water and placed to germinate in a masonry bed (Figure 1a), in the greenhouse with substrate 1:1 (soil:sand). Thirty days after emergence (DAE), the cuttings were selected and transplanted (Figure 2b) into polyethylene vessels with a volume of 4 liters, containing substrate with the doses according to the statistical design (Figure 2c).

The experiment was carried out using experimental design in differentiated casualized blocks (CBD), which totaled 8 treatments, where four levels of dolomitic rock powder (0; 5; 10 and 20 $g.kg^{-1}$) and the presence (1) and absence (0) of commercial biofertilizer, distributed in 3 blocks with 4 repetitions, totaling 96 samples. The treatments were organized as follows: T1 = 0 g, T2 = 5 g, T3 = 10 g and T4 = 20 g of dolomitic rock powder, all without biofertilizer and T5 = 0 g, T6 = 5 g, T7 = 10 g and T8 = 20 g of dolomitic rock powder, all with biofertilizer.

Figure 1

a) Plants germinated in masonry bed; b) Seedlings being transplanted into the vessels; c) Seedlings already transplanted and organized according to the statistical design



The choice was made for the powder of dolomitic rock ($CaCO_3$) because the soils of the region are rich in this type of rock, so as to mimic the natural conditions, as well as quickly supply Ca (28%) and Mg (17%) for the seedlings, since they are micronutrients of great importance for the first stages of vegetative growth of the species, acting directly on photosynthesis (Gonçalves, et al., 2006).

The applied biofertilizer consists of water, yeast extract and organic compound, being activated with sugar cane molasses. It is an organic fertilizer produced by the Bokashi method, which involves the fermentation of organic waste using a mixture of microorganisms, resulting in a compound rich in essential nutrients for plants. The fermentation process used in this type of production helps reduce unpleasant odors often associated with traditional composting (Rivera, 2014). The biofertilizer was applied directly to the soil, around the plants, 1 ml/liter of water, irrigation was carried out weekly manually with watering machines.

2.3 VARIABLES ANALYZED

The experiment was conducted in such a way that 30 days after the implementation of the treatments, the variables height of the plant (AP) and diameter of the base of the stem (DC) were measured with 30, 60, 90, 120 and 150 days respectively, in centimeters, with the use of a graduated ruler and a digital caliper.

2.4 DATA ANALYSIS

The data obtained was organized in Microsoft Excel® spreadsheets and submitted to Variance Analysis (ANAVA) through the statistical software Assiat. The Tukey test was also performed at the 5% significance level in order to verify significant effects and differences between treatments.

From the PsA data, the relative growth rates TRC(Alt), measured in $mm.m^{-1}day^{-1}$, were calculated using Equation 1, for each treatment (Benincasa, 2003; Floss, 2004).

$$TRC(Alt) = \frac{lnM2 - lnM1}{t2 - t1} \qquad (1)$$

Where:

TRC(Alt) = Relative height growth rate;
ln(M1) = Neperian logarithm of the initial height measurement;
ln(M2) = Neperian logarithm of the final height measurement;
t2-t1 = time interval.

3 RESULTS AND DISCUSSIONS

The evaluated treatments were significant for the variable Plant Height (AP) at times of 30 and 60 days (Table 1), indicating that the interventions applied in this period influenced the initial development of *Spondias tuberosa*. At 30 days, treatments 1, 2, 3, 4, 5 and 7 showed superior results and showed no statistical differences among themselves, which suggests that these interventions provided adequate conditions for plant growth, resulting in similar responses. At 60 days, treatments 1, 2, 3, 4, 5, 7 and 8 also showed no significant differences between them.

As per the 99% probability level analysis at 30 days, and at the 95% level at 60 days. However, after 60 days, the treatments did not show statistical significance, indicating that the initial effect on plant growth may have been diluted over time. The blocks, on the other hand, had a significant influence on the times of 90, 120 and 150 days, which suggests a possible variability associated with handling or with the environmental conditions in which the experiments were carried out.

Table 1

ANAVA for the variable Height of plant (AP) in relation to the evaluation days of S. tuberosa

FV	GL	Height of plant (cm)				
		F				
		30 days	60 days	90 days	120 days	150 days
Treatment	07	5.94**	2.92**	1.62^{ns}	1.39^{ns}	1.49^{ns}
Blocks	02	2.70^{ns}	2.40^{ns}	4.27*	5.61**	7.45**
Treatments x blocks	14	3.05**	1.64^{ns}	1.30^{ns}	1.28^{ns}	1.50^{ns}
Residue	72					
Total	95					

^{ns} = Not significant; * = Significant at the 95% probability level; **= Significant at the 99% probability level.

At 30 and 60 days, treatments 2, 3, 4 and 5 presented the best averages of plant height (Table 2). At 90, 120, and 150 days, there were no significant statistical differences between treatments, indicating that all promoted adequate growth of *S. tuberosa* from that period. This behavior can be attributed to stabilizing the development of the plant, after overcoming the initial conditions of stress or stimulus provided by the treatments.

In previous works, such as those by Pereira et al. (2023) and Neves et al. (2021), it has been shown that factors such as irrigation with saline water and the use of organic substrates directly influence the growth of umbuzeiro seedlings. These results corroborate the findings of the present study, in which specific treatments were effective in improving the initial development of the plant. The significant variation in Dickson's index (seedling quality), observed by Neves et al. (2021), also suggests that substrate quality and water management play a key role in the growth of native semi-arid species.

Table 2

Tukey test and coefficient of variation (CV%) for all-time treatments analyzed for the variable Plant height (AP)

	Treatment averages				
Treatment	**30 days**	**60 days**	**90 days**	**120 days**	**150 days**
1.	39.00 abc	48.50 ab	64.75 to	77.33a	81.83 to
2.	48.42 to	60.58 to	76.08 to	87.75 to	90.00 to
3.	46.33 ab	56.42 ab	71.08 to	80.67 to	82.75 to
4.	45.92 ab	60.75 to	76.42 to	84.58 to	86.92 to
5	41.92 ab	53.25 ab	68.92 to	78.50 to	81.83 to
6	30.75 c	42.83 b	59.08 to	69.08 to	71.58 to
7	38.50 abc	52.83 ab	71.00 to	80.58 to	84.08 to
8	36.58 bc	50.50 ab	68.75 to	77.83 to	79.33a
CV (%)	**20.48**	**23.18**	**22.35**	**20.45**	**18.79**

The averages followed by the same letter do not differ statistically. Tukey's test was applied at a 5% probability level.

The interaction between treatments x blocks at 30 days (Table 3) showed significant variations in the results between the blocks. In block 1, treatment 2 presented the best response, in block 2 was treatment 3, and in block 3 treatment 4 was highlighted, all these treatments were carried out without the application of biofertilizer. This pattern of response suggests that the experimental setup in Casualized Block Design (CBD) was adequate, as it was able to compensate for micro-environmental variations, such as the distribution of temperature within the greenhouse, which are influenced by the structure and geometry of the greenhouse, as observed by Furlan et al. (2002). The unevenness in the temperature inside the greenhouse, caused by the position of the sun and by the proximity of the edges, justified the choice of the experimental design.

Table 3

Tukey test for interaction treatments x blocks in 30 days

Treatment	30 days		
	Block 1	Block 2	Block 3
1.	40.75 bA	33.75 bcA	42.50 abA
2.	59.75 aA	49.25 abAB	36.25 bB
3.	48.75 abAB	54.25 aA	36.00 bB
4.	40.50 bB	42.50 abAB	54.75 aA
5	46.50 abA	36.75 abcA	42.50 abA
6	33.25 bA	23.25 cA	35.75 bA
7	38.50 bA	42.75 abA	34.25 bA
8	41.50 abA	37.50 abcA	30.75 bA

The averages followed by the same letter do not differ statistically. Tukey's test was applied at a 5% probability level.

The variations observed in the different blocks indicate that the effect of the treatments is not uniform in all the blocks, but, at the same time, they reinforce that the environmental control and the distribution of the blocks compensated for this heterogeneity, allowing a more robust analysis of the results.

The plant diameter (SD) showed that treatments were significant at 30, 120, and 150 days (table 4), indicating that *Spondias tuberosa* growth was more sensitive to treatments in the early and late stages of the experiment. At 30 days, the treatments with 0, 5 and 10 grams of rock powder (treatments 1, 2 and 3), without biofertilizer, showed the best results. This suggests that the rock powder was effective in promoting early growth, possibly by gradually releasing nutrients. In the periods of 120 and 150 days, the treatments were similar, demonstrating that, in the long term, these treatments provided favorable conditions for the development of the plant.

Table 4

ANAVA for diameter at ground level

FV	GL	Diameter of plant (cm)				
		F				
		30 days	60 days	90 days	120 days	150 days
Treatment	07	5.98**	1.54^{ns}	1.86^{ns}	2.37*	2.80*
Blocks	02	4.51*	4.54*	1.30^{ns}	5.71**	7.30**
Treatments x blocks	14	1.23^{ns}	1.35^{ns}	1.83^{ns}	2.11*	2.05*
Residue	72					
Total	95					

^{ns} = Not significant; * = Significant at the 95% probability level; **= Significant at the 99% probability level.

SD showed significant variations between treatments (table 5). At 30 days, treatment 1, 2 and 3 were superior to the others. At 60 and 90 days, the differences between treatments were not significant, indicating a similar response over this period. However, at 120 and 150 days, treatment 1, 2, 3, 4 and 5 stood out, with greater diameter.

Table 5

Tukey test and coefficient of variation (CV%) for all-time treatments analyzed for plant diameter (SD)

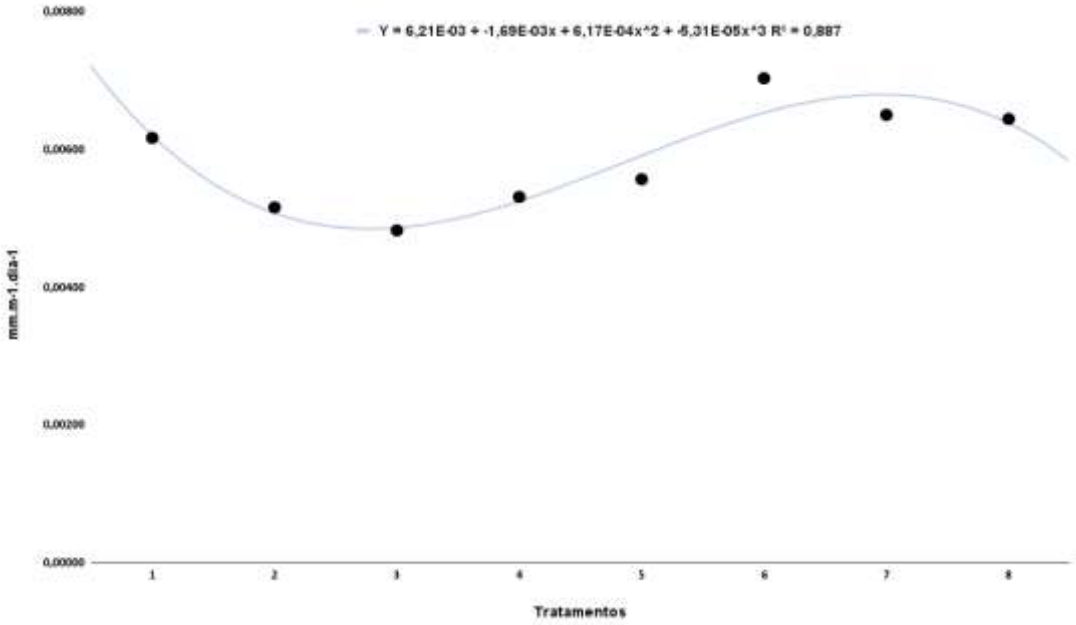
Treatment averages					
Treatment	**30 days**	**60 days**	**90 days**	**120 days**	**150 days**
1.	4.26a	5.80 to	7.52a	9.28 ab	10.01 ab
2.	4.17 ab	6.43a	7.88a	9.62 ab	10.38 ab
3.	3.84 abc	6.51 to	8.12a	9.37 ab	10.40 ab
4.	3.44 c	6.48a	8.25a	9.22 ab	10.02 ab
5	3.53bc	7.06 to	7.04 to	10.26a	11.05 to
6	3.23 c	5.95 to	7.87a	8.65 b	9.37 b
7	3.45c	6.51 to	7.87a	9.22 ab	10.12 ab
8	3.43 c	5.95 to	7.62a	8.76 b	9.40 b
CV(%)	**14.58**	**18.27**	**14.51**	**12.13**	**11.25**

The averages followed by the same letter do not differ statistically. Tukey's test was applied at a 5% probability level.

If we analyze in absolute values the treatment that presented the best Relative Growth Rate (TRC) was treatment 6, which contains 5 grams of rock powder and presence of biofertilizer, contrasting with the results of ANAVA that always tended the treatment 2, which also has 5 grams of rock powder, but no biofertilizer, as best. This could indicate that this quantity of dust from the dolomitic rock shows some effect in the initial phases.

Figure 2

Curve of the polynomial equation that fitted the data model of the experiment



Grafting has been the most widely used vegetative propagation technique for the multiplication of umbuzeiro seedlings. Generally, the seedlings are produced from the seeds of the fruit and used as a rootstock. When the sapling reaches around 0.6 to 0.8 cm in diameter, grafting can be carried out. At this stage, the ideal is that the diameter of the graft and the rootstock should have the same thickness (OLIVEIRA et al., 2018).

4 CONCLUSION

The organic practices with the use of remineralisers in the soil, being these rock powders of the region, and the use of biofertilizer broths favor the growth of umbuzeiro rootstock in height and diameter developing a seedling suitable for the practice of grafting and diffusion of the giant umbu.

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