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ANÁLISE DO ESPAÇAMENTO SOBRE O DESENVOLVIMENTO FISIOLÓGICO DE DIFERENTES CULTIVARES DE ALFACE

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1 RESUMO

A alface é uma das hortaliças folhosas mais produzidas globalmente, apresentando produção mundial de aproximadamente 45 milhões de toneladas por ano. No entanto, seu cultivo na região amazônica apresenta desafios devido às condições climáticas desfavoráveis. Uma alternativa viável para o cultivo dessa importante hortaliça nessa região é a hidroponia em ambiente protegido. Todavia, deve-se ter atenção quanto ao espaçamento entre plantas, pois esse é um fator crucial para o bom desenvolvimento e alcance de altas produtividades em sistemas hidropônicos. Também vêm sendo desenvolvidas novas cultivares de alface capazes de resistir condições climáticas adversas. Nesse contexto, objetivou-se neste estudo analisar o efeito do espaçamento nas condições morfológicas de diferentes cultivares de alface (BRS Leila, Joction Rz e Jade), produzidas em sistema hidropônico com três espaçamentos (25 x 25; 25 x 30 e 30 x 30 cm) em uma propriedade localizada em Moju, PA. O experimento foi conduzido em casa de vegetação, em sistema hidropônico do tipo NFT, com delineamento experimental em blocos casualizados em esquema fatorial 3 x 3 com 10 repetições. Visando um excelente desempenho por planta, bom desenvolvimento e qualidade da parte aérea, atendendo o mercado mais exigente, indica-se a cultivar BSR Leila no espaçamento 30 x 30 cm.

Palavras-chave: BRS Leila, Jade, Joction RZ, hidropônico, clima.

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SPACING ANALYSIS ON THE PHYSIOLOGICAL DEVELOPMENT OF DIFFERENT LETTUCE CULTIVARS

2 ABSTRACT

Lettuce is one of the most widely produced leafy vegetables in the world, with a global production of approximately 45 million tons per year. However, its cultivation in the Amazon Region presents challenges due to unfavorable climatic conditions. A viable alternative for growing this important leafy vegetable in this region is hydroponics in greenhouses. However, attention must be given to the spacing between plants, as this is crucial for good development and achieving high yields in hydroponic systems. New lettuce cultivars that are capable of withstand adverse climatic conditions have also been developed. In this context, the aim of this study was to analyze the effects of spacing on the morphological conditions of different lettuce cultivars (BRS Leila, Joction Rz, and Jade) produced in a hydroponic system with three spacings (25 × 25, 25 × 30 and 30 × 30 cm) on a property located in Moju, PA. The experiment was conducted in a greenhouse in an NFT hydroponic system with a randomized block experimental design in a 3 × 3 factorial scheme with 10 replications. To achieve excellent performance per plant, good development, and high quality of the aerial part and meet the needs of the most demanding market, the BSR Leila cultivar with a 30 × 30 cm spacing is recommended.

Keywords: BRS Leila, Jade, Joction RZ, hydroponic cultivation, climate.

3 INTRODUCTION

Lettuce (*Lactuca sativa* L.) is among the most important leafy vegetables for the global economy (LI *et al.*, 2023), with an average global production of approximately 45 million tons per year (DALASTRA, 2017), with China being the United States and India being the three countries with the highest production, with average production of 14.3, 4.4 and 1.1 million tons, respectively.

In Brazil, lettuce is among the most cultivated vegetables, with an annual production of approximately 900 thousand tons according to the 2017 Agricultural Census (IBGE, 2017; PESSOA; MACHADO JUNIOR, 2021), being one of the five vegetables with the highest representation in production volume and value sold in the country (COSTA JUNIOR *et al.*, 2021; SILVA *et al*., 2020).

In the national territory, lettuce is the most consumed vegetable (BIRCK; DALZOCHIO, 2021), being used in salads, sandwiches, juice, tea, smoothies, soups, and wraps, among others (THE COMPOSITAE GENOME PROJECT, 2017), as it has a significant amount of vitamins A, B1, B2, B6, B9, C, K, calcium, iron, fiber and antioxidants (NTSOANE *et al*., 2016; FERNANDES *et al*., 2002; COSTA JUNIOR *et al*., 2021; SILVA *et al*., 2020; DUTRA *et al*., 2016).

In the Brazilian Amazon region, climatic conditions are unfavorable for the cultivation of vegetables, as they favor the proliferation of diseases (BOARI *et al*., 2017. However, the type of management and the cultivation environment are factors that influence the production and development of culture (ASSIS, 2021). For this reason, these are points on which the horticulture sector has focused to improve lettuce production in this region (CAMPOS; ASSIS; LIVRAMENTO, 2022).

In the state of Pará, vegetables stand out as a developing productive activity, with lettuce cultivation being significantly greater than that of other vegetables, indicating relevant economic importance in the region (AVIZ *et al*., 2019), with an average annual production of 7 thousand tons per year (IBGE, 2017).

Although vegetable production in the state of Pará stands out in the economic sector, there are some bottlenecks to be resolved, such as the use of cultivars adapted to the region's climatic conditions, as cultivars improved for specific climates in other regions of the country are generally used, which is a preponderant factor in the difficulties faced by producers (CARDOSO *et al.*, 2018).

Vegetable production alternatives in the state of Pará, such as the hydroponic system in a protected environment, have gained ground as a viable option for improving leafy vegetable production for distribution centers with a constant supply of vegetables (SAMOYLENKO *et al*., 2020). The hydroponic system reduces the production cycle, increases productivity and improves quality (BOLDRIN *et al*., 2022; PURQUERIO *et al*., 2018); these benefits have attracted producers around Brazil.

In a hydroponic system, lettuce stands out as the vegetable with the highest productivity (MARQUES, 2017). This type of cultivation system has been consolidated among producers due to the associated benefits, such as greater yield per area, quality, and productivity; cycle reduction; lower expenditures on water, agricultural inputs, pesticides and labor; and protection against adverse weather conditions, among others (PAULUS *et al*., 2012; OHSE, *et al*., 2001). However, certain factors can cause poor physiological development of plants in hydroponic systems, including competition caused by reduced spaces between plants due to inadequate planning (KALUZEWICZ *et al*., 2017; MACHADO; ALVES-PEREIRA; FERREIRA, 2018).

Campos, Assis and Livramento (2022) emphasized that the spacing adopted in the cultivation of the lettuce vegetable has a great influence, affecting everything from development and architecture to the weight, production and quality of the plants. High plant density tends to increase steviol glycoside levels due to competition for light and nutrients; on the other hand, low densities increase fresh matter levels (BENHMIMOU *et al*., 2017).

The spacing between plants is a significant factor in hydroponic systems, as it directly impacts the quantity and quality of lettuce (MONDIN, 1988). Cultivation at optimal spacing avoids etiolation and favors the production of vigorous plants (PURBASARI; BAFDAL; PERWITASARI, 2023). Another relevant factor is temperature, and regions with hot climates lead lettuce to physiological disorders such as burning and premature bolting, affecting its commercialization (HOLMES *et al*., 2019).

Increasing the lettuce density in hydroponic systems increases the overall yield; however, the individual yield decreases, causing a decrease in quality during production (ÇEKIN *et al*., 2023).

Factors associated with the resistance and physiological performance of lettuce are influenced by genetics and the environment (CAMPOS; ASSIS; LIVRAMENTO, 2022; SILVA *et al*., 2019). Advances in genetic improvement have made new cultivars of smooth and curly lettuce available to producers, which present greater resistance to premature flowering and good agronomic characteristics (GIORDANO, 1991; YOKOYAMA; MÜLLER; SILVA, 1990).

In this context, the improved lettuce cultivars BRS Leila, combined with RZ and Jade, have shown excellent results under adverse growing conditions, adapting to climatic conditions of high temperatures and humidity, being resistant to disease and prematurely bolting. In this context, the main objective of the present study is to analyze the effects of spacing on the morphological conditions of different lettuce cultivars produced in three spacings in a hydroponic system located on a rural property in the Amazon region.

4 MATERIALS AND METHODS

The experiment was conducted in a greenhouse located on a family farm located in Ramal Primavera-Jambuaçu, Moju, PA, Brazilian Amazon region, from June 18 to August 27, 2022. The greenhouse used was a chapel type, measuring 14 meters long by 7.6 meters wide, with a 150-micron-thick plastic cover and sides protected with black polypropylene screens with 50% shading.

The municipality of Moju belongs to the Mesoregion of Northeast Pará and the Microregion of Tomé-Açu, has an area of 9,094.10 km² and is located at coordinates 01°53'02” S and 48°46'08” W, housing a population of approximately 77 thousand inhabitants. It has an Ami-type climate that is hot and humid according to the Köppen-Geiger classification, with an average annual temperature of 25°C and rainfall in the range of 2,000--3,000 mm/year, with a rainy period between the months of January and June (PINHEIRO *et al*.). *al*., 2022; PIMENTA *et al*., 2018).

The experimental design used was randomized blocks in a 3 × 3 factorial scheme, three lettuce cultivars (BRS Leila, Joction RZ and Jade) and three spacings (25 × 25, 25 × 30 and 30 × 30 cm), with 10 replications, totaling 180 sample units.

The NFT method was used and consisted of keeping the plant roots partially immersed in a nutrient solution under intermittent flow using a motor pump driven by a mechanical “timer” every 15 minutes.

The blocks were arranged according to the position of the plant in the hydroponic profile (upper position - solution entry into the profile and lower position - solution exit into the profile). The plot consisted of 10 plants per treatment in the upper position (block I) and 10 plants in the lower position (block II), with the border being eliminated.

The experiment was conducted on 3 (three) 12-meter cultivation benches with 10% slope each, following the recommendations of Dalastra (2017), who mentioned that the change in slope of 3--4% recommended by Cooper (1996) allows greater flow speed and turbulence in the flow of the nutrient solution, causing greater cooling and greater transport of dissolved oxygen to the submerged roots.

The PS 85 profile, the ECCO line from Schaefer, was used with distances of 25 and 30 cm between the holes. The spacing between profiles was organized so that one bench had a spacing between holes of 25 × 25 cm, another with a spacing of 25 × 30 cm and another with a spacing of 30 × 30 cm.

The nutrient solution reservoir consisted of an excavated tank with a capacity of 3,600 liters, built in masonry, measuring 2.0 mx 1.8 mx 1.0 m. This type of tank was chosen to avoid heating the solution throughout the day.

A 1 hp centrifugal pump, with a flow rate of 3,600 liters per hour, was used to recirculate the nutrient mixture. The electrical conductivity of the solution was maintained in the range of 1,000--1,500 µS/cm, while the pH was maintained between 5.5 and 6.5. Both were measured daily in the early morning and late afternoon and were corrected whenever necessary.

The electrical conductivity was measured via an AK51 pocket conductivity meter. The correction was carried out according to Furlani's recommendations *et al.* (2009). When the macronutrients (N, P, K, Ca, Mg and S) were replaced, 1 L of solution A and 1 L of solution B (Table 1) were added to the stock solution whenever a drop of 250 µS/cm was observed. . To correct for micronutrients, 25% of the amount of iron (Fe) and 50% of the amount of other micronutrients (B, Cl, Mo, Cu, Zn and Mn) were added weekly.

Table 1. Compositions of tuning solutions A and B

Solution	Salts/Fertilizers	g/10 L
THE	potassium nitrate	1200
	purified monoammonium phosphate	200
	magnesium sulfate	240
B	calcium nitrate	600

Source: Adapted from Furlani *et al*. (2009).

The pH was measured via an AK90 pocket pH meter. For correction, 1.0 ml of sodium hydroxide (0.3 N NaOH) was added to the stock solution to increase the pH by 0.1 points on the scale, or 1.0 ml of 10% sulfuric acid (H2SO4) was added to lower the pH by 0.1 points on the scale.

To prepare the nutrient solution, calcium nitrate (750), potassium nitrate (500), monoammonium phosphate (150), magnesium sulfate (400), a chelated nutrient mixture (15) and the iron chelate Q48 EDDHA (30) were used at a concentration of one gram per thousand liters (g/1,000 L) according to Furlani's commercial recommendations. (2009). The water used to prepare the solution had a pH between 5.8 and 6.5 and an electrical conductivity of 68 µS/cm, values considered acceptable for this purpose (FURLANI, 1998).

The seedlings were grown in 200-cell Styrofoam trays in coconut fiber substrate supplemented with nutrients via fertigation, following 50% of Furlani's recommendation. *et al.* (2009). First, the trays were sown and irrigated with water and kept in the dark to improve the germination process. After the seedlings emerged, which occurred 2 (two) days after sowing, the trays were placed in a pool-type nursery where they received fertigation until 21 days after sowing and were subsequently transplanted to the experimental benches.

The plants remained in the hydroponic system in the experimental phase for 30 days. During this period, the necessary culture treatments related to the control of electrical conductivity, the pH of the nutrient solution and the control of pests and diseases were carried out. The plants were subsequently harvested, after which a cut was made to separate the aerial part from the root.

After separation, the following variables were measured: plant height (AP), root length (CR), number of leaves (NF), collection (CO), fresh shoot matter (MFPA), fresh root matter (MFR), stem height (AC), shoot dry matter (MSPA) and root dry matter (MSR). The MSPA and MSR data were obtained after drying in a constant circulation oven at 65 °C for 72 hours, followed by weighing the material on a precision scale.

The collected data were tabulated in Microsoft Excel spreadsheets and subsequently analyzed with the help of the Agroestat and Assistat programs. The null hypothesis of equality of means was analyzed via ANOVA via Snedecor's F test at a 5% level of significance, and multiple comparisons were carried out via the Tukey test at 5% probability.

5 RESULTS AND DISCUSSION

Multiple comparisons of the means of the variables—plant height, root length, number of leaves, collection, shoot fresh matter, root fresh matter, stem height, shoot dry matter and root dry matter—depending on cultivar and spacing revealed that the 25 × 25 cm spacing provided greater height for all the cultivars studied, differing statistically from the other spacings. However, the 25 × 30 cm and 30 × 30 cm spacings did not significantly differ (Table 2).

Table 2. Analysis of multiple comparisons of means for the development variables of lettuce cultivars produced in a hydroponic system under different planting densities

Cultivars	Variables						
	AP (cm)	CR (cm)	NF (un.)	CO (mm)	MFPA (g)	BC (cm)	MSPA (g)
BRS Leila	36.42 a	42.46c	26.33b	10.26c	239.14 a	19.78 a	10.86 to
Jade	33.63b	69.88 to	32.50 to	13.40b	247.22 a	20.99 to	11.07 a
Joction RZ	28.64c	55.99b	26.83b	15.11 a	202.60b	11.78b	09.81 to
Spacing							
25 x 25 cm	35.67 a	59.28 a	26.50 to	11.66b	209.15b	20.49 a	09.40 b
25 x 30 cm	31.94b	55.14b	28.67 a	12.40 b	230.19 ab	16.41b	10.92 ab
30 x 30 cm	31.11 b	53.90b	30.50 to	14.72 a	249.62 a	15.65b	11.42 a
CV (%)	2.46	3.1	10.51	4.01	8.74	8.25	10.05

Means followed by the same letter do not differ statistically from each other according to the Tukey test at the 5% probability level. CV = coefficient of variation, AP = plant height, CR = root length, NF = number of leaves, CO = collection, MFPA = shoot fresh matter, MFR = root fresh matter, AC = stem height, MSPA = dry matter of the shoot and MSR = dry matter of the roots.
Source: Authors (2023)

The results corroborate those of Silva *et al*. (2000), who analyzed the behavior of lettuce cultivars in different spacings under high temperature and light, reported that denser spacings, including 25 × 25 cm spacing, provided greater plant height. The authors also highlighted that denser spacing contributes to plants reaching greater heights, and this result may be related to competition for light.

There was a significant effect of the cultivar and spacing interaction on the plant height variable. At a spacing of 25 × 25 cm, the height of the BRS Leila cultivar was greater than that of the Jade and Jction RZ cultivars, which in turn did not differ from each other. With respect to the 25 × 30 cm spacing, the BRS Leila and Jade cultivars did not differ, unlike the RZ cultivar. All the cultivars differed in terms of 30 × 30 cm spacing, with the BRS Leila cultivar showing greater height, with an average of 34.43 cm, followed by the Jade and Jordan RZ cultivars, whose average height was 31.66 cm. and 24.25 cm, respectively (Table 3).

Table 3. Analysis of interactions (cultivars vs spacing) and multiple comparisons of means for the variables root length and plant height

Variable	**Root length**			**Plant height**		
	Spacing (cm)			**Spacing (cm)**		
Cultivars	25 x 25	25 x 30	30 x 30	25 x 25	25 x 30	30 x 30
BRS Leila	43.20cA	43.12cA	41.05cA	40.64 BC	34.19 BC	34.43 BC
Jade	76.26 aA	64.90 BC	68.48 BC	36.34 bA	32.99 aB	31.66 bB
Joction RZ	58.38 bA	57.40 bA	52.18 bB	30.03cA	28.65 bAB	27.25 cB
CV (%)		3.1			2.46	

Lowercase letters in the columns represent spacing interactions between cultivars. Capital letters in the lines represent interactions of spacing within the same cultivar. Means followed by the same letter do not differ statistically from each other according to the Tukey test at the 5% probability level.
Source: Authors (2023)

Çekin *et al*. In hydroponic systems, (2023) reported that the yield per unit area of lettuce increases, whereas the individual yield decreases with increasing density. Purbasari, Bafdal and Perwitasari (2023), when studying the effects of planting spacing on the growth and yield of lettuce plants grown hydroponically, achieved similar results, noting that denser spacing increased plant height due to the smaller amount of light received, which affected the photosynthetic rate, stimulating etiolation.

Filgueira (2013) defines etiolation as the elongation of plant cells, which occurs when the plant seeks light; this process is irreversible and does not interfere with the accumulation of dry mass. Purbasari, Bafdal and Perwitasari (2023) defined etioplasts as the result of biochemical reactions in chloroplasts, since when these molecules do not have adequate exposure to sunlight, they become etioplasts, which cause the leaves to turn yellow and shrink. in size. The authors also state that etiolation is caused by stress caused by the absence of light, which results in deficiencies in plant development because it reduces the photosynthetic rate, consequently affecting the formation of photoassimilates. These same authors highlighted that to obtain better performance, it is necessary to use greater spacing to make better use of light and better photosynthetic efficiency.

There was a significant difference in root length between cultivars. Compared with BRS Leila, the Jade cultivar presented increases in root length of 81%, 51% and 67% at spacings of 25 × 25, 25 × 30 and 30 × 30 cm, respectively. Compared with those of the RZ cultivar, the root lengths of the RZ cultivar were 31%, 13% and 31% greater at spacings of 25 × 25, 25 × 30 and 30 × 30 cm, respectively (Table 3).

For the BRS Leila cultivar, the spacings did not differ statistically from each other, showing that this cultivar did not suffer from the effect of density on the root growth variable. On the other hand, in the Jade cultivar, the 25 × 25 cm spacing resulted in greater root growth, significantly differing from the other spacings, with increases of 18% and 11% in relation to the 25 × 30 and 30 × 30 cm spacings, respectively. However, in the RZ cultivar, the 25 × 25 and 25 × 30 cm spacings did not differ statistically from each other, being superior to the 30 × 30 cm spacing, presenting increases of 12% and 10%, respectively, in root length. This behavior may be related to greater competition for water, light and nutrients, which is greater in denser spaces and favors root growth as a strategy for nutrient absorption. Vidianto, Fatimah and Wasonowati (2013) reported that a smaller spacing between plants results in greater competition for nutrients, which reduces absorption and leads to excessive root growth. Furthermore, it can be inferred that the energy required for root growth in denser spaces is directed to the growth of the aerial part, which is the part of greatest economic and commercial interest in lettuce.

Baiyin *et al.* (2021) reported that greater root growth provides a greater area for nutrient absorption, promoting better plant growth performance, and this dynamic must be corroborated by analysis of the fresh matter of the aerial part. In the present study, analysis of the fresh matter of the aerial part revealed that the Jade cultivar presented better performance, not significantly different from the BRS Leila cultivar, but rather from the RZ cultivar, which presented an increase in MFPA of 22% (Table 2).

The cultivar × spacing interaction was not significant for the variables number of leaves, collection, shoot fresh matter, root fresh matter, stem height, shoot dry matter or root dry matter. For the number of leaves per plant, a significant effect was observed for the cultivar factor (Table 2). The Jade cultivar had the greatest number of leaves per plant, with increases of 23% and 21% from those of the BRS Leila and Joction RZ cultivars, respectively, which in turn did not differ from each other (Table 2).

According to Çekin *et al.* (2023), the number of leaves is an important indicator of plant yield, whereas Silva *et al.* (2000) emphasized that the difference in the number of leaves between cultivars may be related to genetic characteristics. On the basis of these findings, it can be inferred that the Jade cultivar, which is characterized by a greater number of leaves, can be considered an excellent option for cultivation in a hydroponic system in the Amazon region. Importantly, in terms of performance, the NFT hydroponic system outperforms other types of systems, such as wick hydroponic, subirrigation, aeroponic and floating bed systems.

For the spacing factor, there was no significant difference in relation to the number of leaves; therefore, under the conditions of the present study, spacing did not influence this variable. Different results were reported by Purbasari, Bafdal and Perwitasari (2023), who reported that density influences the number of leaves, resulting in a greater number of leaves with greater spacing.

When the fresh matter of the aerial part was evaluated, the BRS Leila and Jade cultivars did not differ statistically from the Jutta cultivar. The 30 × 30 cm spacing resulted in better performance than the 25 × 25 and 25 × 30 cm spacings did, with increases of 8% and 19%, respectively. The 25 × 25 and 25 × 30 cm spacings had statistically similar values (Table 2). According to Campos, Assis and Livramento (2022), the plants that have the best productive performance are those that have the greatest spacing between them, as they compete less for water, light and nutrients.

In the analysis of the collection variable, the RZ cultivar performed best, with an average of 15.11 mm, differing significantly from the Jade and BRS Leila cultivars, which presented averages of 13.40 mm and 10.26 mm, respectively. In terms of spacing, the 30 × 30 cm spacing method performed better than the other methods did, with an average spacing of 14.72 mm, which significantly differed from the 25 × 25 cm and 25 × 30 cm spacings, which presented averages of 11.66 mm and 12.40 mm, respectively (Table 2). Similar results were reported by Cometti, Galon and Bremenkamp (2019), who reported that the use of smaller spacings in hydroponic cultivation was responsible for reducing the diameter of the culm. Plants with greater spacing have less competition for water, light and nutrient resources, which allows them to achieve more favorable productive performance (CAMPOS; ASSIS; LIVRAMENTO, 2022).

The analysis of the variable stem height revealed that the BRS Leila and Jade cultivars did not differ statistically from each other, presenting higher values than did the Joction RZ cultivar, which was a statistically significant difference. In relation to the Joction RZ cultivar, the Leila cultivar presented an increase in stem height of 68%, whereas for the Jade cultivar, the increase was 78%. With respect to spacing, the 25 × 25 cm spacing achieved greater results, differing statistically from the 25 × 30 and 30 × 30 cm spacings, with increases of 25% and 31%, respectively, compared with those of the other spacings (Table 2). According to Cometti, Galon and Bremenkamp (2019), measuring plant stem length is widely used as an indicator to evaluate the ability of plants to resist bolting and tolerate heat conditions. In this context, we suggest that the BRS Leila and Jade cultivars are more resistant to early bolting and more tolerant to high-temperature conditions, suggesting that, considering exclusively the variable stem height, the 25 × 25 cm spacing may present better results.

The fresh matter of the aerial parts of the cultivars BRS Leila and Jade did not differ statistically from that of the other cultivars, with higher values than those of the cultivar joining RZ. The 25 × 30 and 30 × 30 cm spacings had better performance in this respect, with the 25 × 30 cm spacing not significantly different from the 25 × 25 cm spacing (Table 2). The results corroborate the data obtained by Morais *et al.* (2018), who, when evaluating the Vera cultivar, reported that the 30 × 30 cm spacing positively influenced the production of fresh matter compared with other smaller spacings.

Silva *et al* . (2011) reported that a reduction in planting density has a direct effect on the increase in the average head weight of lettuce, and when an ideal density is provided for the crop, consequently, there are increases in fresh mass and productivity.

There were no statistically significant differences in shoot dry matter among the cultivars. In terms of spacing, the 30 × 30 cm treatment presented the highest yield, with an average of 11.42 g; however, it did not differ statistically from the 25 × 30 cm treatment, which presented an average of 10.42 g, differing only from the 25 × 25 cm treatment, for which an average of 9.40 g was obtained (Table 2).

Similar results were reported by Campos, Assis and Livramento (2022), who, when studying the effects of different plant densities in cultivation with and without vegetation cover, reported that 30 × 30 cm spacing provided greater gains in fresh matter and dry matter. aerial part, differing statistically from the 20 × 20 cm spacing, in which the average fresh matter from the plant density × coverage interaction for the 30 × 30 cm spacing was 10.6 g in the treatment with coverage and 11.0 g in the treatment without coverage. For fresh matter, at the same spacing, the averages were 235.5 g and 232.5 g for the treatments with and without coverage, respectively, highlighting that there was no significant difference between the coverages.

Similar results were also reported by Cecconello (2018), who studied the agronomic performance of the lettuce crop cultivar Mônica in two production systems with different spacings between plants and reported an increase in the fresh and dry masses of the plants when the distance between plants ranged from 20 × 20 cm to 30 × 30 cm.

6 CONCLUSION

Cultivating the Rz combination was more adaptable to denser spacing. Therefore, when the objective of planting is not individual performance per plant, this cultivar is recommended at a spacing of 25 × 25 cm to obtain greater productivity per area.

At the intermediate spacing of 25 × 30 cm, the Jade cultivar performed satisfactorily. Therefore, for this spacing, this cultivar is recommended because it is capable of providing good individual performance and average production performance per aerial plant.

To obtain better performance per plant, with good aerial part development and good quality, thus serving a more demanding market, it is recommended to plant the BSR Leila cultivar at 30 × 30 cm spacing.

Increasing the spacing between plants results in greater individual performance and better quality plants. However, there was a lower performance per planted area, considering that density provides more plants per area.

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