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Post-harvest indices and color parameters in beet roots intercropped with lettuce under organic fertilization and population densities

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Abstract

The objective of this study was to evaluate and estimate the post-harvest indices and color parameters of beet roots in intercropping with lettuce under green manuring with different equitable amounts of *M. aegyptia* and *C. procera* biomass (20, 35, 50 and 65 t ha^{-1} on a dry basis) in diverse population densities of lettuce (150, 200, 250 and 300 thousand plants ha^{-1}), in two cropping seasons in semi-arid environment. The lettuce crop presented the best post-harvest indexes when submitted to fertilization with an amount of *M. aegyptia* and *C. procera* biomass of 20 t ha^{-1} in lettuce population densities between 203 and 300 thousand plants per hectare. The beet crop reached the best indices when it was manured with amounts of the green manures between 20 and 55 t ha^{-1} and between lettuce population densities of 150 and 300 thousand plants per hectare. The color parameters of purple/red beet roots (well appreciated by the consumers) were obtained in the amounts of green manures between 25 and 65 t ha^{-1} and between lettuce population densities of 280 and 300 thousand plants per hectare.

Keywords: *Lactuca sativa*; *Beta vulgaris*; *Merremia aegyptia*; *Calotropis procera*; post-harvest quality.

Practical Application: Studying the post-harvest indices of beet-lettuce in intercropping for use and commercialization.

1 Introduction

Beet and lettuce represent a group of horticultural crops of economic, social and nutritional importance in the production systems of the semi-arid region of the Brazilian Northeast, where their crops are growing. The intercropping of these two vegetables has shown to be promising, where in association these cultures have behaved as companions, that is, helping each other during growth and development (Guerra et al., 2021). One of the questions that has been asked is whether the post-harvest quality of its products can be affected in this cropping system.

However, it is known that the efficiency of an intercropping system depends on the proper management given to treatment-factors applied in the development of the systems (Sá et al., 2021). Thus, crop productivities in this cultivation system and consequently the quality of their products depend on the level of competition between and within crops, resulting from the handling given to treatment-factors such as fertilization and crops population density, as they somehow dictate the good or bad quality of the products, as well as the agronomic efficiency of the system.

The chemical composition of roots and leaves in vegetables can be influenced by genetic factors and growing conditions such as: cropping systems, types of fertilizers, used fertilizers amounts, population densities of the component crops, among others (Ferreira, 2011). The elements provided by a certain type of fertilizer in a certain amount provided, in addition to influencing the productivity of the crop, are related to the final quality of the product, and consequently to the market value (Filgueira, 2008), playing an essential role in numerous physiological and biochemical processes in plant including photosynthesis, increasing the translocation of assimilates (Marschner, 2012). When in adequate doses in the plant, it maintains the balance between the contents of sugars and acids, in addition to improving the storage potential, however, the excess of this nutrient can reduce the storage potential of fruits in post-harvest (Cuquel et al., 2004). Thus, the chemical characterization of fruits allows obtaining important information about the quality of the final product. The content of total soluble solids (sugars) and titratable acidity are considered important parameters to evaluate the quality of fruits in terms of flavor (Portela et al., 2012).

Population density of crops can affect fruit quality, not only in terms of average size, but also in terms of organoleptic characteristics (Portela et al., 2012). The ideal population density to be used for the plant canopy is the one in which the maximum solar radiation useful for photosynthesis is intercepted and, at the same time, maximizes the fraction of dry matter allocated to the fruits. Thus, the plant population can affect the penetration of solar radiation in the canopy and the balance between the growth of the vegetative fraction and the fruits. Alterations in the efficiency of the sources, through modifications in the

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plant population or the increase in the availability of radiation, indirectly affect the distribution of dry matter between the organs of the plant, and there may be alterations in the number of growing fruits, which modify the capacity of plant drain (Schvambach et al., 2002).

Batista et al. (2010) studying the characteristics TA, SS and SS/TA ratio of beet in single cultivation as a function of manuring with green manures, hairy woodrose and roostertree in the Brazilian semiarid at doses of 5.4, 8.8, 12.2, 15.6 and 21 t ha^{-1}, obtained values ranging from 1.09 to 1.57 (% malic acid); 10.64 to 12.06 (°Brix) and from 6.98 to 10.36 (°Brix/% malic acid) in the hairy woodrose and from 1.16 to 1.57 (% malic acid); 9.98 to 11.87 (°Brix) and 6.93 to 8.96 (°Brix/% malic acid) in the roostertree.

Barros et al. (2005), evaluating the quality of carrot roots from systems intercropped with lettuce chemically fertilized under different population densities of the component cultures, recorded carrots with good root quality, with SS ranging from 7.4 to 7.9 (°Brix), TA reaching the value of 0.19% malic acid in the lettuce population of 150 thousand plants per hectare, and pH ranging from 6.17 to 6.18. On the other hand, Bezerra et al. (2005), studying the quality of lettuce intercropped with carrots as a function of lettuce and carrot population densities, observed a decrease in the behavior of SS, TA and SS/TA levels with increasing lettuce population density. Regarding the increase in carrot population density, an increase in lettuce TA was recorded.

The objective of this work was to evaluate and estimate the post-harvest indices and color parameters of beet roots intercropped with lettuce under green fertilization with different equitable amounts of *M. aegyptia* and *C. procera* biomass (20, 35, 50 and 65 t ha^{-1} on a dry basis) at different population densities of lettuce (150, 200, 250 and 300 thousand plants ha^{-1}), in two growing seasons in semi-arid environment.

2 Materials and methods

Field experiments were carried out in the 2018 and 2019 cropping seasons in areas of the Rafael Fernandes Experimental Farm (5º03’44”S, 37º23’52”W, 80 m altitude) of the Universidade Federal Rural do Semi-Árido, UFERSA, located in the district Lagoinha, 20 km away from the urban center of Mossoró-RN, Brazil. The climate of the region, according to the Köppen classification, is “BShw”, semi-arid, dry and hot, with a dry season from June to January and a rainy season from February to May (Nunes et al., 2018). During the experimental periods, the average values recorded for minimum and maximum temperatures, relative humidity and precipitation for the 2018 and 2019 cropping seasons were, respectively: 27.8 and 27.1 ºC; 33.2 and 32.9 °C; 66.2 and 67.1% and 0.4 and 4.4 mm (Instituto Nacional de Meteorologia, 2021).

The soils of the experimental areas were classified as typical Dystrophic Red Yellow Argisol with sandy loam texture (Santos et al., 2018). In each experimental area, simple soil samples were collected from the surface layer of 0-20 cm, homogenized to obtain a composite sample, representative of the area, whose results in cultivation in 2018 were: pH (water) = 8.10; EC = 0.24 dS m^{-1}; O.M. = 4.97 g kg^{-1}; N = 0.35 g kg^{-1}; P = 22.80 mg dm^{-3}; K = 64.70 mg dm^{-3}; Ca = 3.28 $cmol_c$ dm^{-3}; Mg = 0.78 $cmol_c$ dm^{-3}; Na = 32.70 mg dm^{-3}; Cu = 0.10 mg dm^{-3}; Fe = 1.91 mg dm^{-3}; Mn = 11.67 mg dm^{-3}; Zn = 2.63 mg dm^{-3}. In the 2019 cropping, the results were: pH (water) = 7.10; EC = 0.10 dS m^{-1}; O.M. = 5.27 g kg^{-1}; N = 0.28 g kg^{-1}; P = 22.00 mg dm^{-3}; K = 69.47 mg dm^{-3}; Ca = 2.70 $cmol_c$ dm^{-3}; Mg = 0.50 $cmol_c$ dm^{-3}; Na = 26.70 mg dm^{-3}; Cu = 0.24 mg dm^{-3}; Fe = 2.71 mg dm^{-3}; Mn = 12.17 mg dm^{-3}; Zn = 5.27 mg dm^{-3}.

The experimental design used was complete randomized blocks, with treatments arranged in a 4 x 4 factorial scheme, with four replications. The first factor was constituted by doses of 20, 35, 50 and 65 t ha^{-1} on a dry basis of *M. aegyptia* and *C. procera*, and the second factor by four population densities of 150, 200, 250, and 300 thousand plants ha^{-1} of lettuce, corresponding to 60, 80, 100 and 120% of the recommended density for single crop (RDSC) of lettuce, intercropped with 500 thousand plants ha^{-1} of beet, corresponding to 100% of the recommended density for single crop (RDSC). The recommended population densities for the single cultivation of beet and lettuce in the region are 500 and 250 thousand plants ha^{-1}, respectively (Silva et al., 2018; Almeida et al., 2015).

The intercropped system was established in alternating strips of the component cultures in the proportion of 50% of the area occupied with beet and 50% with lettuce, where in each plot the alternating strips were constituted of four rows, flanked by two rows of lettuce on one side and two rows of beet on the other side, used as borders. The total area of each plot was 2.88 m^2 (2.40 x 1.20 m), with a harvest area of 1.60 m^2 (1.60 x 1.00 m). The harvest area consisted of the two central strips of plants, excluding the first and last plants of each row of the strips used as borders (Figure 1).

The spacing of the lettuce in the intercropping was 0.20 m between rows and within the lettuce rows the spacing varied according to the population densities studied, which were 0.166; 0.125; 0.10 and 0.08 m, providing 24, 32, 40 and 48 plants per useful area, respectively, corresponding to population densities of 150, 200, 250 and 300 thousand plants per hectare. The beet spacing was 0.20 m x 0.05 m (Figure 1).

Before setting up the experiments in the experimental areas, the soils were prepared starting with the mechanical cleaning of the areas with the aid of a tractor with an attached plow, followed by harrowing and mechanized lifting of the beds with a rotating harrow. Subsequently, pre-planting solarization was carried out with transparent plastic such as Vulca Brilho Bril Flex® (30 microns) for 30 days to combat phytopathogenic microorganisms in the soil according to the methodology of Silva et al. (2006).

The green manures *M. aegyptia* and *C. procera* were collected in rural areas located in the municipality of Mossoró-RN. Then they were ground in a conventional forager, obtaining fragmented particles around 2.0 to 3.0 cm, dehydrated under sunlight until reaching a moisture content of 10%. Samples of these materials were subjected to laboratory analysis whose chemical compositions were in 2018: N = 16.60 g kg^{-1}; P = 2.79 g kg^{-1}; K = 37.80 g kg^{-1}; Mg = 7.07 g kg^{-1} and Ca = 19.35 g kg^{-1}, for *M. aegyptia* and N = 21.90 g kg^{-1}; P = 1.92 g kg^{-1}; K = 20.90 g kg^{-1}; Mg = 9.22 g kg^{-1} and Ca =

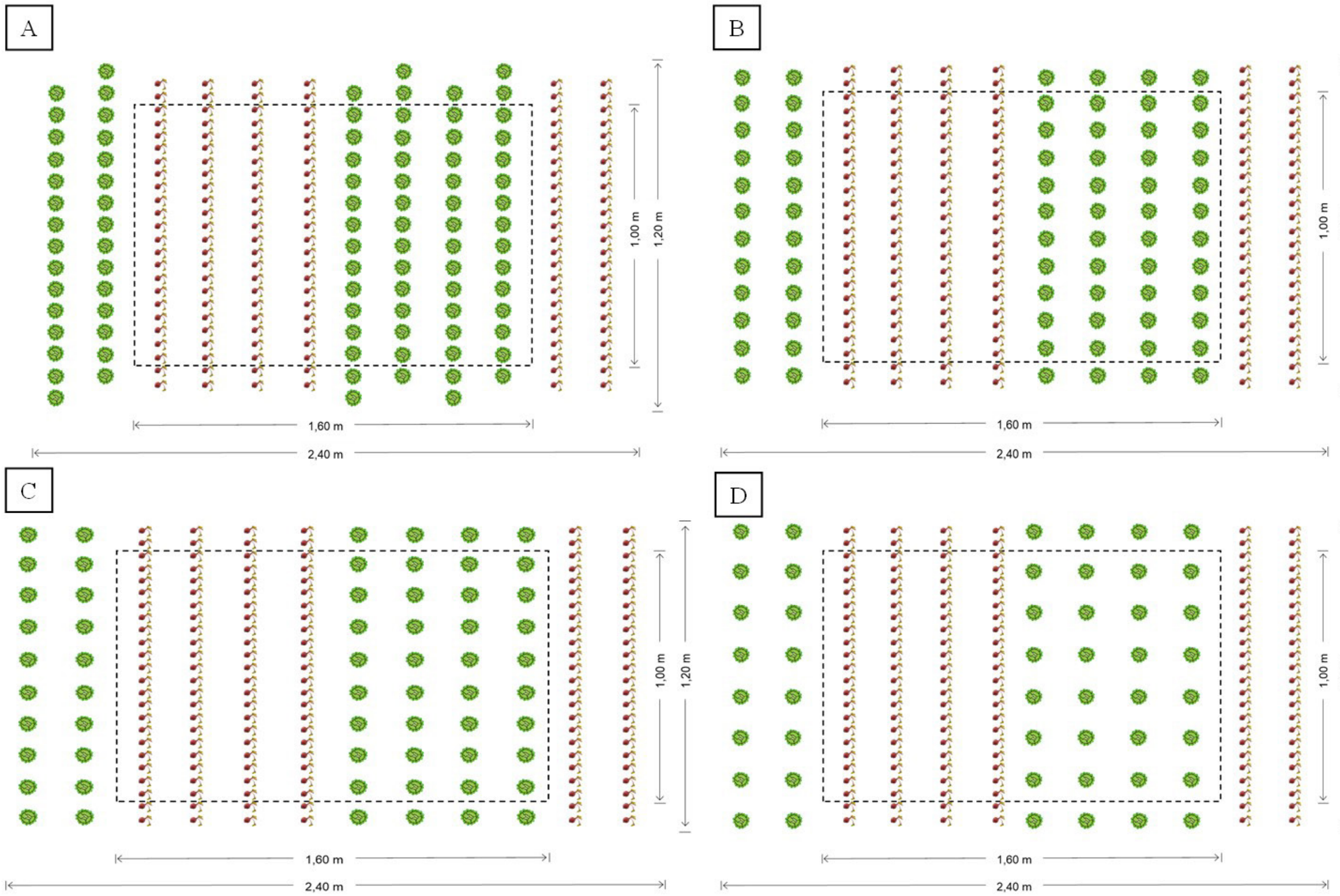

Figure 1. Details of the plots of intercropped beet and lettuce fertilized with a biomass amount of *M. aegyptia* and *C. procera* at population densities of 300 (A), 250 (B), 200 (C) and 150 (D) thousand plants ha^{-1} of lettuce with 500 thousand plants ha^{-1} of beet.

17.00 g kg^{-1}, for *C. procera*. In 2019: N = 15.30 g kg^{-1}; P = 4.00 g kg^{-1}; K = 25.70 g kg^{-1}; Mg = 7.03 g kg^{-1} and Ca = 9.30 g kg^{-1}, for *M. aegyptia* and N = 18.40 g kg^{-1}; P = 3.10 g kg^{-1}; K = 24.50 g kg^{-1}; Mg = 13.50 g kg^{-1} and Ca = 16.30 g kg^{-1} for *C. procera*.

The beet cultivar 'Early Wonder' was sown on September 11, 2018 in the first cropping season and on August 27, 2019 in the second cropping season, in 3.0 cm deep holes, with two to three seeds per hole. Two cultivations of the lettuce cultivar 'Tainá' were carried out each year of cultivation. This cultivar was sown in polystyrene trays of 200 cells with three seeds per cell and the seedlings were transplanted 20 days later to the field, in holes of 5.0 cm depth in the beds. The first lettuce transplant in 2018 was carried out on the same day as the beet sowing and the second transplant on November 6, 2018. In 2019, the lettuce was transplanted on the same day as the beet sowing and the second transplant on the day October 21, 2019. The beet thinning was carried out seven days after planting, leaving one plant per hole and the lettuce thinning was also carried out at seven days, leaving one seedling per cell.

Irrigation of vegetables was performed in a micro-sprinkler system with a daily irrigation shift, divided into two applications, morning and afternoon (Martins et al., 2018). The amount of water supplied was determined by the values of the beet cultivation coefficient (average Kc = 0.83) (Oliveira et al., 2011), with an irrigation depth of approximately 8 mm day^{-1}. Weed control was carried out, whenever necessary, by hand harvesting the plants. No chemical pest and disease control methods were used.

The beet harvests were carried out at 70 and 71 days after sowing (DAS) in the first and second cropping season, while the two lettuce harvests were carried out at 29 DAS in the first year of cultivation, and at 28 and 29 DAS in the second year of cultivation.

The characteristics evaluated in the lettuce crop were titratable acidity (TA), pH, soluble solids content (SS) and soluble solids and titratable acidity ratio (SS/TA). In the beet crop, the same characteristics of lettuce were evaluated, plus the concentration of betalain (BC).

To evaluate the mentioned characteristics, we used a multiprocessor (Juicer Compact Philips Walita®). Titratable Acidity (TA) was performed by titration, using 1.0 mL of pulp in an Erlenmeyer flask, with a beaker adding 49.0 mL of distilled water, which, after stirring, was titrated with a standardized 0.1 M NaOH solution, using 1% phenolphthalein as an indicator and the results expressed in grams of citric acid per 100 g of pulp (Instituto Adolfo Lutz, 2005). Data were expressed in %.

The measurement of pH was performed using a benchtop pH meter model Tecnopon mPA 210®. The content of soluble solids (SS) was determined by refractometry, using a digital refractometer model RTDS-28®, expressing the content in °Brix (Association of Official Analytical Collaboration, 2005). After these determinations, the ratio of soluble solids content and titratable acidity (SS/TA) was calculated.

To determine the concentration of betalain in the beet roots, samples (1 g) of beetroot extract were homogenized in water and transferred to a volumetric flask, where the volume was made up to 100 mL. Then, they were filtered with No. 1 Whatman filter paper. The filtrates were then used for spectrophotometric readings performed in duplicate. The quantification of betalains was performed according to the Beer Lambert-Bougue Law, modified by Tang & Norziah (2007). The calculations performed to determine the betalain concentration were performed using the following formula: $Bc = A \times PM \times 1000/\varepsilon \times l$, where Bc, is the betanin equivalent (mg/L); A, obtained by λmax at 536 nm; MW, is the molecular weight of betanin (550 g/mol); ε is the betanin excitation molar coefficient (60,000 L/mol.cm); l, is the width of the cuvette (1 cm) and 1000 is the dilution factor.

To determine the internal color, it was performed with the aid of a Minolta colorimeter, model CR-410, calibrated on a white porcelain surface under lighting conditions and expressed in the L*, a* and b* module (Figure 2). The Chroma [(a*•2 + b*•2)1/2] and Hue Angle [arc tangent (b*/a*)] were later calculated (McGuire, 1992). The L*, a*, b* coordinates describe the uniformity of color in three-dimensional space, where the L* value corresponds to how light and how dark the analyzed product is (0: black; 100: white), the values of (a*) correspond to the scale from green to red (a* negative; green, a* positive; red) and the values of (b*) correspond to the scale from blue to yellow (b* negative; blue, b* positive; yellow). The Hue angle (h_{ab}) is the angle formed between a* and b*, indicating the color saturation of the object. It can vary from 0 to 360°, with 0° corresponding to red, 90° to yellow, 180° to green and 270° to blue. According to the CIELAB system, if the angle is between 0° and 90°, the closer to 0° the redder, and the closer to 90° the more yellow (MacDougall, 2002). For reading, the fruits were cut transversally with a knife stainless steel and read on cut surfaces.

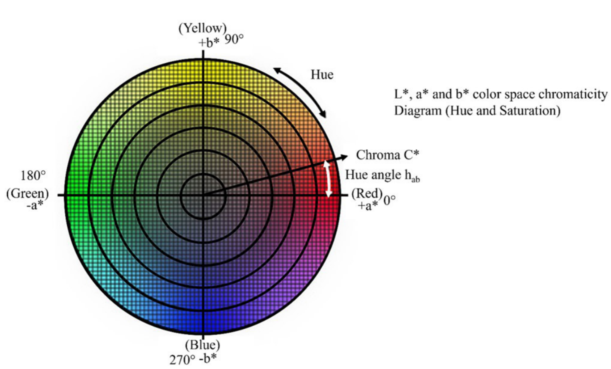

Figure 2. L* (luminosity), a* and b* chromaticity diagram (sensing.konicaminolta.us, 2021).

Univariate analysis of variance for the randomized block design in a factorial scheme was used to evaluate the determined variables. Due to the homogeneity of the variances between the cropping seasons, an average of these variables was made between the years of cultivation. Then, a regression analysis for all post-harvest variables was performed, where a procedure of adjustment of a response surface of each variable was performed as a function of equitable amounts of *M. aegyptia* and *C. procera* biomass incorporated into the soil and population densities of lettuce, performed using the Table Curve 3D software (Systat Software Inc., 2021).

3 Results and discussion

3.1 Lettuce crop

The results of the analysis of variance and regression of the characteristics evaluated in lettuce, titratable acidity (TA), pH, soluble solids content (SS) and SS/TA ratio are shown in Table 1.

However, a response surface was adjusted for all these lettuce characteristics as a function of the treatment-factors, amounts of *M. aegyptia* and *C. procera* biomass and population densities of lettuce plants intercropped with beet, where the maximum values for TA, pH, SS, and SS/TA ratio of 0.45% malic acid, 6.29, 3.67 °Brix and 9.96 °Brix/% malic acid, respectively, were achieved by combining an equitable amount of green manures biomass with a lettuce population density of 65 and 150; 20 and 203; 20 and 300 and 20 t ha^{-1} and 300 thousand lettuce plants per hectare (Figures 3A-3D). It is known that factors such as climate, nutrition management and crop population densities, among others, interfere with the production of sugars and acids in leafy crops products (Batista et al., 2010; Portela et al., 2012). Therefore, it is observed that the titratable acidity was more affected by the amounts of the manures, reaching the maximum value of 0.45% malic acid in the largest amount added to the soil of 65 t ha^{-1}, than by the densities that reached the maximum in the lowest population density of lettuce (Figure 3A).

On the other hand, pH, soluble solids content and SS/TA ratio were more affected by lettuce population densities, reaching the maximum pH value of 6.34 at the density of 203 thousand lettuce plants (Figure 3B). The maximum values of soluble solids content and SS/TA ratio of 8.58 °Brix and 15.68 °Brix/% malic acid were reached at the highest density of lettuce tested, 300 lettuce plants per hectare (Figures 3C-3D). This behavior of the increase in SS and in the SS/TA ratio with the increase in lettuce population densities was similar to that obtained by Portela et al. (2012), studying the increase in strawberry planting density in the SS and SS/TA, obtained an increase in the values of these variables. In these characteristics, maximum values were also obtained with the addition of the smallest amount of tested green manures.

3.2 Beet crop

The results of the analysis of variance and regression of the characteristics evaluated in beet, titratable acidity (TA), pH, betalain content, soluble solids content (SS) and SS/TA ratio are presented in Table 2.

Table 1. F values for titratable acidity (TA), pH, soluble solids content (SS) and SS/TA ratio in lettuce intercropped with beet at diverse lettuce population densities and different equitable biomass amounts of *M. aegyptia* and *C. procera* incorporated into the soil.

Sources of variation	Degree of freedom	Titratable Acidity	pH	Soluble solids	SS/TA ratio
Blocks	3	1.16^{ns}	1.30^{ns}	1.48^{ns}	1.74^{ns}
Amounts of *M. aegyptia* and *C. procera* biomass (A)	3	3.27*	16.89**	21.18**	32.84
Population densities of lettuce (D)	3	20.35**	1.36^{ns}	5.14**	27.03
A x D	9	2.06^{ns}	1.89^{ns}	1.81^{ns}	2.24*
Regression (Response surface)	2	19.10**	44.89**	16.36**	34.38**
Error	13	0.00025	0.00060	0.03894	0.27112
CV (%)		6.08	1.08	8.56	8.43

$^{ns}P > 0.05$. $^{*}P < 0.05$. $^{**}P < 0.01$.

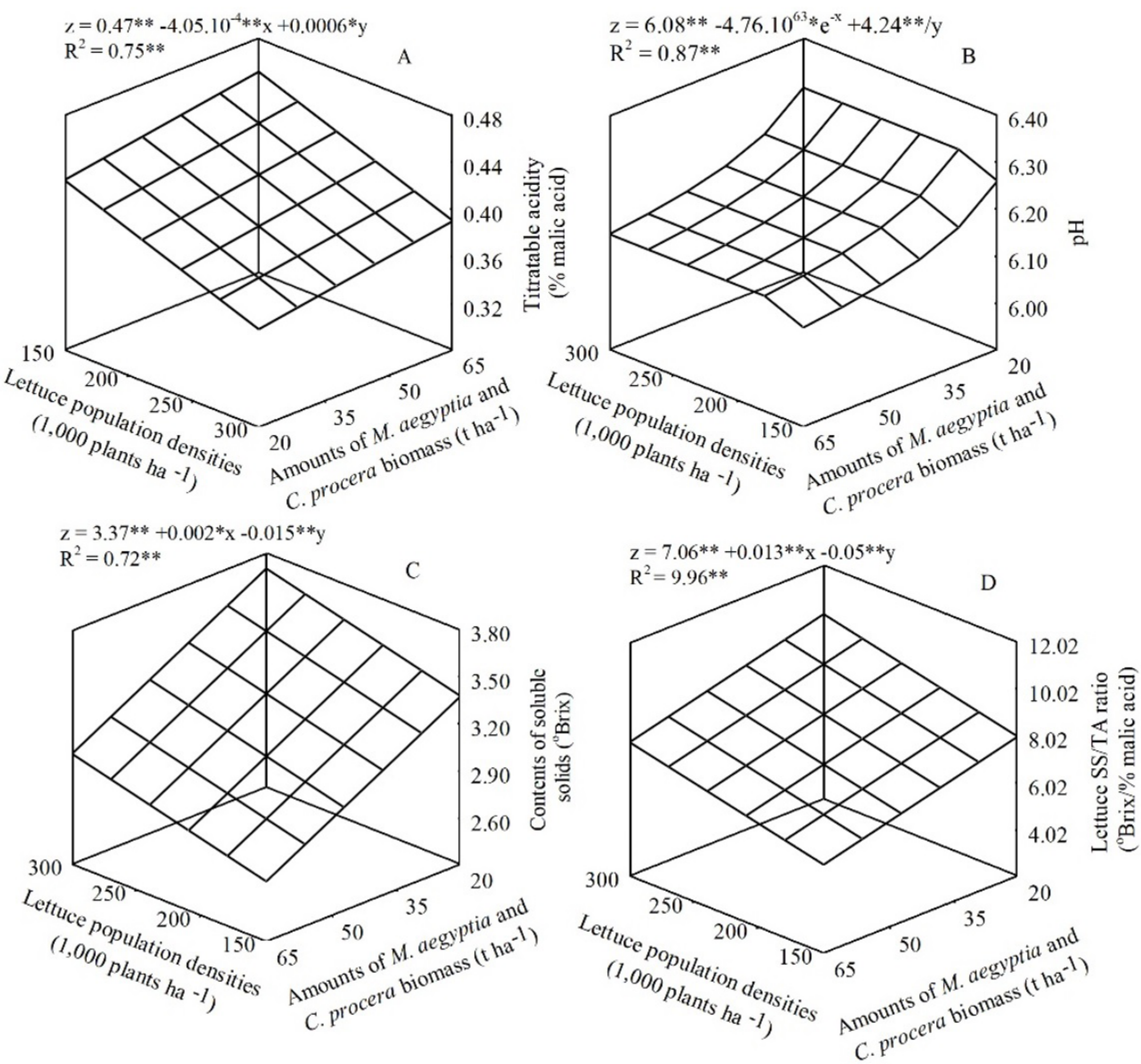

Figure 3. Titratable acidity (A), pH (B), soluble solids content (C) and soluble solids/titratable acidity ratio (D) of lettuce in bi-cropping intercropped with beet in different combinations of equitable amounts of *M. aegyptia* and *C. procera* biomass and lettuce population densities.

However, a response surface was adjusted for all these beet characteristics as a function of the treatment-factors, amounts of *M. aegyptia* and *C. procera* biomass and population densities of lettuce plants intercropped with beet, where the maximum values for TA, pH, BC, SS, and SS/TA of 0.58% malic acid, 6.34, 41.39 mg/100g, 8.58 °Brix and 15.68 °Brix/% malic acid, respectively, were achieved by combining the equitable amount of green manures biomass with the lettuce population density from 20 and 300; 52 and 300; 20 and 300; 25 and 230 and 55 t ha^{-1} and 218 thousand lettuce plants per hectare (Figures 4A-4E).

In view of these results, it is observed that TA and BC were more affected by lettuce population densities, while pH was affected both by the amounts tested and by the lettuce population density. On the other hand, the SS and the SS/TA ratio were also affected by the two production factors tested. It is known that factors such as climate, nutrition management and planting densities, among others, interfere in the production of sugars and fruit acids (Portela et al., 2012), a reality observed in the present work.

On the other hand, it is known that potassium is a macro element capable of influencing the levels of soluble solids in vegetables, increasing the amount of sugar in beets (Instituto da Potassa & Fosfato, 1998). Despite the increasing K content of the treatments with the green manures, it can be concluded that the greater availability of potassium in the soil will not always promote a greater content of soluble solids, showing that for each characteristic, crop, soil and climate, there are different optimal values.

The results of the analysis of variance and regression of the color parameters of the beet surface, L* (luminosity), a* and b* are presented in Table 3.

A response surface was adjusted for all these beet color parameters as a function of the treatment-factors, amounts of *M. aegyptia* and *C. procera* biomass and population densities of lettuce plants intercropped with beet, where the maximum values for a*, b* and L* of 35.43, 9.94 and 32.97, and, respectively, were achieved by combining equitable amounts of the green manures biomass with lettuce population densities of 25 and 188, 65 and 300 and of 65 t ha^{-1} and 280 thousand plants per hectare (Figures 5A-5C).

In view of these results, it is observed that the beet color parameters evaluated were all affected by both the amounts of green manures and the population densities of lettuce, where all had an increase in their values. The a* parameter showed a stronger pink/red color of the beet in the combination of the dose of green manures of 25 t ha^{-1} with the population density of lettuce of 188 thousand plants per hectare in relation to the other combinations tested. This color is well appreciated by the consumer. On the other hand, the parameter b* intensified the more purple color in the highest combination of amounts of green manures and lettuce population densities tested. The parameter L* (luminosity) also behaved in the same way as the parameter b*,

Table 2. F values for titratable acidity (TA), pH, betalain content, soluble solids content (SS), and SS/TA ratio in the beet crop intercropped with lettuce at diverse lettuce population densities and equitable biomass amounts of *M. aegyptia* and *C. procera* incorporated into the soil.

Sources of variation	Degree of freedom	Titratable Acidity	pH	Betalaine content	Soluble solids	SS/TA ratio
Blocks	3	0.78^{ns}	0.75^{ns}	1.11^{ns}	1.48^{ns}	1.46^{ns}
Amounts of *M. aegyptia* and *C. procera* biomass (A)	3	1.95^{ns}	1.41^{ns}	1.95^{ns}	2.81^{ns}	4.73**
Population densities of lettuce (D)	3	2.66^{ns}	3.86*	0.06^{ns}	4.81^{**}	5.43^{**}
A x D	9	1.95^{ns}	1.21^{ns}	2.90^{**}	1.89^{ns}	4.70^{**}
Regression (Response surface)	2	15.91^{**}	24.17^{**}	23.34^{**}	4.77^{*}	4.69^{*}
Error	13	0.00030	0.00031	5.22580	0.57479	2.21447
CV (%)		12.97	5.16	24.58	13.04	15.66

^{ns}P > 0.05. **P < 0.01. *P < 0.05.

Table 3. F values for the L*, a* and b* color parameters of beet intercropped with lettuce at different lettuce population densities and equitable amounts of *M. aegyptia* and *C. procera* biomass incorporated into the soil.

Sources of variation	Degree of freedom	L*	a*	b*
Blocks	3	1.53^{ns}	0.14^{ns}	1.53^{ns}
Amounts of *M. aegyptia* and *C. procera* biomass (A)	3	0.34^{ns}	1.38^{ns}	0.34^{ns}
Population densities of lettuce (D)	3	0.52^{ns}	4.77**	0.52^{ns}
A x D	9	1.30^{ns}	2.31*	1.30^{ns}
Regression (Response surface)	2	8.39^{**}	6.73^{**}	6.47^{*}
Error	13	0.41784	0.79615	0.35432
CV (%)		7.94	4.51	7.95

^{ns}P > 0.05. **P < 0.01. *P < 0.05.

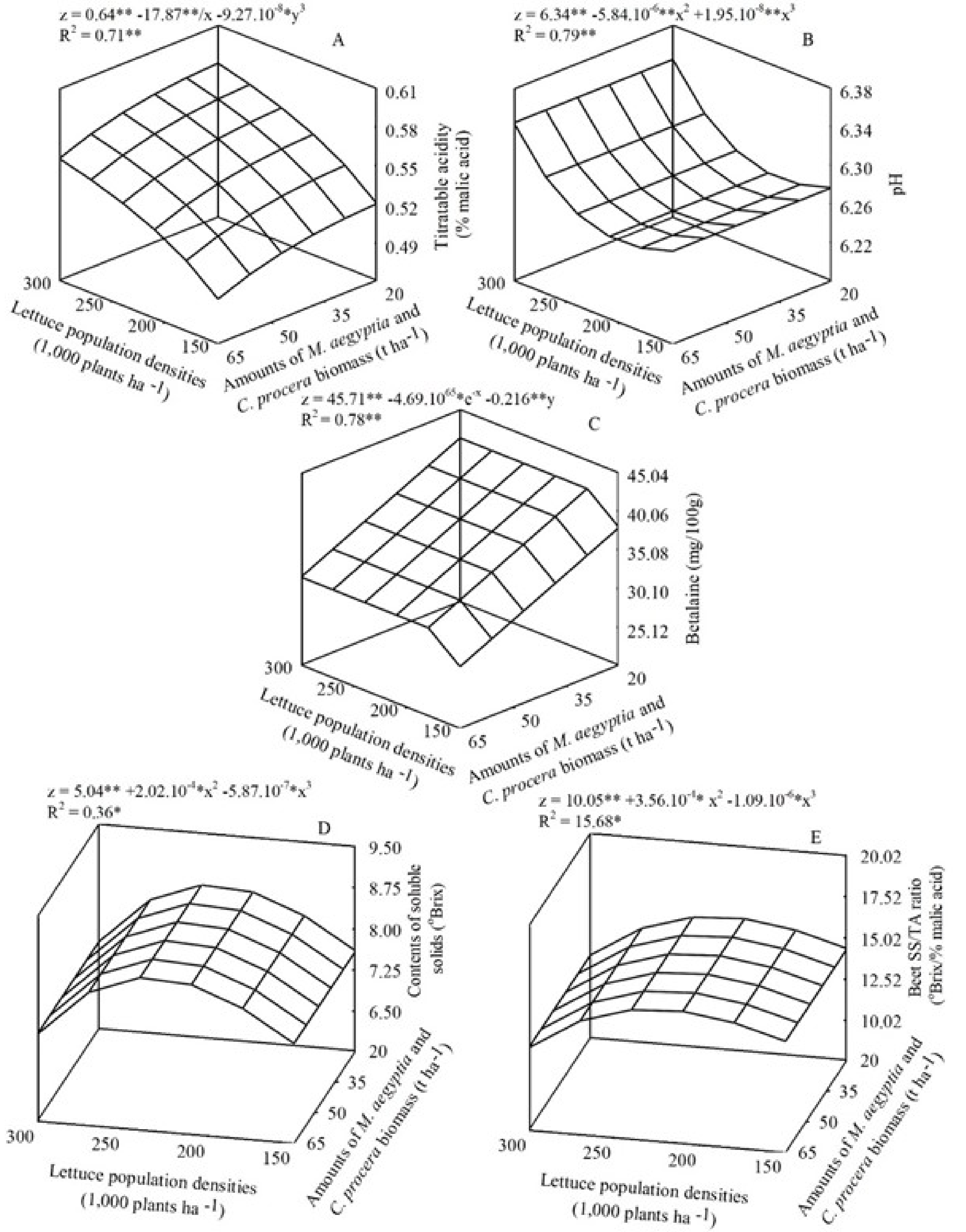

Figure 4. Titratable acidity (A), pH (B), betalaine (C), contents of soluble solids (D) and beet SS/TA ratio (E) in intercropping with lettuce in bi-cropping, in different combinations of equitable amounts of M. aegyptia and C. procera biomass and lettuce population densities.

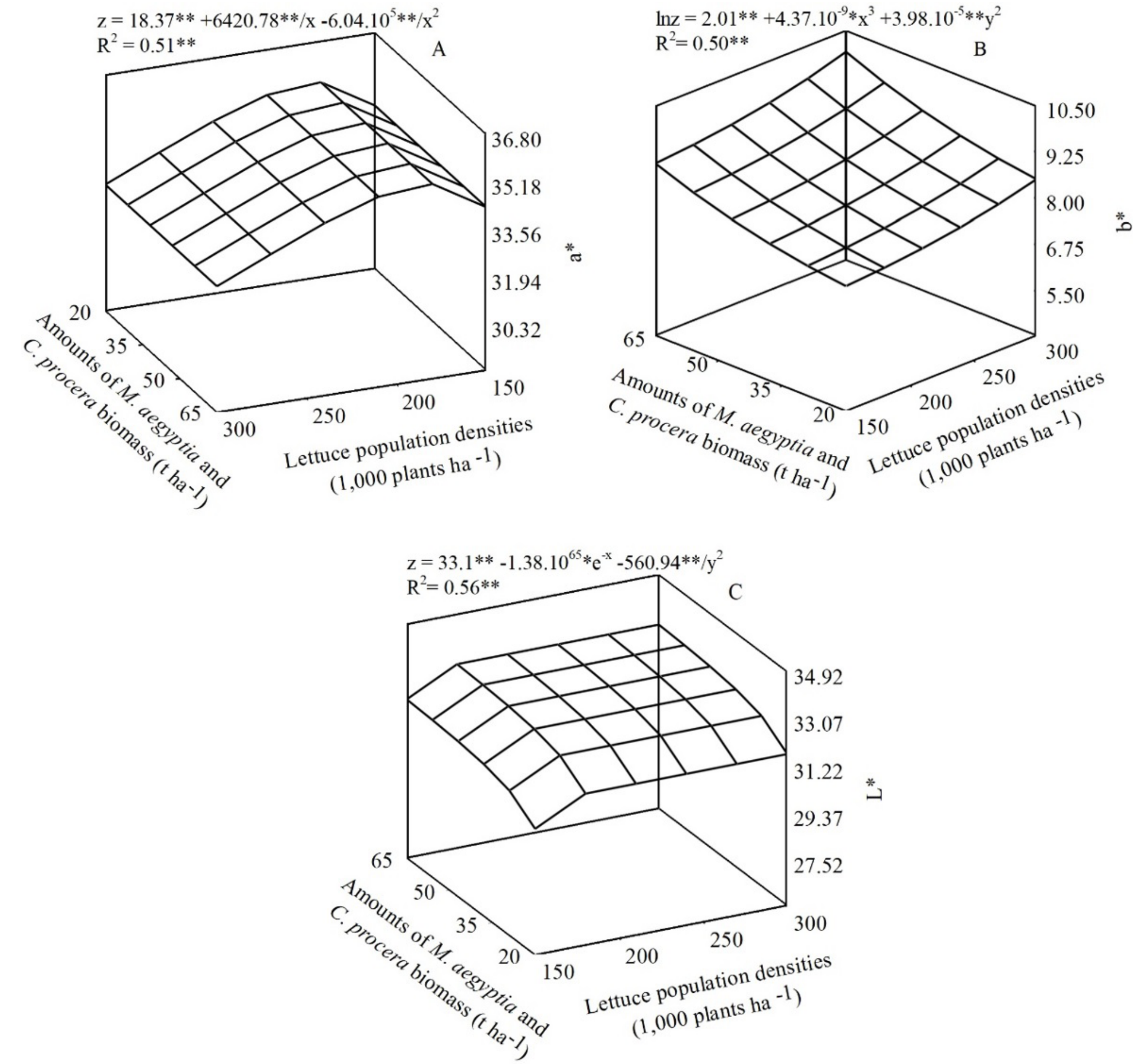

Figure 5. Color parameters a*, b* e L* (luminosity) in the crop of the beet intercropped with lettuce in bi-cropping, at different combinations of equitable biomass amounts of *M. aegyptia* and *C. procera* and lettuce population densities.

intensifying beet color in the highest amount of green manures tested in high population density of lettuce. Franco et al. (2021) working with the cultivation of beet fertilized with doses of potassium obtained behavior similar to those obtained in this research. In turn, Vitti et al. (2003), observing the behavior of the minimally processed beet, verified a decrease in the color indices.

4 Conclusion

The lettuce crop presented the best post-harvest indexes when submitted to fertilization with an amount of *M. aegyptia* and *C. procera* biomass of 20 t ha^{-1} in lettuce population densities between 203 and 300 thousand plants per hectare. The beet crop reached the best indices when it was manured with amounts of the green manures between 20 and 55 t ha^{-1} and between lettuce population densities of 150 and 300 thousand plants per hectare. The color parameters of purple/red beet roots (well appreciated by the consumers) were obtained in the amounts of green manures between 25 and 65 t ha^{-1} and between lettuce population densities of 280 and 300 thousand plants per hectare.

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