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CHICKEN MANURE AND LUMINOUS AVAILABILITY INFLUENCE GAS EXCHANGE AND PHOTOCHEMICAL PROCESSES IN *Alibertia edulis* (Rich.) A. Rich SEEDLINGS

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KEYWORDS

marmelo-do-cerrado, chlorophyll-*a* fluorescence, physiological adjustments, organic residue, shaded.

ABSTRACT

Information on the physiological responses of native plants from the Brazilian Cerrado regarding the use of chicken manure and luminosities are important for their silvicultural management. Thus, aimed to evaluate the effect of chicken manure and luminous availability on the photosynthetic metabolism of *Alibertia edulis* (Rich) A. Rich. The experiment was carried out in pots, testing five doses of chicken manure – CM (0.00, 2.08, 4.16, 6.24 and 8.32 g kg^{-1}) incorporated at Dystroferric Red Latosol, and two luminous environmental (full sun and 50% shaded). The higher CO_2 assimilation rate, stomatal conductance and carboxylation efficiency of Rubisco occurred in seedlings grown in full sun. The seedlings showed higher photochemical indicators in photosystem II in the shaded and with addition of 8.32 g kg^{-1} of CM. The intercellular CO_2 concentration in leaves was lower with addition of 5.55 g kg^{-1} of CM. The leaves presented larger stomatal dimensions under shaded. The cultivation of *A. edulis* in full sun and the addition of about 4.16 g kg^{-1} of CM favored greater stomatal regulation and CO_2 assimilation.

INTRODUCTION

Among the native species of the Cerrado, *Alibertia edulis* (Rich) A. Rich. (marmelo-do-cerrado, Rubiaceae), is a fruiting dioecious semideciduous plant, subarboreal in size, with large leaves, white flowers, globose-like fruits, and a large number of seeds (Paiva et al., 2017). The pulp is brown, fleshy, and sweetish, and may be consumed *in natura* or processed in the form of liqueurs, jellies, and sweets (Lorenzi et al., 2006). The aqueous extract of the leaves of the species has antidiuretic and antihypertensive activities (Aquino et al., 2017).

A. edulis continues to be collected for food and medicinal purposes in native areas. There is no record of its cultivation *ex situ*, which means that there is little information about the species' physiological responses to abiotic factors as well as to luminosity and the use of organic residues. Therefore, studies are necessary to establish silvicultural management practices.

The luminosity in the environment where a species is introduced, planted, and cultivated is a determining factor in the success of silvicultural practices and in the recovery of degraded areas as this depends on the resilience capacity of the species to ensure its survival and stability of growth. High or low light availability can trigger physiological changes such as the photosynthetic metabolism of plants through leaf changes (Bunce, 2016; Souza et al., 2017), involving differences in the magnitude of electron transport and the proton gradient that potentiates phosphorylation (Jim et al., 2016).

Therefore, knowledge regarding the acclimatization strategies of plants through physiological adjustments to contrasting conditions of irradiance are necessary (Gonçalves et al., 2010) because it assists in the selection of the area that will be used for seedling transplantation. It also allows us to understand if the species can be planted in areas that are under full sun and highly anthropized aiming at the restoration of the ecosystem, the enrichment of native forests, or enhancement of the composition of biodiverse agroforestry systems, with a lower incidence of luminous radiation.

In addition, the use of organic residues is an established agronomic practice for the production of tree species seedlings as it contributes to the maintenance of

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humidity and temperature, and releases nutrients gradually, contributing to plant nutrition and metabolism. A vast majority plants native to the Cerrado, show slow growth, and the use of organic residues is a sustainable alternative that favors the establishment of plants in the introduced areas because of the higher quality of seedlings.

Chicken manure (CM) is among the solid organic residues with potential for addition in the formulation of substrates, which in turn, is easily available in broiler chicken producing areas. The addition of chicken manure to the soil improves physical attributes, and during the decomposition/mineralization stage, it contributes to the chemical attributes by contributing to the composition of nutrient content, mainly in terms of nitrogen, phosphorus, and magnesium (Gonzaga et al., 2016; Soremi et al., 2017). The use of organic residue also increases the microbiological activity of the soil (Devi et al., 2012; Malik et al., 2013), which accelerates biogeochemical cycling, favoring the availability of nutrients associated with photosynthetic metabolism and plant biomass production.

However, there are few studies associating ecophysiology and the adequate amount of CM to the photochemical and biochemical reactions within the photosynthetic process of the species. Considering the initial secondary classification of *A. edulis* (Leles et al., 2011), i.e., occurring in locations with moderate shading (Gandolfi et al., 1995), in this study, we hypothesized that its seedlings would reduce photosynthetic metabolism if grown in full sun; however, a greater availability of organic matter would favor metabolism and responses that adjust to contrasting conditions of light. The aim of this study was to evaluate the effect of CM and luminous availability on gas exchange and chlorophyll-*a* fluorescence in *Alibertia edulis* seedlings.

MATERIAL AND METHODS

The fruits of *A. edulis* were collected (Access Registration No. A9CDAAE – CGEN-MMA, of 15/10/2018) randomly from natural populations in the Cerrado area (18°07′03″ S and 54°25′07″ W, 452 m), Dourados – State Mato Grosso do Sul, Brazil. The species was identified and an exsiccate was deposited at the Herbarium DDMS, of the *Universidade Federal da Grande Dourados*, under No.4649. To obtain the seedlings, mature fruits were processed, and the seeds were immersed in 2% sodium hypochlorite for 5 min. After this, sowing was performed in 128-cell expanded polystyrene trays, filled with Bioplant® substrate (pine bark, peat, expanded vermiculite, potassium nitrate, and simple superphosphate) and maintained under nursery conditions with 50% Sombrite® and daily irrigation.

The factors under study comprised five doses of CM with a rice husk base (0.00, 2.08, 4.16, 6.24, and 8.32 g kg^{-1} soil) incorporated into the substrate formulation, and two levels of luminous availability (full sun and 50% shaded) (22º11'43.7"S and 54º56'08.5"W, 452 m). The treatments were arranged in a 5 × 2 factorial scheme, in a randomized block design with four replications. The experimental unit comprised four plastic pots with a capacity of 4.2 dm^3, with one plant each. The doses of CM were established based on the study by Santos et al. (2020) wherein, among the organic residues tested, the CM with rice husk base in a single dose of 4.16 g kg^{-1}, contributed to the production of seedlings of *A. edulis*.

The shaded ambience was achieved by means of a simulation using a black screen with 50% luminosity retention (Sombrite®). The ambience under full sun and shading presented the following conditions on average at the end of the cultivation cycle: temperature, 31.62 and 28.42 °C; relative humidity, 65% and 78%; water vapor pressure deficit (Sadler & Evans, 1989), 4.36 and 2.33 KPa; and photosynthetically active radiation (PAR) 1245.25 and 560.12 µmol m^{-2} s^{-1}; respectively.

The substrate used to fill the pots was Dystroferric Red Latosol (Santos et al., 2018), with clay texture, which had the following chemical properties determined according to the methodology described by Silva (2009): pH in $CaCl_2$ = 6.2; P = 1.7 mg dm^{-3}; Ca = 3.0 mmol$_c$ dm^{-3}, K = 0.30 mmol$_c$ dm^{-3}; Mg = 1.4 mmol$_c$ dm^{-3}; Al = 0.12 mmol$_c$ dm^{-3}; H+Al = 29.9 mmol$_c$ dm^{-3}; Sum of bases (SB) = 4.9 mmol$_c$ dm^{-3}; Cation exchange capacity (CEC) = 42.4 mmol$_c$ dm^{-3} and Bases per saturation (V%)= 60.5. The semi-composted CM came from an aviary after the production of five batches of broiler chicken from Dourados, having the following chemical attributes: pH =7.50; N, P, K, Ca, Mg, S, C, and organic matter (g kg^{-1}) = 23.90, 15.36, 20.00, 19.15, 6.95, 18.65, 260, and 447.00, respectively; C/N ratio = 10.87; and humidity of 11%.

When the seedlings in the expanded polystyrene trays had a mean height of 7.0 cm, which occurred at 60 days after sowing, transplanting to the pots (Days after transplanting – DAT) was performed. The cultural treatments included daily irrigation with the aim of maintaining 70% of the water retention capacity in the substrate according to method described by Souza et al. (2000). The chemical compositions of the substrates in the different treatments are shown in Table 1.

TABLE 1. Chemical composition of substrates for cultivation of *A. edulis* grown with chicken manure, in full sun or shaded, at 210 DAT.

Chicken manure	pH	P	K	Ca	Mg	Al	H+Al	SB	CEC	OM	V
	H_2O	mg dm^{-3}	mmol$_c$ dm^{-3}								%
(g kg^{-1})	Full sun										
0.00	6.24	1.82	0.32	3.89	1.46	0.00	2.30	5.74	8.04	0.82	70.13
2.08	6.75	2.58	0.58	4.81	2.10	0.00	2.20	7.45	9.69	2.41	77.35
4.16	6.66	4.62	0.71	3.84	1.83	0.00	1.98	6.38	8.36	1.25	76.31
6.24	6.66	5.63	0.59	4.67	1.82	0.00	2.35	6.81	9.44	0.60	75.10
8.32	6.54	5.12	0.66	4.37	2.06	0.00	2.55	6.74	9.64	0.57	73.38
	Shaded										
0.00	6.28	4.11	0.27	4.57	2.06	0.08	2.44	7.01	9.45	0.74	74.23
2.08	6.78	3.85	0.55	4.92	2.08	0.00	2.10	7.55	9.65	2.19	78.13
4.16	6.81	5.63	0.55	4.02	2.04	0.00	2.05	6.61	8.66	0.74	76.36
6.24	6.82	4.62	0.54	4.02	1.86	0.00	1.97	6.43	8.39	1.11	75.96
8.32	6.42	5.38	0.67	4.44	1.83	0.00	2.34	6.82	9.29	1.34	74.20

SB: sum of bases; CEC: cationic exchange capacity; OM: organic matter; V (%): bases per saturation.

At 210 DAT, when the seedlings were ready for transplanting in the field and presented an average height of 40 cm, gas exchange was quantified in the morning (8:00 to 11:00 am) in fully expanded leaves located in the middle third of the branch. CO_2 assimilation rate – photosynthesis (A), intercellular CO_2 concentration (C_i), stomatal conductance (g_s), transpiration (E) and leaf temperature (LT) were recorded using a portable photosynthesis meter (LCIPro- SD ADC BioScientific Ltd.; IRGA – *Infra Red Gas Analyzer*). From the obtained data, the water-use efficiency ($WUE = A/E$), intrinsic water-use efficiency ($_iWUE = A/g_s$), carboxylation of Rubisco (A/C_i), and C_i/C_a ratio (atmospheric CO_2 concentration) were calculated.

The chlorophyll index was determined with a portable SPAD chlorophyll meter (*Soil Plant Analyzer Development*; Konica Minolta SPAD 502), on the same leaves as those on which gas exchange was quantified. Subsequently, the leaves were adapted to the dark condition for 30 min, using leaf clips, and soon after, the initial (F_0), variable (F_v), and maximum (F_m) fluorescence emission of chlorophyll-*a* was measured under a 1500 µmol m^{-2} s^{-1} flash using a portable fluorometer OS30p (Opti-Sciences Chlorophyll Fluorometer, Hudson, USA). The photochemical efficiency of photosystem II (PS II) [F_v/F_m = (F_m - F_0/F_m)], absorbed energy conversion efficiency (F_v/F_0), maximum non-photochemical performance (F_0/F_v), and the electron transport rate (ETR) were calculated (Baker, 2008).

To determine the morpho-stomatic characteristics, paradermic sections were made on the leaves in the morning (8:00 to 11:00 am), using the "Super Bonder®" printing technique. Samples from the medial limbus region of the adaxial and abaxial surfaces of fully expanded leaves in the middle third of the branch were used. The material was photographed with a Moticam 2000 digital camera attached to an optical microscope. Subsequently, the polar (PD) and equatorial (ED) diameter, and the ostiolar opening (OO) were measured using the Motic Image 2000 program, and the stomata functionality was calculated using the DP/DE ratio.

Data were subjected to analysis of variance and when significant according to the F test ($p < 0.05$), the means were compared using the Student's *t*-tests for luminous availability, and regression for CM doses ($p \leq 0.05$), using SISVAR 5.6. Multivariate principal component analysis (PCA) was also performed using variance and covariance matrices, as a complementary analysis, with PAST 3.21.

RESULTS AND DISCUSSION

The gas exchange characteristics of *A. edulis* seedlings during the initial growth phase were influenced by the factors under study. The A, g_s, A/C_i, and leaf temperature were influenced by the luminous ambience, with higher values in seedlings grown in full sun (Figure 1). $_iWUE$ was not influenced by the factors under study ($p > 0.05$), with average of 106.75 µmol CO_2/mol H_2O m^{-2} s^{-1}.

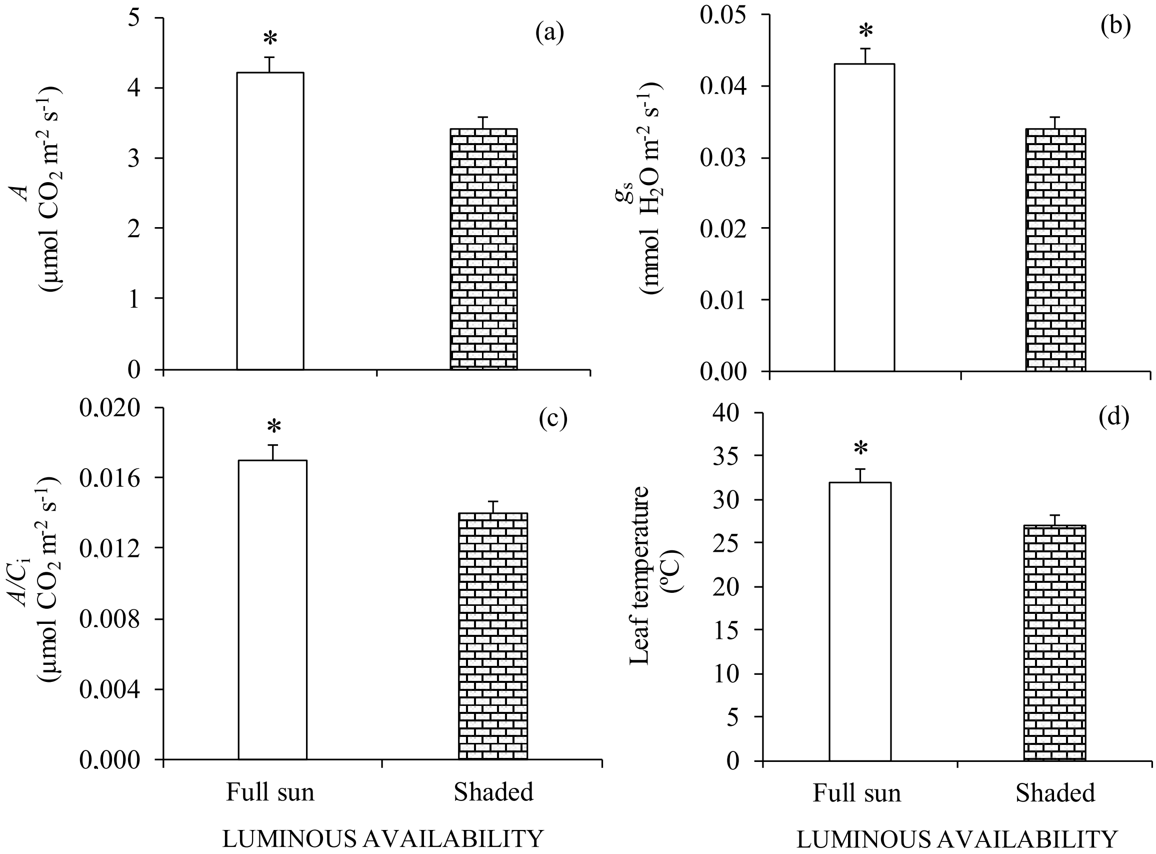

FIGURE 1. CO_2 assimilation rate – *A* (a), stomatal conductance – g_s (b), intrinsic efficiency carboxylation of Rubisco – A/C_i (c) and leaf temperature (d) in *A. edulis* leaves grown in full sun or shaded. *Student's *t*-test ($p < 0.05$).

The higher g_s in full sun contributed to the greater entry of atmospheric CO_2, and A/C_i being more efficient under these conditions, as evidenced by the greater *A* of *A. edulis* seedlings. Similarly, young plants of *Bertholletia excelsa* Bonpl. (Souza et al., 2017), *Anadenanthera falcata* (Benth.) Speg., and *Stryphnodendron adstringens* (Mart.) (Ronquim et al., 2018) showed greater photosynthetic activity under high irradiance, i.e., in full sun.

We observed that *E* and *WUE* were influenced by the interaction between the factors under study; however, the data did not adjust to the mathematical models tested. The highest values of *E* and *WUE* were observed in full sun and shading, with values of 1.43 mmol H_2O m^{-2} s^{-1} and 5.34 µmol CO_2/mmol H_2O m^{-2} s^{-1}, respectively. With the lowest amount of gas in the shaded leaves, seedlings tend to lose less water through transpiration, resulting in greater *WUE* and maintenance of metabolic processes. These changes demonstrate the physiological plasticity of seedlings through adjustments when exposed to limiting conditions (Rosa et al., 2017), as has been reported in the literature for other species in order to optimize environmental resources.

The C_i and C_i/C_a ratio were influenced only by the doses of CM, with both characteristics presenting a minimum of 240.09 µmol CO_2 m^{-2} s^{-1} and 0.51, respectively, with the addition of 5.55 g kg^{-1} of CM (Figures 2a and 2b). The reduction in C_i indicates that with the addition of CM, *A. edulis* seedlings were more efficient in CO_2 carboxylation and assimilation, potentiating the photosynthetic rate, possibly owing to the maintenance of moisture and availability of nutrients in the solution and physical quality of the substrate, ensuring physiological processes.

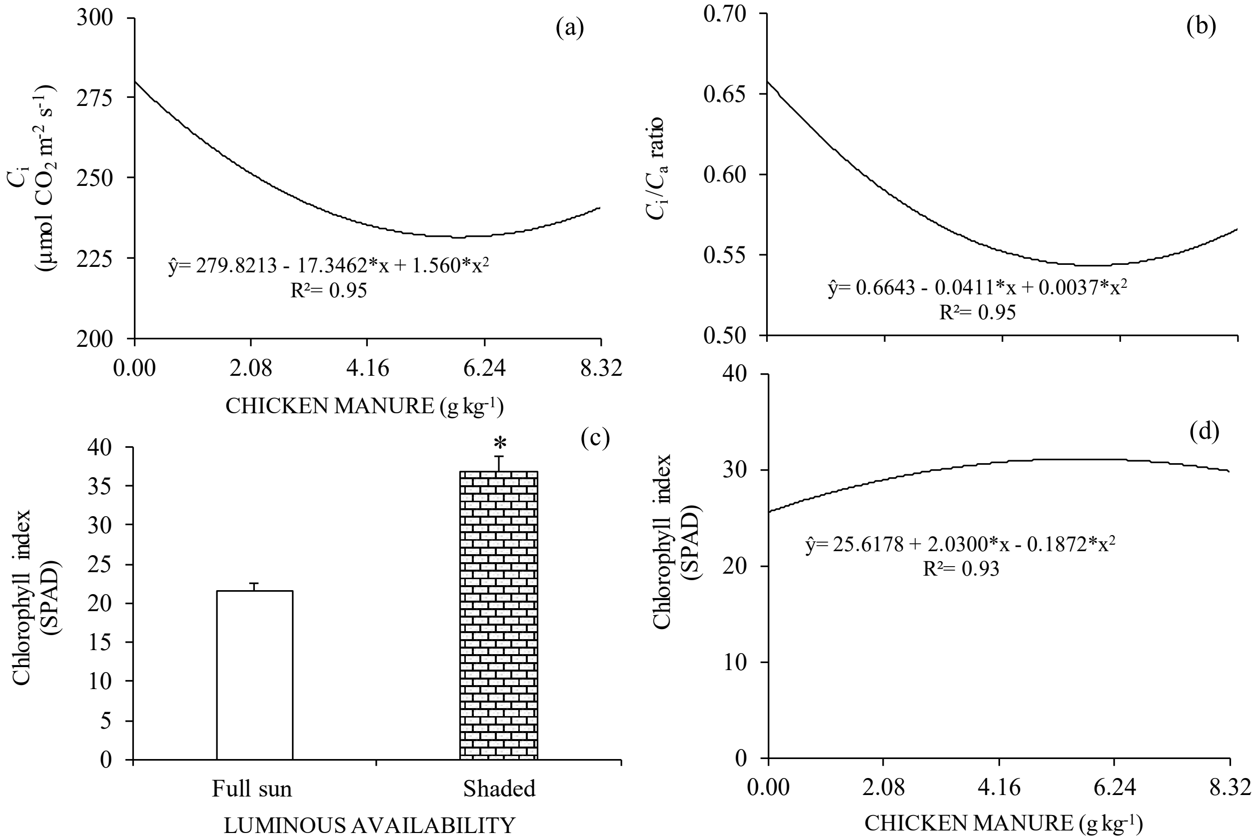

FIGURE 2. Intercellular CO_2 concentration – C_i (a), C_i/C_a ratio – atmospheric CO_2 concentration (b) and chlorophyll index (c-d) in *A. edulis* leaves grown with chicken manure (a–b–d) or in full sun or shaded (c). *Student's *t*-test for luminous availability, and regression for CM doses ($p < 0.05$).

The chlorophyll index was influenced by the isolated factors, showing that the highest index (37 SPAD) occurred in the leaves of shaded seedlings (Figure 2c). This increase in leaves under shade condition has been considered a strategy to compensate the species for the lowest amount of luminous radiation available (Lima et al., 2010), resulting in the maximization of photosynthesis processes. Other native species have shown the same mechanism, as in *Bertholletia excelsa* Bonpl. in a shaded environment (Albuquerque et al., 2015).

As for organic residue, the maximum SPAD index (31) was obtained with the addition of 5.42 g kg^{-1} of CM (Figure 2d). The addition of CM to the soil may have favored the availability/solubilization of nutrients as well as that of N and Mg, which favors an increase in the synthesis of chlorophylls, as these nutrients participate in the structuring of the molecule of this pigment (Guo et al., 2016; Taiz et al., 2017).

The F_0 of chlorophyll-*a*, photochemical efficiency of PS II (F_v/F_m), and electron transport were influenced by the luminous availability. The highest F_0 (0.345 electrons quantum^{-1}) and ETR (253.0 μmol m^{-2} s^{-1} electrons) occurred in the leaves of seedlings in full sun (Figure 3a and 3c, respectively,), and the higher F_v/F_m ratio (0.711 electrons quantum^{-1}) in seedlings under shade (Figure 3b). With the lowest F_v/F_m in full sun, it can be inferred that this growing ambience is stressful for this species and that the highest ETR is associated with the highest PAR in this environment, which favored the greatest levels of gas exchange (*A*, g_s, and A/C_i) (Figure 1).

In contrast, the increase in F_0 and decrease in F_m cause damage to the reaction center P_{680} or a reduction in the capacity to transfer the excitation energy from the antenna to the reaction center (Baker, 2008), owing to the blocking of electron transfer from plastoquinone A to B, as a result of partial inactivation of PS II (Gilmore et al., 1996; Biswal et al., 2011). This is because when plants are exposed to high irradiance, they can generate the degradation of protein D_1, and consequently photoinhibition (Telfer, 2014) if the energy dissipation through the chlorophyll-*a* fluorescence does not occur synergistically.

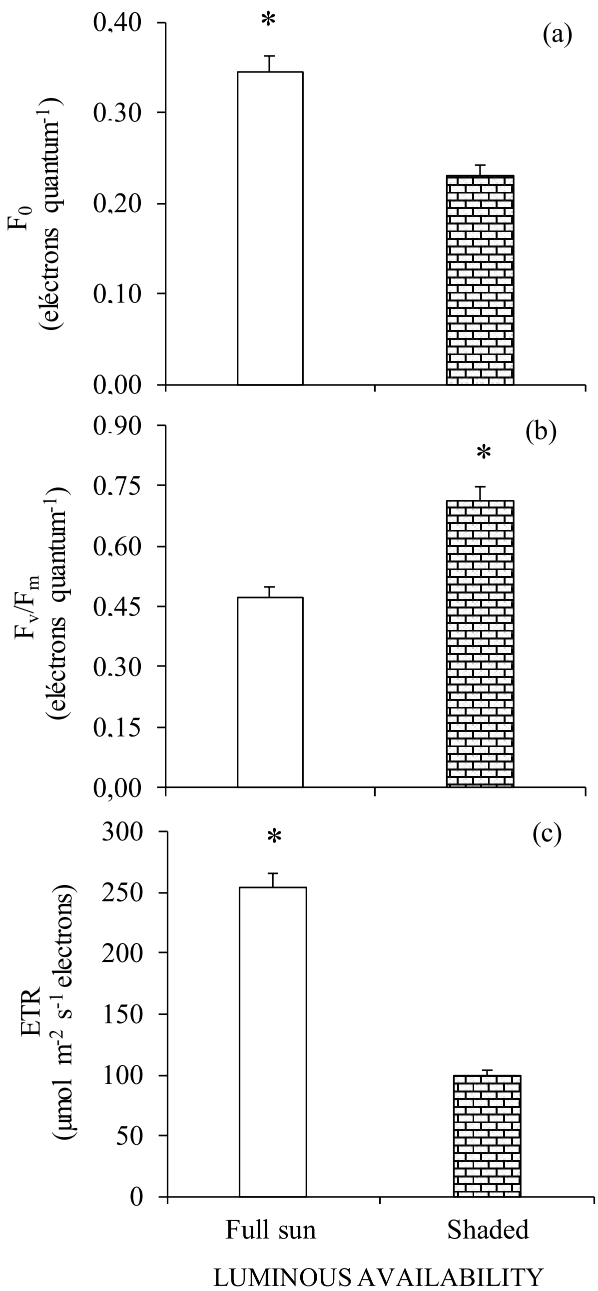

FIGURE 3. Initial fluorescence – F_0 (a), photochemical efficiency of photosystem II – F_v/F_m (b), and electron transfer rate – ETR (c) in *A. edulis* leaves grown in full sun or shaded. *Student's *t*-test ($p < 0.05$).

The maximum (F_m) and variable (F_v) chlorophyll-*a* fluorescence were influenced by the isolated factors, with lower values in the leaves in full sun (Figure 4a and 4b). As for the CM, for F_m, the data did not adjust to the tested mathematical models, with an average of 0.646 electrons quantum^{-1}. For F_v, there was linear growth with a higher value (0.560 electrons quantum^{-1}) with the addition of 8.32 g kg^{-1} of CM (Figure 4c).

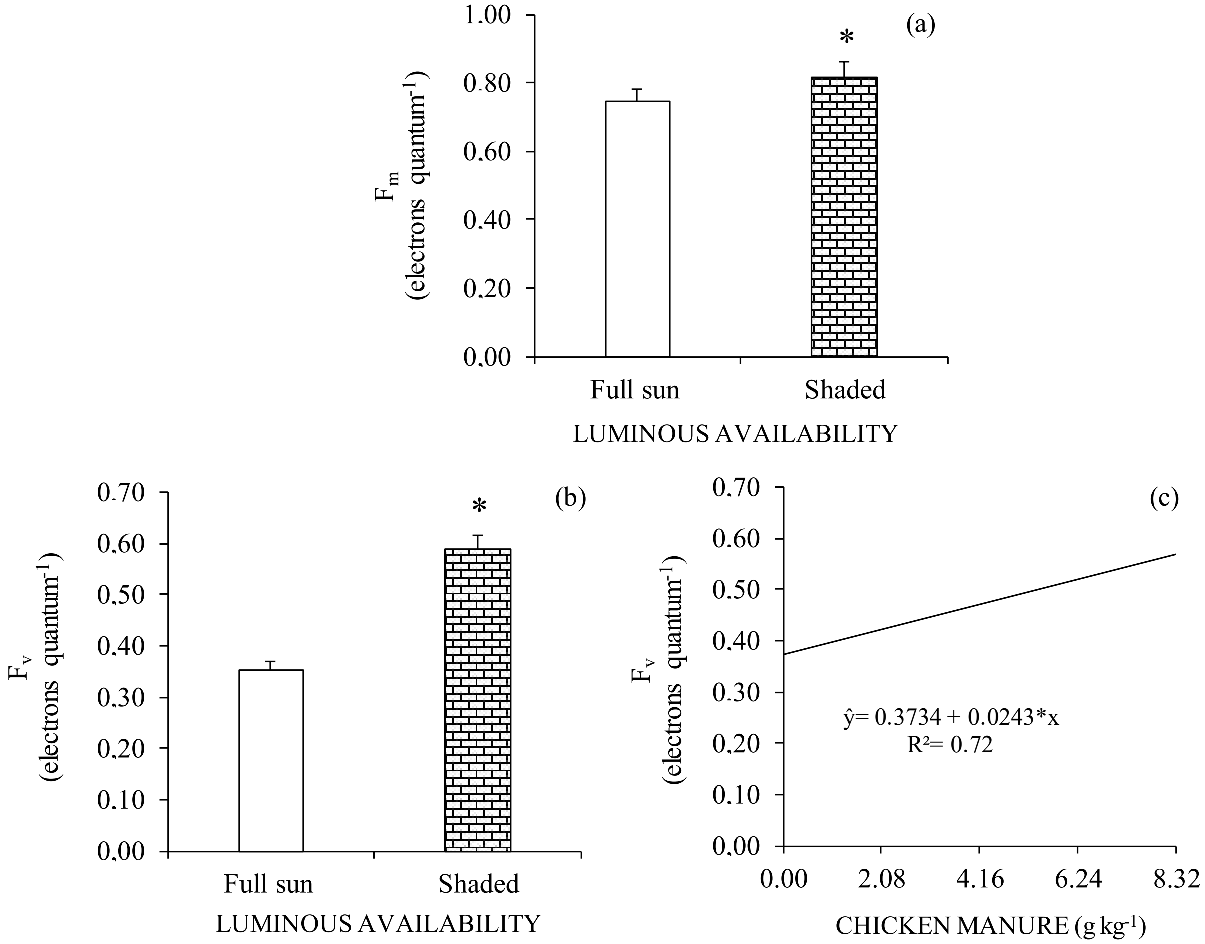

FIGURE 4. Maximum fluorescence (F_m) (a) and variable (F_v) (b–c) in *A. edulis* leaves grown in full sun or shaded (a–b) or with chicken manure (c). *Student's *t*-test for luminous availability, and regression for CM doses ($p < 0.05$).

The absorbed energy conversion efficiency (F_v/F_0) and the maximum non-photochemical performance (F_0/F_v) were influenced by the factors under study (Figure 5). There was an increase in F_v/F_0 and a reduction in F_0/F_v, with increasing doses of CM; the highest (2.18 electrons quantum^{-1}) and the lowest (0.582 electrons quantum^{-1}) ratio were observed with the addition of 8.32 g kg^{-1} of CM, respectively (Figure 5b and 5d). As for the ambience, the highest F_v/F_0 was 2.58 electrons quantum^{-1} in the leaves of the shaded seedlings (Figure 5a), and the F_0/F_v was 1.16 electrons quantum^{-1} at full sun (Figure 5c), demonstrating the stability of electron transfer in the reaction center because the F_v/F_0 ratio is considered as an indicator of the maximum efficiency in the photochemical process in PS II and/or of the potential photosynthetic activity (maximum quantum production reason of photochemical competing processes in PS II) (Silva et al., 2015), demonstrating the beneficial effect of CM on the photochemical reactions of photosynthesis.

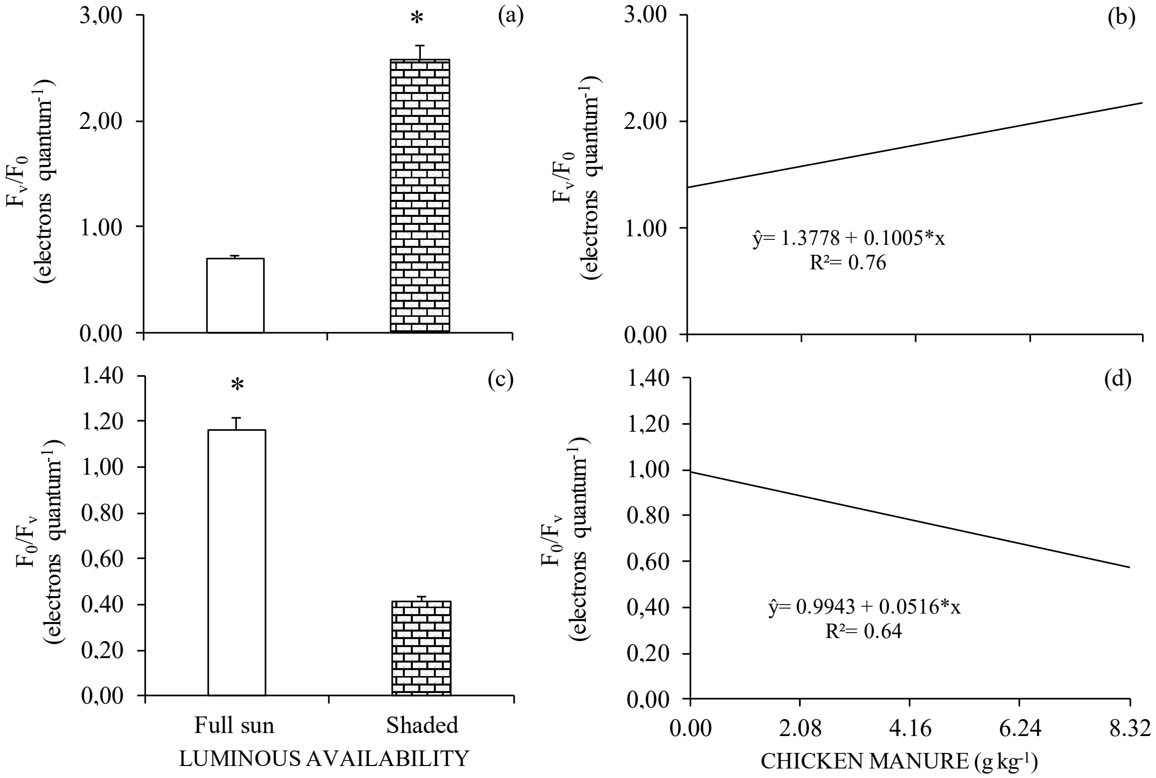

FIGURE 5. Absorbed energy conversion efficiency (F_v/F_0) (a–b) and maximum non-photochemical performance (F_0/F_v) (c–d) in *A. edulis* leaves grown in full sun or shaded (a–b) or with chicken manure (c–d). *Student's *t*-test for luminous availability, and regression for CM doses ($p < 0.05$).

The results of the chlorophyll-*a* fluorescence parameters indicate that *A. edulis* seedlings presented adjustment mechanisms under adverse conditions. They are more efficient in harnessing luminosity because they present a greater photochemical efficiency of photosystem II F_v/F_m in the shaded environment, and a greater dissipation when subjected to full sun exposure. Similarly, young plants of *Dipteryx odorata* showed accentuated changes in the values of F_0 and F_m in leaves exposed to high irradiance (Gonçalves et al., 2010).

Thus, plants under high irradiance tend to have less demand for energy from photosynthetic metabolism, i.e., excess light becomes a saturating factor, requiring plants to be able to dissipate excess energy (Gu et al., 2017), making it possible to maintain PS II integrity by mitigating damage to the photosynthetic apparatus and biochemical reactions later. The ability to use and dissipate excess energy efficiently is crucial for the net assimilation of CO_2 and the establishment of tree species in contrasting conditions of light (Souza et al., 2017), which is important for silvicultural activities.

Physiological adjustments are desirable characteristics, as they contribute substantially so that plants can perform their metabolic processes and ensure stability of growth even under unfavorable conditions, mainly the abiotic factors that are directly related to the habitat and ecological system, allowing them to adapt to different luminous environments.

The best photochemical responses of seedlings under higher doses of CM are owing to the fact that their addition to the soil favored an increase in organic matter; consequently, a greater availability of nutrients (Soremi et al., 2017), such as N and P for seedlings. These nutrients participate effectively in the formation of adenosine triphosphate and nicotinamide adenine dinucleotide phosphate (Carstensen et al., 2018) and the chloroplastid content (Agbor et al., 2018), favoring the stability of the electron transfer process in PS II.

Regarding the morpho-stomatal aspects, it was found that the leaves of *A. edulis* seedlings are hypostomatic, with the presence of trichomes tectors on both epidermal sides, under both luminous availability conditions. The ostiolar opening (OO) and polar diameter (PD) were influenced by the factors under study in isolation, in which the largest OO and PD of stomata occurred in the leaves of the shaded seedlings (3.55 and 11.50 µm, respectively) (Figure 6). Under certain ambient conditions, plants alter their leaf structures as adaptive skills in mitigating water loss through transpiration and stomatal regulation (Taiz et al., 2017), such as having smaller dimensions in full sun. As for organic residue, the OO data did not adjust to the tested models, with an average of 2.4 µm. The maximum PD (11.92 µm) was obtained with 3.06 g of CM per kg of soil (Figure 6c).

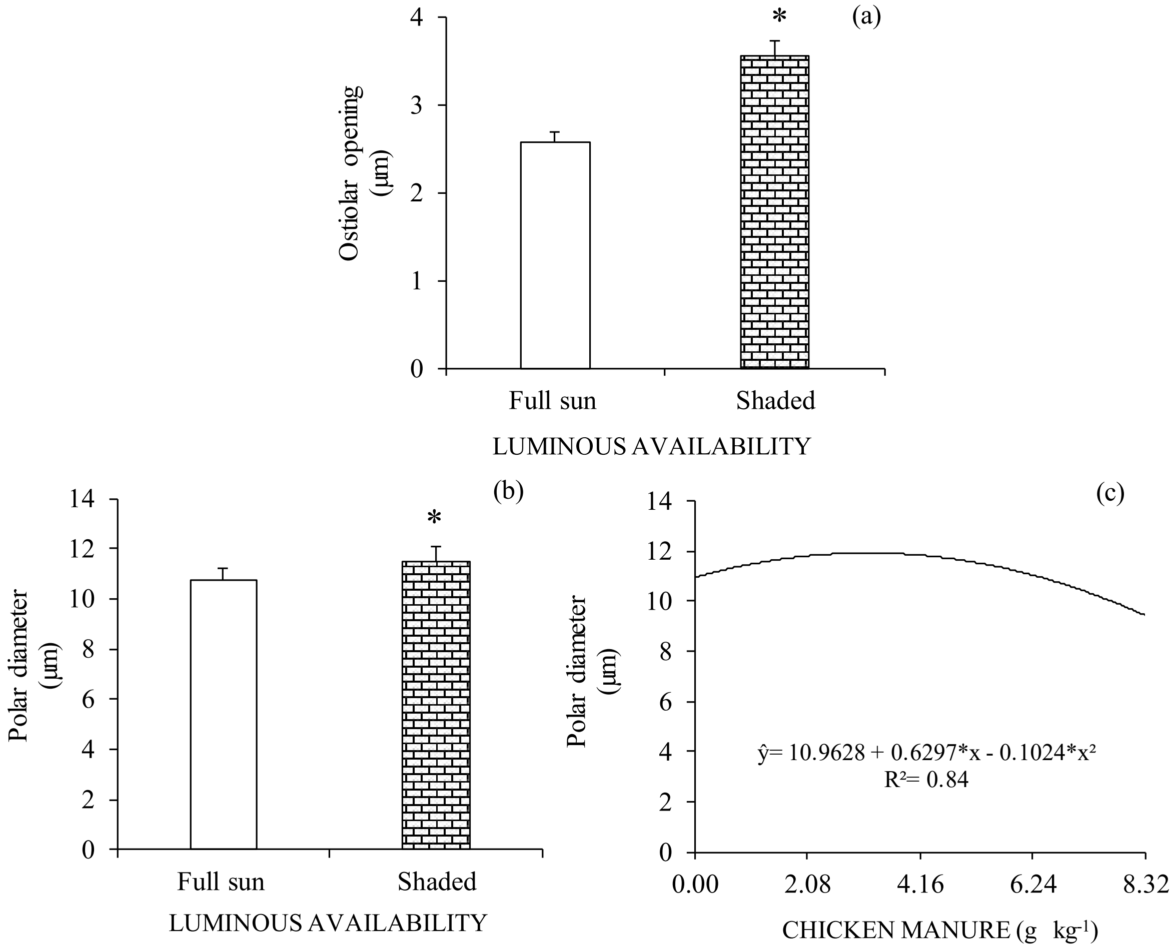

FIGURE 6. Ostiolar opening (a) and polar diameter (b–c) of stomata in *A. edulis* leaves grown in full sun or shaded (a – b) or with chicken manure (c). *Student's *t*-test for luminous availability, and regression for CM doses ($p < 0.05$).

The equatorial diameter (ED) and functionality of the stomata were influenced by the interaction between CM and luminosity. The data for both characteristics in full sun did not adjust to the mathematical models tested, presenting an average of 7.82 and 0.71 µm, respectively (Figure 7). It was observed that the maximum ED and minimum functionality were 14.32 and 0.78 µm, respectively, in seedlings grown with the addition of 3.91 and 4.33 g of CM per kg soil, respectively, when subjected to shading (Figure 5). Similar results regarding light were described by Aragão et al. (2014), wherein young plants of *Carapa guianensis* Aubl. presented larger stomatal dimensions under shaded conditions.

Considering that *A. edulis* is an initial secondary species, its stomata would have a larger size and functionality under shade; thus, the data from the present study are consistent with the information in the literature, according to which reductions in OO, and PD and ED, under stress, favored greater *WUE* and lower *E*. However, our data are contrary to this information because under conditions of full sun, the seedlings presented higher *A*, g_s, and A/C_i (Figure 7), suggesting therefore, its plasticity even with high *E* being able to produce a high rate of photoassimilates.

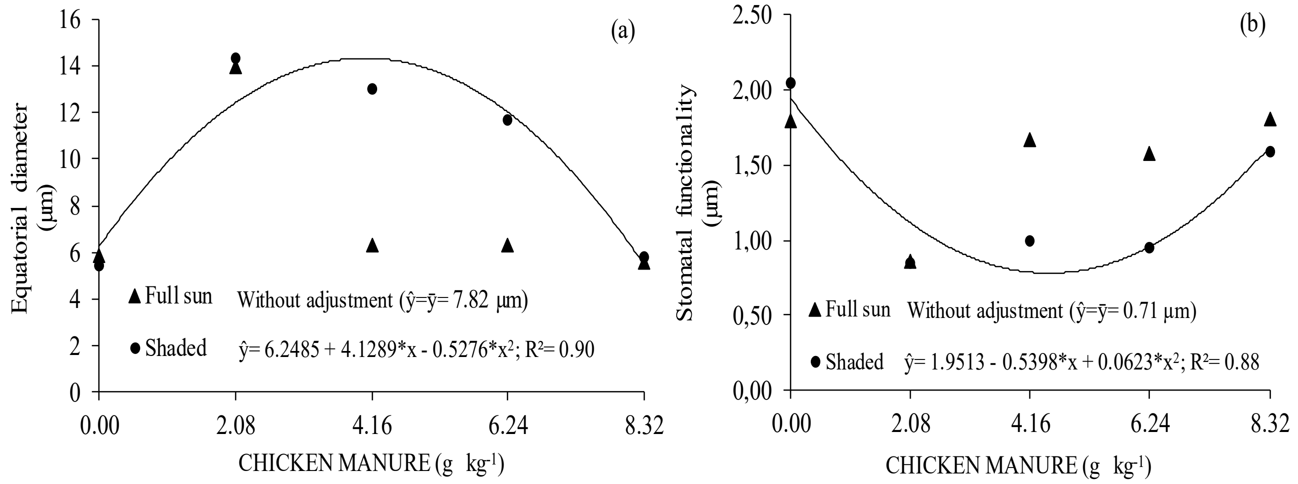

FIGURE 7. Equatorial diameter (a) and stomatal functionality (b) in *A. edulis* leaves grown with chicken manure under full sun and shaded. *Student's t test for luminous availability, and regression for CM doses ($p < 0.05$).

It was found that 78.71% of the remaining variability of the data was explained through the PCA, with 59.42% corresponding to principal component – PC 1 and 19.29% corresponding to PC 2 (Figure 8). The characteristics of F_m, A/C_i, and ostiolar opening were removed from the PCA, considering factor scores < 0.20, in both axes, indicating low representativeness. The use of PCA allows observation of qualitative standards without loss of data information from the difference and similarities represented by two components (dimensions), denoted as PC 1 and PC 2 (Sabharwal & Anjum, 2016). From this multivariate analysis it was identified which characteristics evaluated presented the highest constitution weight in each dimension (axis), considering the loads of factor scores.

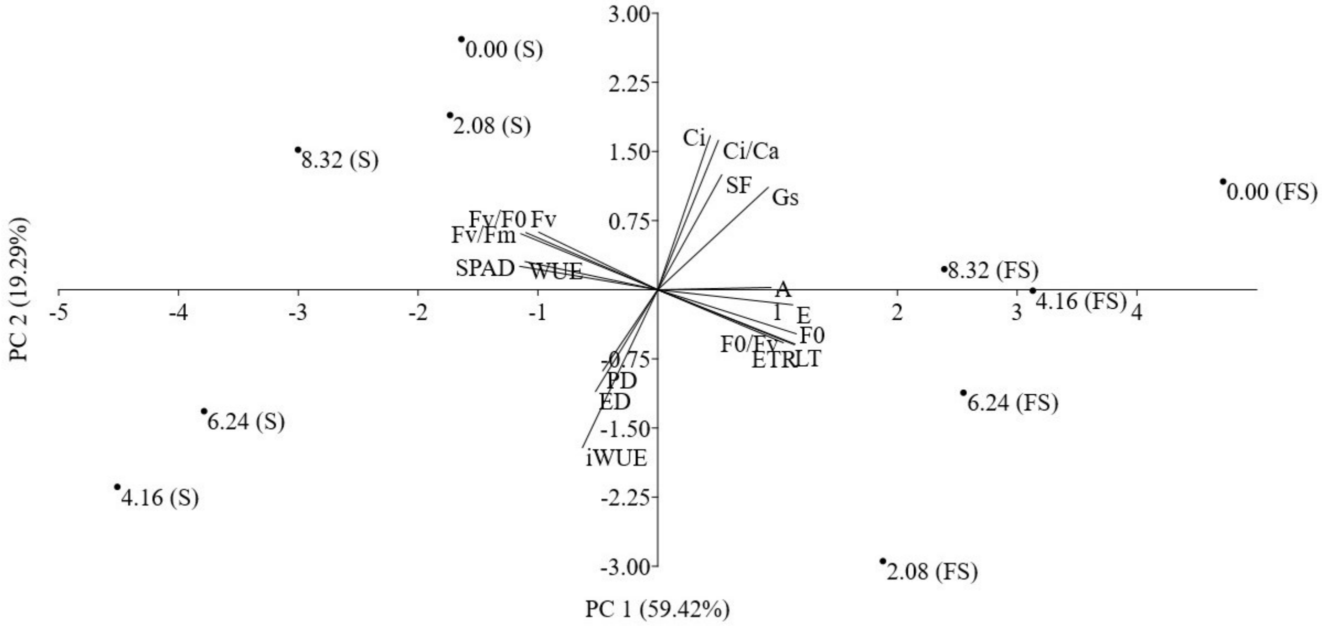

FIGURE 8. Principal components analysis of characteristics evaluated in plants of *A. edulis* grown with chicken manure (0.00, 2.08, 4.16, 6.24 and 8.32) and in full sun – FS or shaded – S.

The fluorescence characteristics in PC 1 had more weight in their constitution and were in the decreasing order of F_0, F_v/F_m, chlorophyll index (SPAD), F_v/F_0, ETR, and *WUE*, being more responsive positively regarding the addition of CM to the soil, under the shaded environment (Table 2). Stomatal characteristics in PC 2 had more weight in their constitution and were represented in decreasing order by C_i, SF, g_s, ED, i*WUE* and PD under intermediate doses of CM. Thus, it was found that the increasing addition of CM contributed to greater photochemical indicators in the leaves of *A. edulis* in the shaded environment, whereas gas exchange was more responsive to full sun and lower doses of this organic residue.

TABLE 2. Eigenvectors and their respective scores for physiological and morpho-stomatic characteristics in *A. edulis* seedlings grown with chicken manure and in full sun or shaded.

	PC 1	PC 2	PC 3	PC 4	PC 5
SPAD	-0.2915	0.0655	-0.0031	0.0973	-0.3879
A	0.2381	0.0098	-0.1031	0.5366	-0.0274
E	0.2854	-0.0370	0.0315	0.2790	0.0582
g_s	0.2083	0.3065	0.1755	0.3087	-0.2340
C_i	0.1110	0.4227	0.3165	-0.1645	0.0386
WUE	-0.2805	0.0740	-0.1209	-0.2737	-0.0714
i*WUE*	-0.1584	-0.4320	-0.1908	-0.0790	0.0228
C_i/C_a	0.1315	0.4073	0.3133	-0.1603	0.0292
LT	0.2901	-0.1485	-0.0539	0.0100	0.2020
F_0	0.2924	-0.1300	-0.0504	-0.0421	0.0707
F_v/F_m	-0.2905	0.1530	0.0443	0.0726	-0.0388
F_v	-0.2547	0.1493	-0.1492	0.3774	0.2861
F_v/F_0	-0.2798	0.1517	-0.0807	0.2491	0.0952
F_0/F_v	0.2664	-0.1390	0.0745	-0.2436	-0.4918
ETR	0.2884	-0.1507	-0.0683	0.0556	0.1407
ED	-0.1304	-0.2697	0.4976	0.1576	-0.0403
PD	-0.1163	-0.2202	0.5037	-0.1091	0.5209
SF	0.1346	0.3031	-0.4060	-0.2927	0.3284

Although the seedlings of *A. edulis* are considered an initial secondary species, which could be proven by the effect of full sun on photosynthesis photochemical, the damage in the reaction centers of PS II does not harm the photosynthetic performance of seedlings considering the high *A*, g_s, and A/C_i. Therefore, it suggests that this species has plasticity to contrasting conditions of light, and it can be planted in environments with different gradients of incident radiation, i.e., full sun conditions (e.g., anthropized open areas) or shade (e.g., understory in agroforestry systems or enrichment of native forest).

Based on our results, we disagree with our hypothesis that seedlings presented less leaf metabolism in full sun; however, we agree that adding organic matter to the substrate, evaluated here by the use of chicken manure, favors the metabolic responses that guarantee the quality of the seedlings under contrasting conditions of light.

CONCLUSIONS

Cultivation in full sun and the addition of 4.32 g CM kg^{-1} soil favored the functioning of the photosynthetic apparatus in the seedlings of *Alibertia edulis* Rich. and provided greater production of photoassimilates. In a shaded environment, the seedlings present more viable photochemical indicators with a maximum dose (8.32 g) of CM.

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