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ECOFISIOLOGIA DA FIGUEIRA 'ROXO DE VALINHOS' NO SEMIÁRIDO: INFLUÊNCIA DE AMBIENTE E ADUBAÇÃO

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RESUMO: O objetivo deste trabalho foi avaliar a influência do ambiente de cultivo e de doses de adubação nas características ecofisiológicas da figueira 'Roxo de Valinhos', cultivada na Chapada do Apodi, no semiárido cearense. O experimento utilizou o delineamento em blocos ao acaso, em esquema de faixas com parcelas subdivididas, com quatro repetições. Foram testados dois ambientes (A1 – 50% de sombreamento e A2 – pleno sol) e três doses de adubação por cobertura (D1 - 50%, D2 - 100% e D3 - 150%), por meio de fertirrigação. As trocas gasosas foram avaliadas nos períodos da manhã e da tarde. A avaliação matinal foi mais sensível para capturar o efeito da interação ambiente e as doses de adubação. Em ambos os ambientes, a aplicação da maior dose de adubação (D3-150%) levou a menores concentrações internas de CO_2 (Ci) e a uma significativa melhoria na eficiência intrínseca do uso da água (A/gs) quando comparada à dose 1 (50%). Menor valor médio da taxa de transpiração (E) foi observado para a maior dose de adubação (D3 – 150%) na avaliação vespertina, a qual foi associada a uma menor condutância estomática (gs) nessa dose, independentemente do ambiente.

Palavras-chaves: *Ficus carica,* cultivo protegido, fertirrigação

ECOPHYSIOLOGY OF 'ROXO DE VALINHOS' FIG TREE IN THE SEMI-ARID REGION: INFLUENCE OF ENVIRONMENT AND FERTILIZATION

ABSTRACT: The objective of this study was to evaluate the influence of the cultivation environment and fertilization rates on the ecophysiological characteristics of the 'Roxo de Valinhos' fig tree, which is grown in the Chapada do Apodi region, in semiarid Ceará. The experiment used a randomized block design in a strip-plot scheme with subdivided plots and four replications. Two environments were tested (A1 – 50% shading and A2 – full sun), and three top-dressing fertilization rates (D1 - 50%, D2 - 100%, and D3 - 150%) were applied via fertigation. Gas exchange was evaluated during the morning and afternoon periods. The morning assessment was more sensitive in capturing the effect of the interaction between the environment and the fertilization rate. In both environments, the application of the highest fertilization rate (D3-150%) led to lower internal CO2 concentrations (Ci) and a significant improvement in the intrinsic water use efficiency (A/gs) compared with dose 1 (50%). A lower mean value for the transpiration rate (E) was observed for the highest fertilization rate (D3 – 150%) in the afternoon evaluation, which was associated with lower stomatal conductance (gs) at this dose, regardless of the environment.

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Keywords: *Ficus carica*, protected cultivation, fertigation

1 INTRODUCTION

The fig tree (*Ficus) (Carica*) is one of the oldest cultivated fruit species and originates from the Middle East and the Mediterranean. In Brazil, the crop is cultivated mainly in the south and southeast, with the most widely used cultivar being "Roxo de Valinhos," characterized by its hardiness, productivity, and good adaptation to drastic pruning (Caetano *et al*., 2012). However, several biotic and abiotic factors influence its production (Silva *et al*., 2010), the understanding of which depends on more specific studies with the crop.

Studies have revealed that the adaptive behavior of fig cultivated plants occurs in response to abiotic stresses (Ammar *et al*., 2020). In this sense, measuring gas exchange can aid in understanding these mechanisms and thus verify the efficiency of the photosynthetic process under different management conditions. The accumulation of internal carbon in the substomatal chambers, for example, may be the result of low photosynthetic efficiency in plants. This situation can be induced by several factors, such as poor mineral nutrition, salinity, and the growing environment, which can induce physiological changes that are crucial to crop development (Chavarria). *et al* ., 2008; Freire *et al* ., 2014).

Despite the importance of understanding the ecophysiological behavior of fig trees in response to horticultural practices, few studies have focused on this aspect under the different soil and climate conditions in which the crop is grown (Ammar *et al*., 2020).

Therefore, determining the ecophysiological characteristics of the 'Roxo de Valinhos' fig tree as a function of the environment and fertilization dose can aid in understanding the adjustment mechanisms in the photosynthetic process, as well as the effects on the efficient use of water by the crop under the edaphoclimatic conditions of the Chapada do Apodi region, Ceará state, Brazil.

2 MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted in a commercial area within the Jaguaribe-Apodi irrigated perimeter in Chapada do Apodi, Ceará, at the coordinates 5° 08'38" S and 37° 59' 44' W.

The region's climate is hot and semiarid and is classified as BSw.h according to Köppen. Preliminary soil analyses of the experimental area (0–20 cm) were performed according to Silva (2009) and revealed the following characteristics: pH (H_2O) = 7.8; organic matter (OM) ($g.kg^{-1}$) = 18.28; Mehlich-1 P ($mg.kg^{-1}$) = 23; and K^{+}, Ca^{2+}, Mg^{2+}, Na^{+}, H^{+}, Al^{-}, and cation exchange capacity (CEC) (mmol $_c$ dm^{-3}) = 8.22, 78.3, 20.0, 5.90, 0.0, and 112.42, respectively. The electrical conductivity (EC) of the soil saturation extract was 0.58 dS m^{-1}.

The experimental area with the fig tree cv. Roxo de Valinhos had 12 rows, each 40 m long, spaced 2.0 m apart, with 0.75 m between plants. The irrigation system used was drip irrigation, with two drip tapes in each row and emitters spaced 0.30 m apart, with a nominal flow rate of 1.6 l/h at a pressure of 100 kPa.

2.2 Experimental design and treatments

The experiment was conducted in a randomized block design in a strip-plot arrangement with split plots and four replications. The plots used two environments: 50% shade (A1) and full sun (A2). The topdressing fertilizer treatments (D1 - 50%, D2 - 100%, and D3 - 150%) were applied in strips (crossing the environmental factor levels and randomly within each block) via fertigation, with D2 corresponding to 63, 35, 84, 21, and 7 g $plant^{-1}$ $cycles^{-1}$ of N, P_2O_5, K_2O, Ca, and Mg, respectively. The doses used in this study had already been applied during the previous crop cycle before the shade netting was installed.

In addition, for all the treatments, approximately 0.14 g of B in the form of boric acid was applied, along with three applications of 2.25 ml of RESTORER® (containing 6% N;

6% P_2O_5; 6% K_2O; 0.5% B; 0.10% Cu; 0.5% Fe; 0.10% Mn; 0.01% Mo; and 0.10% Zn, plus a complexing agent) per plant. The fertilizers were applied via fertigation, using a diversion tank ("buffer") connected to the irrigation network. The application of fertilizers throughout the cycle followed the percentage distribution indicated in Table 1.

Table 1 Percentage distribution of nutrients in fertigation during each period throughout the growing cycle of the Fig tree cv. Roxo de Valinhos in the Chapada do Apodi region, CE.

Nutrient	**Week**		
	0 to 10	10 to 14	15 to 19
N	35%	35%	30%
P_2O_5	30%	35%	35%
K2O	20%	40%	40%
Here	20%	35%	45%
Mg	25%	35%	40%
B	20%	35%	45%

Source: Authors.

The experiment began with production pruning (April 16, 2023), which was carried out approximately 50 cm from the ground, with two main branches, each with two shoots, totaling four shoots per plant, trained vertically in a trellis system.

2.3 Characteristics evaluated

The following ecophysiological characteristics of the fig trees were evaluated: net assimilation (A), stomatal conductance (gs), internal CO_2 concentration (Ci), temperature (Tl), and transpiration rate (E). These data were collected in the morning (9 am) and afternoon (4 pm) of August 3, 2023, and 109 days after pruning (fruit development stage) using an IRGA gas exchange meter (*ADC BioScientific). LCI Analyzer*), using natural light, with the following averages per evaluation shift and environment, in µmol m^{-2} s^{-1}: Morning – 183.3 (A1) and 474.0 (A2); Afternoon: 74.67 (A1) and 110.0 (A2). For these evaluations, mature and fully expanded leaves were chosen from the middle third of the productive branches.

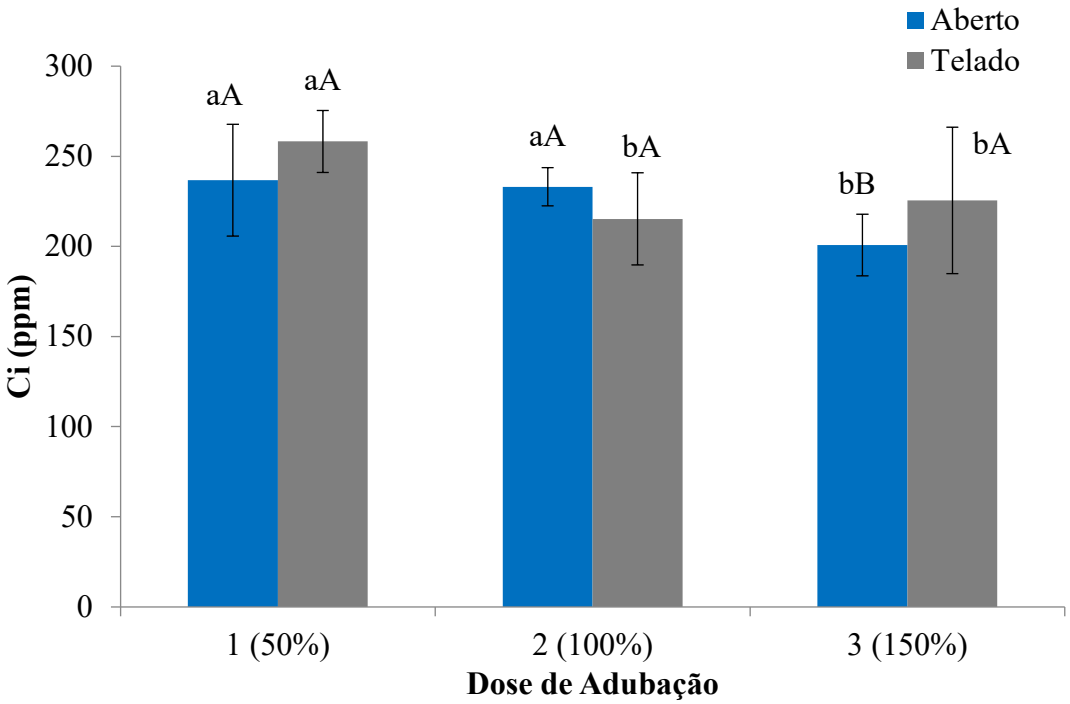
2.4 Statistical analyses

Statistical analyses were performed using the computer program System for Analysis of Variance - SIVAR, version 5.3 (Ferreira, 2010). The data were analyzed using analysis of variance and the F test at the 5% significance level. When this was significant, the means were compared using Tukey's test at the 5% probability level.

3 RESULTS AND DISCUSSION

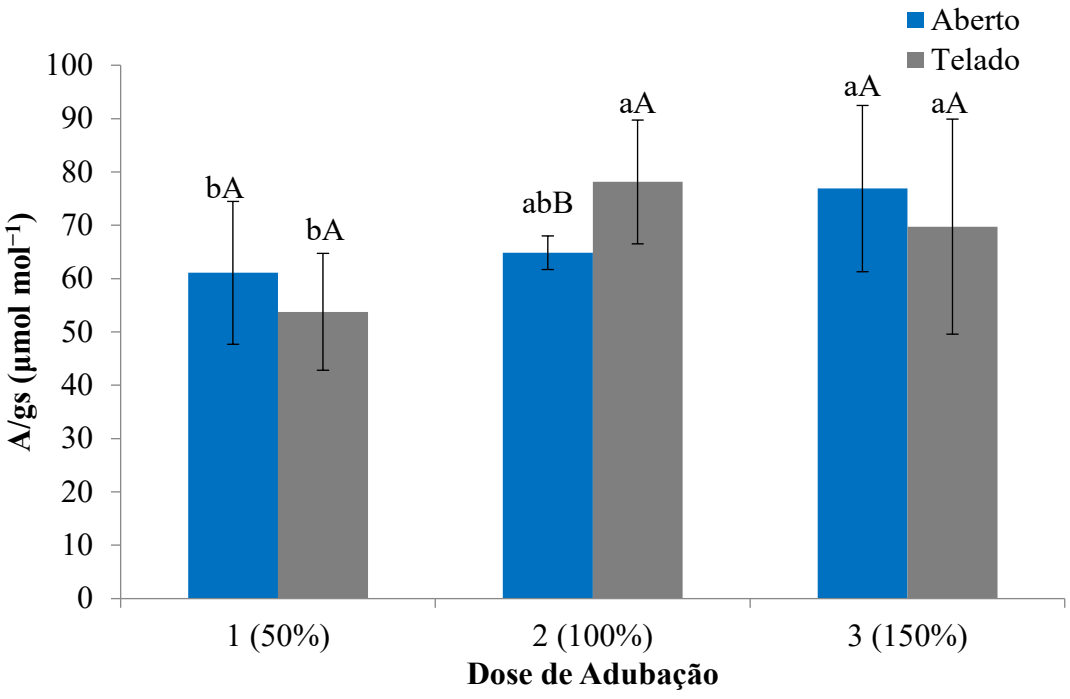
Significant effects of the environment × dose interaction were observed only for the C_i - internal CO2 concentration (Figure 1) and for the A/gs ratio data (Figure 2) in the evaluation carried out in the morning.

Figure 1. Average Ci - Internal CO_2 concentration (ppm) in the morning in the Fig cv Roxo de Valinhos crop under the influence of different environments and fertilization doses.



*Different lowercase letters between fertilizer doses within each environment or distinct uppercase letters between environments within each fertilizer dose differ from each other according to Tukey's test at 5%.
Source: Authors.

Figure 2. A/gs ratios (µmol mol^{-1}) in the morning in the Fig cv Roxo de Valinhos crop under the influence of different environments and fertilization doses.



*Different lowercase letters between fertilizer doses within each environment or distinct uppercase letters between environments within each fertilizer dose differ from each other according to Tukey's test at 5%.
Source: Authors.

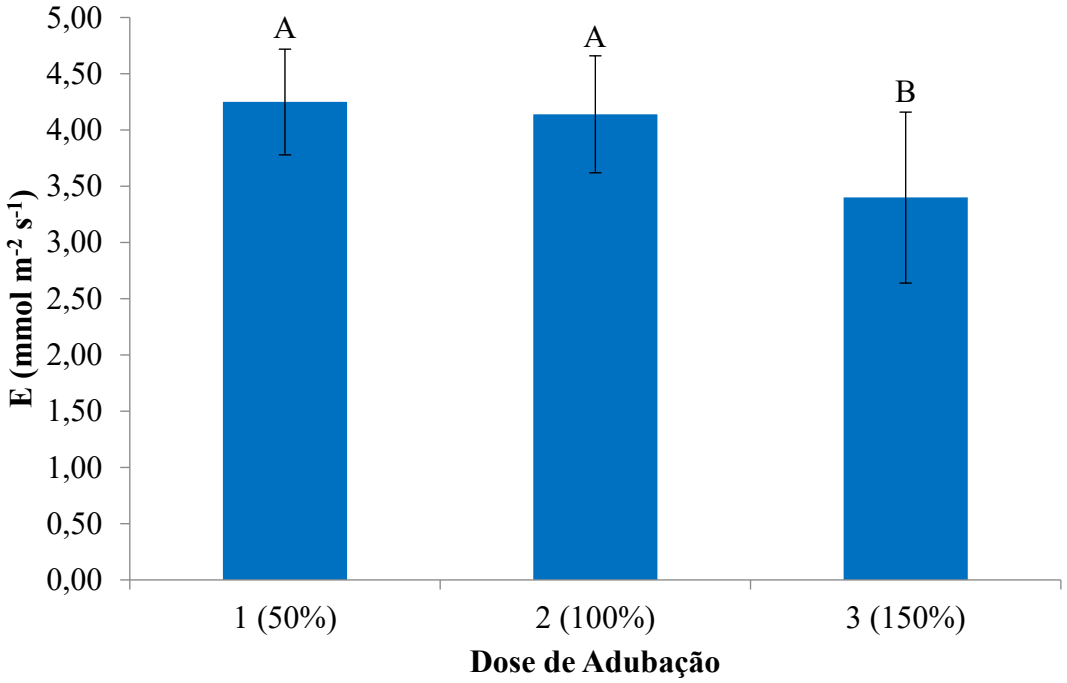
In both environments, a higher fertilization dose (D3-150%) resulted in lower Ci values and a higher intrinsic water use efficiency (A/gs) than did a dose of 1 (50%). This higher efficiency may be related to the increase in the specific surface area of the leaves, since a higher area/thickness ratio allows for a greater density of chloroplasts (Silva *et al.*, 2010).

The greater accumulation of Ci in the covered environment than in the full-sun environment at dose 3 (150%) (Table 1) may indicate that the rate of C assimilation by photosynthesis did not keep pace with its rate of entry through the stomata, although the difference in the A/gs ratio in this treatment was not significant (Table 2).

These results contrast with those found for dose 2 (100%), for which a higher A/gs ratio was observed in the covered environment than in the open environment (Figure 2), but the difference in internal carbon (Ci) was not statistically significant (Figure 1). However, it is clear that to increase the intrinsic efficiency of water use (A/gs), the highest doses of fertilization should be used.

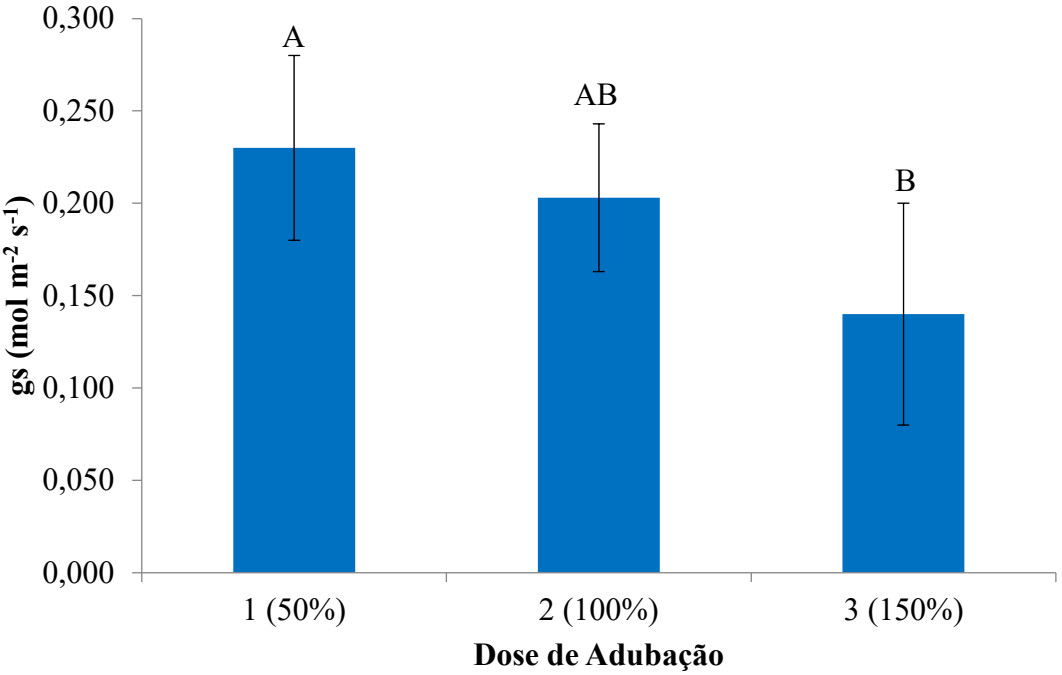
No significant effects of the environment × dose interaction were observed for any of the variables studied in the afternoon evaluation. However, there was an isolated effect of fertilizer dose on the transpiration rate (E) (Figure 3) and stomatal conductance (gs) (Figure 4).

Figure 3. Average E – Transpiration rate (mmol m^{-2} s^{-1}) in the fig tree cv. Roxo de Valinhos in the afternoon under the influence of different doses of fertilization.



*Different letters differ from each other according to Tukey's test at 5%.
Source: Authors.

Figure 4. Averages of E – Transpiration rate (mmol m^{-2} s^{-1}) and gs - stomatal conductance (mol m^{-2} $s^{-1)}$ in the fig tree cultivar Roxo de Valinhos in the afternoon under the influence of different doses of fertilization.



*Different letters differ from each other according to Tukey's test at 5%.
Source: Authors.

The higher stomatal conductance (gs) observed at the lowest dose (D1-50%) likely contributed to the higher transpiration rate (E) at this dose than at the highest dose (D3-150%) (Figure 3). This can be explained by the larger volume of salts applied at this dose. In an experiment with yellow passion fruit, Freire *et al*. (2014) reported that plants under saline stress presented reduced stomatal conductance.

Dias *et al*. (2019) reported an increase in the transpiration rate in acerola trees in response to increasing potassium doses (50% to 125% of the recommended dose), attributing this effect to the role of potassium in regulating stomatal opening. However, the authors reported a reduction in the transpiration rate in plants irrigated with water with higher salinity because of a reduction in stomatal conductance.

The regulation of physiological processes, such as the transpiration rate (E) and stomatal conductance (gs), and their mutual influence may also be the result of the response of the fig tree to avoid the harmful effects of abiotic stresses, such as temperature (Ammar *et al.*, 2020).

4 CONCLUSIONS

The evaluation conducted in the morning proved to be more sensitive in capturing the effect of the interaction between the environment and fertilizer dose on gas exchange.

In both environments, the application of the highest fertilization dose (D3-150%) led to lower Ci values and a significant improvement in the intrinsic water use efficiency (A/gs) compared with those of dose 1 (50%).

The lowest average transpiration rate (E) was observed for the highest fertilization dose (D3 – 150%) in the afternoon evaluation, which was associated with lower stomatal conductance (gs) at that dose, regardless of the environment.

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