

Research Article

Physiology and yield of yellow passion fruit under organic and silicon fertilization in a semiarid environment[1]

José Paulo Costa Diniz[2], Caio da Silva Sousa[2], Evandro Franklin de Mesquita[3], Lauriane Almeida dos Anjos Soares[2], Samuel Barbosa Alves[3], Franklin Suassuna de Sousa[3], Rennan Fernandes Pereira[4], Vitória Carolina da Silva Soares[3]

ABSTRACT

Several semiarid regions have soils with low organic matter content and adverse climates. Organic and silicon fertilization can benefit plants physiologically, thus contributing to increasing the yield of agricultural crops. The present study aimed to evaluate the gas exchanges, cell water status and yield of yellow passion fruit under organic and silicon fertilization and semiarid conditions. The field experiment used a randomized block design, in a 2 × 5 factorial scheme, consisting of two soil organic matter levels (no addition and 4 %) and five silicon doses (0, 27, 54, 81 and 108 g plant^{-1}), with four replications and six plants per plot. The gas exchanges, cell water status and yield of yellow passion fruits were assessed. Regardless of the applied dose, silicon affected certain aspects related to gas exchanges and cell water status. Applying 108 g of silicon per plant results in higher fruit yields, and increasing the soil organic matter to 4 % ensures a better cell water status and yield of yellow passion fruit under semiarid conditions.

KEYWORDS: *Passiflora edulis* Sims, gas exchanges, cell water status, soil organic matter.

RESUMO

Fisiologia e produção de maracujazeiro-amarelo sob adubações orgânica e silicatada em ambiente semiárido

Diversas regiões semiáridas possuem solos com baixo teor de matéria orgânica e condições climáticas adversas. A adubação orgânica e com silício podem resultar em benefícios fisiológicos às plantas, contribuindo para uma maior produtividade dos cultivos agrícolas. Objetivou-se avaliar as trocas gasosas, o *status* hídrico celular e a produção de maracujazeiro-amarelo sob adubação orgânica e silicatada, em condições de semiaridez. O experimento foi conduzido em campo, em arranjo fatorial 2 × 5, correspondendo a dois níveis de matéria orgânica do solo (sem aplicação e 4 %) e cinco doses de silício (0, 27, 54, 81 e 108 g planta^{-1}), no delineamento em bloco casualizados, com quatro repetições e seis plantas por parcela. Foram avaliadas as trocas gasosas, o *status* hídrico celular e a produção dos frutos de maracujazeiro-amarelo. O silício, independentemente da dose aplicada, alterou alguns aspectos relacionados às trocas gasosas e ao *status* hídrico das células. A aplicação de 108 g de silício por planta resultou em maior produção de frutos. A elevação da matéria orgânica do solo para 4 % garante melhor *status* celular e produção de maracujazeiro-amarelo sob condições de semiaridez.

PALAVRAS-CHAVE: *Passiflora edulis* Sims, trocas gasosas, *status* hídrico celular, matéria orgânica do solo.

INTRODUCTION

Brazil is the world's largest producer and consumer of passion fruit, sold for both fresh consumption and industrial use (Nogueira et al. 2021, Sá et al. 2021). In the 2023 growing season, Brazil produced a total of 711,278 metric tons, with the Northeast as the highest-producing region, concentrated mainly in the states of Bahia and Ceará and producing a total of 505,461 t, equivalent to about 71.06 % of the national passion fruit production (IBGE 2024).

However, in semiarid regions, climatic and geomorphological characteristics (low and irregular rainfall; high evapotranspiration rates and temperatures) combined with soil-forming processes (erosion and salinization) lead to discontinuous plant litter decomposition and replacement, which directly affect soil organic matter reserves and result in low soil organic matter content (Giongo et al. 2021, Macedo et al. 2021).

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[2] Universidade Federal de Campina Grande, Pombal, PB, Brazil. *E-mail/ORCID*: josepaulo.rc06@gmail.com/0000-0002-9247-8970; caiosilvafla16@gmail.com/0000-0002-4163-8313; laurispo.agronomia@gmail.com/0000-0002-7689-9628.
[3] Universidade Estadual da Paraíba, Catolé do Rocha, PB, Brazil. *E-mail/ORCID*: evandrofranklin@servidor.uepb.edu.br/0000-0001-5722-2235; ssambarbosa@gmail.com/0009-0007-2568-6503; franksuassunaagro27@gmail.com/0009-0001-9403-7634; vitoria.16carolina@gmail.com/0000-0002-1519-1853.
[4] Universidade Estadual da Paraíba, Campina Grande, PB, Brazil. *E-mail/ORCID*: rennan.fp@gmail.com/0000-0002-2994-3737.
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Organic fertilization is one of the alternatives for crop production in these areas, since it can increase the organic matter content of the soil system, becoming a natural source of nutrients for plants (El-Mageed et al. 2018). Organic fertilizers can improve the soil physical, chemical and biological properties, increasing its buffering capacity, porosity and ability to retain water (Santos et al. 2022). They also affect soil fertility by increasing cation exchange capacity and influencing plant nutrition, thereby contributing to crop growth and yield (Chakma et al. 2023).

In addition to organic fertilizers, silicon (Si) fertilization has emerged as a promising tool, since Si is considered beneficial to plants and positively influences crop growth and yield. Rajput et al. (2021) demonstrated the beneficial effects of Si on crops such as soybean (*Glycine max* L.), barley (*Hordeum vulgare*), wheat (*Triticum aestivum*) and other crops, especially when these plants are exposed to biotic and abiotic stresses, including high temperatures, water deficit and salinity.

Silicon fertilization can improve water relations and gas exchange by increasing chlorophyll levels and photosynthesis, and directing photoassimilates toward growth and production. This leads to higher biomass and crop yields and better fruit quality (Etesami & Jeong 2020, Mendonça et al. 2022, Nazim et al. 2024).

However, the beneficial effects of silicon fertilization depend on the applied dose, species, phenological stage and type of crop (Ferrareze et al. 2019). Thus, it is important to conduct studies that investigate the physiological aspects and yield of yellow passion fruit under different soil organic matter and silicon fertilization levels, with a view to improving yield performance and expanding passion fruit farming under semiarid conditions.

MATERIAL AND METHODS

A field experiment was carried out at the Universidade Estadual da Paraíba, in Catolé do Rocha, Paraíba state, Brazil, from October 2022 to September 2023. The municipality is located in the semiarid Alto Sertão region (6º20’38”S, 37º44’48”W and altitude of 275 m), with hot semiarid climate (Bsh), according to the Köppen’s classification (Alvares et al. 2013). Data on air temperature, relative humidity, reference evapotranspiration (ETo) and rainfall recorded during the experiment are shown in Figure 1.

The experiment used a randomized block design, in a 2 × 5 factorial scheme, consisting of two soil organic matter levels [no organic matter addition (1.2 % of soil organic matter) and increasing the soil organic matter to 4 %] and five doses of silicon fertilization (0, 27, 54, 81 and 108 g plant^{-1}), with four replications and six plants per plot.

The silicon doses were applied at planting (basal application) and then every 45 days, until peak fruiting occurred [225 days after seedling transplanting (DAT)], totaling 6 applications. The used silicon source was orthosilicic acid [$Si(OH)_4$]. In the treatment with organic matter addition, ≈ 8 kg of cattle manure were incorporated into the soil at planting, to increase its organic matter content to 4 % (Nascimento et al. 2016). The soil in the experimental area and the cattle manure were characterized before the application (Tables 1 and 2).

Plants were spaced 3 m apart, with 2 m between rows. Each plot contained 6 plants and was 18 m long, with 2 m between rows, equivalent to a total area of 36 m^2, with the two center plants considered the study area, resulting in a planting density of 1,666 plants ha^{-1}.

The seed-propagated BRS Gigante Amarelo (BRS GA1) yellow passion fruit cultivar was used. Initially, the seedlings were produced in 2-L black polyethylene bags (18 × 12 cm), using 2 seeds bag^{-1}. Thinning was performed at 7 days after emergence (DAE), leaving the most vigorous plant. The bags were filled with substrate at a 1:1 ratio (v/v), using soil material collected at a depth of 0.2 m and cattle manure. The seedlings were transplanted to the field at 41 days after planting (DAP), when the first tendril had emerged.

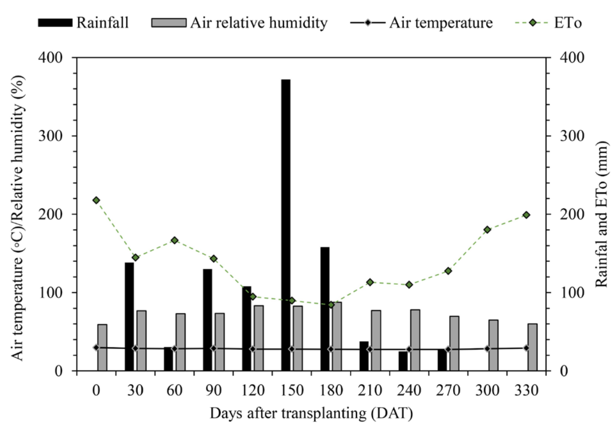

Figure 1. Climate data recorded during the experiment, from October 2022 to September 2023 (Catolé do Rocha, Paraíba state, Brazil).

Table 1. Chemical and physical composition of the soil used in the experiment.

Chemical attributes	
pH	6.00
P (mg dm^{-3})	16.63
K^+ ($cmol_c$ dm^{-3})	0.08
Ca^{2+} ($cmol_c$ dm^{-3})	1.09
Mg^{2+} ($cmol_c$ dm^{-3})	1.12
Na^+ ($cmol_c$ dm^{-3})	0.05
SB ($cmol_c$ dm^{-3})	2.34
$H^+ + Al^{3+}$ ($cmol_c$ dm^{-3})	1.24
Al^{3+} ($cmol_c$ dm^{-3})	0.00
CEC ($cmol_c$ dm^{-3})	3.58
V (%)	65.36
OM (g kg^{-1})	13.58
Si (mg dm^{-3})	29.00
Physical attributes	
Sand (g kg^{-1})	831.50
Silt (g kg^{-1})	100.00
Clay (g kg^{-1})	68.50
WDC (g kg^{-1})	0.00
DF (g dm^{-3})	1,000.00
SD (g cm^{-3})	1.53
PD (g cm^{-3})	2.61
TP (m^3 m^{-3})	0.42
H0.01MPa (g kg^{-1})	65.00
H0.03MPa (g kg^{-1})	49.00
H1.50MPa (g kg^{-1})	28.00
Texture class	SCL

SB: sum of bases; CEC: cation exchange capacity; V: soil saturation; OM: soil organic matter content; WDC: water-dispersible clay; DF: degree of flocculation; SD: soil density; PD: particle density; TP: total porosity; SCL: sandy clay loam.

Table 2. Chemical composition of the cattle manure used in the experiment.

Attribute	Amount
pH (H_2O)	7.7
EC (dS m^{-1})	6.09
OM (dag kg^{-1})	36.2
CO (g kg^{-1})	166.9
N (g kg^{-1})	13.9
C:N	12.0
P (g kg^{-1})	3.2
K^+ (g kg^{-1})	18.7
Ca^{2+} (g kg^{-1})	16.2
Mg^{2+} (g kg^{-1})	6.1
S (g kg^{-1})	2.5
CEC (mmol dm^{-3})	133.9
B (mg kg^{-1})	14.8
Fe (mg kg^{-1})	11,129.9
Cu (mg kg^{-1})	19.3
Mn (mg kg^{-1})	491.4
Zn (mg kg^{-1})	65.3
Si (g kg^{-1})	12.5
Na^+ (g kg^{-1})	3.5

EC: electrical conductivity; OM: organic matter; CO: carbon oxidation by potassium dichromate and determined by colorimetry; N: Kjeldahl method by dry digestion; C:N: carbon-to-nitrogen ratio; P: Mehlich-1 extraction and photocolorimetry at 660 nm; K^+ and Na^+: flame photometry; Ca^{2+} and Mg^{2+}: atomic absorption photometry at 422.7 and 285.2 nm; S: atomic absorption spectrometry at 420 nm; B and Fe: UV-vis spectrometry at wavelengths of 460 and 508 nm, respectively; Cu: atomic absorption spectrometry at 324.7; Mn and Zn: atomic absorption spectrometry at 231.9 and 279.5 nm, respectively, using an air-acetylene flame; CEC: cation exchange capacity.

Field preparation included one plowing and one harrowing, followed by holes dug to 40 × 40 × 40 cm, corresponding to a volume of 64 dm^3. In the treatments where the soil organic matter was increased to 4 %, cattle manure was added. The used support system was a 2.0-m-high vertical trellis consisting of 12-gauge smooth wire installed at the top of the stakes (Cavalcante et al. 2018). Training pruning was performed during the experiment, as well as manual weeding with a hoe to remove weeds, and tendril removal to ensure that the plants concentrated their energy on growth and development.

Formative pruning was carried out when the main stem had extended 10 cm beyond the upper wire, to break apical dominance and induce lateral sprouting. The sprouting of the lateral buds produced two secondary branches, which were trained along the wire in two different directions: left and right. When the secondary branches of two neighboring plants met, they were pruned (once they reached 1.5 m) to induce renewed lateral sprouting and form tertiary and quaternary fruiting branches, which grew downward, forming a curtain. The fruiting branches were pruned 20 cm above the soil to prevent them from reaching the ground. During flowering, artificial pollination was performed daily between 12 and 5 p.m.

The basal fertilization consisted of applying 5 g of P_2O_5 to the soil in the form of single superphosphate (18 % of P_2O_5, 16 % of Ca^{2+} and 10 % of S), equivalent to 27.77 g. Nitrogen and potassium fertilization began on the day of transplanting, supplying 3 g of each nutrient in the form of urea (45 % of N) and potassium chloride (60 % of K_2O), applying 6.66 and 5 g of each fertilizer, respectively. Side dressing with nitrogen and potassium was carried out monthly, while phosphorus fertilization occurred every two months from Oct. 10, 2022 (0 DAT) to Oct. 07, 2023 (270 DAT), totaling 161 g of N $plant^{-1}$ (358 g of urea), 85 g of P_2O_5 $plant^{-1}$ (472 g of single superphosphate) and 161 g of K_2O $plant^{-1}$ (268 g of potassium chloride).

The plant stand was irrigated using groundwater from an Amazonas-type well via a localized drip system at a flow rate of 10 L h^{-1}, with each dripper installed at 10 cm from either side of the plant stem.

The irrigation depths were obtained based on the crop evapotranspiration (ETc), determined by multiplying the reference evapotranspiration (ETo) by the crop coefficients (Kc). The ETo was estimated using evaporation data from a Class A pan installed adjacent to the experimental area and corrected using a pan coefficient of 0.75.

At 220 DAT, the gas exchange was measured during peak fruiting on an intact leaf from the middle portion of the intermediate fruiting branch, using a CIRAS-3 infrared gas analyzer (IRGA), with irradiance of 1,200 μmol of photons m^{-2} s^{-1} and airflow rate of 300 mL min^{-1}, between 7 and 10 a.m. The following parameters were determined: stomatal conductance (*gs*), transpiration (*E*), CO_2 assimilation rate (*A*) and intercellular CO_2 concentration (*Ci*).

The cell water status was determined using the methodology described by Cairo (1995). To that end, the fourth leaf from the apex of the fruiting branch was collected during the same period in which the gas exchange measurements were taken. Ten leaf discs, each 1 cm in diameter, were removed and weighed on a precision scale (0.001 g) to obtain the fresh mass (FM). The discs were then stored in containers with 20 mL of distilled H_2O and allowed to rest overnight. Next, paper towel was used to remove the water excess from the plant material and the discs were weighed again to obtain the turgid mass (TM). Finally, for dry mass (DM) determination, the discs were transferred to paper bags, dried in an oven at 65 ºC, for 48 hours, and then weighed. The values obtained in each stage were used to calculate the relative water content (RWC) via the following equation: RWC = [(FM - DM)/(TM - DM)] x 100.

Additionally, the fresh mass, turgid mass and dry mass data of the leaf discs were used to calculate the leaf turgor loss (LTL), according to the equation: LTL = [(TM - FM)/TM] x 100.

To determine the electrolyte leakage (EL), five leaf discs with 1 cm in diameter were removed and stored overnight in containers with 20 mL of distilled H_2O. An initial electrical conductivity reading (L_1) of the container's contents was performed using an Ak51 ASKO conductivity meter. Next, the content of the containers was transferred to sealed test tubes and placed in a water bath for one hour, at 100 ºC, after which the second reading (L_2) was taken. These data were used to calculate the electrolyte leakage via the following equation (Scotti & Thu Phan Thi 1997): EL = (L_1/L_2) x 100.

Fruits were harvested continuously every day, from 105 to 330 DAT, collecting those on the ground and fruits whose peel was at least 30 % yellow. The harvested fruits were stored in a plastic box, counted and weighed, and, at the end of harvesting, the total number of commercial fruits per plant and yield were obtained by multiplying the yield per plant by the planting density per hectare (1,666 plants ha^{-1}).

The data were submitted to the Shapiro-Wilk and Bartlett tests, followed by analysis of variance (Anova), using the F test ($p \leq 0.05$). First and second-order regression were performed for silicon doses and the effect of silicon within each level of organic fertilization. The statistical analyses were performed using the packages available in the RStudio software (R Core Team 2023).

RESULTS AND DISCUSSION

The analysis of variance for the variables related to gas exchange and cell water status indicated no significant interaction between the tested factors (Table 3). However, silicon influenced stomatal conductance (*gs*), transpiration (*E*) and the CO_2 assimilation rate (*A*). The individual effects of silicon and soil organic matter influenced the intercellular CO_2 concentration (*Ci*).

The stomatal conductance was significantly affected by Si doses, exhibiting a decreasing linear trend (Figure 2A). There was a 0.0004 mmol of H_2O m^{-2} s^{-1} decline for every unit increase in Si dose, with the lowest *gs* recorded at 0.13 mmol of H_2O m^{-2} s^{-1}, with 108 g of Si $plant^{-1}$. The reduction in *gs* observed with increasing Si doses may be associated with the formation of silica gel through the polymerization of this element on the leaves. This process occurs predominantly on the abaxial surface around the stomata, where silica gel accumulation can alter the physical structure of the leaf surface (Irfan et al. 2023).

Similarly, *E* declined as a function of Si doses (Figure 2B), decreasing by 0.01 mmol of H_2O m^{-2} s^{-1} for every unit increase in Si, with the lowest value (3.90 mmol of H_2O m^{-2} s^{-1}) recorded at 108 g of Si $plant^{-1}$.

Table 3. Summary of the analysis of variance based on mean square values for the variables stomatal conductance (*gs*), transpiration (*E*), CO_2 assimilation rate (*A*) and intercellular CO_2 concentration (*Ci*), in yellow passion fruit under different silicon (Si) doses and soil organic matter (SOM) levels, at 210 days after transplanting.

SV	Block	Si	SOM	Si × SOM	Residual	Total	CV (%)
DF	3	4	1	4	27	39	
gs	0.0031^{ns}	0.0004**	0.0014^{ns}	0.0089^{ns}	0.0004	-	12.96
E	2.34**	1.93**	0.29^{ns}	0.32^{ns}	0.29	-	11.54
A	19.76**	8.13*	6.07^{ns}	1.09^{ns}	2.14	-	10.84
Ci	318.68^{ns}	590.28*	1,177.57**	494.63^{ns}	245.78	-	8.17

SV: source of variation; DF: degrees of freedom; CV: coefficient of variation. *, ** and ^{ns}: significant at 5 %, 1 % and not significant, respectively, according to the F test.

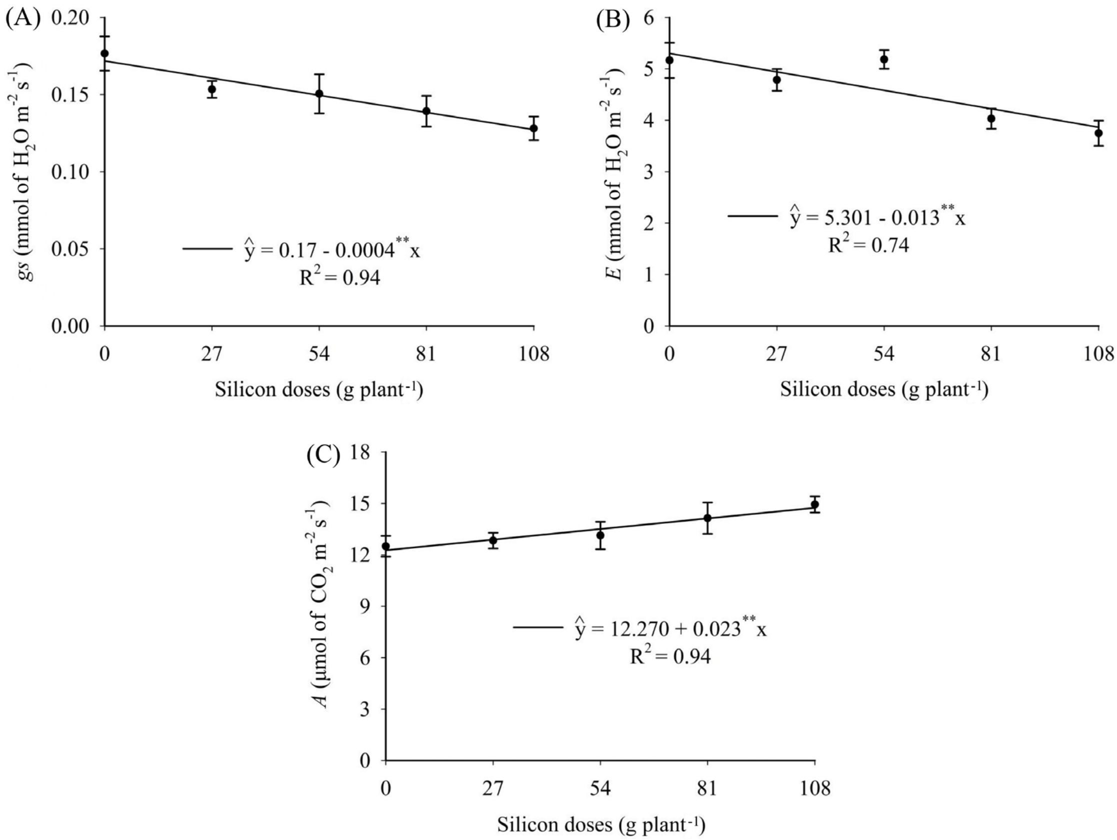

Figure 2. Stomatal conductance (*gs*; A), transpiration (*E*; B) and CO_2 assimilation rate (*A*; C) in yellow passion fruit as a function of silicon doses, at 210 days after transplanting. ** Significant at 1 % of probability according to the F test ($p < 0.05$). The bars indicate the standard error of the mean.

The reduction in the transpiration rate as the silicon dose per plant increased, possibly due to the decline in *gs*, can also be attributed to the Si deposited in the cell wall of the leaf epidermis. This forms a Si-cuticle double layer beneath the cuticle, increasing the epidermal thickness and regulating leaf transpiration (Ma & Yamaji 2006, Nedukha 2022).

The CO_2 assimilation rate had a better fit to the increasing linear model as a function of Si doses, rising by 12.27 µmol of CO_2 m^{-2} s^{-1} per unit increase in Si (Figure 2C). The highest *A* value (14.75 µmol of CO_2 m^{-2} s^{-1}) was obtained at 108 g of Si plant^{-1}. The increase in *A* at higher Si doses per plant can be justified by the element's contribution to enhancing light absorption in the photosystems I and II, reducing the degradation of photosynthetic pigments such as chlorophyll (Nedukha 2022). This increase in *A* aligns with research by Hamoud et al. (2024) and Verma et al. (2021), who also highlighted the role of Si in improving *A*.

The intercellular CO_2 concentration (Figure 3A) was significantly influenced by Si doses, demonstrating a decreasing linear trend. There was a 0.21 µmol of CO_2 m^{-2} s^{-1} decline per unit increase in Si, with the lowest value (180.38 µmol m^{-2} s^{-1}) observed at 108 g of Si $plant^{-1}$. This decline may be related to the reduced *gs* observed (Figure 2A), which may have limited the CO_2 influx into the substomatal chamber.

The *Ci* increased by 6.30 % in plants grown under a high soil organic matter content (4 %), when compared to those in soil with 1.2 % of organic matter, with average values of 197.65 and 185.92 µmol of CO_2 m^{-2} s^{-1}, respectively (Figure 3B). The increase in leaf *Ci* in plants under high soil organic matter (4 %) may be associated with a better soil water retention (Lacerda et al. 2023).

Based on the Anova summary (Table 4), there was a significant interaction effect between Si doses and soil organic matter on electrolyte leakage and leaf turgor loss, according to the F test. By contrast, the relative water content was significantly individually affected by Si and soil organic matter.

The relative water content data (Figure 4A) showed an increasing linear trend as a function of the Si doses, rising by 0.09 % for every unit increase in Si. This behavior suggests that Si may contribute to a better water retention in plants, possibly by influencing mechanisms that enhance water absorption or conservation (Almeida et al. 2024).

There was an 18.17 % increase in relative water content in the yellow passion fruit grown in soil with 4 % of organic matter (78.92 %), when compared to those under the initial soil organic matter level of 1.2 % (66.78 %) (Figure 4B). This may be linked to soil factors, since soils with adequate organic matter content promote particle aggregation and improve water retention, making water available to the root system for longer (Jangir et al. 2020, Santos et al. 2022).

The turgor loss data showed a quadratic trend when plants were submitted to organic fertilization

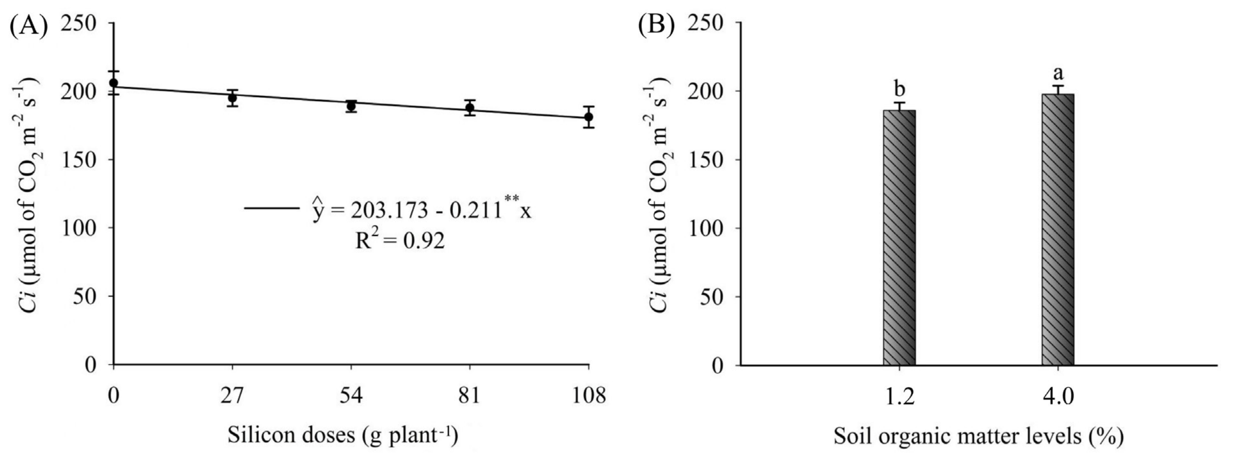

Figure 3. Intercellular CO_2 concentration (*Ci*) in yellow passion fruit as a function of silicon doses (A) and soil organic matter levels (B), at 210 days after transplanting. ** Significant at 1 % of probability, according to the F test ($p \leq 0.05$). Means with different letters differ for soil organic matter levels, according to the F test. Bars indicate the standard error of the mean.

Table 4. Analysis of variance summary, based on mean square values, for the variables relative water content (RWC), leaf turgor loss (LTL) and electrolyte leakage (EL) in yellow passion fruit under different soil organic matter (SOM) levels and silicon (Si) doses, at 210 days after transplanting.

SV	Block	Si	SOM	Si × SOM	Residual	Total	CV
DF	3	4	1	4	27	39	(%)
RWC	20.03^{ns}	137.72**	1,474.88**	28.11^{ns}	13.09	-	4.97
TL	0.83^{ns}	218.94**	512.44*	36.76**	2.28	-	4.77
EL	39.61^{ns}	282.83**	11.35*	23.82**	1.58	-	4.90

SV: source of variation; DF: degrees of freedom; CV: coefficient of variation. *, ** and ^{ns}: significant at 5 %, 1 % and not significant, respectively, according to the F test.

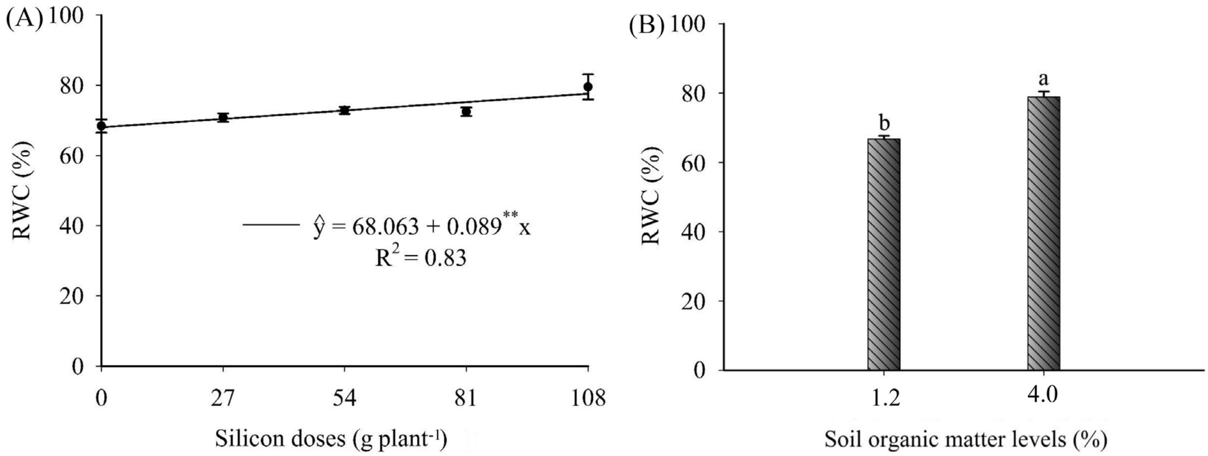

Figure 4. Relative water content (RWC) of yellow passion fruit as a function of silicon doses (A) and soil organic matter levels (B), at 210 days after transplanting. ** Significant at 1 % of probability according to the F test ($p \leq 0.05$). Means with different letters differ for soil organic matter levels, according to the F test. Bars indicate the standard error of the mean.

with 4 % of soil organic matter, with the lowest leaf turgor loss (18.41 %) recorded at 108 g of Si plant^{-1}. On the other hand, a decreasing linear trend was observed in plants grown under 1.2 % of soil organic matter, with a 0.09 % reduction in leaf turgor loss for every unit increase in Si, and the lowest value (30.11 %) obtained at a dose of 108 g of Si plant^{-1} (Figure 5). The low leaf turgor loss observed with increasing Si doses under high soil organic matter (4 %) likely occurred due to Si-induced production of osmoregulatory solutes, such as proline, which contributes to osmotic adjustment (Santos et al. 2021). In this case, the soil organic matter may have contributed to the low leaf turgor loss by preventing soil temperature fluctuations, acting as an insulating layer.

For electrolyte leakage (Figure 6), the plants grown in soil with 1.2 % of organic matter showed a quadratic response to the tested Si doses, with a continuous decline up to the dose of 90.23 g of Si plant^{-1}, when the lowest value (20.27 %) was obtained. By contrast, plants in soil with 4 % of organic matter exhibited a decreasing linear response,

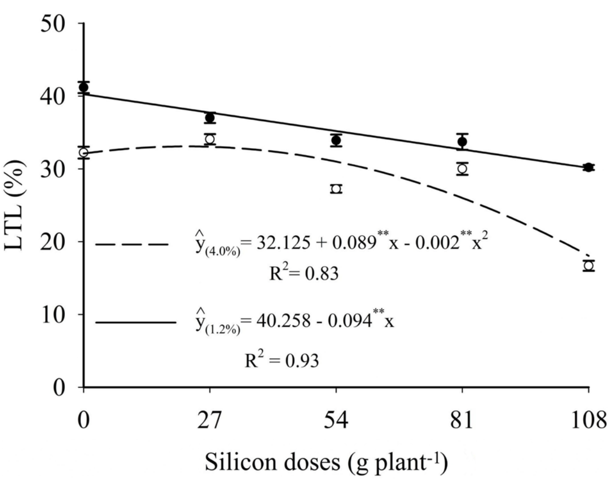

Figure 5. Leaf turgor loss (LTL) in yellow passion fruit as a function of interaction between silicon doses and soil organic matter levels, at 210 days after transplanting. ** Significant at 1 % of probability according to the F test ($p \leq 0.05$). Bars indicate the standard error of the mean.

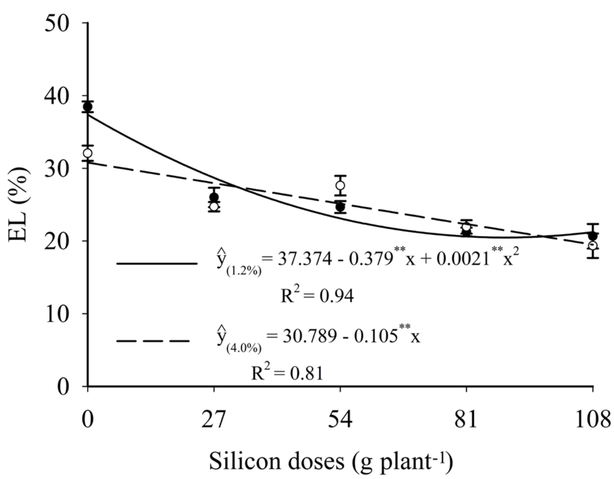

Figure 6. Electrolyte leakage (EL) in yellow passion fruit as a function of interaction between silicon doses and soil organic matter levels, at 210 days after transplanting. ** Significant at 1 % of probability according to the F test ($p \leq 0.05$). Bars indicate the standard error of the mean.

with a constant 0.10 % decrease in electrolyte leakage per unit increase in Si. The highest electrolyte leakage was observed in plants not treated with Si, possibly due to a greater production of reactive oxygen species, which react with biomolecules in the cell, causing significant damage (Rachappanavar et al. 2024). The electrolyte leakage reduction in plant stands with low (1.2 %) and high (4 %) soil organic matter as Si doses increased is likely related to the role of Si in reactive oxygen species regulation at the cellular level balance, promoting a greater plasmalemma stability and permeability (Ali et al. 2021).

In relation to the yield variables, the Anova summary (Table 5) shows a significant interaction effect between silicon doses and soil organic matter levels for the number of fruits per plant and yield of yellow passion fruit.

The number of fruits per plant data followed a quadratic trend in the soil with 1.2 % of organic matter, with the optimal dose estimated at 75.42 g of Si plant^{-1}, when the highest number of fruits per plant (42.14 fruits) was recorded (Figure 7). On the other hand, there was an increasing linear response in the soil with 4 % of organic matter, with the highest value (56.88 fruits) obtained at 108 g of Si plant^{-1} and a constant increase of 0.10 fruits plant^{-1} for every unit increase in Si. This represents a 34.97 % increase in the number of fruits per plant at 4 % of soil organic matter, when compared to plants grown under 1.2 % of soil organic matter.

Regardless of the applied Si dose, yield was higher in plants grown under high soil organic matter (4 %) than in those cultivated in soil with low organic matter (1.2 %) (Figure 8). It should be noted that, even in the absence of Si, the higher yield in both stands was attributed to the soil organic matter. The significant yield increase in plants under 4 % of soil organic matter and Si treatment can be explained by the role of organic matter in favoring a greater soil biodiversity, buffering capacity and nutrient cycling

Table 5. Analysis of variance summary, based on mean square values, for the variables number of fruits per plant (NFP) and yield in yellow passion fruit under different soil organic matter (SOM) levels and silicon (Si) doses, at 240 days after transplanting.

SV	Block	Si	SOM	Si × SOM	Residual	Total	CV
DF	3	4	1	4	27	39	(%)
NFP	27.99^{ns}	474.92**	12,948.08**	1,028.09*	11.41	-	7.30
Yield	8.27^{ns}	115.07**	655.69**	12.01*	4.50	-	10.88

SV: source of variation; DF: degrees of freedom; CV: coefficient of variation; *, ** and ^{ns}: significant at 5 %, 1 % and not significant, respectively, according to the F test.

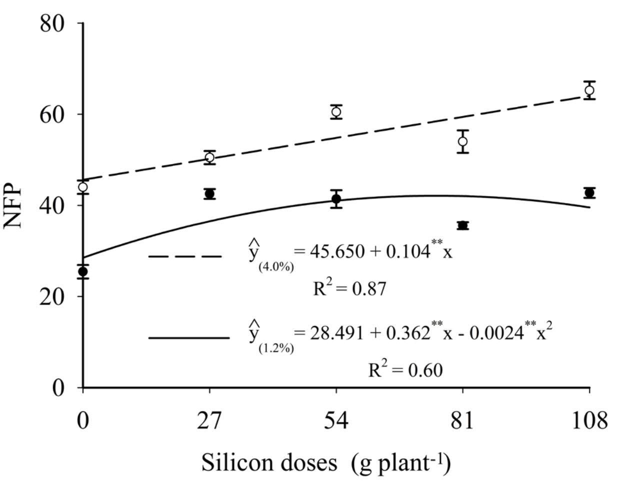

Figure 7. Number of fruits per plant (NFP) in yellow passion fruit as a function of interaction between silicon doses and soil organic matter levels, at 330 days after transplanting. ** Significant at 1 % of probability according to the F test ($p \leq 0.05$). Bars indicate the standard error of the mean.

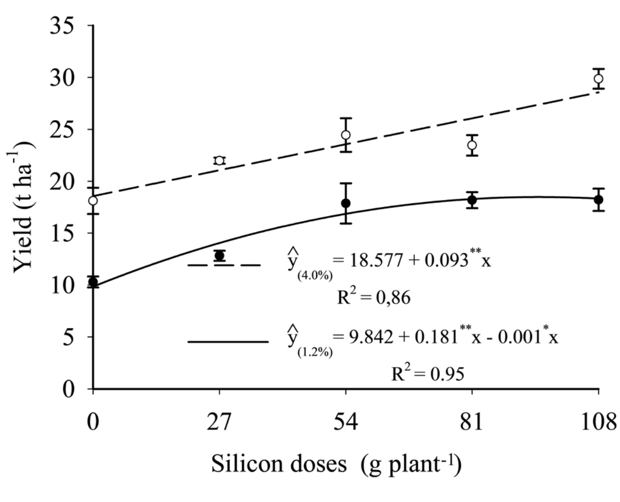

Figure 8. Yield of yellow passion fruit as a function of interaction between silicon doses and soil organic matter levels, at 330 days after transplanting. * and **: significant at 5 and 1 % of probability, according to the F test ($p \leq 0.05$). Bars indicate the standard error of the mean.

and storage, since the nutrients in the soil organic matter become available to plants after mineralization (Jangir et al. 2020).

Furthermore, Si had a significant effect in promoting higher yields in plants with (4 %) and without (1.2 %) added organic matter. This increase may be linked to the increased *Ci*, which boosted a photoassimilate production for fruit development (Zhou et al. 2024) and stimulated the vegetative growth in the passion fruit plants. The treatments increased the number of shoots and branch growth rate, resulting in a larger number of flowers. When combined with the region's favorable photoperiod and the efficiency of natural and artificial pollination, these factors contributed to the increases observed for yield. According to the Brazilian Institute of Geography and Statistics (IBGE 2024), the highest recorded yield (29 t ha^{-1}) was 86.61 and 204.62 % higher than the national (15.54 t ha^{-1}) and state average for the Paraíba state (9.52 t ha^{-1}), respectively.

CONCLUSIONS

1. Increasing the soil organic matter to 4 %, combined with silicon fertilization, improves the gas exchange efficiency in yellow passion fruit;
2. Increasing the soil organic matter to 4 % ensures a better cell water status and yield in yellow passion fruit under semiarid conditions;
3. Silicon doses between 81 and 108 g $plant^{-1}$, combined with 4 % of soil organic matter, increase the number of fruits per plant in yellow passion fruit.

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