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Impact of nitrogen (N) and silicon (Si) on anthracnose incidence in scarlet eggplant fruits

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ABSTRACT

This study aimed to evaluate the influence of the interaction between nitrogen (N) fertilization and foliar silicon (Si) application on anthracnose incidence in scarlet eggplant fruits. The experiment was established and conducted with five N rates (0, 25, 50, 100, and 200 kg ha^{-1}) combined in a factorial arrangement with five Si concentrations (0, 0.2, 0.4, 0.6, and 0.8 L 100 L^{-1}). Nitrogen rates had a significant effect on the Area Under the Disease Progress Curve (AUDPC) for disease incidence. The lowest AUDPC value, 161.9, was observed at an N rate of 111.33 kg ha^{-1}. The highest yield, 20.66 t ha^{-1}, was obtained at an N rate of 123.5 kg ha^{-1}. For the mean number of fruits, the highest value, 45 fruits per plant, was observed at an N rate of 140.91 kg ha^{-1}. For mean fruit length, the greatest value, 7.17 cm, was observed at an N rate of 125.05 kg ha^{-1}. Finally, the greatest mean fruit diameter, 4.43 cm, was observed at an N rate of 123.07 kg ha^{-1}. In contrast, N imbalance resulting from either low or high N rates led to the least favorable responses for the variables analyzed. There was no significant interaction between N rates and Si concentrations. Likewise, there was no significant main effect of Si concentrations. However, to better investigate the influence of Si on anthracnose incidence and scarlet eggplant yield, further studies should evaluate different concentrations, sources, application timings, and application methods of the product.

Keywords: *Solanum aethiopicum* L., *Colletotrichum* sp., Plant disease, Mineral nutrition.

Impacto do nitrogênio (N) e silício (Si) na incidência da antracnose em frutos de jiló

RESUMO

Objetivou-se com este trabalho avaliar a influência da interação entre adubação com nitrogênio (N) e aplicação foliar de silício (Si) na incidência da antracnose em frutos de jiló. O experimento foi instalado e conduzido com cinco doses de N (0; 25; 50; 100 e 200 kg ha^{-1}) combinadas em esquema fatorial com cinco concentrações de Si (0; 0,2; 0,4; 0,6 e 0,8 L por 100 L^{-1}). As doses isoladas de N tiveram efeito significativo sobre a Área Abaixo da Curva de Progresso da Doença (AACPD) para incidência da doença. A menor AACPD, 161,9, foi constatada com 111,33 kg ha^{-1} de N. A maior produtividade, 20,66 t ha^{-1}, foi encontrada na dose de 123,5 kg ha^{-1} de N. Para o número médio de frutos, o maior valor, 45 frutos por planta, foi observado na dose de 140,91 kg ha^{-1} de N. Já para o comprimento médio dos frutos, na dose de 125,05 kg ha^{-1} de N, foi verificado o maior comprimento, com 7,17 cm. Por fim, o maior diâmetro médio dos frutos, 4,43 cm, foi observado na dose de 123,07 kg ha^{-1}. Por outro lado, o desbalanço de N provocado por doses baixas ou altas resultou nos piores resultados para as variáveis analisadas. Não houve interação significativa entre as doses de N e as concentrações de Si. Também não houve efeito isolado das concentrações de Si. Entretanto, para investigar melhor a influência do Si na intensidade da antracnose e produtividade do jiló, recomenda-se variar concentrações, fontes, épocas e métodos de aplicações do produto.

Palavras-chave: *Solanum aethiopicum* L., *Colletotrichum* spp., Doença de planta, Nutrição mineral.

1. Introduction

Scarlet eggplant (*Solanum aethiopicum* L.; family: Solanaceae) is a vegetable traditionally cultivated in Africa and in some parts of the Caribbean, Brazil, and southern Italy (Aguessy et al., 2021). The species produces an edible fruit with a characteristic bitter taste and provides several benefits to human health, as it contains carbohydrates, proteins, and fats, as well as fiber and essential vitamins. In addition, the species has medicinal properties (Choi and Choi, 2024). Besides its nutritional and food importance, the crop is an excellent source of income for smallholder farmers (Han et al., 2021; Mwinuka et al., 2021).

Among the major diseases affecting scarlet eggplant production, anthracnose, caused by fungi of the genus *Colletotrichum*, is one of the most damaging (Oliveira et al., 2023). *Colletotrichum* species can infect leaves, branches, and fruits. However, the most significant damage occurs in the fruits, both in the field and during postharvest (Pinheiro et al., 2015). Under favorable conditions and in the absence of control measures, the disease can affect 100% of the fruits (Pereira et al., 2012). Chemical control through fungicide application is the most commonly used strategy for anthracnose management (Alexandre et al., 2014; Oliveira et al., 2023). Despite its effectiveness, chemical control has several negative consequences, including human and environmental contamination, reductions in natural enemy populations, selection for fungicide-resistant fungal populations, and high costs (Wilson and Tisdell, 2001; Mikaberidze et al., 2017).

To reduce disease incidence and, consequently, the number of fungicide applications, plants should be maintained under adequate nutritional conditions (Freitas et al., 2017; Pozza and Pozza, 2012). However, understanding the effects of nutrients within each specific pathosystem is essential (Tripathi et al., 2022). Among the nutrients most extensively studied in relation to plant nutrition and disease intensity, nitrogen (N) stands out. It is well established that plants subjected to N deficiency or excessive N fertilization may exhibit reduced disease resistance (Marschner, 2012). Nitrogen deficiency affects fundamental physiological processes involved in plant defense responses to stress (Valenzuela, 2024). Conversely, high N levels increase plant growth, the amount of young susceptible tissue, and the concentration of amino acids that may favor pathogen infection (Huber et al., 2012).

In a study conducted with scarlet eggplant, yield increased by up to 35.7% as the N rate increased from 0 to 96 kg ha^{-1} (Torres et al., 2003). Because of the potential for higher yields, growers often empirically apply N rates above the official recommendations for scarlet eggplant production (Lopes et al., 2026). However, this practice may result in greater disease incidence, including anthracnose. Several studies conducted with other crops have supported this relationship (Hoffland et al., 2000; Rodrigues et al., 2019; Sun et al., 2020). Nevertheless, studies correlating N fertilization with disease occurrence in scarlet eggplant are scarce.

Silicon (Si) is another element recognized for its promising effects in reducing disease intensity (Huber et al., 2012; Pozza et al., 2015; Rodrigues and Dallagnol, 2024). Although many studies have confirmed the effectiveness of Si in enhancing plant resistance to fungal pathogens, the underlying mechanisms remain poorly understood (Ahammed and Yang, 2021). Silicon is believed to activate physical defense mechanisms that prevent or hinder pathogen penetration, as well as biochemical mechanisms, such as increased activity of defense-related enzymes, induction of antimicrobial compound production, and regulation of systemic signaling (Panicker et al., 2022; Elsherbiny and Taher, 2018; Wang et al., 2017). In addition, Si improves mineral nutrition, resulting in greater photosynthetic potential and antioxidant capacity (Ahammed and Yang, 2021).

Pre- or postharvest Si application has proven effective in controlling anthracnose caused by *Colletotrichum* species in several vegetable crops (Weerahewa and Somapala, 2016). However, for scarlet eggplant, there are no studies demonstrating the effectiveness of this element in controlling anthracnose in this crop. In general, Si is believed to exert mitigating effects when plants are subjected to some stress, whether biotic or abiotic (Camargo, 2016; Menegale et al., 2015). In strawberry fruits, potassium silicate was shown to alleviate salt stress and improve fruit quality and health-related constituents (Yaghubi et al., 2019).

In this context, Si may enable plants to use N more efficiently, thereby reducing the negative impacts caused by either excess or deficiency of this element (Mabagala et al., 2020). Previous studies have shown that Si contributes to the functioning of N metabolism in plants by increasing the activity of enzymes such as glutamine synthetase, glutamate synthase, and glutamate dehydrogenase (Feng et al., 2010; Bybordi, 2012). Likewise, foliar Si application during scarlet eggplant cultivation may increase the activity of defense-related enzymes, such as phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO), peroxidase (POD), chitinase (CHI), and β-1,3-glucanase (GLU) (Song et al., 2021; Elsherbiny and Taher, 2018), thereby enhancing resistance to anthracnose.

Additionally, Si may act preventively by promoting the formation of physical barriers that hinder fungal penetration into scarlet eggplant fruits. In postharvest papaya, preventive Si treatment was found to reduce the incidence and severity of anthracnose caused by

Colletotrichum brevisporum (Vidal-Vergara et al., 2022). The authors attributed these results to the formation of physical and mechanical barriers at the cell wall level, which hindered pathogen penetration into fruit tissues. According to Rodrigues and Dallagnol (2024), this effect occurs because Si polymerization beneath the cuticle and in cell walls prevents pathogen penetration. It is worth noting that the positive effects of Si on reducing fruit diseases are not limited to postharvest applications. In a study conducted with chili pepper (*Capsicum annuum* L.), Si supply during the vegetative and flowering stages resulted in reduced lesion size caused by *Colletotrichum gloeosporioides* (Jayawardana et al., 2015).

In addition to these effects, foliar Si application during scarlet eggplant cultivation may contribute to vegetative development and positively affect yield and final fruit quality. As reported by Rodrigues and Dallagnol (2024), Si-supplemented plants exhibit enhanced photosynthesis and a more robust antioxidant system. These responses result from the effects of Si on the modulation of nutrient dynamics within plants, enhancing the uptake and distribution of macro- and micronutrients essential for photosynthesis (Mukarram et al., 2026). In sweet pepper, increases in the number of fruits per plant, fruit yield, and fruit fresh weight may have been associated with these benefits (Abdelaal et al., 2020).

Given this information, there is a clear need to better understand the relationship between nitrogen fertilization and anthracnose intensity in scarlet eggplant, as well as to identify strategies, such as foliar Si application, which may help overcome potential nutritional imbalances. Therefore, this study aimed to evaluate the influence of the interaction between nitrogen fertilization and foliar Si application on anthracnose incidence in scarlet eggplant fruits.

2. Material and Methods

The experiment was conducted in an experimental area of the Department of Entomology and Plant Pathology at the Federal Rural University of Rio de Janeiro (UFRRJ), Seropédica Campus, Rio de Janeiro, Brazil, located at 22°46′8.78″ S latitude and 43°41′38.33″ W longitude.

The experiment was conducted in a randomized complete block design (RCBD), with 25 treatments and three replications, totaling 75 plots. The 25 treatments were arranged in a 5 × 5 factorial scheme, consisting of five N rates (0, 25, 50, 100, and 200 kg ha^{-1}) combined with five Si concentrations (0, 0.2, 0.4, 0.6, and 0.8 L 100 L^{-1}). Each plot consisted of six plants transplanted at a spacing of 1.0 × 0.8 m, resulting in a plot area of 4.8 m^2 per plot (Figure 1A).

Initially, the chemical properties of the soil in the experimental area were determined by collecting 20 soil subsamples randomly from the 0–20 cm soil layer. The subsamples were homogenized to form a composite sample, from which 500 g of soil was collected and sent to the Soil and Water Management and Conservation Laboratory at UFRRJ. The chemical analysis yielded the following values: pH in H_2O = 5.55; Ca = 1.90 cmolc dm^{-3}; Mg = 0.30 cmolc dm^{-3}; H + Al = 2.97 cmolc dm^{-3}; K = 2 mg dm^{-3}; P = 100 mg dm^{-3}; and C = 29.3 g kg^{-1}.

The soil in the experimental area, which had previously been fallow, was prepared by one plowing and two harrowing operations. Plowing and the first harrowing were performed 60 days before transplanting. The second harrowing was performed immediately before transplanting.

Seedlings of scarlet eggplant cv. Português, which is susceptible to anthracnose, were produced in 162-cell plastic trays filled with a commercial substrate (Natus Solos do Brasil®), with two seeds sown per cell. Thinning was performed five days after seedling emergence, leaving one plant per cell. The seedlings were transplanted 55 days after sowing, when they had four to five true leaves.

Fertilization was performed according to the recommendations for scarlet eggplant cultivation in the state of Rio de Janeiro (Freire et al., 2013). Dolomitic limestone was applied at a rate of 1.85 t ha^{-1} 60 days before seedling transplanting. Basal potassium fertilization at 90 kg ha^{-1} was applied in the planting furrow to all treatments using potassium sulfate as the K source. The application was split into two equal portions, with half applied at seedling transplanting and the remaining half 30 days later.

The different N rates (0, 25, 50, 100, and 200 kg ha^{-1}) were equally divided into three applications and applied in the planting furrow. The first application was performed on the day of transplanting, and the remaining applications were made 30 and 60 days later. Ammonium sulfate was used as the N source.

The Si concentrations (0, 0.2, 0.4, 0.6, and 0.8 L 100 L^{-1}), supplied as potassium silicate (Silica®; 15% K and 14% Si), were diluted in water and sprayed over the entire aboveground portion of the plants until runoff using a manual backpack sprayer. Nine applications were performed, with the first at 35 days after transplanting (DAT) and the subsequent applications at 7-day intervals. In the 0 Si treatment, the plants were sprayed with water only.

Because the experiment was conducted in a previously fallow area, artificial inoculation of the fungus was necessary. Inoculated fruits were distributed throughout the experimental plots to allow the natural spread of the pathogen.

The fungus was isolated from scarlet eggplant fruits showing typical anthracnose symptoms. Isolation was performed by removing fungal structures from typical lesions and transferring them to Petri dishes containing potato dextrose agar (PDA) supplemented with 100 µg mL^{-1} streptomycin sulfate. After the isolate was obtained, its pathogenicity was confirmed on healthy scarlet eggplant fruits, and morphological and cultural characterization was performed.

Symptoms on the inoculated fruits were characterized by dark to grayish-brown lesions that varied in shape, initially circular and later becoming irregular or elliptical. The lesions became grayish in the central region, with orange to pinkish coloration corresponding to spore masses. Acervular conidiomata with brown, septate setae were observed in the center of the lesions. For cultural characterization, colonies were incubated at 25 °C under a 12-h light/12-h dark photoperiod. After 12 days, the colonies, which were initially whitish, became grayish and developed pinkish-orange masses of conidia. Optical microscopy revealed hyphae 1–4 µm in diameter, hyaline to light brown, septate, branched, and smooth-walled. Appressoria measured 6–12 × 5–8 µm, were brown, and varied in shape from clavate to irregular. Conidiogenous cells were 2–5 µm in diameter and hyaline to light brown. Conidia measured 9–16 × 4–7 µm and were oblong to fusiform, guttulate, and smooth-walled (Figure 1A and B). Based on these characteristics, the isolate was identified as belonging to the genus *Colletotrichum*.

Inoculation was performed at the onset of fruiting, 76 days after transplanting. Two central plants from each plot were selected, and two fruits on each plant were inoculated (Figure 1C). Small wounds were made near the fruit peduncle using a multi-needle device (Figure 1D), after which a 5-mm-diameter mycelial plug of the fungus was placed over the wounded area (Figure 1E). To keep the mycelial plug in contact with the fruit surface, it was secured with white masking tape (Figure 1F). The inoculated fruits were marked with a string and remained attached to the plants until the end of the experiment.

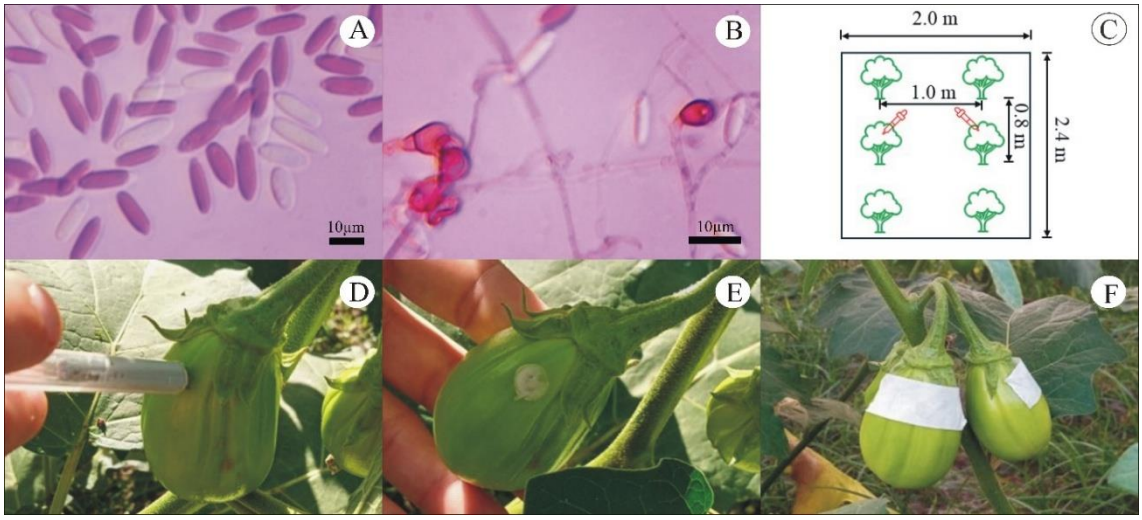

Figure 1. Morphological characteristics of Colletotrichum sp. isolated from scarlet eggplant fruits and procedures used for fruit inoculation. Conidia (A). Conidia and appressoria (B). Schematic representation of the experimental plot dimensions and plant spacing (C). Wounding of fruits using a multi-needle device (D). Placement of a fungal mycelial plug on the fruit (E). Mycelial plugs covered with masking tape after inoculation (F).

To promote the natural spread of the fungus throughout the experimental plots, sprinkler irrigation was applied according to crop water requirements. As previously reported, anthracnose is more severe during the rainy season or under sprinkler irrigation (Pereira et al., 2012).

Disease incidence was evaluated only in fruits that became naturally infected. The onset of symptoms was monitored daily to determine when the first symptomatic fruits appeared. The first assessment was performed 18 days after inoculation, and the final assessment was conducted when disease incidence reached 100% in at least one experimental plot. A total of four assessments were performed at 8-day intervals, recording the number of healthy and diseased fruits.

The percentage of diseased fruits in each plot was calculated according to the following equation:

$$\text{Disease incidence (\%)}: \frac{\text{Number of disease fruits}}{\text{Total number of fruits}} \text{x} 100$$

Based on the percentage of diseased fruits in each plot, the area under the disease progress curve (AUDPC) for disease incidence was calculated according to the equation proposed by Shaner and Finney (1977):

$$AUDPC = \sum_{i=1}^{n-1} \left(\frac{yi+(yi+1)}{2}\right)(ti+1 - ti)$$

In which:

AUDPC: area under the disease progress curve;

yi: proportion of disease in i-th observation;

ti: time, in days, in i-th observation;

n: total number of observations.

At 70 days after transplanting, fruits at the marketable stage were harvested and evaluated for the number of fruits per plant and fruit characteristics, including weight (g), diameter (cm), and length (cm). A total of six harvests were performed at 8-day intervals. Fruit weight was subsequently converted to yield (t ha^{-1}).

The variables analyzed were subjected to analysis of variance (ANOVA) in a 5 × 5 factorial arrangement, consisting of five N rates and five Si concentrations, for a total of 25 treatments. Variables showing a significant effect according to the F-test ($p \leq 0.05$) were subjected to polynomial regression analysis. The criteria used for model selection were the significance of the regression coefficients, lower standard errors of the coefficients, and regression mean square error, and a higher coefficient of determination (R^2). Statistical analyses were performed using Sisvar software (Ferreira, 2011).

3. Results and Discussion

The first symptoms on fruits inoculated with *Colletotrichum* sp. were observed four days after inoculation (DAI). However, symptoms resulting from natural infections were first observed at 18 DAI. At the final assessment, conducted at 39 DAI, the mean incidence of symptomatic fruits across all experimental plots was 95.76%.

According to the results of the analyses, N rates had a significant effect ($p \leq 0.05$) on the area under the disease progress curve (AUDPC) for disease incidence. The lowest AUDPC value, 161.9, was observed at an N rate of 111.33 kg ha^{-1}. In contrast, N rates of 0 and 200 kg ha^{-1} resulted in the highest AUDPC values, 246.19 and 215.37, respectively (Figure 2).

Nitrogen fertilization had a significant effect ($p \leq 0.05$) on yield and fruit characteristics of scarlet eggplant. The highest yield, 20.66 t ha^{-1}, was observed at an N rate of 123.5 kg ha^{-1} (Figure 3A). For the mean number of fruits per plant, the highest value, 45 fruits per plant, was observed at an N rate of 140.91 kg ha^{-1} (Figure 3B). The greatest mean fruit length, 7.17 cm, was observed at an N rate of 125.05 kg ha^{-1} (Figure 3C). Finally, the greatest mean fruit diameter, 4.43 cm, was observed at an N rate of 123.07 kg ha^{-1} (Figure 3D).

At the 5% significance level, no significant interaction between N rates and Si concentrations was observed for the area under the disease progress curve (AUDPC) for disease incidence, yield, mean number of fruits per plant, mean fruit length, or mean fruit diameter. Likewise, there was no significant main effect of Si concentrations on any of the variables analyzed.

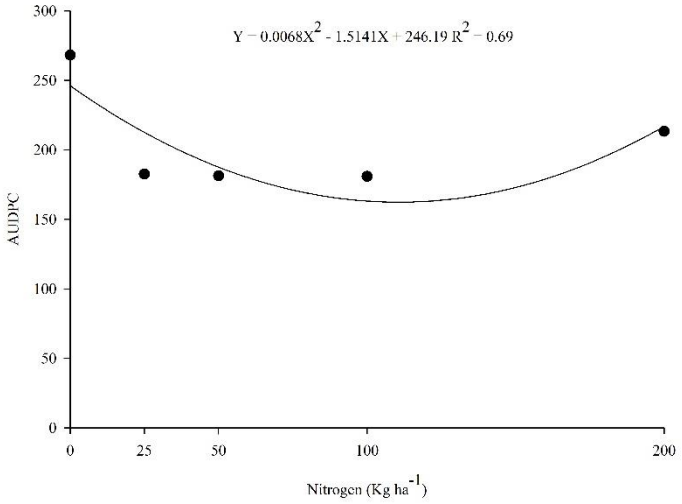

Figure 2. Area under the disease progress curve (AUDPC) for anthracnose incidence in scarlet eggplant fruits as a function of nitrogen (N) rates applied to the soil.

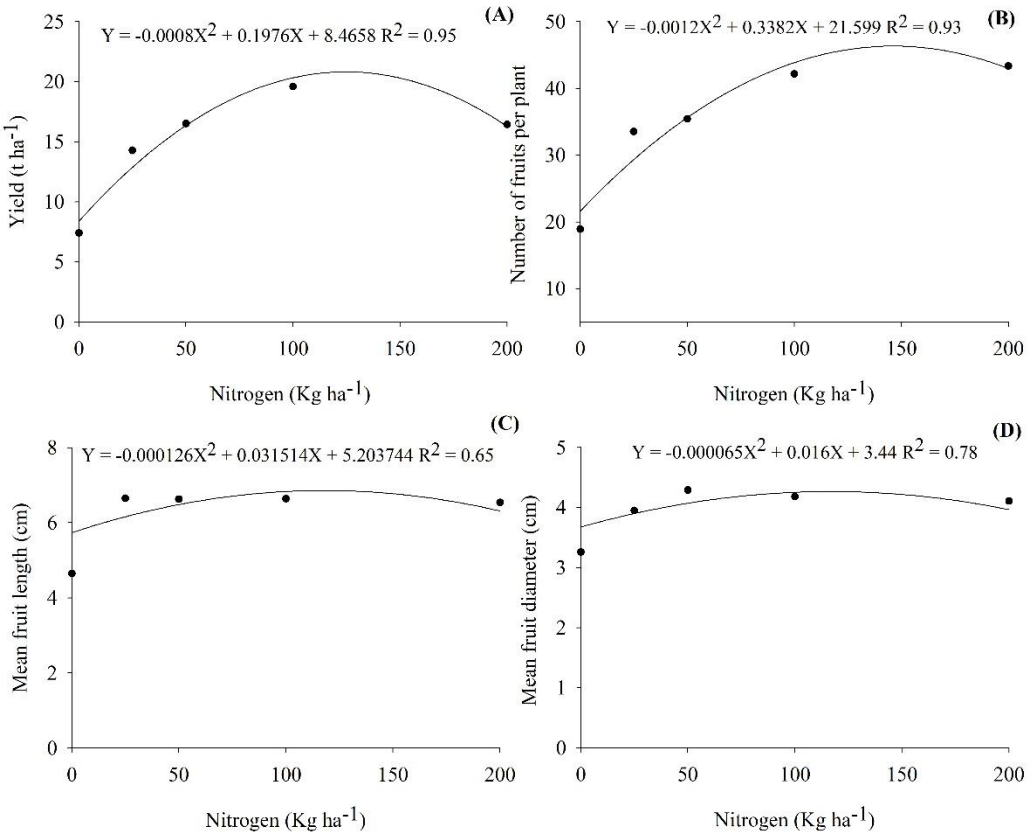

Figure 3. Yield (A), number of fruits per plant (B), mean fruit length (C), and mean fruit diameter (D) of scarlet eggplant as a function of nitrogen (N) rates applied to the soil.

Artificial inoculation of the pathogen and sprinkler irrigation favored disease epidemic development in the experimental area. Under favorable environmental conditions, *Colletotrichum* species develop acervuli in infected plant tissues, producing masses of conidia on conidiophores (Silva et al., 2017). The conidia are dispersed throughout the crop to new fruits by irrigation water and wind (Zakaria, 2025). As long as environmental conditions remain favorable, conidia are produced repeatedly, resulting in the polycyclic nature of the disease (Salotti et al., 2023). In the present study, environmental conditions and sprinkler irrigation favored epidemic development. At 39 days after artificial inoculation of the fungus, the incidence of symptomatic fruits resulting from natural infections had reached nearly all fruits in most experimental plots. As previously reported, during rainy periods and under conditions of high inoculum pressure, anthracnose incidence in scarlet eggplant fruits can reach 100% (Pereira et al., 2012).

Variation in nitrogen (N) rates was another factor that influenced disease incidence. The lowest area under the disease progress curve (AUDPC) for disease incidence was observed at an N rate of 111.33 kg ha^{-1}, indicating that both lower and higher N rates resulted in greater anthracnose incidence in the fruits. Several studies have shown that N supply can either decrease or increase disease incidence; however, in most studies, disease levels increased with increasing N availability (Sun et al., 2020; Rodrigues et al., 2019). These findings demonstrate that balanced N nutrition is a key factor in disease management (Tripathi et al., 2022). Nitrogen deficiency contributes to reductions in physiological processes and plant signaling pathways that are essential for defense responses to stress (Valenzuela, 2024). Excess N may also increase plant susceptibility because it promotes host growth, increases the amount of young susceptible tissue, and raises amino acid concentrations that may favor infection (Huber et al., 2012). However, adequate N levels contribute to the synthesis of lignin, phytoalexins, and tannins and, consequently, enhance plant resistance to pathogens (Freitas et al., 2015).

Few studies in the literature have addressed the effects of N supply on disease intensity in scarlet eggplant. However, studies in other solanaceous crops have shown both reductions and increases in disease development in response to N supply. In tomato, increased N supply resulted in greater plant resistance to *Fusarium oxysporum* f. sp. *lycopersici* and *Botrytis cinerea* (Hoffland et al., 2000). In the same crop, low N supply reduced plant susceptibility to the bacterial pathogens *Pseudomonas syringae* pv. *tomato* and *Ralstonia solanacearum* (Ding et al., 2021). In potato, a high N fertilization rate of 180 kg ha^{-1} reduced plant

resistance to *Phytophthora infestans* by approximately 78% (Jin et al., 2014).

The nutritional imbalance caused by inadequate N supply significantly affected yield. For scarlet eggplant cultivation, an N rate of 100 kg ha^{-1} is recommended (Pinheiro et al., 2015). However, under commercial production conditions, growers may increase N supply in an attempt to increase yield. The results of the present study may support this practice, since scarlet eggplant yield increased up to an N rate of 123.5 kg ha^{-1}. Torres et al. (2003) observed an increase of up to 35.7% in scarlet eggplant yield with increasing N fertilization; however, the highest N rate evaluated by the authors was 96 kg ha^{-1}. In a study conducted under different irrigation depths and N rates, an N rate of 187 kg ha^{-1} resulted in higher scarlet eggplant yield (Mwinuka et al., 2021).

In the present study, the number of fruits per plant required the highest N rate, exceeding 140 kg ha^{-1}. Similar results were reported by Mwinuka et al. (2021), who observed a marked increase in this variable as the amount of N applied increased. According to these authors, this response may directly influence the economic return to growers. However, excessive N rates may reduce the number of fruits and, consequently, yield (Pinheiro et al., 2015). For the other variables, fruit length and diameter, the responses to N supply were similar to those observed for yield. In a previous study, increasing N rates did not significantly affect these variables, although this may be related to the range of N rates evaluated, since the highest rate applied was 96 kg ha^{-1} (Torres et al., 2003). These results highlight the importance of balanced fertilization. For all variables, there was an optimal balance between plant responses and N rates. Therefore, excessive N application may increase anthracnose incidence in scarlet eggplant fruits, reduce yield and fruit quality traits, increase production costs, and contribute to environmental pollution.

In the present study, silicon (Si), either applied alone or in interaction with N, did not affect the area under the disease progress curve (AUDPC) for disease incidence. Specifically for scarlet eggplant, studies investigating the benefits of Si for crop development are scarce, particularly regarding the interaction between this element and disease intensity. However, in other solanaceous crops, both effective and ineffective responses of Si in reducing disease have been reported. Similar to the results obtained in the present study, tomato plants sprayed with different Si concentrations (10, 20, 30, 40, and 50 g L^{-1}) showed no reduction in bacterial spot caused by *Xanthomonas* spp., regardless of the concentration applied (Anjos et al., 2014). In contrast, in potato (*Solanum tuberosum* L.), foliar Si application enhanced the activation of plant defense responses and, consequently, increased resistance to *Phytophthora infestans* (Xue et al., 2021).

The effectiveness of silicon in reducing diseases and other stresses may be influenced by several factors, including application method, plant species, plant age, and Si source (Kaushik and Saini, 2019). In pepper (*Capsicum annuum* L.), Si supplied through the nutrient solution during vegetative growth and flowering reduced the area of fruit lesions caused by *Colletotrichum gloeosporioides*. However, when Si was supplied only during the vegetative growth stage, no significant reduction in lesion area was observed (Jayawardana et al., 2015). In the present study, Si was applied only to the leaves.

According to Kaushik and Saini (2019), foliar spraying may be an effective method of Si application, although it has not been adequately investigated. In addition, solanaceous species are considered poor Si accumulators (Mandlik et al., 2020). Therefore, further studies are needed to better establish the influence of Si on anthracnose intensity in scarlet eggplant. Future studies should evaluate different product concentrations, Si sources, application timings, and application methods.

4. Conclusions

Nitrogen rates ranging from 0 to 200 kg ha^{-1} in scarlet eggplant cultivation significantly influenced anthracnose incidence, fruit characteristics, and yield. Extreme N rates, either low or high, resulted in greater anthracnose incidence and reduced yield and fruit quality. Therefore, N fertilization in scarlet eggplant cultivation should be balanced according to crop nutritional demand to reduce the number of fruits affected by anthracnose, thereby potentially reducing the need for fungicide applications, improving the economic viability of production, and contributing to environmental preservation. Finally, foliar application of silicon (Silica®; 15% K and 14% Si) to scarlet eggplant plants at product concentrations of up to 0.8 L 100 L^{-1}, either alone or combined with N supply, did not affect anthracnose incidence in the fruits, yield, or fruit characteristics. Therefore, further studies with scarlet eggplant are recommended, evaluating different Si concentrations, sources, application timings, and application methods.

Authors' Contribution

Conceptualization and methodology: A.S.F. and M.B.P.; investigation, data collection, and data curation: M.B.P., A.S.F., I.S.L., F.M.S., and M.S.M.; project administration and supervision: A.S.F; data analysis and figure design: A.S.F.; data interpretation: A.S.F. and

M.B.P.; writing the original draft of the manuscript: M.B.P., A.S.F. and C.A.I.; writing, review and editing: M.B.P., A.S.F., I.S.L., F.M.S., M.S.M. and C.A.I.; All authors have read and agreed to the published version of the manuscript.

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