

AVALIAÇÃO PRODUTIVA E BIOMÉTRICA DA ABOBRINHA ITALIANA COM DIFERENTES FONTES E DOSES DE NITROGÊNIO VIA FERTIRRIGAÇÃO

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1 RESUMO

A avaliação de respostas produtivas e biométricas da cultura da abobrinha são essenciais para verificar o comportamento da planta quanto a diferentes manejos, como diferentes fontes e doses de fertilizantes nitrogenados, além das características produtivas do fruto, a análise de folhas e quantidade de fotoassimilados são importantes, pois o nitrogênio é o elemento essencial na produção de folhas e na composição da clorofila, além da síntese de aminoácidos, proteínas e enzimas. Assim, objetivou-se com o trabalho avaliar doses e fontes de nitrogênio, aplicados via fertirrigação nos parâmetros produtivos e biométricos da abobrinha italiana, em Latossolo Vermelho Distroférrico em Dourados/MS. O delineamento experimental foi inteiramente casualizados em esquema de fatorial (2 x 5), duas fontes de nitrogênio (ureia e nitrato de cálcio) e cinco doses de nitrogênio (0, 60, 120, 240 e 480 kg ha⁻¹) nas subparcelas. A colheita foi iniciada aos 48 dias após a semeadura. Os resultados mostraram que a abobrinha respondeu significativamente as doses aplicadas, tendo melhor resultado na dose de 480 kg de N ha⁻¹ via Nitrato de Cálcio, com Ureia as respostas ficaram iguais de 60 a 240 kg de N ha⁻¹, o índice SPAD apresentou diferenças significativas entre as doses do tratamento de Ureia.

Palavras-chave: ureia, nitrato de cálcio, irrigação, índice SPAD

SCHWERZ, F.; BISCARO, G. A.; SOUZA, D. P. DE; LOPES, A. DA S.; OLIVEIRA, G. Q. DE
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2 ABSTRACT

Assessment of the productivity and biometric responses of zucchini crops is essential for understanding plant behavior under different management practices, such as varying sources and rates of nitrogen fertilizers. In addition to fruit yield characteristics, leaf analysis and the amount of photoassimilates are important, since nitrogen is a key element in leaf production, chlorophyll composition, and the synthesis of amino acids, proteins, and enzymes. Thus, the objective of this study was to evaluate the effects of nitrogen rates and sources applied via fertigation on the productivity and biometric parameters of Italian zucchini grown in a Dystroferric Red Latosol in Dourados, MS. The experimental design was completely randomized in a factorial scheme (2×5), consisting of two nitrogen sources (urea and calcium nitrate) and five nitrogen rates (0, 60, 120, 240, and 480 kg ha⁻¹) in the subplots. Harvesting began 48 days after sowing. The results indicated that zucchini responded significantly to the applied nitrogen rates, with the best performance occurring when 480 kg N ha⁻¹ was supplied as calcium nitrate. For urea, the responses were similar across the 60 to 240 kg N ha⁻¹ range. The SPAD index significantly differed between nitrogen rates within the urea treatment.

Keywords: urea, calcium nitrate, irrigation, SPAD index

3 INTRODUCTION

Zucchini is a plant from the Cucurbitaceae family that originates from the American continent (Fernandes, 2015). The genus *Cucurbita* (native to the Americas) is considered, throughout the plant kingdom, as one of the most diverse in terms of plant morphology/architecture and fruit characteristics (Amaro *et al.*, 2014). Zucchini cultivation is recommended during the dry season, but the use of irrigation ensures adequate water consumption (Carpes *et al.*, 2008).

With the goal of meeting market demands and improving resources, the use of fertigation allows for a greater distribution of fertilizers and greater nutrient absorption efficiency by plants (Blanco; Folegatti; Nogueira, 2002). Fertigation consists of the simultaneous application of fertilizers and water through an irrigation system. For this technique to be efficient, a balance is needed between the amount of nutrients and the amount of water to be applied during each phase of the crop cycle, which determines the concentration of fertilizers in the

irrigation water (Blanco *et al.*, 2002; Villas Boas; Souza, 2008).

The most mobile nutrient in the soil is nitrogen (N) in the form of nitrate (NO₃⁻). Although plants readily absorb nitrate, ammonium, and urea, responses to NO₃⁻ are usually faster because nitrate is carried by water to the root surface via mass flow. In cucurbits, increasing the N dose to a certain limit increases the plant's leaf area, affecting the production of photoassimilates and, consequently, fruit production (Queiroga *et al.*, 2007). According to Costa *et al.* (2015), among nutrients, nitrogen most strongly influences the dynamics of flowering and fruit set. This effect of nitrogen on increasing the fruit set rate is related to its role in regulating the photosynthetic rate and carbohydrate synthesis, leaf specific mass, total biomass production, and carbon allocation in different plant organs, which favor the nutrition of flower buds (Nava, 2007).

However, a high number of flowers does not always result in a relatively high fruit load, as their formation requires high production, translocation, and carbohydrate consumption.

If irrigation management is inadequate, for example, with excess water, nitrate will be leached below the root zone. Therefore, studies testing different doses and sources of nitrate are necessary to determine which dose results in greater conversion to fruit productivity and efficiency in terms of fertilizer use. Despite the economic and nutritional importance of zucchini, few studies have been conducted on the effects of fertilization using irrigation on this crop, especially studies related to the effects of nitrogen fertilization on productivity gains.

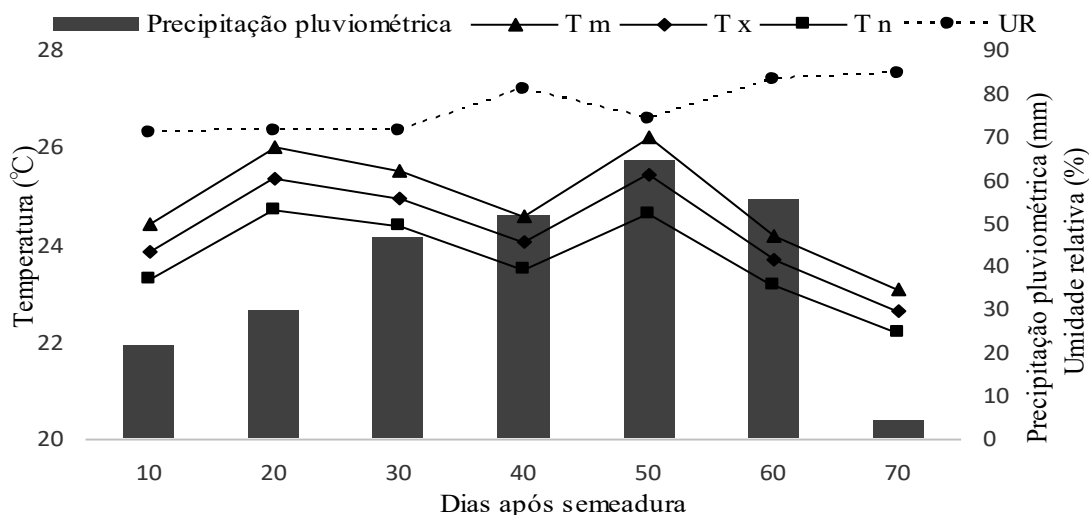
In this context, the present work aimed to evaluate the productive and biometric responses of Italian zucchini cultivated under different doses and sources of nitrogen applied via fertigation in a localized irrigation system in Dourados/MS.

4 MATERIALS AND METHODS

The experiment was conducted from September 29 to December 4, 2015, in the Irrigation and Drainage area of the Faculty of Agricultural Sciences (FCA) at the Federal University of Grande Dourados (UFGD), in Dourados-MS, with geographic coordinates 22° 11' 45" S and 54° 55' 18" W, at an altitude of 446 m.

The soil in the experimental area is classified as a Dystrophic Red Latosol, with a very clayey textural class (Santos *et al.*, 2013). During the experiment, the average daily air temperature was 24.2°C, with minimum temperatures ranging from 22.2°C to 24.2°C and maximum temperatures ranging from 23.2°C to 27.8°C. The total precipitation volume was 312.6 mm, with the highest rainfall observed 56 days after emergence at 59.2 mm (Figure 1).

Figure 1 Tm), minimum (Tn), average (Tx) temperature, relative air humidity (RH) and rainfall observed during the experimental period in Dourados, MS, 2015.



Source: Prepared by the author

Thirty days before sowing, the soil was prepared with plowing and harrowing to break up clods. The “Caserta” variety of zucchini, from the ISLA brand, was used and sown manually in rows spaced 1.0 m and 0.6 m apart (16,666.67 plants ha⁻¹). After sowing, 15 mm of initial irrigation was carried out to

reach field capacity. Irrigation was performed via a drip irrigation system, using a PETRODRIP® Manari model drip hose with emitters spaced 0.2 m apart, a flow rate of 1.5 L h⁻¹ and a working pressure of 10 mca, with one irrigation line installed for each row of crops.

The experiment was conducted in a completely randomized design (CRD) with a 2 x 5 factorial arrangement, with two treatments using different nitrogen sources and five doses. The treatments consisted of two nitrogen sources, urea (46% N) and calcium nitrate (15.5% N and 19% Ca), and five N doses (0, 60, 120, 240, and 480 kg ha⁻¹), with four replications, applied via fertigation, split into four applications, with the first application 15 days after sowing and the others spaced every 10 days. The experimental plot consisted of 18 plants, arranged in three rows of six plants each. The useful area of the plot corresponded to that occupied by the four central plants of the central rows.

Irrigation management was based on the estimation of crop evapotranspiration (ETc). The daily estimate of reference evapotranspiration (ETo) was calculated using data from the Dourados-A721 Automated Meteorological Station (INMET), according to the Penman–Monteith method as described by Allen *et al.* (1998). The Kc values adopted were based on Doorenbos and Pruitt (1977) and Doorenbos and Kassam (1979) and ranged from 0.40 to 0.50 (vegetative phase), 0.65–0.75 (flowering phase), 0.90 to 1.0 (fruiting phase), and 0.7 to 0.80 in the senescence phase.

To adjust the corrected ETc for the localized irrigation method (mm day⁻¹), the correction factor (KL) was adopted and estimated according to Equations 1 and 2 of Keller and Bliesner, as described by Bernardo, Soares and Mantovani. (2008), which considers the percentage of wetted area (PAM), in this experiment with a value of 50%.

$$ET_{C_{Loc}} = ET_c \times KL \quad (1)$$

$$KL = 0,10 \times PAM^{1/2} \quad (2)$$

The maximum net water depth at the time of irrigation (LL) was calculated using Equation 3, where P is the accumulated rainfall on the days observed between irrigation events (mm).

$$LL = ET_{C_{Loc}} - P \quad (3)$$

The gross water depth was calculated according to Equation 4, considering the maximum net water depth (LL) as the sum of ETcLoc until the maximum amount of easily available water (AFDLoc) was reached = 9.5 mm. Thus, the calculation of the maximum net water depth at the time of irrigation was taken as a reference to be applied with drip irrigation. When the sum of ETcLoc was less than or equal to AFDLoc, irrigation was carried out, always keeping values below the maximum net water depth.

$$LB = \frac{LL_{m\acute{a}xima}}{Ef} \quad (4)$$

where LB is the gross irrigation depth (mm) and Ef is the irrigation system efficiency (0.95).

Therefore, the irrigation time was calculated according to Equation 5 with respect to the irrigation time (Ti).

$$Ti = 0,001 \frac{LL(E_{LL} \times E_A)}{0,95 \times Q_n} \quad (5)$$

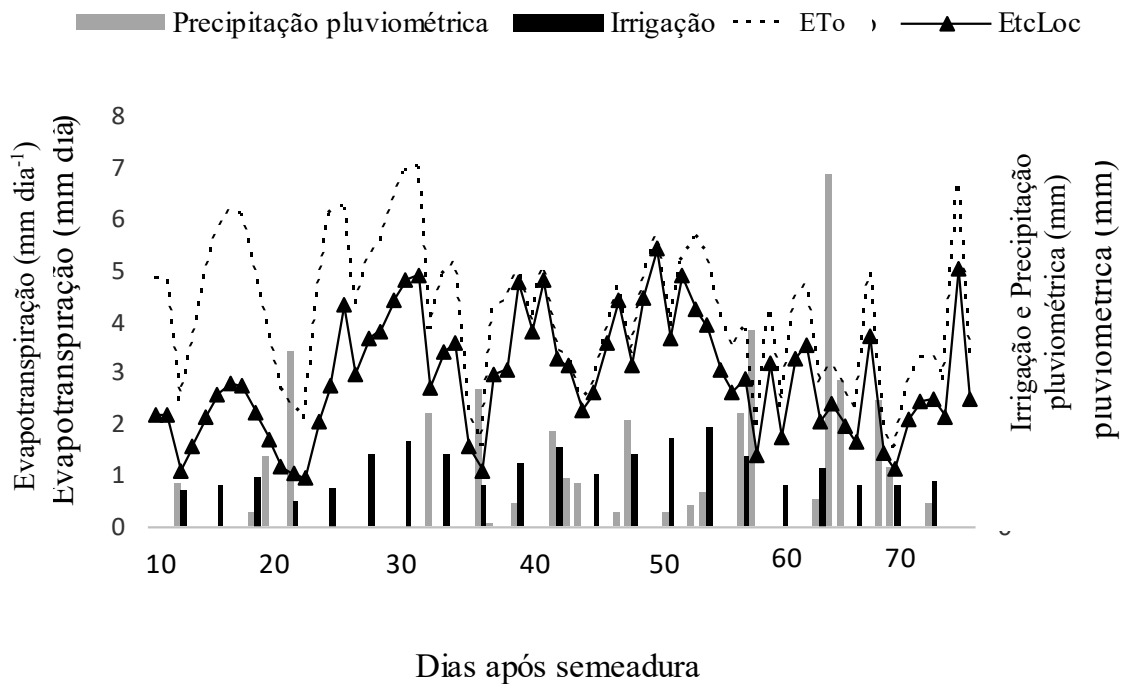
where Ti is the irrigation time (hours), LL is the liquid depth (mm), ELL is the spacing between plant rows (m), EA is the spacing between plants (m), Q is the flow rate (m³ h⁻¹), and n is the number of emitters.

Twenty-one irrigations were carried out during the experiment, with an average water depth of 8.9 mm (Figure 2). The nitrogen source treatments were applied using a differential pressure fertilizer injection system (Figure 3) adapted for small areas or plots. The normal water flow

through the hoses was interrupted by closing a valve attached to the hose, thus forcing the flow of the irrigation water toward a reservoir (PET bottle) containing the fertilizers at their respective doses. After 30

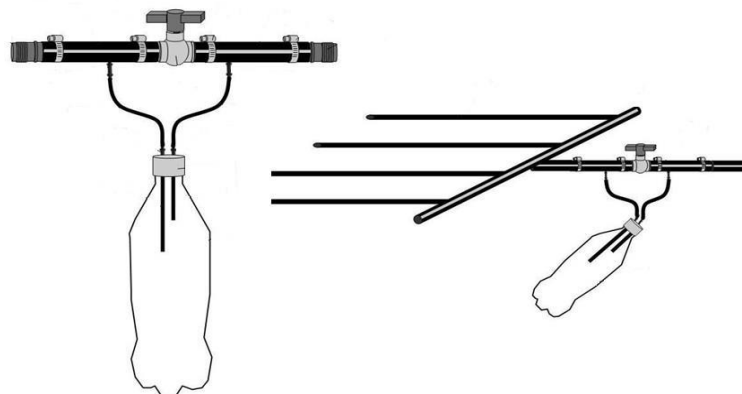
minutes, the valves were reopened to allow the water to flow normally, completing the established irrigation time and thus cleaning the drip irrigation hoses to minimize the effect of emitter clogging due to excess salt.

Figure 2. Reference evapotranspiration (ET_o), crop evapotranspiration in a drip irrigation system (ET_{cLoc}), irrigation, and rainfall observed during the experimental period in Dourados, MS, 2015.



Source: Prepared by the author

Figure 3. Differential pressure fertigation system. Dourados, MS.



Source: Prepared by the author

Harvesting began at 46 DAS (days after sowing), continued until 66 DAS, and was carried out manually three times a week. For production evaluation, immature fruits with lengths ranging from 17 to 23 cm were harvested. Productivity evaluation was performed considering the following parameters: number of fruits per plant (NFP), fresh fruit mass (MFF), fruit length (CF), fruit diameter (DF), and productivity (PROD). Biometric evaluation was performed considering the following parameters: plant height (AP), number of leaves (NF) per plant, dry leaf mass (MSF), and chlorophyll content. AP was determined using a ruler, and the plant was measured from the collar to the tip. Chlorophyll was evaluated using the SPAD index at 28 DAS on the fourth fully expanded leaf from the apex with a SPAD-502 portable chlorophyll meter (Minolta). Five SPAD index measurements were taken per leaf in the central region of the leaf blade of each plant in the useful plot, totaling 20 measurements per plot in each treatment.

The data were subjected to analysis of variance, and the means were compared using the F test at 5%, 1%, and 0.01% probability levels for the nitrogen sources. Regression analysis was performed for the nitrogen doses. The data were analyzed using the RStudio program.

5 RESULTS AND DISCUSSION

There was a significant difference in the applied doses for all the evaluated characteristics. The NFP, MFF, and PROD variables also significantly differed depending on the use of nitrogen sources, indicating that for this study, calcium nitrate or urea appeared to produce different responses in terms of fruit weight and number but not in terms of their dimensions or quantity per plant (Table 1). The MFF means were compared using Tukey's test (Figure 4).

Table 1. Summary of the analysis of variance for the number of fruits per plant (NFP), fresh fruit mass (MFF), fruit length (CF), fruit diameter (DF), and productivity (PROD) of zucchini in relation to nitrogen sources and doses. Dourados, MS .

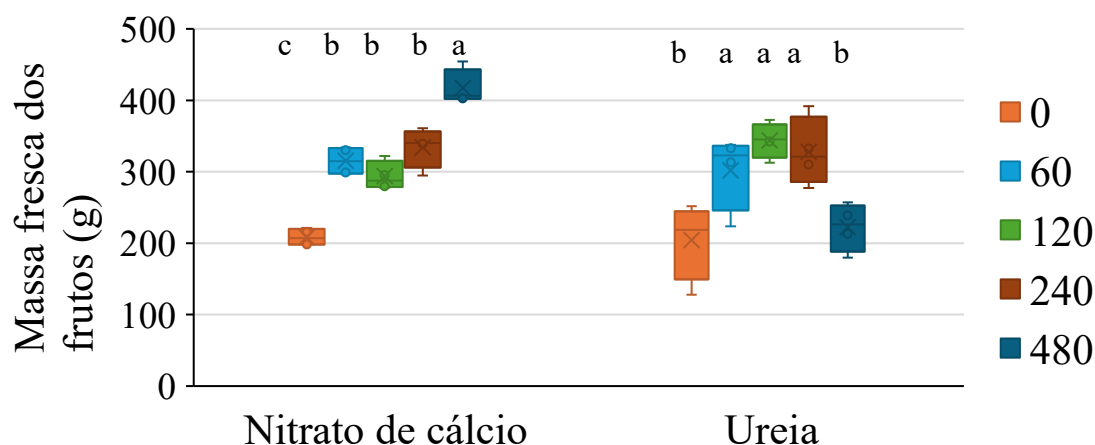
	Fv	GI	NFP	MFF	CF	DF	PROD
Dose	4	143.34 ***	21049 ***	41.08 ***	4,739 ***	6.293e+13 ***	
Source	1	216.23 ***	11415 **	3.23 ns	0.001 ns	2.825e+13 ***	
Dose x Source	4	17.16 ns	17538 ***	0.60 ns	0.758 **	2.591e+13 ***	
Residue	30	14.49	1211	1.59	0.166	1.339e+12	

ns: not significant; *, **, and ***: significant at 5%, 1%, and 0.01% probability, respectively, according to the test.

Source: Prepared by the author

With respect to the biometric variables, there was a significant difference for the doses applied in terms of all the variables, and in the NF, MSF, and SPAD, there were significant differences in terms of the use of nitrogen sources, indicating that

for this study, calcium nitrate or urea appeared to elicit different responses. The chlorophyll content differed according to the interaction (dose \times source), as presented in Table 2, and the results of the Tukey test are presented in Figure 5.

Figure 4. Fresh fruit weight (g) per dose for each nitrogen source.

Tukey's test for comparison of means. Lowercase letters compare doses within each source. CV (%): Calcium nitrate: 7.24 Urea: 9.002.

Source: Prepared by the author

Table 2. Summary of the analysis of variance for the variables plant height (PH), number of leaves (NL), leaf dry mass (LDM) and SPAD index of zucchini leaves in relation to nitrogen source and dose. Dourados, MS.

Fv	GI	AP	NF	MSF	SPAD
Dose	4	75.50 ***	53.14 ***	2351 ***	58.29 ***
Source	1	3.31 ns	3.78 *	11182 **	65.14 ***
Dose x Source	4	6.16 *	1.2 ns	17,16 ns	22.24 ***
Residue	30	1.68	0.60	14.49	2.02

^{ns} not significant; *, *, *, and *** indicate significance at 5%, 1% and 0.01% probability, respectively, according to the F test.

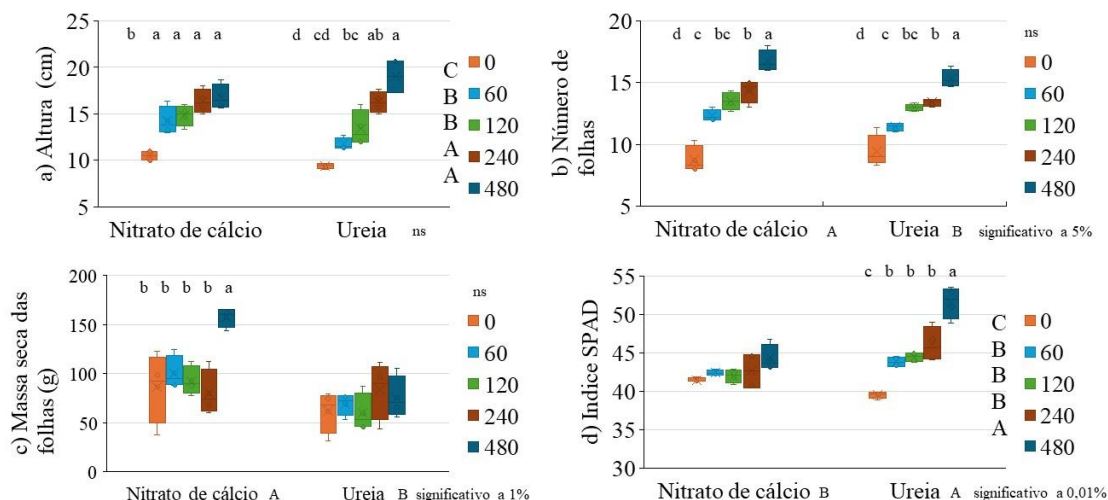
Source: Prepared by the author

Compared with urea, calcium nitrate provided statistically superior averages, as it resulted in a greater increase in MFF (Figure 4). This behavior is likely related to the calcium present in the nitrogen fertilizer, indicating the preference of zucchini for absorbing N in a nitric form (calcium nitrate) compared with the amidic form (urea). According to Larcher (2000), among other factors, the species/cultivar has implications

for metabolic adjustments to ammonium and nitrate absorption.

Calcium nitrate increased the availability of nitrogen in the soil because of its high solubility and ionic form. Furthermore, it is among the most water-soluble nitrogen fertilizers and is suitable for fertigation, especially in localized irrigation systems such as drip irrigation (Borges; Silva, 2011; Costa *et al.*, 2015).

Figure 5. Tukey's test for comparison of means: a) Height; b) Number of leaves; c) Leaf dry mass; d) SPAD index.



Lowercase letters compare doses within each font. Uppercase letters compare fonts and average doses; ns, not significant.

Source: Prepared by the author

The application of nitrogen doses via fertigation, regardless of the source used, increased zucchini productivity. When the equations (dose x productivity) were derived, the necessary dose of calcium nitrate to obtain maximum productivity (47,641.66 kg ha⁻¹) was found with a dose of 355 kg ha⁻¹, whereas for the urea source, the maximum production was 39,579.83 kg ha⁻¹ with a dose of 263.07 kg ha⁻¹. Oliveira *et al.* (2022), also studied doses of calcium nitrate and reported that the maximum dose for zucchini cultivation was 326.64 kg ha⁻¹.

The use of urea was significantly different between doses; the highest dose resulted in the highest SPAD index (Figure 5d), with an increasing trend in the (dose x chlorophyll) relationship. With the use of calcium nitrate, no differences were observed between doses, with a linear relationship between dose and the SPAD index; however, the number of leaves increased with increasing dose. A comparison of the averages of the two sources revealed that the dose of 480 kg ha⁻¹ resulted in the highest chlorophyll content, whereas the intermediate dose did not significantly differ.

The SAPD values and indices are within the normal range reported by other studies for different crops and nitrogen sources and doses, between 20 and 75 (Freitas *et al.*, 2020; Gil *et al.*, 2002; Jesus; Marengo, 2008; Cunha *et al.*, 2015).

6 CONCLUSION

Nitrogen sources via irrigation increase fruit mass and, consequently, productivity. Compared with the use of urea, the fertigation treatment using calcium nitrate resulted in greater results at a dosage of 480 kg ha⁻¹, which resulted in a decrease in fruit mass at the same dose. Nitrogen sources via fertigation increase height, number of leaves and leaf dry mass, and chlorophyll content. The difference in chlorophyll content between the different doses of fertigation treatment with urea was detected.

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