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Cucumber response to different growing seasons and nitrogen doses

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Abstract

The purpose of this study was to verify the effect of growing season and nitrogen doses on the pickling cucumber. This work was carried out in a greenhouse at the Federal Institute of Goiás (IF Goiano) - Campus Urutaí. A randomized block design in a 2 x 5 factorial scheme with four replications was used. Two growing seasons (the first sown in January and second in April) and five nitrogen doses (0, 50, 100, 150, and 200 kg ha^{-1} of N) were evaluated. The seed of pickling cucumber used was the Kybria F1 hybrid. Nitrogen doses were applied at 15, 30, and 45 days after plant emergence. Each plot was composed of 10 plants, and the four central plants of each plot with a spacing of 0.2 m between plants and 0.8 m between rows were evaluated. Leaf nitrogen content, relative chlorophyll index, stem diameter, length and diameter of fruits, fresh and dry matter of fruits, the fresh matter of shoot, number of fruits, and yield per plant were evaluated. The growing seasons and nitrogen doses influenced the productive traits of the cucumber crop. The first growing season of the cucumber crop shows satisfactory results in terms of yield components at a dose of 100 kg ha^{-1} of nitrogen.

Keywords: greenhouse; *Cucumis sativus* L.; production; nutrition.

Resposta de pepino a diferentes épocas de cultivo e doses de nitrogênio

Resumo

Objetivou-se com este estudo verificar o efeito de épocas de plantio e doses de nitrogênio sobre a cultura do pepino para conserva. Este trabalho foi desenvolvido em casa de vegetação no Instituto Federal Goiano (IF Goiano) - Campus Urutaí. O delineamento experimental utilizado foi em blocos casualizados em esquema fatorial 2 x 5, sendo duas épocas de cultivo (primeira época semeada em janeiro e a segunda em abril) e cinco doses de nitrogênio (0, 50, 100, 150 e 200 kg ha^{-1} de N), com quatro repetições. Utilizou-se a semente de pepino para conserva híbrido Kybria F1. As doses de nitrogênio foram parcelas aos 15, 30 e 45 dias após emergência das plantas. Cada parcela foi constituída 10 plantas, sendo avaliadas as quatro plantas centrais de cada parcela com espaçamento de 0,2 m entre plantas e 0,8 m entre linhas. Avaliou-se o teor de nitrogênio foliar, índice relativo de clorofila, diâmetro do caule, comprimento e diâmetro de frutos, matéria fresca e seca de frutos, matéria fresca de parte aérea, número de frutos e produtividade por planta. As épocas de cultivo e doses de nitrogênio influenciaram nas características produtivas da cultura do pepino. A primeira época de plantio da cultura do pepino apresentou resultados satisfatório quanto aos componentes de produção na dose de 100 kg ha^{-1} de nitrogênio.

Palavras-chave: casa de vegetação; *Cucumis sativus* L.; produção.

Introduction

Classified as one of the main most consumed and commercialized vegetables in Brazil, cucumber (*Cucumis sativus* L.) belongs to the Cucurbitaceae family, showing high yield when grown under conditions of high temperatures, high luminosity, and adequate nutrients supply (AMARO *et al.*, 2014).

The cucumber is an annual herbaceous plant with long stems that has a habit of "indeterminate" growth, with development in the vertical direction or prostrate, depending on the presence or not of support. Its fruits are of the berry type, and its branches have tendrils that serve as a support to fix them (FILGUEIRA, 2012).

Pickling cucumbers have a high water content, close to 96%, and have low amounts of vitamins C and minerals. Due to its low acidity, it is necessary to add acetic acid to prolong the preservation in pickling by decreasing the pH, avoiding the development of microorganisms (SANTANA *et al.*, 2018).

There are numerous cucumber varieties and hybrids available on the market, which vary in shape, size, color, flavor, and vegetative traits (size, habitat, cycle, and reproductive biology). They are classified into five groups: Japanese, aodai, caipira, Dutch and industrial, with the groups most found in Brazil being: aodai, caipira, and Japanese (SEDIYAMA *et al.*, 2014).

High temperatures influence the development of these plants as it is a hot climate crop. Therefore, cultivation in open fields must be carried out during hot seasons, with temperatures varying between 18 and 20 °C at night, and from 25 to 28 °C during the day (SEDIYAMA *et al.*, 2014). However, the growing use of protected cultivation is notorious, as the quality of the products obtained is superior to that achieved in the field; besides pest control and the seasonality effects reduction, thus fruits are produced in a shorter cycle and throughout the year (OLIVEIRA *et al.*, 2011, SEDIYAMA *et al.*, 2012).

Even with the increase in the quality and yield of fruits that the protected cultivation provides, one must take into account two traits of great importance when planning to grow cucumber, the choice of the variety to plant and the growing season. When these factors are combined, they help make better use of the area, reduce the idle period and, consequently, increase yield and the producer profit (VIEIRA NETO *et al.*, 2018).

The temperature must also be taken into account, as it is one of the climatic factors that greatly affect the development and yield of species from the Cucurbitaceae family. The cucumber has low yield when grown in cold seasons, as it is a specie of a hot climate; therefore, greenhouses are an alternative for growing throughout the year. Nevertheless, temperature control becomes limited in greenhouses with a low technological investment. Thus, for the yield and quality of Cucurbitaceae fruits to remain the same at different growing periods, the leaf nitrogen content must be maintained during the flowering season, throughout topdressing fertilization (YANG *et al.*, 2015).

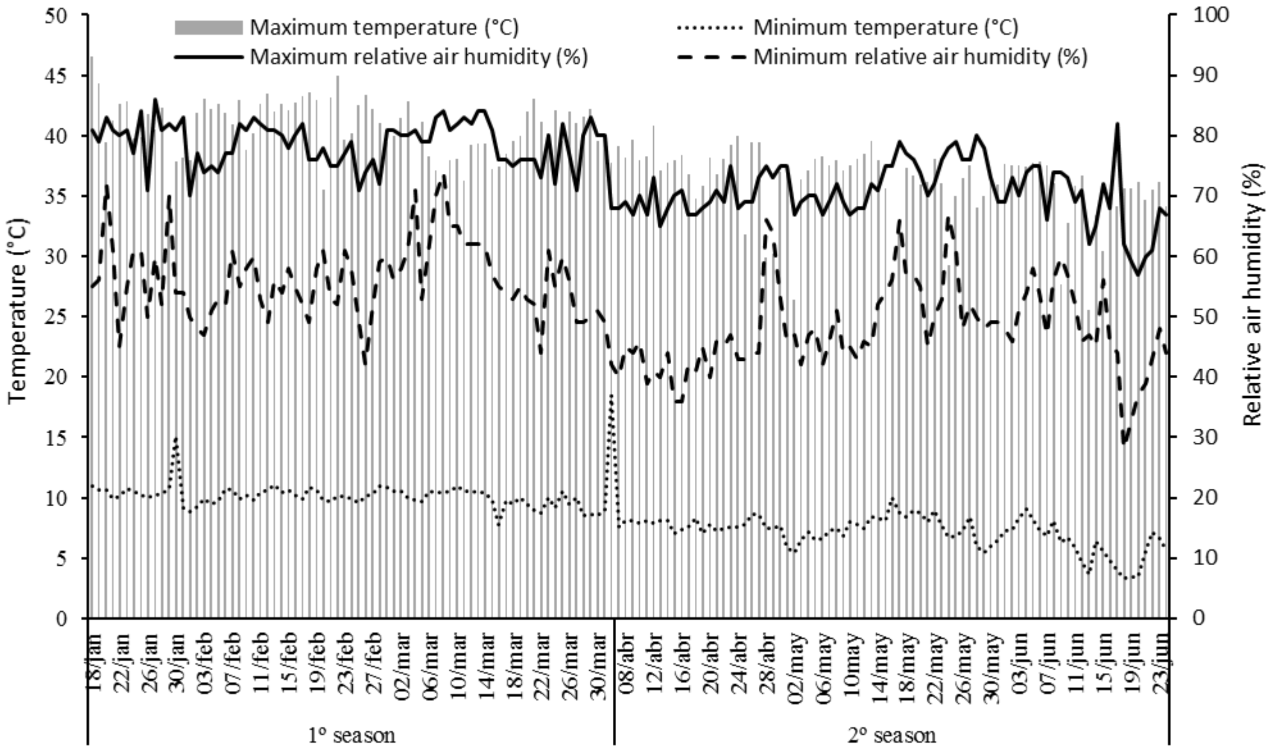
Nitrogen (N) is the nutrient required in the highest amounts by plants, especially by vegetables, responsible for the growth and development of plants by acting on the source-drain relationship and distribution of photoassimilates. Its efficient use is important in economic terms for the producer because the excess of N not only negatively affects the development and production of cucumber plants but also damages the environment. Consequently, the rational use of this nutrient is essential for agriculture’s sustainable development (XU *et al.*, 2012).

Nitrogen (N) influences processes involved in plant growth and development, promoting morphophysiological changes related to photosynthesis, root development and root activity, ionic nutrient uptake, cell growth and cell differentiation (Costa *et al.* 2015). There is a direct connection between the yield and the nitrogen supply. Pereira *et al.* (2021); Souza *et al.* (2018) and Antunes *et al.* (2015) observed an increased number of fruits per plant and the accumulation of mass when using nitrogen doses of 150 kg ha^{-1}. Therefore, the purpose of this study aimed to evaluate the effect of growing seasons and nitrogen doses on the pickling cucumber crop.

Material and methods

This study was conducted in a greenhouse at the Federal Institute of Goiás (IF-Goiano) – Urutaí campus, Urutaí, GO, at 17° 27'49'' S, longitude 48°12'06'' W, and the average altitude of 744 m. According to Koppen, the region´s climate is classified as humid tropical (AW-type) with rainy summer, an average air temperature above 22 °C (CARDOSO *et al.*, 2014). The temperature was recorded in the greenhouse during the project execution period, as shown in Figure 1.

Figure 1. Maximum and minimum air temperature values and maximum and minimum relative air humidity between January and June, in the greenhouse. Urutaí-GO.



The soil in the experimental area was classified as a Latossolo Vermelho distrófico (EMBRAPA, 2018). The soil chemical attributes were determined before the installation of the experiment, according to the methodology proposed by Ribeiro *et al.* (1999); The results of chemical analysis in the 0.0-0.20 m soil layer were 920 mg dm^{-3} of P (Melich-1); 23 g dm^{-3} of O.M.; pH ($CaCl_2$) of 5.7; K, Ca, Mg, and H + Al of 8.0; 89.0; 23.0, and 16.0 $mmol_c$ dm^{-3}, respectively, and 88.5% of base saturation.

A randomized block design in a 2 x 5 factorial scheme and four replications was used. Two growing seasons (the first season was sown in January and the second in April), and five nitrogen doses (0, 50, 100, 150, and 200 kg ha^{-1} of N) were evaluated. Nitrogen doses were split and applied at 15, 30, and 45 days after plant emergence. Each plot was constituted by ten plants, evaluating the four central plants of each plot with a spacing of 0.2 m between plants and 0.8 m between rows.

The greenhouse used for planting the cucumber was the agricultural nursery, with dimensions of 6.4 x 18.0 m, height under the gutter of 4.00 m and 6.00 m on the ridge and arch cover, built with galvanized steel arches, covered with a 150 µm light-diffusing polyethylene film.

The hybrid pickling cucumber seed (*Cucumis sativus* L.) Kybria F1 was used, with the first sowing season taking place in the second half of January, and the second sowing period in the first half of April, with two seeds, put directly in the planting hole. After crop emergence, thinning was carried out, leaving only one plant per hole. The irrigation was carried out by the drip irrigation system, keeping the soil close to the field capacity, that is, the potential of 15 kPa, being monitored by a set of mercury tensiometers, installed at 0.10 m from the crop at depths of 0.15-0.30 m in the experimental area. Manual weeding and phytosanitary control were performed as recommended for the crop.

For the first growing season, harvests began 37 days after sowing, continuing over 36 days. For the second growing season, harvests started 44 days after sowing, continuing over 34 days. In both growing seasons, harvests were carried out daily.

The content of leaf nitrogen was evaluated, where the fourth leaf was collected, with petiole completely expanded from the apex, from the four central plants of each parcel at 51 days after emergence (DAE). These leaves were placed to dry in an air-forced circulation oven at 65 °C for 48 hours. After drying, the material was grounded in a Wiley-mill, equipped with a mesh sieve with a 1 mm opening and packed in paper bags for analysis, according to the method described in Malavolta *et al.* (1997).

The relative chlorophyll index was also evaluated using a portable chlorophyll meter (ChlorofiLOG model CFL 1030). The reading was made on the fourth leaf fully expanded from the apex of four plants of each plot in the useful area. Readings were taken at 20, 35, and 50 days after emergence (DAE). The results were expressed in Chlorophyll Falker Index (CFI).

Phytotechnical evaluations were also performed: **a)** stem diameter was obtained with the aid of a digital caliper, the results were expressed in millimeters; **b)** the length and diameter of the fruits, measured with the aid of a graduated ruler and digital caliper, respectively; **c)** fresh and dry matter of fruits were determined by weighing the material, harvested in the useful area of each parcel, using a precision scale of 0.01 g before and after drying in an air-forced circulation oven at 65 °C, respectively. For the shoot fresh matter, the four plants of the useful area of each plot were collected and weighed; **d)** the number of fruits was obtained by counting the fruits produced per plant and then transformed into fruits per hectare; **e)** yield per plant was obtained through the weighing of the fruits produced per plant, and the values were transformed into kg ha^{-1}.

The data were submitted to analysis of variance (F test) and the means compared by the Tukey test at 5% probability for the growing seasons. A regression analysis was performed when the data showed significance for the N doses. Statistical analyses were processed using the Sanest statistical analysis program.

Results and discussion

The average values for leaf N content, relative chlorophyll index at 20, 35, and 50 days, and stem diameter are shown in Table 1. It is possible to observe a significant effect (p> 0, 05) of growing seasons of the cucumber crop on all variables, except for leaf nitrogen content (Table 1).

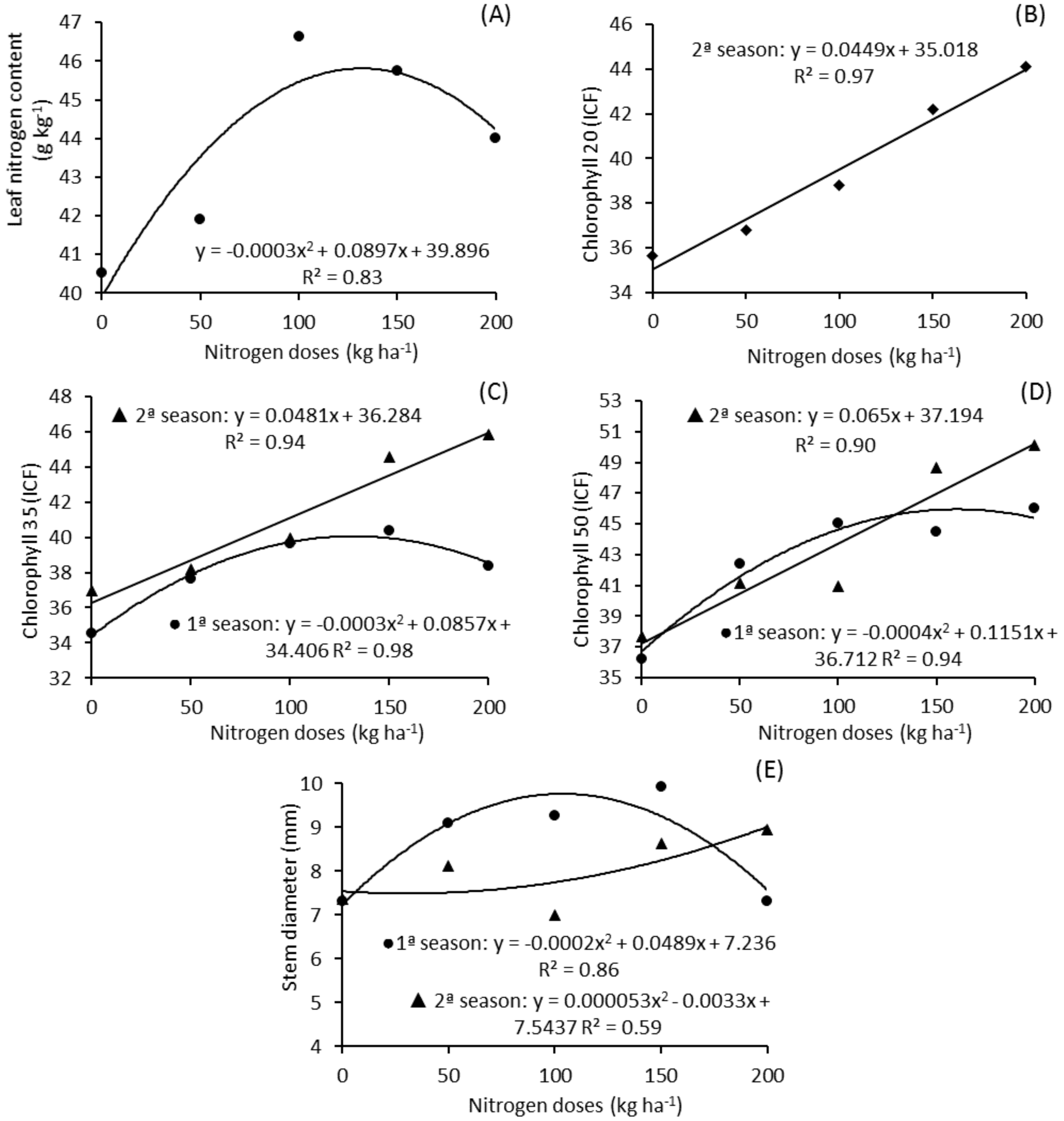
Table 1. Summary of variance analysis for leaf N content (LNC), relative chlorophyll index at 20, 35, and 50 days (CLOR 20, 35, and 50, respectively), and stem diameter (SD) of cucumber plants according to growing seasons and nitrogen doses. Urutaí-GO.

Growing season	**LNC --g kg^{-1}--**	**CLOR 20**	**CLOR 35**	**CLOR 50**	**SD --mm--**
		------------- RCI -------------			
1ª season	43.94 a	30.17 b	38.10 b	42.84 b	8.58 a
2ª season	43.59 a	39.51 a	41.09 a	43.69 a	8.02 b
F-value	0.35^{ns}	323.78*	81.61*	4.46*	14.66*
Nitrogen doses (kg ha^{-1})					
0	--	--	--	--	--
50	--	--	--	--	--
100	--	--	--	--	--
150	--	--	--	--	--
200	--	--	--	--	--
F-value	15.65*	8.96*	58.09*	93.20*	18.48*
Regression	(2)	(2)	(2)	(2)	(2)
Interaction	--	(1)	(1)	(1)	(1)
CV (%)	4.18	4.70	2.64	2.96	5.63

Means followed by the same lowercase letter, for each variable studied do not differ by Tukey's test at 5% probability, ns = not significant; * = significant at 5% probability; (1) = Significant interaction for the effect of growing seasons and nitrogen doses and (2) = Significant regression for the effect of nitrogen doses.

The values of leaf nitrogen content did not differ for the growing seasons; however, when evaluating the influence of nitrogen doses, it was possible to observe a significant effect, with the highest leaf content (46.6 g kg^{-1}) being observed for the estimated nitrogen dose of 149.5 kg ha^{-1} of nitrogen (Figure 2A).

Figure 2. (A) Average values of leaf nitrogen content; **(B)** chlorophyll content evaluated at 20 days; **(C)** 35 days; **(D)** 50 days after emergence; and **(E)** stem diameter of cucumber plants according to growing seasons and N doses. Urutaí-GO.



Similar results were reported by Souza *et al.* (2018) for nitrogen fertilization evaluation in the same cucumber hybrid. These results are efficient compared to those observed by Pôrto *et al.* (2014), who verified 48 g kg^{-1} for the estimated dose of 406 kg ha^{-1} of nitrogen. This result shows that the plants were adequately nourished since the leaf nitrogen content is within the range considered sufficient for the cucumber crop, which is between 45 and 60 g kg-1 of dry matter (TRANI; RAIJ, 1996).

There was a significant interaction between the growing seasons and nitrogen doses for the relative chlorophyll index at 20, 35, and 50 days as shown in Table 1 and illustrated in Figure 2B, 2C, and 2D. For the first growing season, the effect of the interaction on chlorophyll was observed at 35 and 50 days after emergence, and the data were adjusted to the quadratic model with the maximum values (40.52 and 45.0 RCI units) for the doses of 142.83 and 143.87 kg ha^{-1} of nitrogen, respectively (Figure 2C and 2D).

As a constituent in the synthesis and structure of chlorophyll molecules, nitrogen is a nutrient that, when supplied, up to a certain limit, produces an increase in chlorophyll content and green color intensity in the leaves of the plants (PÔRTO *et al.*, 2014).

For the second growing season, the data showed adjustment to a linear model with values between 35 and 44, 36 and 45, and 37 and 50 RCI units, for the relative chlorophyll index evaluated at 20, 35, and 50 days, respectively. This difference in results between the first and second growing seasons may be due to the temperature variation between growing seasons. In the second growing season, minimum temperatures below 18 °C were registered (Figure 1). Because it is a hot climate specie, absorption, metabolism, and nitrogen transport in the plant were affected (YANG *et al.*, 2015).

When evaluating the stem diameter, it was possible to observe a significant interaction between growing seasons and nitrogen doses. The data, for both growing seasons, were adjusted to the quadratic model. For the first season, at the estimated dose of 122.25 kg ha^{-1} of N, it was obtained a diameter of 10.22 mm. On the other hand, in the second growing season, similar results were found from the N dose of 31.13 kg ha^{-1}, with a minimum value of 7.49 mm (Table 1, Figure 2E). Souza *et al.* (2018) described values adjusted to the quadratic model with a maximum point of 99.5 kg ha^{-1} of N with a stem diameter of 10.13 mm when evaluating nitrogen doses and crop treatments in the cucumber crop.

Table 2 shows the average values for fruit length, fruit diameter, number of fruits, fresh and dry matter of fruits, and fresh matter of shoot, besides the yield per plant. A significant effect for length, number, fresh and dry matter of fruits, and fresh matter of shoot was observed concerning growing seasons. For the other variables studied, no significance was found.

Table 2. Summary of variance analysis for fruit length (FL), fruit diameter (FD), number of fruits (NF), fruit fresh matter (FFM), fruit dry matter (FDM), shoot fresh matter (SFM), and yield per plant (YIELD) of cucumber plants according to growing seasons and N doses. Urutaí-GO.

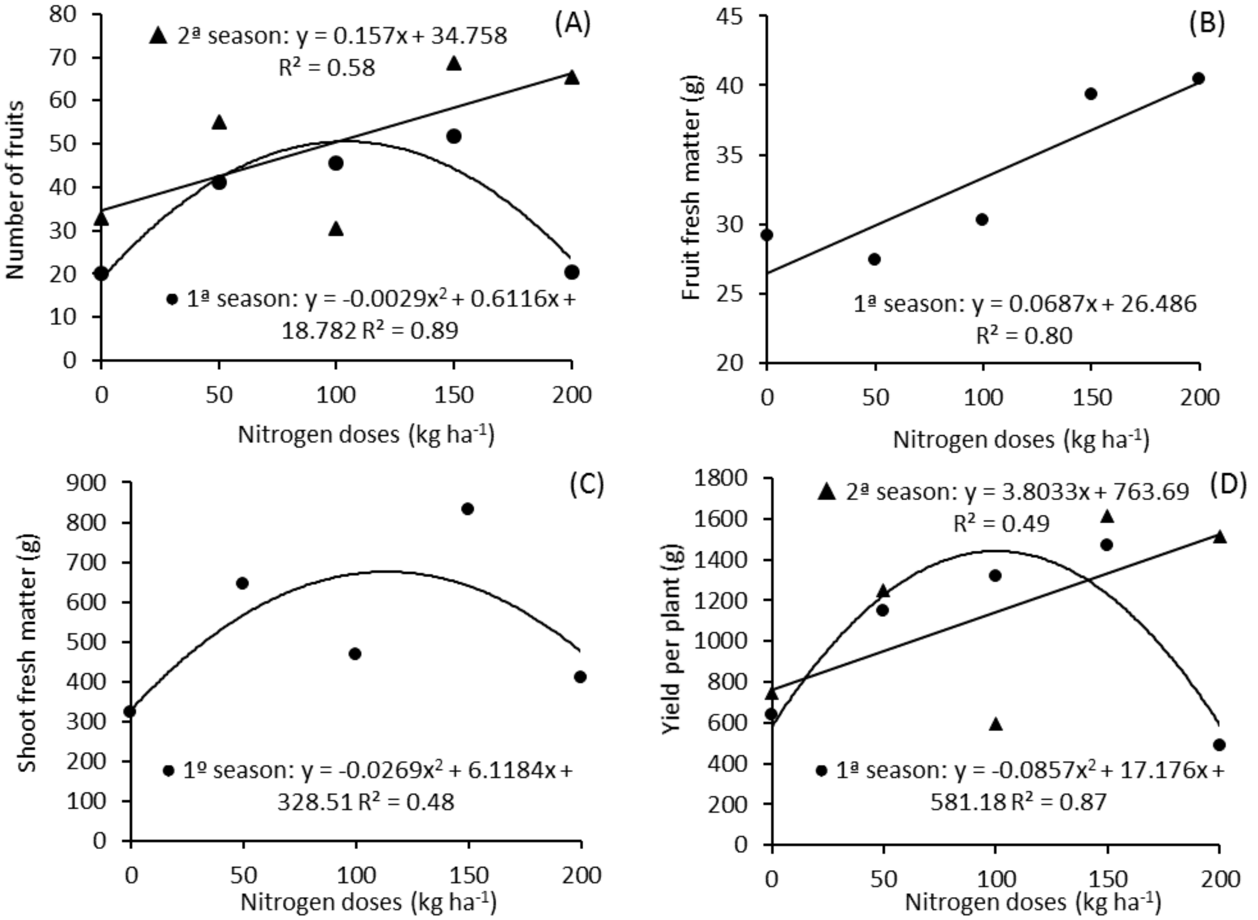
Growing season	**FL**	**FD**	**NF**	**FFM**	**FDM**	**SFM**	**YIELD**
	cm	**mm**			**-----------g-----------**		**g plant^{-1}**
1ª season	7.46 a	21.40 a	35.80 b	33.35 a	1.50 a	536.15 a	1014.29 a
2ª season	7.05 b	21.57 a	50.46 a	23.08 b	1.23 b	411.82 b	1144.01 a
F-value	126.16*	0.83^{ns}	17.65*	41.77*	4.95*	22.38*	1.85^{ns}
Nitrogen doses (kg ha^{-1})							
0	7.22	21.28	--	--	1.04	--	--
50	7.25	21.28	--	--	1.40	--	--
100	7.25	21.83	--	--	1.42	--	--
150	7.31	21.69	--	--	1.38	--	--
200	7.24	21.33	--	--	1.46	--	--
F-value	0.62^{ns}	1.69^{ns}	10.21*	5.16*	1.24^{ns}	27.73*	8.69*
Regression	--	--	(2)	(2)	--	(2)	(2)
Interaction	--	--	(1)	(1)	--	(1)	(1)
CV (%)	1.58	2.64	25.58	17.79	27.56	17.53	28.12

Means followed by the same lowercase letter, for each variable studied do not differ by Tukey's test at 5% probability, ns = not significant; * = significant at 5% probability; (1) = Significant interaction for the effect of growing seasons and nitrogen doses and (2) = Significant regression for the effect of nitrogen doses.

Also, it is possible to observe an influence by the growing seasons on crop traits such as fruit length, fresh and dry matter of fruit besides the shoot fresh matter (Table 2), showing the best results when the cucumber was sown in January (first growing season). Besides the N fertilization, the temperature may have altered these results, as this is a factor that directly influences the metabolism of photoassimilates by plants and the consequent emission of flower buds and fruit yield, as shown in Figure 1 (VIEIRA NETO *et al.*, 2018). Although the number of fruits was smaller in the first growing season, they showed greater length, fresh matter, and dry matter accumulation, which compensated the production.

It was not observed the influence of N doses on the fruit length and diameter (Table 2). Concerning the number of fruits, the effect of interaction between growing seasons and nitrogen doses was found. The data for the first growing season was adjusted to the quadratic model with 82.96 fruits for an estimated N dose of 105.44 kg ha^{-1} (Figure 3A). For the second growing season, the data showed a linear fit with values between 30 and 68 fruits (Figure 3A).

Figure 3. (A) Average values of the number of fruits; **(B)** fruit fresh matter; **(C)** shoot fresh matter; and **(D)** yield per plant of cucumber plants according to growing seasons and N doses. Urutaí-GO.



The data for fruit fresh matter showed an interaction between growing seasons and N doses ($p > 0.05$). Only in the first growing season, the data was adjusted to a linear model with values between 29 and 40 g (Figure 3B). These values are similar to those reported by Vieira Neto *et al.* (2018) of 21.41 g for fruit fresh matter when they studied the same crop.

There was the influence of the interaction between growing seasons and nitrogen doses on the shoot fresh matter (Table 2). The values of the first growing season were adjusted to the quadratic model with maximum values of 676.42 g for the estimated nitrogen dose of 113.72 kg ha^{-1} (Figure 3C). The higher shoot fresh matter values can be related to leaf area index (LAI), that is, the heavier the plant, the higher the LAI and, consequently, higher photosynthesis. Besides, the leaf is directly related to the translocation and distribution of photoassimilates and N metabolism, which helps in the formation of cellular constituents such as amino acids, proteins, among others, which are necessary for plant development and future production (SCHVAMBACH *et al.*, 2002).

There was an influence of the Interaction between the growing seasons and nitrogen doses on the yield per plant. In the first growing season, the data was adjusted to the quadratic model with the maximum value of 1441.78 g for the dose of 100 kg ha^{-1} of N (Figure 3D). For the second growing season, the data showed adjustment to the linear model with values between 594 and 1617g (Figure 3D). These results are superior to those stated by Silva *et al.* (2017), that when evaluating the growth and yield of cucumber fruits submitted to different sources of N fertilizers, observed production of 1030 g plant-1 regardless of the source used and close to the results of Souza *et al.* (2018) when studied pruning and N doses in cucumber crop. Wahocho *et al.* (2016) observed the highest rates when applied from 100 to 150 kg ha^{-1} of nitrogen in the plants.

Conclusion

The growing seasons and N doses influenced the yield traits of the cucumber crop.

The first growing season of the cucumber crop showed satisfactory results for the yield components at a dose of 100 kg ha^{-1} of nitrogen.

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