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ARTICLE

Heliconia development as a function of different soil types and nitrogen doses

Desenvolvimento de helicônia em função de diferentes tipos de solo e doses de nitrogênio

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Abstract: *Heliconia psittacorum* is a plant that stands out in tropical floriculture due to its inflorescence with bracts of different colors and its high ornamental value. The aim of this study was to assess the influence of nitrogen applied under different management methods on the development of heliconia plants (*H. psittacorum*). The experiment was carried out in a greenhouse, in the soil science area, from May to December 2018, at the Belém Campus of the Federal Rural University of Amazonia (UFRA). A completely randomized design was used, in a 4 x 2 factorial scheme, distributed over 5 replications. The factors were 4 doses of nitrogen fertilization (0, 20, 40 and 60 kg ha^{-1} of N) and 2 types of soil (conventional cultivation and forest). The variables used to analyze the treatments were: height, pseudostem diameter, fresh weight of the pseudostem, flower stem, leaves, rhizome and root. The results of the experiment were subjected to analysis of variance, compared using the Tukey test, where appropriate, and regression studies by adjusting the equations according to the doses of N used. There were significant differences in all the variables studied. The results of this study show that there is probably a certain shortage of the elements needed for plant nutrition and, with a greater supply of N, there is greater root development to make up for this deficiency.
Keywords: *Heliconia psittacorum*, plant nutrition, soil fertility, soil management.

Resumo: A *Heliconia psittacorum* é uma planta que possui destaque na floricultura tropical devido a sua inflorescência com brácteas de diversas colorações e seu elevado atributo ornamental. O objetivo deste trabalho foi avaliar a influência do nitrogênio aplicado, sobre diferentes manejos, no desenvolvimento de plantas de helicônia (*H. psittacorum*). O experimento foi desenvolvido em casa de vegetação, na área de ciências do solo, no período de maio a dezembro de 2018, no Campus Belém da Universidade Federal Rural da Amazônia (UFRA). Foi utilizado o delineamento inteiramente casualizado, em esquema fatorial 4 x 2, distribuído em 5 repetições. Os fatores foram 4 doses de adubação nitrogenada (0, 20, 40 e 60 kg ha^{-1} de N) e 2 tipos de solo (cultivo convencional e de mata). As variáveis utilizadas para a análise dos tratamentos foram: altura, o diâmetro do pseudocaule, peso fresco do pseudocaule, da haste floral, das folhas, do rizoma e da raiz. Os resultados do experimento foram submetidos à análise de variância, comparadas pelo teste de Tukey, quando pertinente, e estudos de regressão através do ajuste das equações de acordo com as doses de N utilizadas. Houve diferenças significativas em todas as variáveis estudadas. Os resultados do presente trabalho mostram que, provavelmente, há uma certa escassez dos elementos necessários para a nutrição da planta e com maior suprimento de N, há um maior desenvolvimento de raízes para suprir essa deficiência.
Palavras-chave: fertilidade do solo, *Heliconia psittacorum,* manejo do solo, nutrição de plantas.

Introduction

The production of flowers and ornamental plants is dynamic and promising in Brazilian agribusiness, responsible for strong economic results and with percentage performance indicators above the average obtained by other sectors of recent rural production (Junqueira and Peetz, 2018). The activity of floriculture has gained prominence in the national context, standing out as an economically promising area that contributes to strengthening agribusiness (Stutz et al., 2020).

Participation in the flower and ornamental plant sector is recognized as one of the most lucrative segments, attracting a significant number of investors. The reasons or motivations driving these investments were identified. It was noted that 43% of investors attribute their participation to the commercial market scenario, since the activity is often conducted in a family context. In addition, 38% see this activity as a commercial market with great potential, reinforcing the idea that this sector is constantly expanding (Reis et al., 2020).

Global floriculture activity is projected for significant growth in the coming years driven by the growing demand for these products in up-and-coming developing nations, such as some countries in Latin America, Africa and Southeast Asia (Hakeem, 2020). Brazil stands out as a country consolidated in scientific progress, especially in the areas of production, post-harvest and the flower market. Progress in the sector is driven by research covering topics such as propagation, fertilization, productivity, genotype characterization, irrigation and in vitro cultures. These studies contribute significantly to ongoing development in the field of floriculture (Linares-Gabriel et al., 2020). On the national stage, floriculture has experienced remarkable growth in recent decades, establishing itself as an economically solid agricultural activity (Junqueira and Peetz, 2018).

Heliconia psittacorum, belonging to the genus Heliconia and composed of approximately 250 to 300 species, which is the only one in the Heliconiaceae family, is an herbaceous, rhizomatous, perennial plant of small size and is an ornamental plant with an exotic style (Linares-Gabriel et al., 2019; Malakar and Biswas, 2020). The plant stands out in tropical floriculture due to its inflorescence, which has bracts in different colors, as well as its post-harvest durability, exuberance and remarkable ornamental attribute (Krause, 2023). The distinctive shapes and colors of tropical flowers, including various species of heliconia, are gaining popularity (Carrera-Alvarado et al., 2021). Climatic diversity is a factor of great importance and distinction in Brazil, highlighting the need for research aimed at the area of floriculture in the country (Monteiro et al., 2019).

The nutrients available in the soil are divided into macronutrients and micronutrients, according to the plants' ability to absorb significant or small amounts. Nutritional maladjustments, whether due to lack or excess, cause changes in plant metabolism, resulting in characteristic symptoms. With regard to flowers and ornamental plants, nutritional deregulation affects post-harvest durability and production costs, depreciating the product or making it difficult to sell (Cardoso et al., 2021).

Experimental studies have indicated that nutrient scarcity can influence productivity and various other processes in tropical forests on an ecosystem-wide scale (Cunha et al., 2022; Wright, 2019). Nitrogen

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in heliconia is very important for the correct development of the inflorescence, the main commercial part of the plant, as it influences the length and diameter of the floral stem, the length of the inflorescence, post-harvest durability and the carbohydrate content in the floral stems. It is also important to mention that the other organs of the plant are highly affected by a lack of nitrogen, as this element has the function of regulating important biochemical and physiological processes such as the expression of various genes, root development and leaf expansion (Bouguyon et al., 2012).

According to Castro et al. (2015), when assessing nutrient omission, they found that N and P deficiency had a more intense effect on the following variables: leaf area, number of leaves, leaf dry mass and number of tillers. In addition, the omission of N, P and S led to leaf chlorosis; K caused darkening and necrosis of the leaves; Mg caused necrosis on the edges of the leaves, indicating the importance of the fertilization process. In general, the application of nutrients such as N, P and K contributes to plant development, promoting vegetative growth and favoring the production of flower stalks and rhizomes, as highlighted by Goh et al. (2018).

In relation to the soil's chemical characteristics, with the higher rate of organic matter and its decomposition in a soil, various cations (potassium, calcium, magnesium, etc.) are generally released in easily exchangeable forms in the surface horizon of mineral soils, thus providing soils that are more fertile in nutrients for plants (Brady and Will, 2013).

In this sense, it is known that nitrogen plays many roles in plant development, so it is important to know the effects that this macronutrient can have on different types of soils in terms of making nutrients available to seedlings. Therefore, the aim of this study was to assess the influence of nitrogen applied to a yellow latosol under different managements on improving the development of heliconia plants (*H. psittacorum*).

Material and Methods

The experiment was carried out in a greenhouse, in the soil science area, from May to December 2018, at the Belém Campus of the Federal Rural University of Amazonia (UFRA) in the state of Pará, with geographical coordinates 1° 27′ 31″ S, 48° 26′ 4.5″ W. The region is characterized by high humidity, temperatures ranging from 23 ºC to 33 ºC, and is classified as an Afi type location by Koppen (Fig. 1).

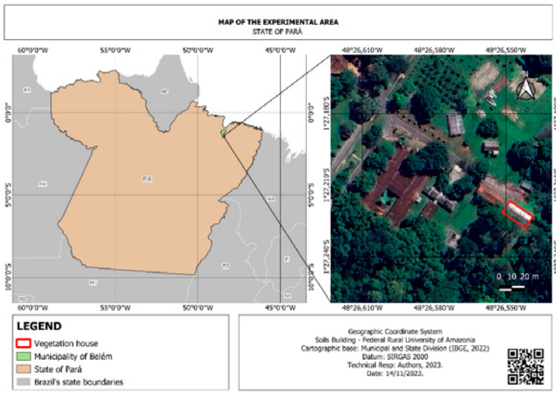

Fig. 1. Vegetation house in the Soil Science Area.
Source: Authors, 2023

A completely randomized design was used, in a 4 x 2 factorial scheme, distributed over five replications. The factors were four doses of nitrogen fertilization (0, 20, 40, and 60 kg ha^{-1} of N) and two soil managements (cultivated soil and forest soil). The nitrogen source used was urea, applied at the beginning of the experiment. The doses were selected on the basis of previous studies carried out on Amazonian soils.

The soils were characterized as Dystrophic Yellow Latosols with a medium texture (EMBRAPA, 2018). The uncultivated soil was collected from the CEPLAC (Executive Commission of the Cocoa Farming Plan) area in the municipality of Marituba, which had never been previously managed for cultivation. The previously conventionally cultivated soil was used as a clonal garden for rubber trees and has been fallow for 30 years, and was collected from the soil science area at the Federal Rural University of Amazonia. The chemical analysis of the soils in question was carried out and the results are presented below (Table 1).

Table 1. Results of the chemical analysis of the samples of cultivated soil (SC) and forest soil (SM).

Corg	pH	P	K	Ca	Mg	H+Al	Al	SB	t	T	V
Sample	H_20	mg dm^{-3}				$cmol_c$ dm^{-3}				%	g kg^{-1}
SC	4.55	23.60	0.02	0.50	1.00	6.08 0.94	1.52	2.46	7.60	20.00	9.29
	4.00	1.70	0.60	1.10	5.20	61.80 15.00	6.90	21.90	68.70	10.04	10.40

pH: hydrogen potential; P: available phosphorus; K: available potassium; Ca: exchangeable calcium; Mg: exchangeable magnesium; H+Al: potential acidity; Al: exchangeable aluminum; SB: sum of bases; t: Effective CEC; T: CEC at pH 7; V: base saturation; Corg: organic carbon.

Both types of soil were corrected using dolomitic limestone in order to reach a base saturation level of 60%, with quantities of 3.5 t ha^{-1} being applied to the CEPLAC soil and 2.53 t ha^{-1} to the UFRA soil. For phosphate fertilization, ARAD was used at a rate of 1.3 t ha^{-1} for the forest soil and 0.3 t ha^{-1} for the cultivated soil. Potassium fertilizer (KCl) was used at a rate of 3.3 t ha^{-1} for both soils. FTE was also applied as a source of micronutrients at a dosage of 30 kg ha^{-1} for both soils.

Initially, rhizomes were selected from *H. psittacorum* plants in an area on the UFRA campus, using wild matrices of the species. Before planting, the organ was cleaned with water and then planted in trays containing washed sand as a substrate. After 30 days of sowing, the plants were transplanted and planted individually in polyethylene pots with a capacity of 10 kg. The heliconia was irrigated using the individual weighing method, which aimed to maintain the soil's field capacity at 60%.

After the 7-month experiment, the plants in each pot were collected and the height and diameter of the pseudostem were measured. After the phytometric measurements, the fresh weight of the pseudostem, floral stem, leaves, rhizome and root were observed. The plant organs were weighed on a digital scale with a precision of around 0.01 g. The height of the plants was measured using a tape measure. The diameter of the pseudostem was measured using a caliper. The results of the experiment were subjected to analysis of variance, compared using the Tukey test, where appropriate, and regression studies by adjusting the equations according to the doses of N used, using the statistical software Sisvar 5.3 (Ferreira, 2019).

Results and Discussion

According to the treatments applied, we can see that there were significant differences in all the variables studied (Table 2), either separately or in their interactions.

Table 2. Results of analysis of variance based on different doses of nitrogen fertilization.

Source of variation	GL	DS (cm)	ALT (cm)	PFO (g)	PIN (g)	PPS (g)	PRI (g)	PRA (g)
Management	1	**	**	**	**	**	**	**
Dose	3	**	**	**	**	**	**	**
Management Dose	3	**	**	**	**	**	**	**
Error	32	-	-	-	-	-	-	-
CV (%)	-	3.87	2.94	4.55	8.36	3.00	4.13	5.21

DPS (pseudostem diameter); ALT (plant height); PFO (leaf weight); PIN (inflorescence weight); PPS (pseudostem weight); PRI (rhizome weight); PRA (root weight). ** is statistically significant at 1% by Tukey's test.

In the pseudostem diameter variable, significant effects were observed for the treatments applied. In both soil managements, the behavior fitted the quadratic regression model in relation to the doses applied. The forest soil showed better results than the conventionally cultivated soil (Fig. 2). In SM, the maximum significant dose was 42.7 kg ha^{-1} for a diameter of 1.01 cm. In the SC, the maximum dose was 37.58 kg ha^{-1} for a diameter of 0.92 cm.

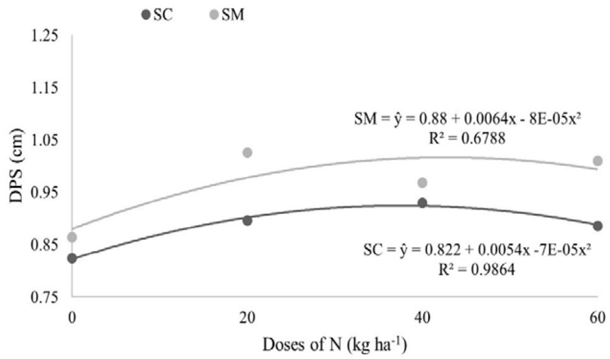

Fig. 2. Diameter of the pseudostem submitted to the treatments in the experiment. DPS (pseudostem diameter); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p<0.05$).

N acts in the synthesis of chlorophyll, participating as an essential component in the photosynthetic process, which, with increasing doses, led to a significant increase in the development of the pseudostem of *H. psittacorum* plants. Forest soils generally have good fertility and high concentrations of organic matter when compared to areas that use monoculture production systems, as the variety of species in the native system promotes the availability of variable plant residues, diversity of microorganisms and improves the soil's physical conditions, which is beneficial for plant development (Ferreira and Oliveira, 2003; Brady and Will, 2013). Corroborating these authors, the pseudostem fresh mass results for heliconia cultivation found in this experiment showed superior results when cultivated in soil from the forest area.

Ferreira and Oliveira (2003), researching the application of doses of nitrogen, phosphorus and potassium on the development of heliconia organs, showed significant effects of nitrogen doses on the pseudostem diameter variable, with a linear fit for Golden Torch heliconia. The same authors found no significant effects for St. Vincent Red. The wild-growing heliconia used in the experiment may have a lower sensitivity to the nutrient compared to the Golden Torch cultivar and a higher sensitivity compared to the St. Vincent Red cultivar.

The greatest plant heights were found under forest soil conditions, with around 12.8 cm more than in cultivated soil. The two types of soil management showed regression effects adjusted to the quadratic model. The maximum economical dose found in SM was 50 kg ha^{-1} for a height of 59.7 cm and, for SC, the dose was 36.6 kg ha^{-1} for a height of 45.4 cm (Fig. 3).

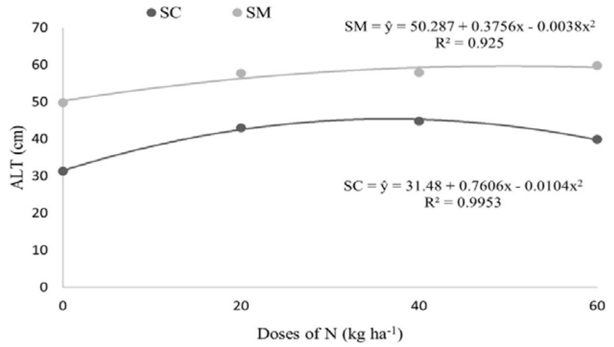

Fig. 3. Height of the plant subjected to the treatments in the experiment. ALT (plant height); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

Height, like the diameter of the pseudostem, is greatly influenced by nitrogen because this element is highly related to the vegetative growth of plants. The nutrient is strongly related to the process of photosynthesis and the accumulation of carbohydrates in plant tissues, as well as participating as a component in the genetic code of these living beings, and its importance for cell multiplication and plant development is clear.

Considering the possible better fertility present in soils with higher organic matter content in the physical, chemical and biological properties of the soil, and the importance of these for good vegetative development, treatment with forest soil becomes very important for increasing the values of the height variable (Brady and Will, 2013). This data is therefore corroborated by the data from the current study, as the best results were found for the height of *H. psittacorum* in the treatments in which there was forest soil with adequate doses of nitrogen.

Work carried out by Beckmann et al. (2015) and Linares-Gabriel et al. (2019) found results contrary to those of this research, considering the use of nitrogen doses in *Heliconia stricta* Dwarf Jamaican and *H. psittacorum* cv. Golden Torch, respectively, with no significant responses for the height variable. It can therefore be inferred that the significant increase in the height of the heliconia plants in the study may be related to the plant matrix, which differs from the commercial heliconia varieties. Lima et al. (2019), evaluating the use of agro-industrial, waste as nutrient sources for *Heliconia* var. Golden Torch, concluded that the residue from burning cocoa beans was the source that showed the best results as a source of potassium, phosphorus, manganese and copper, in addition to reducing the Al levels in the soil and consequently raising the soil pH.

For the leaf weight variable, the treatments using forest soil (SM) obtained higher values than those using cultivated soil (SC), both fitting the quadratic regression models (Fig. 4). The ideal doses for the forest and cultivated soils were 40.1 kg ha^{-1} and 28.6 kg ha^{-1} respectively, to achieve maximum leaf weight production levels of 62 and 43.1 g.

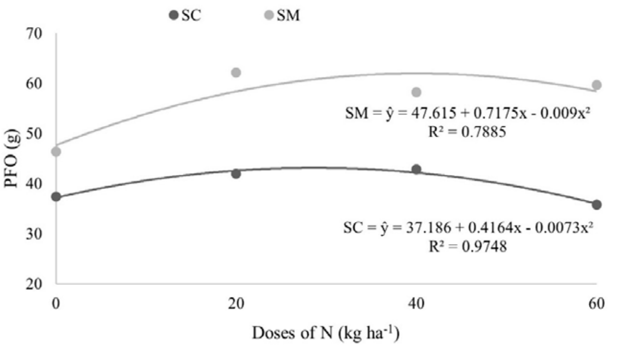

Fig. 4. Weight of leaves subjected to the treatments in the experiment. PFO (leaf weight); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

The importance of nitrogen in leaves and green organs is mainly due to the need for nitrogen in the formation of chlorophyll, which is responsible for photosynthesis in plants. The diameter of the pseudostem, leaf area and number of leaves are characteristics that indicate the vigor of the plant, due to the estimation of the photosynthetically active area (Silva et al., 2018). The number of leaves is related to the plant's photosynthetic area, as a greater number of leaves implies a larger area for capturing light energy in the photosynthesis process (Bonfim-Silva et al., 2020). Contrary to what was found in this research, Linares-Gabriel et al. (2019) found results that did not agree when working with *Heliconia stricta* Dwarf Jamaican under the application of different doses of NPK, finding non-significant results for the leaf area variable and for the number of leaves present in the heliconia. For the inflorescence, which is heliconia's most commercially important organ, the difference between the weights of the inflorescence between the forest soil and the cultivated soil in the maximum weight condition was 2.88 g (Fig. 5). To reach the maximum efficiency of 9.97 g, the forest soil required 25.1 kg ha^{-1} of N, while for the cultivated soil to reach the same cost-effective level of 7.09 g, 26.5 kg ha^{-1} was needed. The effects of both soils fitted the quadratic regression model. Based on the data cited above, it can be said that a slightly lower dose of nitrogen was needed in the soil with a high organic matter content for the best production of heliconia inflorescences.

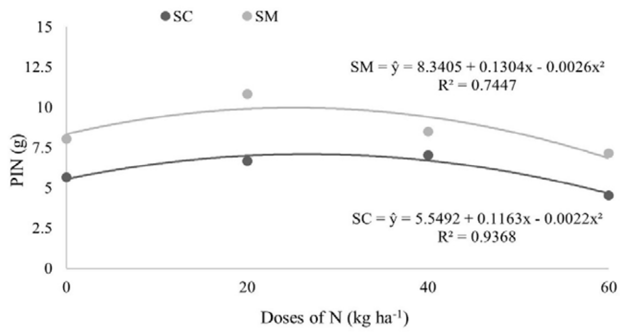

Fig. 5. Weight of the inflorescence subjected to the treatments in the experiment. PIN (inflorescence weight); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

In the research by Castro et al. (2015), nitrogen omission was the nutrient that most significantly reduced the length of the inflorescence and one of the nutrients that most reduced the length of the floral stem, in other words, the nutrient is important for the growth and development of the organ, since the respective difference between the treatments with complete fertilization and the treatments with nitrogen omission for the variables mentioned were 8.2 and 5.4 cm. For the treatments without nitrogen, flower buds were produced on the first tiller, but from the second tiller onwards production decreased, and the application of nitrogen was essential for the effective production of flower stalks. It was also observed in this study that the lack of nitrogen in heliconia production led to a loss in product quality, with the production of pale, defective inflorescence bracts and the weakening of the floral stems. Another result found in the same study is that larger stems generate larger inflorescences, which may suggest that the best inflorescence weight values in the current study express larger inflorescences.

Amaral et al. (2015), when studying the conservation of heliconia inflorescences previously fertilized with increasing doses of nitrogen and potassium using various variables in the analysis of this organ, found that doses of nitrogen in *H. psittacorum* significantly improved the variables water absorption by the inflorescences and the dry mass of the organ, while the variables loss of fresh mass of the floral stems and post-harvest durability were not influenced by the addition of the nutrient. In other words, the average fresh mass found by the author, which was an average of 4.71 g (dry mass of the floral stems + loss of fresh mass of the floral stems), is similar to that obtained in the cultivated soil of the present experiment, even though the experiment by Amaral et al. (2015) experiment was carried out over 14 months and produced with a substrate composed of sand + cattle manure in a 2:1 ratio, which may mean that the soil from uncultivated woodland may be better in terms of fertility than the organic substrates commercially used on the market.

Albuquerque et al. (2010), on the other hand, researching the production of Golden Torch heliconia as influenced by mineral and organic fertilization, found that organic fertilization (cattle manure, poultry litter or filter cake) plus mineral fertilization raised the values of flower stem length and flower stem diameter to values that are more commercially acceptable, and the author explains that this change probably comes from the increase in soil fertility caused by the addition of organic matter to the system.

The difference between the maximum pseudostem weight of heliconia grown in forest soil and cultivated soil was the most significant among the variables studied in the experiment, with a value of 46.1 g. Considering the maximum pseudostem weights for both soils, 103 g for SM and 56.9 g for SC, the doses required were 23.1 kg ha^{-1} and 31.4 kg ha^{-1}, respectively. In other words, the presence of organic matter probably caused changes in soil fertility that favored the growth and development of the plant's pseudostem without a large addition of soluble nitrogen in the soil, compared to the plant grown in soil with a low organic matter content. The regression models for the variable in question were adjusted to the quadratic model (Fig. 6).

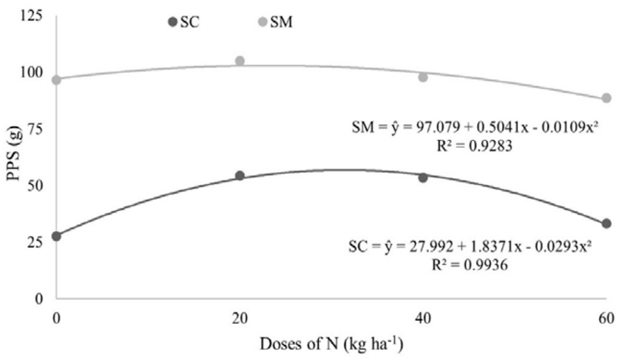

Fig. 6. Weight of the pseudostem submitted to the treatments in the experiment. PPS (pseudostem weight); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

Working with the production of *H. psittacorum* seedlings with different forms of fertilization and propagation, Pinto et al. (2007) presented expressive results for the number of pseudostems formed with the addition of organic fertilizers to the system. The author identified that all the treatments that used organic fertilizer showed statistically equal results to those that used only conventional fertilizers, since the highest values were found in the treatment that used organic compost + granulated soluble fertilizer via fertigation, again expressing the need to use both types of fertilizer for the viable growth and development of heliconia. The author's results corroborate this work, as the best result for this variable was found in the treatment in which there was an interaction between nitrogen and soil with a higher organic matter content.

Ferreira and Oliveira (2003), researching the effects of NPK application on the organs of 'Golden Torch' heliconia, found that the pseudostem length variable was statistically significant. The same authors concluded that nitrogen is important for increasing the length of the pseudostems and floral stems, as well as the linear increase in inflorescence productivity, representing the importance of the nutrient for the organ. In terms of rhizome weight, the weight of the representative organ for the most economically efficient dose for SM was 65.8 g and for SC was 43.5 g, which have the most satisfactory N doses of 23.7 kg ha^{-1} and 30.4 kg ha^{-1} respectively. Regression effects fitted to the quadratic model were found for both soils in the experiment (Fig. 7). The difference in rhizome weight at maximum production between the two soils was 22.3 g, in other words, a big difference, possibly representing a better accumulation of nutrients and photoassimilates in the underground stem due to the better fertility conditions in the forest soil.

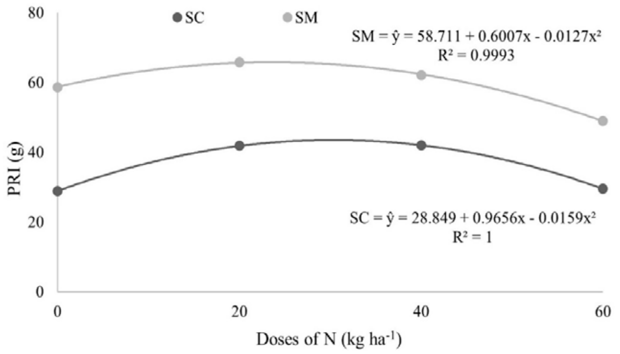

Fig. 7. Rhizome weight submitted to the experiment treatments. PRI (rhizome weight); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

The rhizome is an extremely important organ for heliconia, as it stores nutrients and photoassimilates, as well as promoting the most common propagation of the plant through rhizome multiplication and being able to maintain the growth and development of the plant in its initial period. Castro et al. (2015), however, working with nutrient omission in *H. psittacorum* and its consequences, observed that the nutritional reserve stored in the rhizomes alone is not enough to generate more than one tiller and one inflorescence, requiring an external supply of nutrients.

It can be seen that there was a reduction in this variable when nitrogen levels increased in the doses used in the experiment, as well as in other variables analyzed. Some possible reasons for this are antagonism with other nutrients and salinity stress. When nitrogen is in excess in the plant, it causes certain conflicts with other elements, such as potassium, chlorine and copper, depending on the form in which the nitrogen is found (ammonium or nitrate), reducing its absorption or blocking it, generating problems related to their respective deficiencies.

Pinto et al. (2007) found that with the application of organic fertilizer (non-composted mixture) + mineral fertilization via soil, the highest value of rhizome fresh mass was obtained (79.92 g), which is a higher value than those found in the present work, but agrees with the results of the increase with the addition of organic matter to the soil. This is because the higher fresh weight of the organ may be due to the shorter experiment time of the current work (7 months) compared to that of the aforementioned author (12 months).

For the cultivated soil, as the amount of nitrogen applied increased, the weight of the root grew initially and then began to decrease, since the weight of the maximum production was 51.7 g and the dose representing this weight was 31 kg ha^{-1}. For the forest soil, the maximum weight of 62.6 g was found with the treatment without additional nitrogen application, since for the roots the SM graph was the only one that differed from the others, due to its falling and then growing behavior. A quadratic regression model was found for the soils (Fig. 8).

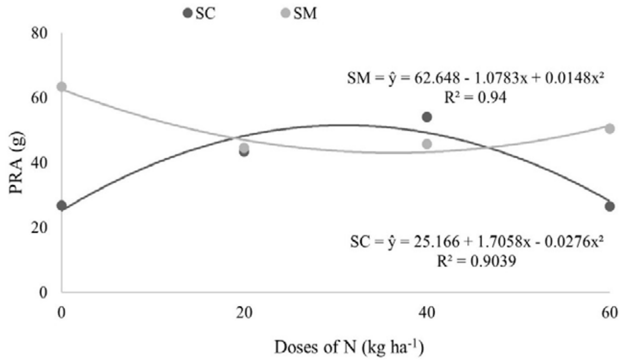

Fig. 8. Root weight submitted to the treatments in the experiment. PRA (root weight); SM (forest soil); SC (cultivated soil). Statistically significant differences ($p < 0.05$).

One possible explanation for the different behavior of the graph representing the heliconia roots is the availability of nutrients in each type of soil. The forest soil, with its higher organic matter content, tends to provide better nutrient availability and soil fertility, which does not favor root growth, as there is no need to increase these organs if the nutrients needed by the plant are already in its root area. As the doses of nitrogen increase, the only nutrient that was not previously introduced into the system, the roots don't need to develop in order to look for more nutrients, since root production decreases to the point where the dose of nitrogen was so high that it began to have a negative impact on the plant, probably due to the effect of salinity stress, causing the plant to increase the volume of its roots in search of water. Conventionally used soil with less organic matter generally has less nutrients than soil with more organic matter without the addition of mineral fertilizers. The results of the study show that there is probably a certain shortage of the elements needed for plant nutrition and this means that as the doses of nitrogen increase, the roots grow and develop in order to cover a greater volume of soil to make up for deficiencies.

In relation to organic matter, the work by Sales et al. (2018) observes that, for maize, the application of soil + soluble fertilizer + organic compost was significant for the increase in fresh and dry root mass compared to the treatments in which only soil + soluble fertilizer or only soil was used. Organic compounds offer a wide range of beneficial elements that play a crucial role in vegetative growth, acting as a source of nitrogen and potassium (Sales et al., 2018). In other words, with the composts in the study, especially the urban compost, the root can grow more effectively due to factors such as increased nutrient availability and an increase in the soil's CTC, which may be more effective as a fertility treatment for the soil that was conventionally cultivated in the current study.

Conclusions

Applying doses of nitrogen to the heliconia crop has a positive effect on its growth and development and is essential for the plant to achieve good production. For both SM and SC, the appropriate nitrogen dose for the crop was 40 kg ha^{-1}. The forest soil promoted greater growth in the heliconia plants.

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Author contributions

LAO: conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **JRG**: conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **MVCP:** conceptualization, data curation, investigation, methodology, visualization and writing-original draft. **JCS:** visualization, writing-review and editing and translation. **AKAF:** visualization, writing-review and editing and translation. **MNHO:** visualization, writing-review and editing and translation.

Conflict of Interest

The authors declare that they have no potential conflict of interest in the submitted work.

Data Availability Statement

Data will be made available on request.

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