



MORPHOLOGICAL ASPECTS IN SEEDLINGS OF *Adenanthera pavonina* UNDER DOSES OF POULTRY MANURE

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ABSTRACT

Purpose: To analyze the growth and development of *Adenanthera pavonina* seedlings submitted to substrates containing different proportions of chicken manure.

Theoretical framework: Based on scientific articles found on search engines and in books on seedling production; types, characteristics and functions of substrates, with emphasis on poultry manure; morphological characteristics that characterize the growth and quality of seedlings and; characteristics of *Adenanthera pavonina*, which was the studied species.

Method: The experiment was carried out in a greenhouse for a period of 90 days, in which the *Adenanthera pavonina* seedlings were submitted to different proportions between soil and chicken manure, 100% soil, 75% soil + 25% chicken manure, 50% soil + 50% chicken manure, 25% soil + 75% chicken manure, 100% chicken manure. During 90 days of growth, growth in height and diameter and; at the end of 90 days, the dry mass of the aerial part and the root part of the seedlings was obtained.

Results and conclusion: The proportion of 25% chicken manure + 75% soil is the most suitable for the growth and dry mass production of *Adenanthera pavonina* seedlings, allowing to obtain quality seedlings for planting. While proportions such as the one with 100% bird manure make germination of seeds of this species unfeasible.

Research implications: These results provide a correct and ideal recommendation for the studied species, because it proves that the amount of chicken manure in the substrate composition interferes in order to improve or reduce the growth capacity of the seedlings. Proving, therefore, that there is an ideal amount to be used and that this should be the focus of attention for the nurseryman who wants to produce quality seedlings of this species.

Originality/value: Use of organic waste for the seedlings production, which is an environmentally correct destination.

Keywords: Organic Fertilization, Carolina Tenta, Seedling Production, Chicken Litter.

ASPECTOS MORFOLÓGICOS EM MUDAS DE *Adenanthera pavonina* SOB DOSES DE ESTERCO DE AVES

RESUMO

Objetivo: Analisar o crescimento e desenvolvimento de mudas de *Adenanthera pavonina*, submetidas a substratos contendo diferentes proporções de esterco de aves.

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Referencial teórico: Fundamentado em artigos científicos encontrados em sites de buscas e em livros da área de produção de mudas; tipos, características e funções dos substratos, com ênfase no esterco de aves; características morfológicas que caracterizam o crescimento e a qualidade das mudas e; características da *Adenanthera pavonina*, que foi a espécie estudada.

Método: O experimento foi realizado em casa de vegetação por período de 90 dias, no qual as mudas de *Adenanthera pavonina* foram submetidas a diferentes proporções entre solo e esterco de aves, 100% solo, 75% solo + 25% esterco de aves, 50% solo + 50% esterco de aves, 25% solo + 75% esterco de aves, 100% esterco de aves. Durante 90 dias de crescimento, foram avaliados o crescimento em altura e em diâmetro e; ao final de 90 dias, obteve-se a massa seca da parte aérea e da parte radicular das mudas.

Resultados e conclusão: A proporção de 25% de esterco de aves + 75% de solo é a mais adequada para o crescimento e produção de massa seca de mudas de *Adenanthera pavonina*, permitindo a obtenção de mudas de qualidade para o plantio. Enquanto que, proporções como a com 100% de esterco de aves inviabilizam a germinação das sementes dessa espécie.

Implicações da pesquisa: Esses resultados proporcionam uma recomendação correta e ideal para a espécie estudada, porque comprova que a quantidade de esterco de aves na composição do substrato interfere de modo a melhorar ou reduzir a capacidade de crescimento das mudas. Comprovando, portanto, que existe uma quantidade ideal a ser utilizada e que isso deve ser alvo de atenção para o viveirista que deseja produzir mudas de qualidade dessa espécie.

Originalidade/valor: Utilização de resíduos orgânicos para a produção de mudas, sendo esta, uma destinação ambientalmente correta.

Palavras-chave: Adubação Orgânica, Tênto Carolina, Produção de Muda, Cama de Frango.

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1 INTRODUCTION

The search for economically viable alternatives and the development of environmental awareness have heated up the field of research on the use of agricultural and agro-industrial waste, which can be used in the formulation of substrates for the production of forest seedlings (Kratz et al., 2013). This is because, according to Oliveira et al. (2014a), there is an increasing need to use natural resources and to assimilate the residues arising from production activities to minimize the impacts on ecosystem capacity.

It is known that some solid residues have the potential to be reused, depending on their nutrient levels, such as those originating from the timber and sugarcane industry, leather tanning, animal husbandry, urban pruning, among others. One example is dung, which stands out as one of the most commonly used types of waste.

One of these applications is in the production of seedlings, as they provide chemical, physical and biological advantages for the substrate formed, improving the conditions for the seedlings to grow. According to Gonçalves and Poggiani (1996), the organic material is an essential component in the substrates, the basic purpose being to increase the capacity for retaining water and nutrients for the seedlings. Other advantages of this component on plant development should also be considered, such as: reduction in the apparent and overall density and increase in the porosity of the medium, characteristics that can have a positive participation of organic materials.

According to Cavalcanti et al. (2019) in the seedling production stage, it is fundamental to choose a substrate with physical and chemical characteristics that favor its development.



However, in order to choose this material, one must consider its physical and chemical characteristics, the species to be planted, as well as the economic aspects: low cost and high availability (Fonseca, 2001). Characteristics found in the dung, especially in that derived from birds.

The poultry manure is applied with the bed, placed to accommodate chickens in poultry houses (Trazzi et al., 2013) and, when well tanned, is well brassy, dark and cold, rich in N and without excess ammonia (Weinärtner et al., 2006). Therefore, if used in adequate quantities, it can be a source of nutrients in the production of seedlings or in soil fertilization (Torres et al., 2011).

One of the species with potential use in rural and urban areas is *Adenanthera pavonina* (L.), a *Fabaceae*, popularly known as tento carolina, originating in India and Malaysia. In Brazil, it is widely used in the afforestation of squares and gardens, for its rapid development. Another feature is its potential to recover from degraded environments.

In addition, its seeds are used for making earrings, necklaces, bracelets, and medical formulas; its wood can be used in civil constructions, in making packaging, tool handles and joinery, depending on its durability and strength.

In view of this, this study aimed to analyze the growth and development of *Adenanthera pavonina* seedlings, submitted to substrates containing different proportions of bird manure.

2 THEORETICAL FRAME

The theoretical benchmark was based on scientific articles and books published in the areas of Seedling Production, Substrates, Morphological Characteristics and Quality of seedlings of forest species. For a better understanding of the study carried out, the theoretical reference will be composed of some items characterizing the species studied; the properties of the substrates and their importance in the production of seedlings, with emphasis on the manure of birds and; the use of the manure of birds in the production of seedlings of forest species.

2.1 *Adenanthera pavonina* - Tento Carolina

Adenanthera pavonina L., popularly known as: tento carolina, or dragon's eye or false brazilwood, is a plant originating from Asia and Africa, of tropical climate environments, belonging to the *Fabaceae* family (Gonçalves, 2018). However, it is already introduced and distributed throughout Brazilian territory (Gugé et al., 2019).

It is a semi deciduous tree, which can reach 15-20 meters in height and trunk characterized by having a smooth brown bark while the branch is long and sparse forming open crown. Its long stalk inflorescences tend to be axillary to the terminals, in short racemes, with yellow flowers, formed in the months of March to April. The fruits are narrow, flattened, brown, spiraled pods when opened, exposing globose, flattened, hard, bright red seeds. The seeds are of average size, 10 x 12mm, and can vary in hue, size and shape (Fonseca and Perez, 2003).

This species has the capacity to biologically fix air N, through the association of its roots with diazotrophic bacteria present in the soil, therefore tends to provide it gradually (Alves et al., 2015). It shows rapid growth, is ideal for shading and its canopy can be used by herbaceous plants, shrubs and creepers that do not tolerate high luminous intensities, so it can be used in the recovery of areas and in reforestation (Fanti, 1997).

In addition, it can be used for the production of packaging, boards, partitions, tool handles, wood (Silva e Lemos, 2002) and for afforestation (Gugé et al., 2019). Baking of seeds and wood of the caroline temper allows its use in the treatment of pulmonary infections, and may also be applied Externally in the treatment of the (Fanti, 1997).



2.2 Substrates in Seedling Production - Poultry Dung

Within the seedling production process, the substrate is one of the most important items and the diversity of which has been widely studied (Cavalcanti et al., 2019), and should present characteristics such as high water retention capacity, balanced amounts of nutrients, sufficient air availability, reduced salinity; slightly acidic pH and moderate buffering capacity, and absence of seeds of undesirable species, pathogens and toxic substances (Wagner Júnior et al., 2006; Rebelo, 2014).

For this reason, organic residues have been used in the formulation of substrates, since, in addition to these previously commented characteristics, they stimulate the development of beneficial microorganisms, provide increased capacity for water and nutrient retention, improve aeration and aggregation of the substrate to plant roots and increase the availability of nutrients for molting (Wendling and Gatto, 2002).

In particular, dung, which, according to Oliveira et al. (2015), improves the physical conditions of the substrate, such as aeration and drainage, and the chemical characteristics, because it is rich in nutrients, which can be released to plants. Being the type of material most used due to its ease of handling and for presenting good results in the production of seedlings of forest species (Trazzi, 2011). Of the types of manure, that of birds is one of the most employed.

Dung from birds is usually applied with the bed, placed to accommodate chickens in aviaries (Trazzi et al., 2013). According to Silva et al. (2013), it is a bird husbandry residue, consisting of the overgrown feed, feces, urine, feathers and absorbent substrate used to line the floor of the sheds of the farms, such as: wood sawdust, rice straw, corn cobs, cane bagasse and others.

The composition of the aviary bed with seven to eight batches is 3.8% N, 4% P in the form of P_2O_5 , 3.5% K in the form of K_2O , 4.5% Ca and 1% magnesium (Mg). It has a rapid availability of nutrients, being its release of 50%, 80% and 100%, respectively, for N, P and K, in the first crop cycle (Nicoloso et al., 2016). However, when destined for the soil, without being stabilized, they can cause adverse effects to plant crops, and inhibit plant growth (Heylmann et al., 2013). Besides adversely affecting the characteristics of seedlings such as height, foliar area and dry matter (Duarte et al., 2010).

2.3 Poultry manure in the production of seedlings of forest species

In study with *Myrsine coriacea* seedlings (Sw.) R.Br. ex Roem. & Schult. (Queiroz and Frassetto, 2014) observed that the fresh mass and dry mass of the root part of the seedlings were influenced by treatments with chicken bedding in doses of 20%, 30% and 40%. Similar proportion was recommended for *Eucalyptus dunnii* (Hill ex Maiden). Menegatti et al. (2017) indicated the use of 20% of poultry bed fertilizer in the commercial peat-based substrate and carbonized rice husk for this species. This was also recommended for the production of *Eugenia involucre* (DC.). For this species, Thiesen et al. (2020) observed that, substrates with 35% soil + 35% sand + 10% vermiculite + 20% porcine compound and 35% soil + 35% sand + 10% vermiculite + 20% bird litter may be alternatives, as in these treatments, plants showed greater increment in height and fresh root mass.

Studying the formulation of chicken bed substrates for the production of *Tetona grandis* seedlings (L.f.), Trazzi et al. (2013) found that the highest biometric gains were in a larger proportion, 35%. The same as indicated by Faria et al. (2016) for the production of seedlings of *Mimosa setosa* (Benth.), in this case, 25% commercial substrate + 35% chicken bed + 40% subsoil land.



For *Hymenaea courbaril* (L.), the best combination was in even greater proportion, containing 50% Plantmax® + 50% decomposed chicken bed, which provided the highest growth and better nutritional conditions for seedlings (Vieira and Weber, 2015). Similar to that observed by Ribeiro et al. (2018) for the development of *Acacia mearnsii* seedlings (de Wild.). For this species, the authors found that the morphological variables and quality indices were superior with mixtures of up to 50% poultry bed, clay soil and sand.

While, Krefta et al. (2017) recommended, for the development of seedlings of *Bauhinia variegata* (L.) and *Ceiba speciosa* (A.St.-Hil), substrate composed of 100% aviary bed.

3 METHOD

The experiment was carried out in a vegetation house, belonging to the Faculty of Agronomy of the University of Cuiabá (UNIC), located on the campus Beira Rio I, in Cuiabá - MT, at the coordinates 15°37'28"S and 56°05'11"O. The predominant climate in the area is of type Aw, classified as tropical savanna, according to Koppen classification.

The soil used was the dystrophic Red Latosol with a sandy loam texture, collected in an area of native Cerrado belonging to the Federal Institute of Mato Grosso (IFMT), campus of São Vicente da Serra - MT. While the Vitaplan® poultry manure was purchased commercially and is a simple organic fertilizer, class A. According to the supplier, this fertilizer contains limestone poultry manure, processed and decomposed shells and expanded vermiculite, 1% total N, pH 5.5, 20% total organic carbon (TOC) and cation exchange capacity (CTC) of 2.0 cmolc dm⁻³.

The treatments tested in this experiment were made up of proportions between poultry manure and soil, being: 100% soil, 75% soil + 25% poultry manure, 50% soil + 50% poultry manure, 25% soil + 75% poultry manure, 100% poultry manure. The five treatments were arranged in an entirely casualized design, with six repetitions, totaling 30 sample units.

For the constitution of each treatment, a container with a capacity of 2.0 L was used, which helped in the proportions to be tested. To do so, soil was added up to the desired proportion of the treatment, as well as the quantity of bird manure, then the material was placed on a flat surface for homogenization, and afterwards the substrate was used to fill the plastic bags with a capacity for two kilos (40 x 50 cm), the definitive containers of the experiment. At the end, samples of the treatments to be tested were characterized as to their chemical composition, before the experiment, and the results can be observed in Table 1.

**Table 1** - Chemical characteristics of treatments before experiment

Treatment	Before the experiment					
	pH	pH	P	K	Ca	Mg
	water	CaCl ₂	mg dm ⁻³		cmolc dm ⁻³	
Control (T0)	6.2	5.4	9.4	61.6	2.95	1.
25% birds (T1)	7.1	6.4	75.0	1696.8	4.35	1.54
50% birds (T2)	7.3	6.5	75.0	848.4	7.40	1.99
75% birds (T3)	7.1	6.3	86.6	1535.2	7.80	1.99
100% birds (T4)	7.0	6.2	82.3	464.6	7.70	2.16
Treatment	Al	H	MO	SB	CTC	V
	cmolc dm ⁻³		g dm ⁻³	cmolc dm ⁻³		%
Control (T0)	0.00	3.45	28.5	4.21	7.66	54.96
25% birds (T1)	0.00	1.73	38.9	10.30	12.	85.62
50% birds (T2)	0.00	1.32	39.7	11.60	12.93	89.71
75% birds (T3)	0.00	2.35	43.3	13.78	16.13	85.43
100% birds (T4)	0.00	2.10	40.0	11.07	13.17	84.05

T0 - 100% soil; T1 - 75% soil + 25% residue; T2 - 50% soil + 50% residue; T3 - 75% residue + 25% soil; T4 - 100% residue. P - phosphorus; K - potassium; Ca - calcium; Mg - magnesium; Al - aluminum; H - hydrogen; MO - organic matter; SB - sum of bases; CTC - total capacity for exchange of cations; V - saturation by bases.

Source: Prepared by the authors (2022).

After the constitution of each treatment, seeds of *Adenanthera pavonina* were placed to germinate. These seeds were collected in the Cerrado area, where some individuals of the species were sown. The collection took place directly on the ground or in the trees (when in fruit already open), starting from seeds with a suitable phytosanitary aspect, which were packaged in plastic bags and in a refrigerated place. Due to the dormancy, the seeds underwent mechanical scarification in water $\log_{10}$ 80, then were arranged in the previously prepared plastic bags, depositing two seeds per container. When the formation of the second pair of leaves was observed, the grating was carried out, to leave only one seedling per vessel, this being the most vigorous and central, which occurred 30 days after sowing.

Next, the first measurements of height and neck diameter were carried out, to get to know the initial characteristics of the cuttings, since they were produced from seeds and did not have the same measurements at the beginning of the period for analyzing growth. The height was obtained with the aid of a graduated scale, measuring from the surface of the substrate until the last leaf of each cutter; and the diameter, with the help of a digital caliper. Next, the counting of the period of growth of the seedlings was started, to get the information pertinent to the experiment.

Measurements in height and diameter continued every 30 days. At the end of 90 days, other morphological characteristics were performed. To do so, the cuttings were collected, sectioned into leaves, stalks and roots, washed in running water for the removal of the substrate from the root part. They are then placed in a forced circulation oven at 65°C, until they weigh constantly. The dried biomass of the leaves (in grams), the stem (in grams) and the root (in grams) were obtained from the analytical weighing scale to an accuracy of 0,01 g.

To identify significant differences between the means of the treatments, the data were arranged in an entirely randomized design, with six repetitions and, compared by Tukey's test at the level of 5% probability, with the help of the R software (R CORE TEAM, 2021).

To analyze the development of the seedlings, the data were adjusted by means of a linear regression model, containing as an independent variable the proportions of manure and as a dependent variable the morphological characteristics. The significance of the regressions was obtained by means of the null hypothesis test in which, for the choice of the appropriate equation, the regression with lower probability of error and higher coefficient of determination (r^2) was considered.



4 RESULTS AND DISCUSSIONS

4.1 Treatment 4 (100% Poultry Manure)

In this treatment, the seeds were placed to germinate at two different times. The first attempt occurred along with sowing in the other treatments, placing two seeds in each plastic bag. However, after two weeks, there was already germination in the others, only in T4 did not occur. For this reason, it was chosen to sow again, this time with three seeds for repetition. After the second sowing, germination was observed in one of the containers, but the seedling died a few days later.

To try to avoid a seedless treatment condition, the excess seedlings of the other treatments were transplanted twice. After the first transplant, all seedlings died, then transplanted surplus seedlings again, however, only two seedlings grew and remained until the time of the first measurement. They subsequently dried and also died.

4.2 Growth of the Seedlings of *Adenanthera pavonina* in Different Proportions of Poultry Dung

The statistical analyzes for the growth in height (H) and in diameter (DC) of the cuttings, over 90 days, are presented in Table 2. It is observed that by adding the bird manure in the substrate composition for the production of seedlings, this provided the best growth condition in the whole period of the study.

Table 2 - Comparison of the mean morphological variables height and diameter of the caroline cuttings submitted, over 90 days, to the different proportions of poultry manure

Treatment	Height (cm)			Diameter (mm)		
	30 days	60 days	90 days	30 days	60 days	90 days
Control (T0)	14.66 c	15.17 b	15.67 b	2.71 b	2.80 b	3.07 c
25% birds (T1)	33.16a	38.33a	41.01 to	4.25a	4.83a	5.42a
50% birds (T2)	26.83 b	32.83a	35.83 to	3.77a	4.14a	4.61 b
75% birds (T3)	15.01c	17.01 b	22.67 b	3.03 b	3.25 b	3.71 c
<i>pa</i>	**	**	**	**	**	**
CV (%)	14.96	19.14	15.87	9.86	13.25	11.04

** Significance less than 1% probability of error. Vertical averages followed by the same letter do not differ statistically, by Tukey's test at the 5% probability level of error.

Source: Prepared by the authors (2022).

To assist in the visualization of the results obtained for the growth of *Adenanthera pavonina* seedlings, some graphs were produced, whose coefficients of regression are presented in Table 3.

Table 3 - Regression coefficients for the estimation of morphological variables of caroline saplings submitted to different proportions of poultry manure

Variables	β_0	β_1	β_2	β_3	r^2	<i>pa</i>
Diameter	3.067**	0.1989**	-0.00508**	0.00003294 **	0.78	**
Height	15.67**	1.923**	-0.0424**	0.00024*	0.83	**
BioF	0.1517*	0.3258**	-0.009319**	0.00006834**	0.91	**
BioC	0.0983*	0.0951**	-0.002536**	0.00001723**	0.89	**
BioR	0.1733**	0.1048**	-0.002908**	0.00002046**	0.89	**

BioF - foliar dried biomass; BioC - cauline dried biomass; BioR - root dried biomass. ** Significance less than 1% error probability; * Significance less than 5% error probability.

Source: Prepared by the authors (2022).



It was found that all the coefficients presented significance and probability of error less than 1%. As for r^2 , only for the analysis of diameter, a value lower than 80% was observed, which represents the significance and reliability of the data analyzed and, therefore, of the results obtained. In this case, the highest value for r^2 was found when analyzing the biomass of the leaves, which showed 91% reliability. Corroborating that, this morphological characteristic helps to explain the growth in the other parts of the plant.

For the treatments where germinations were observed, it was found that the most favorable for growth in height (Table 2) of the saplings of tendercaroline, since the beginning of the analyzes, were T1 (75% soil + 25% poultry manure) and T2 (50% soil + 50% poultry manure), the latter being highlighted after 60 days. While the seedlings submitted to the control and T3 treatments (25% soil + 75% birds) showed the lowest average growth. At 30 days, the mean presented was 33.16 cm in T1, an increase of 55.8% in relation to control (14.66 cm) and 54.7% in relation to T3 (15.01 cm). This growth in height was higher than that observed by Freitas (2019) when testing the bovine manure in the production of saplings of tendercaroline, with analysis carried out at 57 days, when verifying average height of 11 cm.

At 60 days, the T2 (32.83 cm) cuttings presented average similar to T1 (38.33 cm), while the control (15.17 cm) and T3 (17.01 cm) remained the least favorable for this morphological characteristic, since there was the maintenance of average growth of only 0.5 cm in the control and of two centimeters in T3. According to Sousa et al. (2015) the growth in height of seedlings grown with the substrates plus organic compound may be associated with the increase of nutrients, provided by this residue to the growing substrate.

When comparing the growth in height at 60 days, in control and in T3, with the growth in T1, it was verified that in the latter, the average of 38.33 cm (at 60 days) was 60.4% higher in relation to the control and, 55.6% in relation to the T3. These characteristics for growth in height were maintained until 90 days. However, in this period, the increase was 61.8% in relation to control and 44.7% in relation to T3. This lower growth in 100% soil conditions may be related to the lower nutritional potential of the soil used in relation to the nutrient levels of the other substrates (Silva et al., 2014). This makes it possible to indicate that the addition of bird manure may be an option for assisting in the production of seedlings of the species under study.

This may have occurred because bird droppings are sources of nutrients and when handled properly, they can partially or totally supply the chemical fertilizer, because it is composed of organic matter. This organic matter improves the physical attributes of the soil, resulting in an increase in water retention capacity and improvement in the aeration of the substrate, as well as creating a suitable environment for the development of microbial flora (Menezes et al., 2004).

Another explanation may be related to the C/N ratio of the substrate. According to Peixoto Filho et al. (2013), the C/N ratio of poultry manure is practically half of the other manure, ensuring its mineralization faster and consequently greater availability of nutrients. This is the case, according to Bonela et al. (2017), because poultry manure has average values of 3.2% of total N, while bovine manure has 1.5%. For this reason, the manure of birds provides weighted quantities of macro and micronutrients, and in nutritional terms it is superior to the bovine as an alternative source of N (Filgueira, 2003).

By analyzing growth in diameter (Table 2), we observe similarities with the data on growth in height. This characteristic is important to be analyzed, along with the height of the seedlings, because, according to Souza et al. (2006), it is directly related to the survival of the seedlings after planting in the field. This similarity with the growth in height indicates that the total growth of the plant is taking place in an adequate manner, since both the aerial and root parts are growing in a balanced manner. Furthermore, according to Vieira et al. (2020), in a nursery for the production of seedlings, height and diameter are the morphological



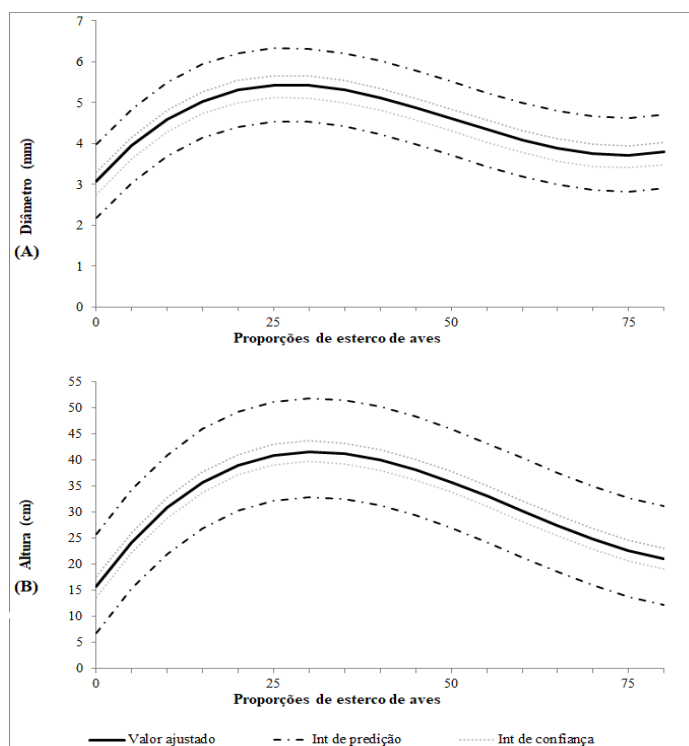
characteristics most easily determined to identify those that are suitable for definitive planting in the field.

In this case, T1 (75% soil + 25% poultry manure) and T2 (50% soil + 50% poultry manure) proved similar up to the period of 60 days, since the growth averages in these treatments were considered equal. For this period, the average growth of seedlings was 4.25 mm in T1 and 3.77 mm in T2; it was 36.2% higher than the control (100% soil) and 19.6% in relation to T3 (25% soil + 75% birds). At 60 days, this growth was 42% higher in T1 (4.83 mm) than control (2.80 mm) and 32.7% in relation to T3; for T2 (4.14 mm), the increase was 32.4% and 21.5%, respectively. However, at 90 days, the highest growth was seen only in T1 (5.42 mm), which was 43.3% higher than control (3.07 mm) and 31.5% in relation to T3 (3.71 mm). On the basis of this data, the increase in plant growth may be related to the increase in the levels of organic matter.

According to Cavalcante et al. (2019), the organic matter of poultry manure has high levels of nutrients, so it provides a better result for variables such as plant height, diameter, dry mass and quality index. This type of dung presents high quantities of macronutrients like P and N and some micronutrients like Fe, Zn and Cu (Commission, 2016), so when used, it presents rapid solubilization and availability of nutrients to plants (Alcântara, 2016). In addition, the N content influences n of P and, the higher the N content, the greater the microbial multiplication to promote the release of P from organic matter (Aziz et al., 2022).

Another advantage is that it has low cost, can be produced on the property, which would further reduce its price (Pereira, 2017). In the light of these results already analyzed and of the characteristics of the dung, it can be seen that its addition in the soil, for the formation of substrates for the production of seedlings of *Adenanthera pavonina*, is a practice that favors both the growth of the plant, and the reduction of costs in the production process.

From Graph 1, one can evaluate, in a general manner, the analysis made for the growth in height and in diameter.



Graph 1 - Growth curves for the morphological variables height (in cm) and diameter (in mm) of the caroline saplings, over 90 days, submitted to the different proportions of poultry manure. (A) - Diameter; (B) - Height.

Source: Prepared by the authors (2022).



It was found that, for these two morphological characteristics, there was an improvement in the conditions of growth of the offshoots, comparing the control treatment with those in which the addition of poultry manure up to the proportion of 50% occurred. Proportions of poultry manure higher than this were not favorable, implying results similar to the non-application condition.

Some authors have obtained similar results regarding the proportion of bird manure in the substrate composition. For the growth of *E. dunnii*, Menegatti et al. (2017) observed that high proportions of chicken litter impair plant growth. In this study, the authors found that the proportion most indicated was 20% of the total volume of the substrate, with chicken bed, higher percentages compromised the growth of the species.

Following this same proportion, Gonçalves et al. (2013) observed *Acacia farnesiana* seedlings (Willd.) with better quality in substrate containing at least 20% bird manure and 40% bovine manure, based on the total dry mass. Proportion that was also recommended by Andrade et al. (2014) for the production of *Annona muricata* seedlings (L.) and, by Oliveira et al. (2014b) for the production of *Psidium guajava* (L.) seedlings. According to Miranda et al. (1998), this is due to the fact that the chicken bed is rich in ammonia, so its proportion should not exceed 30% of the total of the mixture, otherwise the growth of the seedlings will be jeopardized.

This unfavorable characteristic of the manure with more than 50% may be related to the chemical characteristics of the final substrate obtained, since as shown in Table 4, the addition of manure provided increases in the levels of P and K, but also in those of Ca.

Table 4 - Chemical Characteristics of Treatments after the Experiment

Treatment	pH	pH	P	K	Ca	Mg
	water	CaCl ₂	mg dm ⁻³		cmolc dm ⁻³	
Control (T0)	5.8	5.0	1.7	42.4	2.55	1.00
25% birds (T1)	7.1	6.3	70.0	215.1	5.70	1.83
50% birds (T2)	7.2	6.4	62.6	212.1	7.20	1.99
75% birds (T3)	7.4	6.6	56.6	217.2	13.60	2.57
100% birds (T4)	7.5	6.8	67.3	210.1	43.75	3.24
Treatment	Al	H	MO	SB	CTC	V
	cmolc dm ⁻³		g dm ⁻³	cmolc dm ⁻³		%
Control (T0)	0.00	4.17	29.5	3.66	7.83	46.74
25% birds (T1)	0.00	1.43	32.1	8.09	9.52	84.98
50% birds (T2)	0.00	1.43	36.4	9.74	11.06	88.07
75% birds (T3)	0.00	0.80	39.5	16.73	17.53	95.44
100% birds (T4)	0.00	0.82	41.6	47.54	48.37	98.28

T0 - 100% soil; T1 - 75% soil + 25% residue; T2 - 50% soil + 50% residue; T3 - 75% residue + 25% soil; T4 - 100% residue. P - phosphorus; K - potassium; Ca - calcium; Mg - magnesium; Al - aluminum; H - hydrogen; MO - organic matter; SB - sum of bases; CTC - total capacity for exchange of cations; V - saturation by bases.

Source: Prepared by the authors (2022).

These Ca levels are out of balance with respect to Mg. Since, the Ca:Mg ratio needs to be maintained, in general, at 3:1 (it is important to analyze this for each species, since its nutritional requirement may undergo modifications). In this case, this ratio was greater than 3:1 at the beginning of the experiment, in T2 and T3. High levels of Ca may impair absorption by Mg, as these macronutrients are considered antagonistic. For this reason, Sena et al. (2010) warn that correcting the acidity of the substrate may not be the main benefit of liming, but it also provides correction of the Ca²⁺ and Mg²⁺ levels of the soil.

However, this imbalance was even more evident at the end of the experiment, when the levels of Ca reached 13.6 cmolc dm⁻³ and of Mg of 2.6 cmolc dm⁻³ of Mg, in T3, increasing the ratio to more than 5:1. This probably occurred as a function of the decomposition of organic matter, which was another high chemical characteristic with the addition of manure. In this case, the high levels of bases, such as Ca, brought about an increase in the sum of bases (SB), in the



capacity for exchanging cations (CTC), and, consequently, in saturation by bases (V%). In addition, according to Whalen et al. (2000), dung from animals fed with feed and concentrates is rich in carbohydrates that are probably contributing hydroxylates (OH⁻) to the soil solution.

This V% was, in general, 85%, mainly between T1, T3 and T4, in the initial conditions. For this reason, it is believed that, in the first few weeks, the growth of these cuttings may have been favored in an equal manner. However, in the end, it was observed that, with the release of Ca, this V% was raised to values higher than 85% in T2 and T3; and, in the condition of T1, this value remained similar to that of the beginning of the experiment, with the largest growth of *Adenanthera pavonina* seedlings.

The biomass of leaves, stem and root was analyzed at the end of 90 days and its results are presented in Table 5, corroborating the observed results for growth in height and diameter.

Table 5 - Comparison of mean morphological variables biomass of leaves, stem and root, of caroline cuttings submitted to different proportions of poultry manure

Treatment	Dry biomass			
	Sheets	Stem	Root	Total
Control (T0)	0.15 d	0.10 c	0.17c	0.42 d
25%birds (T1)	3.54a	1.16a	1.30a	5.99 to
50%birds (T2)	1.69 b	0.66 b	0.70 b	3.05 b
75%birds (T3)	1.00 c	0.24c	0.31c	1.54c
<i>pα</i>	**	**	**	**
CV(%)	24.59	26.95	23.73	17.14

** Significance less than 1% probability of error;

Vertical averages followed by the same letter do not differ statistically, by Tukey's test at the 5% probability level of error.

Source: Prepared by the authors (2022).

The highest mean for the biomass of the leaves (3.54 g) was observed in T1 (75% soil + 25% poultry manure), in contrast, the lowest was in the control (100% soil). Proving that the growth in height in T1 was accompanied by the production of dry mass, which is important for the plant, because this production is related to the plant's photosynthetic capacity. With more leaves, the plant will show greater photosynthetic capacity and, as a consequence, greater growth. However, this higher growth needs to be followed by greater mass production for the plant to sustain itself. Thus, these results indicate that this positive relationship may have occurred for the tense caroline.

According to Gomes and Paiva (2011), the dry mass of the aerial part indicates the rusticity of a seedling, the higher values representing more lignified and rustic seedlings, having greater use in environments with adverse conditions.

By analyzing the stem biomass, which is related in a more direct way to the physical support of the plant and to the carrying of sap from the root to the part above ground, this result was maintained. The cuttings in T1 showed the greatest mass production, with an average of 1.16 g (an increase of 91.4% in relation to the control). However, both in the control and in T3 (25% soil + 75% bird manure), the lowest averages were observed, similar to the one observed for growth in height and in diameter over 90 days of analyzes. Therefore, both the condition of 100% soil, as well as the proportion of 25% soil + 75% bird manure, are unfavorable for the production of dry mass in the *Adenanthera pavonina* cuttings, depending on the chemical conditions that were altered in the substrate.

When analyzing the root biomass, the increase in T1 (5.99 g) was 93% in relation to the production of dry mass in the seedlings of the control (0.42 g). This data is important because the root system will influence the plant's capacity to absorb water and nutrients. Therefore, this greater biomass in T1 probably collaborated for the adequate absorption of the seedlings, which



managed to stock nutrients in the upper part, contributing to the production of stem and leaf biomass, having as a consequence a greater height and diameter.

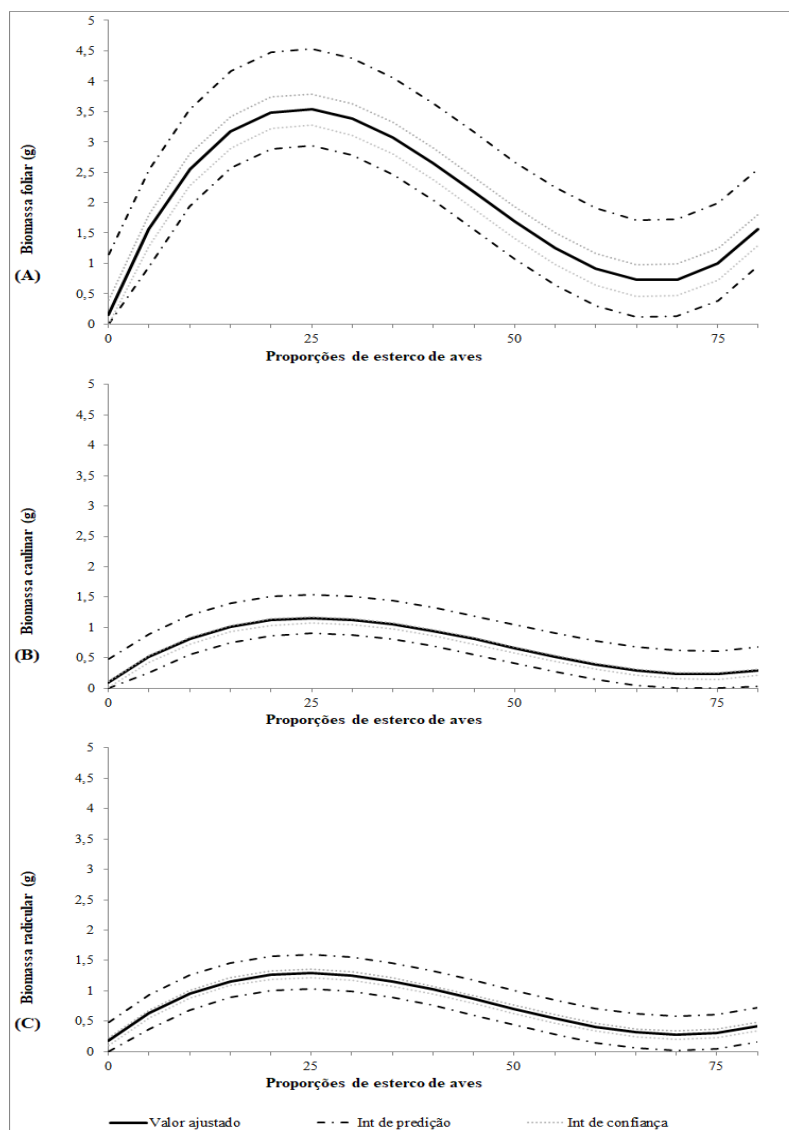
This is because the addition of organic matter in the form of dung directly influences the physical, chemical and biological properties of the soil and consequently its fertility, as it conditions the soil structure and carbon chains, aggregating mineral particles (Schimiguel et al., 2014).

According to Carneiro (1995), the better growth of the root is important to support the green mass produced by the plants, and this growth is a consequence of the quality of the substrates (chemical and physical properties). It is worth noting that the geometry of the roots influences the plant growth and the acquisition of nutrients (Stahl et al., 2013). According to Lisboa et al. (2018), if the roots do not develop sufficiently, problems with water stress and nutrient absorption capacity may occur, especially in field conditions.

The analysis of the total biomass reinforces the previous data, proving the largest production under substrate conditions with 25% of poultry manure, significantly higher than the other treatments. However, it also reinforces that additions of dung higher than this percentage can be detrimental to the growth and development of caroline cuttings.

Thus, the growth of *Adenanthera pavonina* was higher than observed by Alves et al. (2015), studying the same species. In this case, the greatest growth occurred in substrate with vegetable land (10.89 cm), sand and vegetable land 1:1 (10.51 cm), sand and wood powder 1:1 (10.01 cm); the production of dry mass of the aerial part, in the husk of carbonized rice (0.09 g/seedling) and; of the root part, in fine vermiculite and wood powder 1:1 (0.021 g/seedling) and fine vermiculite and vegetable land 1:1 (0.045 g/seedling). This study also presented growth averages higher than those observed by Barbosa (2017) who studied the production of *Adenanthera pavonina* seedlings in organic compound formed by material of pruning trees, plus bovine and caprine manure in different proportions, obtaining, at the end of 90 days, the highest growth in height of 13 cm and in diameter, of 2.40 mm; already the production of dry mass of the aerial part reached 1 g/plant and, 0.45 g/plant in the root part.

From Graph 2 one can analyze, visually, the differences in the production of foliar biomass, kaolin and root of the cuttings.



Graph 2 - Growth curves for morphological biomass variables (in g), of the caroline saplings submitted to the different proportions of poultry manure. (A) - Foliar biomass; (B) - Stem biomass; (C) - Root biomass. **Source:** Prepared by the authors (2022).

It is observed that, in the first 90 days of growth, the largest production was of leaves, which is related to the plant's photosynthetic process. However, regardless of the part analyzed, the chemical conditions of the substrate containing 75% soil + 25% bird manure was the most appropriate. After these substrate conditions, there was a reduction in biomass production. Therefore, larger amounts of manure can make the substrate chemically unfavorable.

5 FINAL CONSIDERATIONS

Dung ratios of more than 25% reduce plant growth and dry mass production, and the substrate containing 100% bird dung can inhibit germination and thus be detrimental to the production of *Adenanthera pavonina* seedlings.

The proportion of 25% bird manure + 75% soil is the most suitable for *Adenanthera pavonina* seedlings, so its use is recommended.

Results such as these can stimulate the use, more often, of organic waste for the production of seedlings. This would be an environmentally correct way of disposing of them, causing positive impacts on society, as it would be a way of not leaving them outdoors and, in



this way, preventing the proliferation of insects; avoiding their deposition in places that may bring about contamination of the soil and water; reducing discarding in natura and; promoting the re-use of these kinds of waste. As well as being a way of reducing costs with the production of seedlings by looking for an alternative form of fertilizing the soil and dependence on commercial mineral fertilizers, at the same time as stimulating the production of seedlings of the species studied.

Further work should be carried out if the objective is to test with other proportions, other types of waste, and/or other species. It is also important to use waste that is the cheapest and easiest to buy near the place where the seedlings are produced. Accordingly, depending on the place of study, the same proportions worked in the present case can be tested, however, with other residues.

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