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CHICKEN MANURE IN THE INITIAL GROWTH AND PHYSIOLOGY OF *Amburana acreana* SEEDLINGS

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ABSTRACT

Objective: To analyse the initial growth and physiological characteristics of *Amburana acreana* seedlings, produced in substrates formulated with different proportions between soil and chicken manure.

Theoretical Framework: Based on scientific articles found on search engines and books in the field of physiology and forestry. This is to support the explanation of how the physiological characteristics of the seedlings were influenced by the type of substrate and how they may have contributed to the morphological characteristics of these plants.

Method: The experiment was conducted in a greenhouse for 90 days. During this period, the seedlings were subjected to proportions of 0%, 25%, 50%, 75% and 100% chicken manure. At the end, they were evaluated regarding growth in height, diameter, dry mass production, height/diameter ratio, dry mass ratio, Dickson quality index, net photosynthetic rate, transpiration rate, stomatal conductance and intercellular CO_2 concentration, and intrinsic water use efficiency.

Results and Conclusion: The proportion of 25% soil + 75% chicken manure provided the best conditions when analysing physiological characteristics, which resulted in greater growth and greater dry mass production of *A. acreana* seedlings.

Implications of the Research: These results allow us to verify that, for seedlings to grow in soil containing bird manure, firstly, improvements occur in the physiological conditions of the plants, which are reflected in faster growth. Therefore, there is a need to study the type of manure and the dose that is applied, before recommending a type of substrate.

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

Keywords: Cherry, Seedling Production, Organic Waste, Plant Physiology, Plant Morphology.

ESTERCO DE AVES NO CRESCIMENTO INICIAL E NA FISIOLOGIA DE MUDAS DE *Amburana acreana*

RESUMO

Objetivo: Analisar o crescimento inicial e as características fisiológicas das mudas de *Amburana acreana*, produzidas em substratos formulados a partir de diferentes proporções entre solo e esterco de aves.

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Referencial Teórico: Baseado em artigos científicos encontrados em sites de buscas e em livros da área de fisiologia e silvicultura. Isso para embasar a explicação de como as características fisiológicas das mudas foram influenciadas pelo tipo de substrato e como podem ter contribuído para as características morfológicas dessas plantas.

Método: O experimento foi conduzido em casa de vegetação por 90 dias. Durante esse período, as mudas foram submetidas as proporções de 0%, 25%, 50%, 75% e 100% de esterco de aves. Ao final, foram avaliadas quanto ao crescimento em altura, diâmetro, produção de massa seca, relação altura/diâmetro, relação entre as massas secas, índice de qualidade de Dickson, taxa líquida fotossintética, taxa transpiratória, condutância estomática e concentração intercelular de CO_2 e a eficiência intrínseca no uso da água.

Resultados e conclusão: A proporção de 25% solo + 75% esterco de aves proporcionou as melhores condições ao analisar as características fisiológicas, o que implicou em maior crescimento e maior produção de massa seca das mudas de *A. acreana*.

Implicações da Pesquisa: Esses resultados permitem verificar que, para que ocorra o crescimento das mudas em solo contendo esterco de aves, primeiramente, acontecem melhorias nas condições fisiológicas das plantas, que se refletem em crescimento mais rápido. Existindo, portanto, a necessidade de estudar o tipo de esterco e a dose que é aplicada, antes de recomendar um tipo de substrato.

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

Palavras-chave: Cerejeira, Produção de Mudas, Resíduos Orgânicos, Fisiologia de Plantas, Morfologia de Plantas.

ESTERCO DE AVES NO CRESCIMENTO INICIAL E NA FISIOLOGIA DE MUDAS DE *Amburana acreana*

RESUMEN

Objetivo: Analizar el crecimiento inicial y las características fisiológicas de las mudas de *Amburana acreana*, producidas en sustratos formulados a partir de diferentes proporciones entre solo y esterco de aves.

Referencial Teórico: Basado en artículos científicos encontrados en sitios de búsqueda y en libros del área de fisiología y silvicultura. Isso para embasar a explicação de como as características fisiológicas das mudas foram influenciadas pelo tipo de sustrato y como podem ter contribuído para as características morfológicas dessas plantas.

Método: O experimento realizado en casa de vegetación por 90 días. Durante ese período, las mudas se submetieron en proporciones de 0%, 25%, 50%, 75% y 100% de esterco de aves. Al final, foram avaliadas quanto ao crescimento em altura, diámetro, producción de masa seca, relación altura/diámetro, relación entre masas secas, índice de calidad de Dickson, taxa líquida fotosintética, taxa transpiratoria, conducción estomática e concentración intercelular de CO2 y eficiencia intrínseca sin uso de agua.

Resultados y Conclusión: A proporção de 25% solo + 75% esterco de aves proporcionou as melhores condições ao analisar as caracteristicas fisiológicas, o que implicou em mayor crecimiento e mayor producción de masa seca das mudas de A. acreana.

Implicações da Pesquisa: Estos resultados permiten verificar que, para que ocorra o crescimento das mudas em solo contendo esterco de aves, primeiramente, acontecem melhorias nas condiciones fisiológicas de las plantas, que se reflejan en crecimiento más rápido. Existen, por tanto, una necesidad de estudiar o tipo de esterco y una dosis que se aplica, antes de recomendar un tipo de sustrato.

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

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1 INTRODUCTION

The suppression of forested areas, especially those belonging to the Brazilian Cerrado, for the installation of monocultures and pasture, with economic purposes; and / or even practices such as fires, has caused the reduction of natural vegetated areas and, thus, biodiversity (Berti *et al*., 2017; Bandeira *et al*., 2018). In an attempt to recover part of these areas, some environmental agencies have stimulated the restoration from the planting of native species, that is, the recomposition with native and exotic species with commercial characteristics. One of the native species with potential for the restoration of urban or rural natural areas is the cherry tree (*Amburana acreana*).

The *A. acreana* is a forest species of the Fabaceae family, whose seeds can be consumed roasted, besides having phytochemical constituents and; its wood, be destined to the manufacture of cellulose, paper and coal (Carvalho, 2007). It is known as cumaru-de-cheiro or cherry tree, being considered of great size because it can reach up to 30 meters in height. In the Amazon region it is distributed in the States of Rondônia, Acre and Amazonas (Albrecht *et al*., 1986). Due to the reduction in its habitat, *A. acreana* is vulnerable to extinction (SNIF, 2020). Characteristics that justify its inclusion in the list of species with potential for the recovery of areas. However, for this, it is necessary to know more about its production process, starting with the molting phase.

The production of seedlings of forest species with quality for planting in the field requires the observation of a number of factors, since these will influence the nutrition, growth and development of these seedlings, both in the nursery phase and after planting. Among these factors is the substrate, whose chemical, physical and microbiological characteristics will directly influence the quality of the seedling obtained. According to Silva Júnior *et al*. (2018) substrates are listed as a factor of high influence on the development capacity of plants, *because it is responsible for providing physical support to the root system and conditions to adequately meet the water and nutritional demand of the seedling (Siqueira et al*., 2018).

In order to reduce costs, it is possible to choose the use of easily obtained organic substrates, such as manure. According to Vendruscolo *et al*. (2017) the large-scale use of commercial substrates can be a factor that contributes to the burden on seedling production. On the other hand, because they are easily found, residues such as manure, instead of being discarded in inappropriate places, can be reused as input, becoming low-cost substrates for the production of quality forest seedlings (Maranho; Paiva, 2011).

In this sense, poultry manure can be an alternative and some studies have shown that it would be an option for the production of forest species seedlings, to mention: Menegatti *et al*. (2017) and Thiesen *et al*. (2020) who recommended the use of 20% poultry litter in the substrate composition for the production of *Eucalyptus dunnii* and *Eugenia involucrate*, respectively. E, Trazzi *et al*. (2013) and Faria *et al*. (2016) recommended that 35% of chicken litter, for *Tectona grandis* and *Mimosa setona*, respectively. Thus, it is understood that, before using poultry manure for the production of seedlings, it is necessary to study the ideal proportion for the species to be produced.

This is because the addition of manure to form substrates can change the chemical composition of the final product and thus promote physiological changes in plants, which may be beneficial or not. According to Mondini *et al*. (2019), functional changes in plants by the application of different fertilizers (such as organic) can be investigated by means of non-destructive tools involved directly or indirectly in the photosynthetic process. Like those employed in the present case.

Therefore, this study was developed with the objective of analyzing the initial growth and physiological characteristics of *A. acreana* seedlings, produced in substrates formed by different proportions between soil and poultry manure.

2 THEORETICAL FRAMEWORK

The theoretical framework was based on scientific articles and books published in the areas of Physiology and Forestry. For a better understanding, this theoretical reference is composed of some items; one of them, characterizing the studied species; another, explaining the properties that the substrates need to present to be used in the production of seedlings, with emphasis on organic residues, and; a final item, highlighting the use of poultry manure in the production of seedlings.

2.1 *AMBURANA ACREANA*

The species of the genus *Amburana*, family Fabaceae, occur in the Amazon forest, such as *A. acreana* and; in the caatinga and cerrado, such as *A. cearenses* (Lorenzi, 2016). The *A.*

acreana (Ducke) A.C. Smith presents arborescent form of high stem, occurring in high and closed forests in the western Amazon of Brazil (AM, AC, RO and MT) and Bolivia. It is classified as a deciduous tree, reaching dimensions close to 40 m in height and 150 cm in DBH (diameter at breast height, measured at 1.30 m from the ground), in adulthood (Carvalho, 2007).

This species is popularly known as cherry or cumaru-de-cheiro (Albrecht *et al*., 1986), its fruiting occurs in the months of August to October and the winged seeds are dispersed by the wind, making it difficult to collect inside the forests (Firmino *et al*., 1995).

The *A. acreana* is widely marketed, both nationally and internationally, with high economic value, however, it is vulnerable to extinction (Brazil, 1992, SNIF, 2020). In Acre, for example, it is one of the most consumed species in the timber market and subjected to the greatest pressure of selective exploitation (Oliveira, 1995).

According to Remade (2024), the wood of this species is similar to that of European oak (*Quercus* spp.), it is smooth and pleasant in appearance, much sought after mainly by the national luxury furniture industries, which use it in the form of sawn and plywood (decorative knives). It can also be used in civil construction: in internal finishes such as skirting boards, moldings, cords, frames, doors, slats, decorative knifed sheets, turned parts etc.

In Acre, its bark is used as a medicine against anemia and flu, and in the preparation of alcoholic beverages. With the seeds, snuff is prepared, used to relieve nasal constipation, headaches and toothache (Carvalho, 2007).

2.2 THE SUBSTRATE IN SEEDLING PRODUCTION

In order to be successful in the implantation of a forest plantation, regardless of the species, it is necessary to pay attention to the quality of the seedling produced (Reis *et al*., 2019). Within the seedling production phase, the choice of substrate, based on its dose and / or quantity, is one of the most important requirements for achieving quality (Barbosa *et al*., 2014). This choice may also influence the final cost of the seedling (Cruz *et al*., 2016).

According to Silva Júnior *et al*. (2018) substrates are listed as a factor of high influence on the development capacity of plants, because it is responsible for providing physical support to the root system and conditions to adequately meet the water and nutritional demand of the seedling (Siqueira *et al*., 2018).

There is no perfect substrate for all conditions and species. It is advisable to use components of a substrate in the form of a mixture, since they may present characteristics not suitable for the plant, when used alone (Caldeira *et al*., 2011). However, this formulation usually involves the products available in a region, making the final material cheaper and thus justifying the use of organic products, for example. In addition to, environmentally, giving a suitable destination for different types of waste (Ribeiro *et al*., 2018).

For Pagliarini *et al*. (2012) the ideal substrate should present: uniformity in composition; and be free of pests, pathogens and weeds. Menezes Júnior *et al*. (2000) add that it should also provide good aeration, to allow the diffusion of oxygen to the roots; good water storage capacity; low resistance to penetration of the roots; and good resistance to loss of structure.

The use of organic residues in the composition of substrates for the cultivation of seedlings contributes significantly to the aeration, water retention capacity and formation of a physical *structure suitable for the development of the roots (Santos et al*., 2010). Pereira *et al*. (2010) also emphasize favoring the development of mycorrhizae and tamponic reactions that prevent pH changes, in addition, the addition of organic waste to the substrate can suppress certain pathogens.

2.3 CHICKEN LITTER OR POULTRY MANURE IN THE PRODUCTION OF SEEDLINGS OF FOREST SPECIES

The use of organic compounds such as poultry litter, also called poultry manure, in the production of seedlings, are alternatives that reduce the cost of production, being important for agroecological and organic production systems (Brugnara, 2015).

In addition to being an alternative for reuse, since, according to Gonzaga *et al*. (2021), the environmental issue is one of the most important challenges of society, and it is important to search for solutions for the disposal of solid waste. Thus, reducing expenses with its deposition, from the transformation of these sources that may have nutritional characteristics (Kniess *et al*., 2019). So the reuse of manure, for example, is one way to promote this.

This type of material is rich in nutrients such as P, K and N, due to the concentrated ration that the birds receive. Among these nutrients, N stands out due to the high protein content of the diets (Minho *et al*., 2012). However, not only N, since also P and K, can reach high values, of 36.5g, 13.3g and 33.6g kg^{-1}, respectively (Virtuoso *et al*., 2015). As well as, high levels of Ca and Mg, which are quite variable according to the origin: broiler or laying birds (Ribeiro *et al*., 2018). For this reason, poultry manure has nutritional levels higher than the manure of other domestic animals (Serrano *et al*., 2011).

In a study in which different substrates were tested for the production of *Tectona grandis* seedlings, Trazzi *et al*. (2013) found the highest gain in dry mass, height and diameter, in the treatments consisting of poultry litter. Recommending the proportion of 35%, to the substrate. The same recommended by Faria *et al*. (2016) for the production of *Mimosa seedlings*.

In other studies, Gonçalves *et al*. (2013) observed *Acacia farnesiana* seedlings with better quality in substrate containing at least 20% poultry manure and 40% bovine manure. Situation similar to that observed for the production of *Eucalyptus dunnii*, for which, Menegatti *et al*. (2017) recommended the use of 20% poultry litter in the total volume of the substrate. And, de Andrade *et al*. (2014), who recommended 20% of chicken litter in the substrate composition for the production of *Annona muricata* seedlings.

3 METHOD

The experiment was carried out in a greenhouse, belonging to the Faculty of Agronomy of the University of Cuiabá (UNIC), located on the campus Beira Rio I, in Cuiabá - MT, at coordinates 15º37'28 "S and 56º05'11" O. The predominant climate in the area is of the Aw type, that is, tropical savanna, according to the Köppen classification. This greenhouse is a protected environment, with transparent canvas cover.

The soil used was classified as dystrophic Red Latosol with sandy loam texture, and collected in an area of native Cerrado belonging to the Federal Institute of Mato Grosso (IFMT), campus of São Vicente da Serra - MT, in a layer of 0-20 cm depth. Whereas, the Vitaplan® poultry manure was purchased commercially and it is a simple organic fertilizer class A. According to the supplier, this fertilizer contains poultry manure with limestone, processed and decomposed shells and expanded vermiculite, 1% total N, pH 5.5, 20% total organic carbon (TOC) and cation exchange capacity (CEC) of 2.0 $_{cmolc}$ dm^{-3}.

The treatments tested were constituted from proportions between poultry manure and soil, being: 100% soil (control); 75% soil + 25% poultry manure; 50% soil + 50% poultry manure; 25% soil + 75% poultry manure; 100% poultry manure. These five treatments were arranged in a completely randomized design with six replications, totaling 30 sample units.

For the constitution of each treatment, a container with a capacity of 2.0 L was used. For this, soil was added up to the desired proportion (as for the treatment), as well as the amount of poultry manure. Then, the material was placed on a flat surface for homogenization and, later, the resulting substrate was used to fill the plastic bags with a capacity of three kilograms (40 x 50 cm), which were the definitive containers of the experiment.

Samples of the tested treatments were characterized for their chemical composition, and the results can be observed in Table 1.

Table 1

Chemical characteristics of treatments

Treatment	pH	pH	P	K	Ca	Mg
	water	$CaCl_2$	mg dm^{-3}		CMOLC DM^{-3}	
T0	5.8	5.0	1.7	42.4	2.55	1.00
T1	7.1	6.3	70.0	215.1	5.70	1.83
T2	7.2	6.4	62.6	212.1	7.20	1.99
T3	7.4	6.6	56.6	217.2	13.60	2.57
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}		%
T0	0.00	4.17	29.5	3.66	7.83	46.74
T1	0.00	1.43	32.1	8.09	9.52	84.98
T2	0.00	1.32	36.4	9.74	11.06	88.07
T3	0.00	0.80	39.5	16.73	17.53	95.44
T4	0.00	0.82	41.6	47.54	48.37	98.28

T0 – 100% soil; T1 – 75% soil + 25% waste; T2 – 50% soil + 50% waste; T3 – 75% waste + 25% soil; T4 – 100% waste. P – phosphorus; K – potassium; Ca – calcium; Mg – magnesium; Al – aluminum; H – hydrogen; MO – organic matter; SB – sum of bases; CTC – total cation exchange capacity; V – base saturation.
Source: Elaborated by the authors (2022).

After the constitution of each treatment, the seeds of *A. acreana* were placed to germinate. These seeds were collected from trees located in an area belonging to the Federal University of Mato Grosso, Cuiabá campus, located at coordinates 15º36'36" S and 56º03'57" O. The collection took place from the dried and half-opened fruits or seeds, already fallen to the ground. Then, they were stored in plastic bags and taken to the nursery, being used later in sowing.

For sowing, three seeds were placed per plastic bag and, after germination, when the seedlings were already five centimeters high, thinning was carried out to leave only one per bag, choosing the most central and vigorous. However, in the treatment with 100% poultry manure, germination was not observed, so some seedlings from thinning were transplanted into plastic bags containing this treatment.

After this practice, the seedlings were expected to catch for 15 days, until new shoots were observed. Once this was done, the first measurements of the height and diameter of the neck were carried out, in order to know the initial characteristics of the seedlings, since they were produced from seeds. The height was obtained with the aid of a graduated ruler, measuring from the surface of the substrate to the last leaf of each seedling; and the diameter, with the aid of a digital caliper. Then began counting the period of growth of seedlings and to obtain the relevant information to the experiment. These measurements in height (H, in cm) and diameter (DC, in mm) continued every 30 days.

At the end of 90 days, the physiological characteristics were evaluated, from three plants, of each treatment, being: photosynthetic net rate (A, in µmol m-2 s-1), stomatal conductance (gs, in µmol m-2 s-1), intercellular CO2 concentration (Ci, in mmol m-2 s-1), transpiratory rate (E, in mmol m-2 s-1) and intrinsic water use efficiency (A/Ci). These characteristics were measured with the aid of a portable photosynthesis measurement system, model LI-6400 XP (LI-COR, Lincoln, NE, USA). For the measurements, the apparatus was adjusted to a temperature of 28 °C, relative humidity of 60% and photosynthetically active flux density of 1000 μmol m^{-2} s^{-1}. They were carried out on the first or second fully expanded leaf, from the shoot apex (usually the fourth or fifth leaf), exposed to solar radiation and without phytosanitary impairment. And, occurred in the daytime period, between 07:00 and 11:00 h (local time), registering the values only after the stability of the gs.

In addition to the physiological characteristics, the morphological characteristics (after 90 days), such as height and diameter, were also obtained. In the continuity of the measurements, the seedlings were harvested, sectioned in aerial part and root part, washed in running water to remove the excess of substrate, mainly from the root part. Then, they were taken to a forced air circulation greenhouse at 65 °C, until constant weight. Both the dry mass of the aerial part (MSPA, in grams) and the root part (MSPR, in grams) were obtained from the weighing in an analytical balance with precision of 0.01g. From these data, it was possible to obtain the total dry mass (TDM, in grams) and the quality indexes: height and neck diameter ratio (H / DC), dry shoot and root dry mass ratio (MSPA / MSPR) and Dickson quality index (DQI), according to Dickson *et al.* (1960).

The data were statistically analyzed using the Sisvar 5.6 program to compare means, using the Tukey test at 5% probability.

4 RESULTS AND DISCUSSIONS

4.1 MORPHOLOGICAL CHARACTERISTICS OF *A. ACREANA* SEEDLINGS PRODUCED IN DIFFERENT PROPORTIONS OF POULTRY MANURE

The results obtained for the growth in height and diameter of the *A. acreana* seedlings submitted to the different proportions of poultry manure, over 90 days, are presented in Table 2.

Table 2

Comparisons of means of morphological variables height (H, in cm) and neck diameter (DC, in mm) of A. acreana seedlings submitted, over 90 days, to different proportions of poultry manure

Treatments	H			DC		
	30 days	60 days	90 days	30 days	60 days	90 days
Control (T0)	31.50 to	43.00 to	56.33 to	2.49 b	3.28 to	4.34 b
25% birds (T1)	18.00 b	29.00 b	39.83b	2.59 b	3.54 to	4.70 ab
50% birds (T2)	14.00 C	24.17 C	31.50 C	2.23b	3.28 to	4.39 b
75% birds (T3)	33.00 to	42.83 to	53.83 to	3.02 to	3.84 to	5.26 to
100% birds (T4)	19.50 b	29.50 b	39.50b	2.29 b	3.29 to	4.38 b
pα	**	**	**	**	**	**
VC (%)	7.99	8.26	9.68	9.88	10.03	9.84

** Significance less than 1% error probability.
Means followed by the same letter vertically do not differ statistically, by the Tukey test at the 5% error probability level.
Source: Survey data.

The height growth (Table 2) was higher for seedlings submitted to T0 (100% soil) and T3 (75% poultry manure + 25% soil) during the 90 days of analysis. In T0, the average was 31.50 cm to 56.33 cm (24.83 cm of growth in the period) and; in T3, from 33.00 cm to 53.83 cm, therefore, 20.83 cm of growth after 90 days. Only in these treatments, seedlings with more than 50 cm of growth were observed after 90 days.

The addition of poultry manure also provided an increase in diameter growth. With emphasis on T3 over the 90 days of analysis. In this case, at 30 days, the average was 17.5% higher than that observed for seedlings at T0; after 60 days, no significant difference was obtained between treatments; whereas, at 90 days, the average diameter at T3 was also 17.5% higher than that of seedlings at T0. It is noteworthy that, at 90 days, the only treatment in which seedlings with a diameter greater than 5 mm were observed, was T3, with growth of 3.02 mm (after 30 days) to 5.26 mm (after 90 days), that is, 2.24 mm in the period of 90 days.

According to Xavier *et al*. (2009), the most suitable seedlings for planting in the field are those that present growth in height between 20 and 40 cm and, two mm in diameter. As for height, these values were observed from 30 days of growth, at T0 and T3. As for the diameter, this was also observed at 30 days, in all treatments tested. These data are pertinent because, in a nursery, this implies in having saplings with aptitude for planting in the field in less time. In addition, in a commercial nursery, this corresponds to more seedlings sold in less production time.

Important results because these are the two morphological characteristics (height and diameter) most used to qualify cuttings to be planted in the field. According to Gomes; Paiva

(2013), the height for being fast and easy to determine, since it is a non-destructive analysis and; the diameter for being related to the capacity of formation and growth of new roots (Souza *et al*., 2006). The stem and the region of the thick neck are related to the presence of reserve substances in the internal tissues of the plant, indicating that the seedling presents a healthy aspect and is nutritionally suitable for planting in the field, since part of the reserves to form new roots comes from nutrients contained in the stem (Scremin-Dias *et al*., 2006). Therefore, the stem diameter explains 70 to 80% of the differences that exist in the dry weight of seedlings (Gomes; Paiva, 2013).

The seedlings in T3 also stood out in terms of dry mass production (Table 3).

Table 3

Comparisons of means of morphological variables shoot mass (MSPA, in g), root dry mass (MSPR, in g) and total dry mass (MST, in g) of A. acreana seedlings submitted to different proportions of poultry manure

Treatments	MSPA	MSPR	MST
Control (T0)	0.78 BC	0.39 b	1.17 bc
25% birds (T1)	1.24 b	0.37 b	1.61 b
50% birds (T2)	1.04 b	0.26 C	1.31 b
75% birds (T3)	5.16 to	1.05 to	6.21 to
100% birds (T4)	0.36 C	0.08 d	0.44 C
pα	**	**	**
VC (%)	23.01	12.49	20.61

** Significance less than 1% error probability;
Means followed by the same letter vertically do not differ statistically, by the Tukey test at the 5% error probability level.
Source: Survey data.

The average for dry mass production in the aerial part was higher in T3 in 85% in relation to T0 (0.78 g); already in relation to root dry mass, it was higher in 63%. Due to these results, it was higher in T3 when analyzing the total dry mass (by 81%). Corroborating the results obtained for the growth in height and diameter of the seedlings and the importance of improving soil characteristics with the addition of poultry manure for the production of *A. acreana* seedlings.

Aerial dry matter production indicates the hardiness of the seedling, and the highest values represent the most lignified and rustic, with greater production potential in *environments with adverse conditions (Gomes; Paiva, 2013).* Therefore, one of the best characteristics to evaluate the quality of the seedlings, although destructive, as it reflects the net photosynthesis of the plant (Fernandes *et al*., 2019). What was also reported by Tatagiba *et al*. (2015), and that complement, the increase in leaf matter is a significant factor in plant growth, since the leaf is the organ responsible for photosynthesis.

The best root growth in the treatment in which it was also observed higher averages in height, diameter and dry mass of the aerial part, is important because the geometry of the roots influences the growth of the plant and the acquisition of nutrients (Stahl *et al*., 2013). Therefore, Gomes; Paiva (2013) recommend that the more abundant the root system, the greater the chance of survival of the seedling in the field. And probably this has favored the previous results for the growth of seedlings, in height and diameter.

As for the H/DC ratio (Table 4), the seedlings in T3 did not stand out, however, this was an expected result since, when it comes to relationships between different parts of the plant, it is desired that one does not grow much more, compared to the other, as what should happen for the H/DC ratio. In this case, one cannot have seedlings with much greater aerial growth in relation to diameter growth (which refers to root growth), since this would imply etiolated plants. According to Birchler *et al*. (1998), the values for this characteristic should be less than 10, which was not observed in T3, however, this did not affect the quality of the seedling obtained.

Table 4

Comparisons of the morphological variables height / neck diameter ratio (H / DC), dry shoot / root dry mass ratio (MSPA / MSPR) and Dickson quality index (IQD) of A. acreana seedlings subjected to different proportions of poultry manure

Treatments	H/DC	MSPA/MSPR	DQI
Control (T0)	13.00 to	2.01 d	0.08 to
25% birds (T1)	8.49 bc	3.35 C	0.13 b
50% birds (T2)	7.37 C	3.94b	0.12 b
75% birds (T3)	10.30b	4.87 to	0.41 to
100% birds (T4)	9.06 bc	4.79 to	0.03 d
pα	**	**	**
VC (%)	14.00	7.36	24.12

** Significance less than 1% error probability;
Means followed by the same letter vertically do not differ statistically, by the Tukey test at the 5% error probability level.
Source: Survey data.

Regarding the MSPA/MSPR ratio, the lowest means were not observed in T3. Parviainen (1981), explain that this is an efficient and safe index to evaluate the quality of seedlings and that it should present averages with a value of up to 2.0 (Brissete, 1984), which was not observed in the treatments tested in this study. However, this does not seem to have negatively affected the growth of seedlings, especially in treatments with addition of manure.

To prove this, the quality of the seedlings was analyzed from the IQD, which was higher for the seedlings in T3, consolidating the results previously observed for the growth and dry mass production of the seedlings in this treatment. Gomes; Paiva (2013), say that the higher the value for this characteristic, the better the quality standard of the seedlings to be taken for transplanting in the field.

4.2 PHYSIOLOGICAL CHARACTERISTICS OF *A. ACREANA* SEEDLINGS PRODUCED IN DIFFERENT PROPORTIONS OF POULTRY MANURE

The growth of *A. acreana* seedlings was influenced by the physiological changes that occurred throughout the experiment and this can be analyzed from Table 5.

Table 5

Comparisons of means for net photosynthetic rate (A, in µmol m-2 s-1), stomatal conductance (gs, in µmol m-2 s-1), intercellular CO2 concentration (Ci, in mmol m-2 s-1), transpiration rate (E, in mmol m-2 s-1) and intrinsic water use efficiency (EIUA, A/Ci) of A. acreana seedlings submitted to different proportions of poultry manure

Treatments	A	gs	Ci	E	EIUA
Control (T0)	9.60 to	0.151 to	237.32 to	2.31 to	63.35 C
25% birds (T1)	3.51 C	0.031 d	187.44 b	0.70 c	112.42 to
50% birds (T2)	5.49 b	0.067 b	225.90 to	1.98 b	81.97 b
75% birds (T3)	9.61 to	0.151 to	237.32 to	2.31 to	63.37 bc
100% birds (T4)	4.87 b	0.040 c	192.47 b	0.90 c	123.20 to
pα	**	**	**	**	**
VC (%)	4.32	3.35	3.82	6.40	9.59

** Significance less than 1% error probability.
Means followed by the same letter vertically do not differ statistically, by the Tukey test at the 5% error probability level.
Source: Survey data.

The highest averages for the net photosynthetic rate (A) were observed in treatments with 0 and 75% poultry manure. Considering the treatments with poultry manure, the means were increasing from 25% (T1 - average of 3.51 µmol m^{-2} s^{-1}) to 75% (T3 - average of 9.61 µmol m^{-2} s^{-1}), reducing again when 100% of manure was used. For the seedlings in T3 this indicated an increase of 63.5% in relation to that observed in the seedlings in T1 and was reflected in the higher growth in the treatment with 75% of poultry manure.

It is known that photosynthesis is the process by which the plant produces organic compounds capable of keeping it alive and its active growth. When the conditions of a substrate change, it also changes its nutritional and physical conditions, which implies changes in its photosynthetic capacity. In the present case, the addition of poultry manure improved the conditions for *A. acreana* seedlings, allowing the increase in photosynthetic rate and, consequently, in the capacity of the plants to grow.

According to Kirschbaum (2011) 30% increase in photosynthetic rate can result in 10% increase in plant growth. Regarding the diameter, for example, according to Larcher (2006), there is a direct relationship between it and liquid photosynthesis. In addition, as leaves grow, their ability to produce photoassimilates increases until reaching maturity (Silva *et al.*, 2013). Since the increase in leaf dry matter is a significant factor for plant growth, since the leaf is the organ responsible for photosynthesis (Tatagiba *et al.*, 2015).

As for stomatal conductance (gs), the same treatments stood out in relation to the highest and lowest average. In this case, T0 and T3 averaged 0.151 µmol m^{-2} s^{-1} and T1 averaged 0.031 µmol m^{-2} s^{-1}. These results followed what was observed for the net photosynthetic rate because there was also an increase according to the increase in the proportion of poultry manure in relation to the soil, until reaching 75% of manure. Above that, that is, in 100% of manure (T4), the conductance reduced, which provided the lowest growths and dry matter yields.

These results influenced the intercellular concentration of CO_2 and the transpiration rate, as they are correlated characteristics. The entry of CO_2 is a necessary process for its carbon to be used for the production of organic matter during the dark phase of photosynthesis and that occurs from the transpiration of the plant. For this, the stomata need to open up and allow the entry of the gas and, with more CO_2 entering, the greater the stomatal conductance and transpiration rate occurring, since the plant will be constantly using it for the process. This happens because the conditions of the substrate allow this photosynthetic constancy, otherwise these results would not have been observed.

According to McDermit (1990) leaf stomatal conductance can be understood as the rate of water vapor passage through the stomata of the leaves. Being, the stomatal opening, the main route by which there is exchange of CO_2 from the atmosphere to the leaves. Thus, the opening of the stomata is controlled by complex mechanisms in order to maintain a balance between the absorption of CO_2 and the control of water vapor loss (Taiz; Zeiger, 2013).

This occurs despite the functioning of the stomata constitute a physiological impairment, because when opened, they allow the assimilation of CO_2 and the loss of water (H_2O). Closing, it reduces the entry of CO_2 to the rubisco carboxylation sites within chloroplasts and preserves H_2O, reducing the risk of dehydration (Tatagiba *et al.*, 2015). Therefore, the highest values of intercellular concentration should be associated with the highest water availability in the soil (Silva *et al.*, 2015).

This water availability was favored by the addition of manure to the soil, mainly in T3 (75% manure), with an average similar to that of T0 (100% soil) and T2 (50% manure), when analyzing the intercellular concentration of CO_2. For this case, the means were higher in 21% when comparing T3 and T0 with T1 (25% of manure) and; in 17% when comparing T2 with T1. While, for the transpiration rate, the plants in T0 and T3 presented similar averages and 70% higher in relation to the seedlings in T1.

Thus, among the treatments with addition of manure, T3 was the one that best collaborated with the water issues for the *A. acreana* seedlings, and considering that water is the main route for the conduction of nutrients, it also allowed the greater availability and absorption of these for the seedlings. An example is the study by Scalon *et al*. (2011), who observed water restriction in the soil aggravated by evapotranspiration, causing the partial closure of the stomata, which reduced the stomatal conductance, which in turn resulted in a decrease in transpiration and assimilation of CO_2, reducing the production of photoassimilates by *Guazuma ulmifolia* seedlings.

According to Ferraz *et al*. (2012) plants, when under some kind of stress, reduce stomatal conductance and transpiration and increase water use efficiency. Under these conditions, the rate of photosynthesis also ends up being reduced. However, this did not occur in the present case, because the treatments with the highest averages for photosynthetic rate, stomatal conductance, intercellular CO2 concentration and transpiration rate, were not those that stood out with respect to intrinsic water use efficiency (EIUA).

This demonstrates that these were, in fact, the treatments with the highest capacities to provide water for *A. acreana* seedlings, which, in turn, showed the highest photosynthetic efficiency with what was made available to them. This is corroborated by Silva *et al*. (2015) who mention that, in a situation of optimal water availability (field capacity), plants have high transpiration rates so that, as soil water becomes scarce, the plant begins to reduce its transpiration rate to reduce water loss and save available water in the soil.

5 FINAL CONSIDERATIONS

The addition of poultry manure improved soil conditions and allowed obtaining the highest averages in growth and dry mass production of *A. acreana* seedlings.

Treatment 3 (75% poultry manure + 25% soil) provided the highest averages for height, diameter, shoot and root dry mass and Dickson quality index, due to the positive changes that occurred in the photosynthetic rate, stomatal conductance, intercellular concentration and transpiratory rate of the seedlings. Indicating that poultry manure can be added to the soil to form a suitable substrate for the production of *A. acreana* seedlings, however, higher amounts than this, are not recommended.

Results like these can stimulate the use, more frequently, of organic residues for the production of seedlings. This would be an environmentally correct way to: dispose of these residues, positively impacting society, as it would be a way not to leave them outdoors, since this can also promote the proliferation of insects; prevent their deposition in places that may lead to soil and water contamination, therefore, reduce disposal in natura; promote the reuse of these materials. In addition to being a way to reduce costs with the production of seedlings when seeking them as organic fertilizer, while stimulating the production of seedlings of the species studied.

Other works should be developed if the objective is the test with other proportions, other types of waste, or other species. It is important to use waste that is the easiest and cheapest to be purchased, and that is close to the place of production of seedlings. Thus, depending on the region of study, the same proportions worked in the present case can be tested, however, with residues that are more common in the area.

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