

Agronomic viability of mint in succession to cowpea in addition to rooster tree (*Calotropis procera*) plus cattle manure in an argisol

Viabilidade agronômica da hortelã em sucessão ao feijão-caupi em adição com flor-de-seda (*Calotropis procera*) mais esterco bovino em um argissolo

Viabilidad agronómica de la menta en sucesión de caupí con adición de algodoncillo (*Calotropis procera*) y estiércol bovino en un suelo argisol

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ABSTRACT

The successive cultivation of legumes is of paramount importance, since these species are nitrogen-fixing, which is beneficial for the subsequent crop. The objective of this study was to evaluate the agronomic viability of cultivating mint in succession to cowpea, in addition to rooster tree (*Calotropis procera*) and bovine manure in an argisol. The study was conducted at the Rafael Fernandes Experimental Farm, belonging to the Federal Rural University of the Semi-Arid Region (UFERSA). The experimental design was a randomized complete block design with five treatments and four replicates. The treatments consisted of a combination of five doses of rooster tree (*Calotropis procera*) plus cattle manure (0.0; 1.0; 2.0; 3.0 and 4.0 kg m⁻²). Mint (*Mentha piperita* L.) seedlings were transplanted at a spacing of 0.2 x 0.2 m in four planting rows. The characteristics evaluated were: biomass height, biomass production, number of bunches and dry mass. Maximum mint production (stem + leaf) and exclusive leaf production was observed at doses of 4.0 and 3.5 kg m⁻² of silk flower plus cattle manure. The mixture of fertilizers of animal and plant origin contributed significantly to the increase in the evaluated agronomic characteristics of the mint crop,

being of great relevance for family farmers who work in this activity. The use of the rooster tree (*Calotropis procera*) constitutes an alternative option for farmers in the semi-arid region, given the availability of the species throughout the year, which allows its use as organic fertilizer.

Keywords: medicinal plant, agriculture, organic system, spontaneous plant.

RESUMO

O cultivo sucessivo de leguminosas é de suma importância, visto que essas espécies são fixadoras de nitrogênio, o que é benéfico para a cultura subsequente. O objetivo deste estudo foi avaliar a viabilidade agrônômica do cultivo de hortelã em sucessão ao feijão-caupi, em adição com flor-de-seda (*Calotropis procera*) mais esterco bovino em um argissolo. O estudo foi conduzido na Fazenda Experimental Rafael Fernandes, pertencente à Universidade Federal Rural da Região Semiárida (UFERSA). O delineamento experimental foi em blocos casualizados completos, com cinco tratamentos e quatro repetições. Os tratamentos consistiram na combinação de cinco doses de flor-de-seda (*Calotropis procera*) mais esterco bovino (0,0; 1,0; 2,0; 3,0 e 4,0 kg m⁻²). Mudanças de hortelã (*Mentha piperita* L.) foram transplantadas em espaçamento de 0,2 x 0,2 m, em quatro fileiras. As características avaliadas foram: altura da biomassa, produção de biomassa, número de cachos e massa seca. A produção máxima de hortelã (caule + folha) e a produção exclusiva de folhas foram observadas nas doses de 4,0 e 3,5 kg m⁻² de flor-de-seda mais esterco bovino. A mistura de adubos de origem animal e vegetal contribuiu de sobremaneira para o aumento das características agrônômicas avaliadas da cultura da hortelã, sendo de grande relevância para os agricultores familiares que labutam nessa atividade. O uso da flor-de-seda (*Calotropis procera*) constitui em opção alternativa para os agricultores da região semiárida, tendo em vista, a disponibilidade da espécie durante todo o ano, o que possibilita a sua utilização como adubo orgânico.

Palavras-chave: planta medicinal, agricultura, sistema orgânico, planta espontânea.

RESUMEN

El cultivo sucesivo de leguminosas es de suma importancia, visto que estas especies son reparadoras de nitrogenado, lo que es beneficioso para la cultura posterior. El objetivo de este estudio fue evaluar la viabilidad agronómica del cultivo de menta en sucesión de caupí, además de algodocillo (*Calotropis procera*) y estiércol bovino en un argisol. El estudio fue conducido en la Fazenda Experimental Rafael Fernandes, perteneciente a la Universidad Federal Rural de la Región Semiárida (UFERSA). El diseño experimental fue en bloques casualizados completos, con cinco tratamientos y cuatro repeticiones. Los tratamientos consisten en una combinación de cinco dosis de flor de seda (*Calotropis procera*) más esterco bovino (0,0; 1,0; 2,0; 3,0 y 4,0 kg m⁻²). Mudanças de hortelã (*Mentha piperita* L.) foram transplantadas em espaçamento de 0,2 x 0,2 m, em quatro fileiras. Como características disponibles para el foro: altura de biomasa, producción de biomasa, número de cachos y masa seca. A produção máxima de hortelã (caule + folha) e a produção exclusiva de folhas foram observadas nas dosis de 4,0 y 3,5 kg m⁻² de flor-de-seda mais esterco bovino. La mezcla de fertilizantes de origen animal y vegetal contribuyó significativamente al aumento de las características agronómicas evaluadas del cultivo de menta, siendo de gran relevancia para los agricultores familiares que trabajan en esta actividad. El aprovechamiento de la flor de seda (*Calotropis procera*) constituye una opción alternativa para los agricultores de la región semiárida, dada la disponibilidad de la especie durante todo el año, lo que permite su utilización como fertilizante orgánico.

Palabras clave: planta medicinal, agricultura, sistema orgânico, planta silvestre.

1 INTRODUCTION

Within the *Mentha* genus, belonging to the Lamiaceae family, *Mentha arvenses* and *Mentha piperita* stand out, popularly known, mainly due to the commercial exploitation of their essential oil extracted from its aerial part and also for medicinal use in combating stomach disorders, respiratory system disorders and intestinal parasites (Chagas et al., 2011). Essential oil, rich in crystallized menthol, and dementholated oils are some commercial products of this species.

In Brazil, the genus *Mentha* is widely used for medicinal and food purposes (Lorenzi; Matos, 2002). One of the factors that interferes with essential oil production is soil fertility, since the nutritional conditions of the soil are essential for the balance between biomass accumulation and oil production in *Mentha* cultivation (Rodrigues et al., 2004; Valmorbida; Boaro, 2007; Souza et al., 2007).

In addition to large-scale crops that are cultivated during the rainy season, the production of vegetables for sale and consumption is common in these family farming systems, and is of great importance to the farmers who work in this activity.

Vegetable production is quite intensive in the semi-arid region, where manure (bovine, caprine, and poultry) is used exclusively. However, farmers do not always have this resource available on their property, which increases production costs in vegetable farming (Linhares et al., 2018; Linhares et al., 2014). Among the medicinal crops produced in the Mossoró region of Rio Grande do Norte, peppermint (*Mentha piperita* L.) stands out, being widely sold on supermarket shelves and of great commercial value.

This species is native to Europe and is cultivated worldwide. It belongs to the Lamiaceae family, which includes the genus *Mentha*, known in Brazil as mints or spearmints, popularly used for medicinal and food purposes (Lorenzi; Matos, 2002).

In this context, the use of organic fertilizers derived from the addition of semi-arid species is a positive factor, due to the amount of phytomass that will be incorporated or made available as topdressing, contributing to an increase in organic matter in the soil. Among the species present within the herbaceous layer in the semi-arid region, there is the rooster tree (*Calotropis procera*), which is very common in the semi-arid region, remaining with its leaves green throughout the year and with the ability to regrow, with a nitrogen concentration of 17.5 g kg⁻¹ and a carbon/nitrogen ratio of 26/1 (Linhares et al., 2022). The use of organic fertilizers is of utmost importance for family farmers (Santos et al., 2023).

Family farms, which often adopt agroecological practices, are particularly well-positioned for the cultivation of medicinal plants. Agroecology is a crucial factor for the sustainable and efficient cultivation of these plants (Reis, Mariot and Seenbock, 2004).

Given the importance of seeking sustainable alternatives that increase productivity per unit area, through alternative sources within the context of family farmers, the objective was to evaluate the agronomic viability of cultivating mint in succession to cowpea, in addition to rooster tree (*Calotropis procera*) and bovine manure in an argisol.

2 MATERIAL AND METHODS

2.1 CHARACTERIZATION OF THE EXPERIMENTAL AREA

The experiment was conducted at the Rafael Fernandes Experimental Farm of the Federal Rural University of the Semi-Arid Region (UFERSA), in soil classified as Eutrophic Red-Yellow Argisol (Embrapa, 2018). The area is located in the district of Alagoinha, 20 km from Mossoró, Northeast Brazil. The farm has approximately 400 hectares (Rêgo et al., 2016).

According to Kottek et al. (2006) and the Köppen classification, the local climate is BSwH', dry and very hot, with the dry season normally from June to January and the rainy season from February to May. The average annual rainfall is 673.9 mm and the average relative humidity is 68.9%.

Before the experiment was set up, soil samples were collected at a depth of 0-20 cm, air-dried, and sieved through a 2 mm mesh. They were then analyzed at the Soil Chemistry and Fertility Laboratory of UFERSA, with the following results: pH (water 1:2.5) = 7.15; Ca = 145.50 mg dm⁻³; Mg = 148.70 mg dm⁻³; K = 60.21 mg dm⁻³; Na = 10.34 mg dm⁻³; P = 53.29 mg dm⁻³ and O.M. = 1.3 g kg⁻¹.

2.2 EXPERIMENTAL DESIGN AND TREATMENTS

The experimental design used was a randomized complete block design with five treatments and four replications. The treatments consisted of the combination of five doses of rooster tree (*Calotropis procera*) plus bovine manure (0.0; 1.0; 2.0; 3.0 and 4.0 kg m⁻²). The transplanting of peppermint (*Mentha piperita* L.) seedlings was carried out at a spacing of 0.2 x 0.2 m in four planting rows. Irrigation will be carried out by micro-sprinkling in 1-hour shifts per day.

The rooster tree (*Calotropis procera*) was harvested within the campus of the Federal Rural University of the Semi-arid Region, being cut from the apex to the green insertion of the plant and added to the experimental plots. Four samples were taken and sent to the soil laboratory of the Center for Agricultural Sciences for chemical determinations, resulting in the following: 600 g kg⁻¹ C, 21.3 g kg⁻¹ N, 13.1 g kg⁻¹ P, 25.4 g kg⁻¹ K, 11.6 g kg⁻¹ Ca, 10.2 g kg⁻¹ Mg and a nitrogen/carbon ratio of 28/1 (Figure 1).

Figure 1. Roostre tree (*Calotropis procera*) in full bloom in the semi-arid region.



Fonte: Elaborado pelos autores (2026).

2.3 EVALUATION OF THE CHARACTERISTICS OF PEPPERMINT (*Mentha piperita* L.) CULTIVATION

The harvest was carried out 90 days after transplanting the mint, cutting all plants from the usable area. After harvesting, the plants were transported to the Post-Harvest Vegetable Laboratory of the Department of Phytotechnics at UFERSA, where they were analyzed.

For mint cultivation, the following characteristics were evaluated: biomass height (measured in the field, in centimeters, with a millimeter ruler), green mass (obtained by cutting above the ground, weighed on a precision scale of 1.0 g and expressed in grams m², corresponding to family farmers who cultivate areas in the Mossoró-RN region), number of bunches (determined by dividing the fresh mass in an area of 1.0 m² by 100 g, comparable to the weight of a bunch of mint sold at the local agroecological fair and on supermarket shelves in Mossoró-RN and measured in units per m²), dry mass (obtained in an oven with forced heating at 65 °C, until constant mass and expressed in g 100 m²).

2.4 STATISTICAL ANALYSIS OF THE EXPERIMENT

Statistical analysis was performed according to conventional analysis of variance methods (Kronka and Banzato 1995), using the statistical software ESTAT (Barbosa, Malheiros and Banzatto, 1992). The response curve fitting procedure was performed using the ESTAT software (Barbosa, Malheiros and Banzatto, 1992), applying regression analysis and conducting hypothesis testing, which helps the researcher accept or reject a statistical hypothesis based on experimental results (Assis, Sousa and Linhares, 2020; Assis, 2013).

3 RESULTS AND DISCUSSION

The agronomic characteristics of mint (phytomass height, stem plus leaf production, leaf production, and mint dry mass) showed a significant effect at the $p < 0.01$ and $p < 0.05$ probability

levels, with no statistically significant difference between the blocks (Table 1). The use of a mixture of two fertilizer sources, one of plant origin [roostre tree (*Calotropis procera*) and one of animal origin (bovine manure)], probably contributed to increased soil fertility and consequently to better development of mint plants.

Table 1. Plant height values, expressed in cm (ATH), stem plus leaf production, expressed in g m^{-2} (PCFH), mint leaf production, expressed in g m^{-2} (PFH) and mint dry mass, expressed in g m^{-2} (MSH) as a function of the agronomic viability of mint in succession to cowpea in addition with roostre tree (*Calotropis procera*) plus bovine manure in an Oxisol.

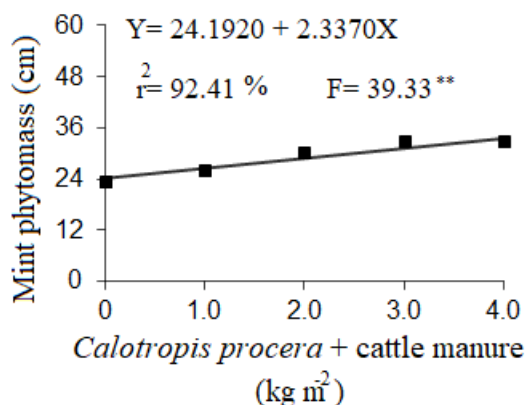
Causes of Variation	GL	ATH	PCFH	PFH	MSH
Treatments	4	11.51**	6.46**	5.09*	4.32**
Blocks	3	2.96 ^{ns}	0.73 ^{ns}	0.57 ^{ns}	0.92 ^{ns}
Residue	12	----	-----	----	----
Average	----	28.86	1,265.2	928.99	215.64
Coefficient of variation (%)	----	8.16	24.11	23.79	24.29

** = significant at 1% * = significant at 5% ns = not significant.

Fonte: Elaborado pelos autores (2026).

The different doses of the mixture of roostre tree (*Calotropis procera*) plus bovine manure contributed significantly to the increase in mint phytomass height, with a maximum value of 33.54 cm at a dose of 4.0 kg m^{-2} (Figure 2). Cunha (2017), studying the agroeconomic viability of intercropping mint with coriander fertilized with jitirana plus bovine manure, found a phytomass height of 33.2 cm at a dose of 3.0 kg m^{-2} , lower than that of the aforementioned research. This value was lower than that found in this research. This difference in value may be related to the type of fertilization, considering that the edaphic conditions for mint development are the same. Similarly, Neves (2017), studying mint production under different densities of mung bean (*Vigna radiata*) in a Latosol, found a phytomass height of 28.4 cm at the highest density ($150 \text{ plants m}^{-2}$), which was lower than the aforementioned research.

Figure 2. Phytomass height as a function of different doses of roostre tree (*Calotropis procera*) plus bovine manure. Fonte: Elaborado pelos autores (2026).



For stem + leaf production and leaf-only production, there was an increase depending on the different doses of roostre tree (*Calotropis procera*) plus bovine manure, with maximum values of 1,950 g m⁻² and 1,138 g m⁻² at doses of 4.0 and 3.5 kg m⁻², respectively (Figures 3A and 3B). Regarding dry matter, there was accumulation as a function of the different doses of rooster tree (*Calotropis procera*) plus bovine manure, with a maximum value of 284.36 g m⁻² at the dose of 4.0 kg m⁻² (Figure 4).

Almeida (2016), evaluating mint production with different doses of jitirana and harvest times, obtained a phytomass production of 344.5 kg 100 m⁻², equivalent to 3,440 g m⁻², 90 days after transplanting, which is higher than the aforementioned research. Probably, the harvest time contributed to such a significant production. Linhares et al. (2023), evaluating the biomass production of mint fertilized with a mixture of hairy woodrose (*Merremia aegyptia* L.) and pasture grass (*Senna uniflora* L.), found a biomass production of 200 kg 100 m⁻², equivalent to 2,000 g m⁻² with the addition of 4.8 kg m⁻² of the mixture, which is similar to the aforementioned research.

Neves (2017), studying green manure with mung beans in the agroeconomic viability of mint, found a mint green mass of 2,508.3 g m⁻², which is higher than the aforementioned research. Cunha (2017), studying the agroeconomic viability of intercropping mint with coriander fertilized with jitirana plus bovine manure, found a green mass of mint of 176.8 kg/100 m⁻², equivalent to 1,768 g m⁻², which is lower than the aforementioned research. Almeida (2018), evaluating the agroeconomic viability of peppermint (*Mentha piperita* L.) in two successive crops under different doses of jitirana and harvest times, found a productivity of 344.5 kg/100 m², equivalent to 3,445 g m⁻² at a dose of 1.0 kg m⁻² 60 days before transplanting, which is higher than the aforementioned research.

Figure 3. Stem + leaf production (A) and leaf production (B) as a function of different doses of rooster tree (*Calotropis procera*) plus bovine manure. Fonte: Elaborado pelos autores (2026).

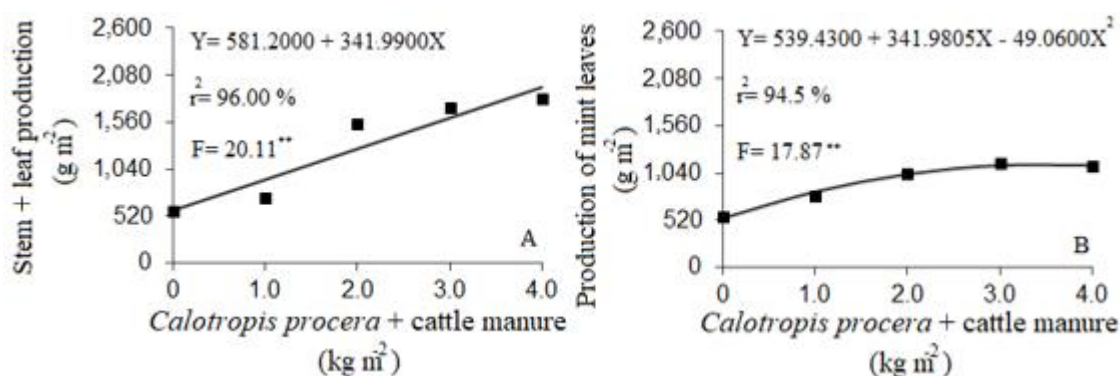
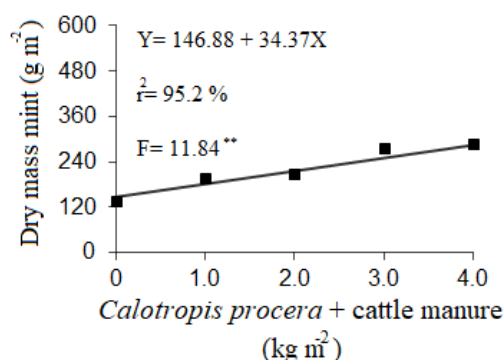


Figure 4. Dry mass of mint as a function of different doses of rooster tree (*Calotropis procera*) plus bovine manure. Fonte: Elaborado pelos autores (2026). Fonte: Elaborado pelos autores (2026).



4 CONCLUSIONS

Maximum mint production (stem + leaf) and exclusive leaf production were observed at doses of 4.0 and 3.5 kg m⁻² of rooster tree (*Calotropis procera*) plus bovine manure. The use of organic fertilizer mixtures is of paramount importance for the development of mint cultivation. The use of the rooster tree (*Calotropis procera*) constitutes an alternative option for farmers in the semi-arid region, given the availability of the species throughout the year, which allows its use as organic fertilizer.

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