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Organic cultivation of rosemary in an urban environment of Juiz de Fora-MG

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ABSTRACT
Rosemary, *Rosmarinus officinalis,* is a plant of the Lamiaceae family, with stomach, stimulant, antispasmodic, emmenagogue and healing properties. Thus, considering the lack of information on the cultivation of *R. officinalis* in the urban environment, this study aimed to evaluate the effect of two doses of organic fertilization on the growth and biomass production of rosemary. The treatments consisted of two doses of organic fertilization of cattle manure (1 L and 3 L cova-1) in four evaluation periods (128, 149, 170 and 191 days after planting). The plants submitted to the two organic fertilization treatments did not show significant differences in all evaluation periods in the variables evaluated. However, in the treatment of 3 L of cova-1 organic fertilization, the plants showed higher biomass production. In the treatment with 3 L of organic fertilization, the production of fresh biomass allows estimating a yield of 3.9 t $^{ha-1}$. From the results obtained in the present study, it was found that the production of rosemary presented great potential to be implemented in small urban areas or in the homes of consumers with the reduction of transportation costs and the final product.

Keywords: *Rosmarinus officinali,* Organic fertilization, Urban agriculture, Growth analysis, Biomass production.

INTRODUCTION

Rosemary *(Rosmarinus officinalis L.*) is a species of perennial woody plant in the Lamiaceae family, native to the Mediterranean, its leaves are commonly used as a culinary condiment and also for medicinal purposes. Currently, this species is cultivated on several continents as a medicinal plant and spice. Rosemary is also known by the popular names of rosemary-da-horta, rosemary-de-jardim, rosemary-de-cheiro, rosemary-rosmarinho, roris marino (Latin), rosemary (English), romero (Spanish), romarin (French), ramerino (Italian), rosmarin (German) (Tressino and Gabriel, 2009; El-Beltagi at el., 2011; Frescura et al., 2013; Ferreira Filho et al., 2015; Coskun et al., 2019; Flores-Villa et al., 2020).

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Rosemary essential oil consists of monoterpenes (α-pinene, camphene, β-α-pinene, β-myrcene, m-cymene, limonene, eucalyptol, linalool, borneol, camphor, terpine-4-ol, α-terpinene), sesquiterpenes (β-caryophyllene, α-caryophyllene), terpene esters, among other compounds. The chemical composition may vary due to environmental and plant management factors, as well as the way they are extracted and stored, interfering with their antimicrobial activity (Silva et al., 2008; Cleff et al., 2012; Ribeiro et al., 2012; Maia et al., 2014; Souza et al., 2014; Santos et al., 2020; Pereira et al., 2020; Medeiros et al., 2021; Souza et al., 2022b).

Rosemary has analgesic, antidepressant, antirheumatic, antiseptic, antimicrobial, anti-inflammatory, skin moisturizing, stomach, stimulant, antispasmodic, emmenagogue and healing properties. The antioxidant properties of rosemary extract have received special attention in recent years and have been recognized since antiquity. Rosemary essential oil is widely used in the cosmetic, hygiene, and perfumery industries in the manufacture of soaps, shampoos, deodorants, colognes, disinfectants, and has insecticidal activity (Genena et al., 2008; Gauch et al., 2014; Oliveira and Veiga, 2019; Meccatti et al., 2021; Takayama, et al., 2022; Morsi et al., 2024).

Elevated blood pressure is a risk factor for cardiovascular disease (Barochiner et al., 2012). Among the nutritional factors associated with the high prevalence of arterial hypertension is the high consumption of sodium, a common practice of hypertensive patients who report that when salt (NaCl) is removed from food, it "loses" its flavor (Rique et al., 2002; Molina et al., 2003). Inserted in the context of the non-pharmacological treatment of patients with arterial hypertension, the use of spices based on spices based on spices that are functional foods is recommended. The recovery of aromatic species in traditional cuisine, especially the use of rosemary, is easily accepted by hypertensive patients and can be used to enhance the flavor of food by reducing the use of salt (Oliveira and Araújo, 2007; Brazilian Society of Cardiology, 2010; Gonçalves et al., 2011; Traesel et al., 2011; Waller et al., 2016; Souza et al., 2022a).

Species considered spices, such as oregano (*Origanum vulgaris*), rosemary (*Rosmarinus officinalis*) and basil (*Ocimum basilicum*), stand out mainly for their antioxidant capacity. However, only rosemary is widely used in food products to confer palatability. Other studies have reported the use of *Rosmarinus officinalis* as hypotensive, discussing the mechanisms of pharmacological action (Ara tachjian et al., 2010; Silva et al., 2011; Zanella et al., 2012; Mendes et al., 2015; Zamberlan et al., 2016; Amaral et al., 2021; Hussain et al., 2022).

In the area of medicinal plants, studies are preferentially associated with knowledge of the chemical composition of the species that produce phytopharmaceuticals. Genetic and environmental processes influence the production of active compounds in medicinal plants and must be evaluated to improve the quality of the raw material. Within this context, it is essential that the production of medicinal plants considers the regional edaphoclimatic conditions, since the production of active ingredients by them can be affected by the cultivation environment (Santos and Innecco, 2004; Braga et al., 2020; Castro, 2021).

Urban and peri-urban agriculture has been considered one of the possibilities to alleviate some of the various problems of cities, especially those related to food, health, the environment, and income generation (Ribeiro et al., 2015; Aquino and Assis, 2007). However, it is necessary to develop new technologies applied to small-scale production from urban agriculture activities (Benincassa et al., 2019; Castro et al., 2022).

The use of organic fertilization is one of the practices associated with agroecological production that can contribute to increasing the efficiency of fertilization by reducing the number of agricultural operations and the use of mineral fertilizers. Thus, the practice of organic supply can reduce the consumption of fossil fuels and the cost of production (Soares et al., 2014; Costa et al., 2008b).

OBJECTIVE

Considering the lack of information on the cultivation of *R. officinalis* in urban areas under the edaphoclimatic conditions of Juiz de Fora, Minas Gerais, Brazil, this study aimed to evaluate the effect of two doses of organic fertilization on the growth and biomass production of rosemary.

METHODOLOGY

EXPERIMENTAL DESIGN AND CULTIVATION

The experiment was conducted in the garden of the Faculty of Pharmacy of the Federal University of Juiz de Fora (University Campus of Juiz de Fora), located at 21° 76' south latitude and 43° 36' west longitude, with an average altitude of 940 m (Braga et al., 2020). The Genetic Heritage of *R. officinalis* was registered in SisGen under No. AC1CFC9.

The climate of Juiz de Fora, according to the Köppen classification, is of the Cwa type (mesothermal climate with hot summers and rainy season also in summer). This climate can also be generically defined as Tropical Highland, as it corresponds to a tropical type influenced by altimetric factors (Torres, 2006).

The collection of simple samples (subsamples) for the chemical analysis of the soil (Table 1) was performed at a depth of 20 cm with the aid of a shovel. The simple samples (eight samples), collected at random, were mixed in a plastic bucket to form the composite sample. After the formation of the composite sample, 500 g of soil was separated and sent to the laboratory (Laboratory of Soil, Plant Tissue and Fertilizer Analysis of the Federal University of Viçosa).

Table 1. Chemical characteristics of the soil collected in the 0-20 cm layer in the garden of the Faculty of Pharmacy of the Federal University of Juiz de Fora*.

ph	P	K	Ca	Mg	Al	H+Al	SB	T	V	m	MO	P-rem
H2O	mg/dm3---		----------------------CMOLC/DM3-----------------						------%-----		DAG/kg	mg/L
5,45	148,7	56	8,49	1,96	0,0	5,6	10,59	16,19	65,4	0,0	7,52	37,0

* Analysis carried out at the Laboratory of Soil, Plant Tissue and Fertilizer Analysis of the Federal University of Viçosa.

The experimental design was completely randomized, in a 4 x 2 factorial scheme, with six replications, totaling 8 treatments and 48 experimental units. The treatments consisted of two doses of organic fertilization (cattle manure), 1 L and 3 L cova-1, and four sampling periods (128, 149, 170 and 191 days after planting).

The seedlings were obtained by cuttings from existing matrices on the University Campus of Juiz de Fora (Schoffel et al., 2019). The seedlings were prepared with cuttings (about 15 cm) and transplanted on 04-22-19.

The following characteristics were evaluated: fresh leaf biomass, leaf dry biomass, dehydrated leaf biomass, height, stem diameter, number of branches and vigor. To obtain the dry biomass, fresh biomass samples were kept in an oven with forced air circulation at 70 °C for 72 h, until constant mass was reached.

STATISTICAL ANALYSIS

Data were interpreted using analysis of variance and regression. In the organic fertilization factor, the means were compared by Tukey's test, at 5% probability. Regression equations were adjusted for the sampling time factor based on the t-test of the coefficients at 5 or 1% probability and the coefficient of determination. In the variables fresh biomass, dry biomass and dehydrated biomass, the means were compared by the Kuskal-Wallis test at 5% probability.

DEVELOPMENT

Under the conditions in which the study was carried out, in all the evaluation periods in the variables evaluated, no significant differences were observed between the plants submitted to the two organic fertilization treatments (1 L and 3 L) (Table 2). However, in the treatment of 3 L of cova-1 organic fertilization, the plants showed higher biomass production (Table 3).

In the treatment of 1 L of organic fertilization, cova-1 was observed in the variables height, number of branches and stem diameter, higher growth rate. On the other hand, the plants of the treatment with 3 L of organic fertilization, although they presented lower growth rate in height, number of branches and stem diameter, presented visibly, in all evaluation periods, more vigorous and with a greater number of leaves, which resulted in greater biomass in this treatment.

The absence of significant differences in rosemary plants submitted to the two organic fertilization treatments can be explained by the hardiness of this species. *R. officinalis* has the ability to respond to different levels of water and nutrient supply in the field that allows it to develop under conditions of low soil fertility (Sardans et al., 2005).

Similar to the present study, Soares et al. (2014) in a study carried out with citronella grass in the State of Tocantins, no significant difference was observed between organic fertilization treatments in all sampling periods. However, citronella grass organically fertilized with 9 kg of manure-1 showed the highest growth rate in height.

GROWTH ANALYSIS

In the height variable, the plants did not show significant differences between the organic fertilization treatments at any harvest time. In both treatments (1 and 3 L of organic fertilization $^{cova-1}$), it was observed that height increased linearly as a function of time. In plants with 1 L of cova-1 organic fertilization, higher growth rates in plant height were observed at each time interval, reaching 55.029 cm plant-1 at 191 days after planting. On the other hand, plants with 3 L of cova-1 organic fertilization presented, according to the adjusted regression equations, a lower growth rate, reaching 54.35 cm plant-1 in the last sampling period (Table 2) (Figure 1).

Table 2. Mean values, regression equations and coefficient of determination of the effect of two doses of organic fertilization (OA) (1 L and 3 L) of *R. officinalis* on the variables height (ALT), number of branches (NR), stem diameter (CC) and vigor (VIG), in four sampling periods.

	Sampling times (days after planting)					
TO	128	149	170	191	Equations/Regression	r2 (%)
	Height (cm $^{plant-1}$)					
1L	29,00 a	37,83 a	43,33 a	56,50 a	Y = -25 + 0.419 EP	62,13
3L	32,5 a	35,67 a	42,67 a	55,50 a	Y = -16.32 + 0.37 EP	78,96
	Number of bouquets					
1L	7,67 a	18,50 a	29,33 a	54,17 a	Y = -86.8 + 0.716 EP	44,36
3L	10,17 a	15,67 a	28,17 a	44,00 a	Y = -62.1 + 0.54 EP	61,67
	Stem diameter (cm$^{, plant-1}$)					
1L	0,32 a	0,33 a	0,42 a	0,52 a	Y = -0.123 + 0.0033 EP	45,25
3L	0,38 a	0,41 a	0,47 a	0,48 a	Y = 0.14 + 0.0018 EP	27,84
	Vigor					
1L	2,83 a	3,17 a	3,50 a	3,17 a	Y = 3.17	
3L	3,50 a	3,33 a	3,67 a	3,33 a	Y = 3.46	

Means followed by the same letter in the column, in each variable, do not differ from each other according to Tukey's test (P > 0.05); ** = significant at 1% probability by the "t" test.

Regarding the variable number of branches, linear regression models were adjusted in the two treatments evaluated to explain the variation of the data. The treatment with 1 L of organic fertilization, similarly observed in the height variable, showed the highest growth rate at each time interval, reaching 50 plant-1 branches in the last sampling period (Table 2) (Figure 2).

There was also no statistical difference (P > 0.05) between the treatments analyzed in the stem diameter and vigor variables. In the stem diameter variable, there was a higher rate of increase at each time interval in the treatment with 1 L of organic fertilization, 0.0033 cm $^{day-1}$ (Table 2).

No regression model was adjusted for the vigor variable to explain the variation in the data. In the treatment with 3 L of organic fertilization, the highest value was obtained in all four sampling periods, with a final mean value of 3.46 (Table 2).

In the study by Soares et al. (2014) With citronella grass submitted to two fertilization treatments (with and without organic fertilization), no regression model was adjusted for the vigor variable. The authors observed that citronella grass plants treated with organic fertilizer were more vigorous and had better vegetative development, as well as a greener color. In another study, Costa et al., (2008b) obtained similar results in the cultivation of lemongrass (*Cymbopogon citratus*) fertilized with poultry manure.

Other studies carried out with organic fertilization in medicinal plants were also positively influenced on growth, such as in basil anise (*Ocimum selloi*) (Costa et al., 2008a) and on the dry matter production of marigold (*Calendula officinalis*) capitula (Valadares et al., 2010).

Figure 1. Estimation of the height of rosemary (*R. officinalis)* as a function of four sampling times (128, 149, 170 and 191 days after planting).

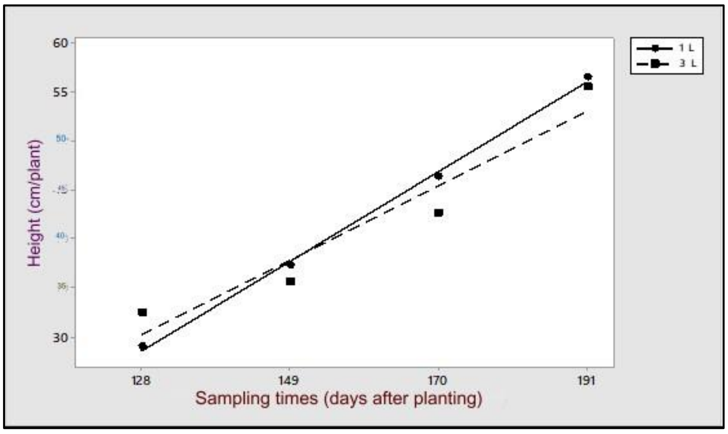
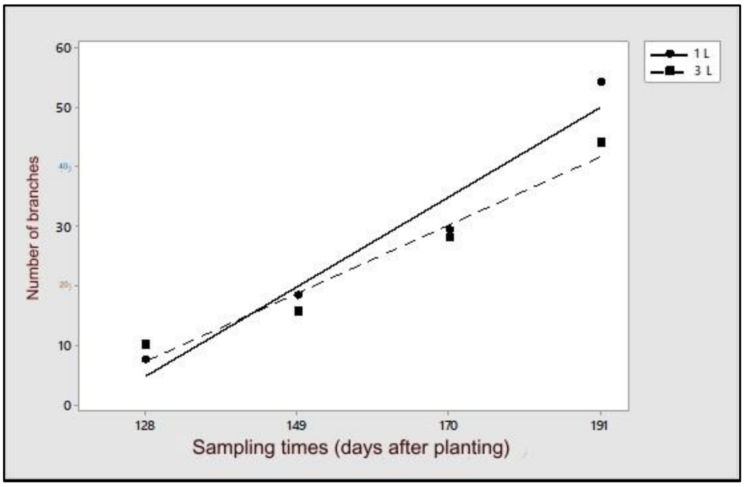


Figure 2. Estimation of the number of rosemary branches (*R.* officinalis*)*, as a function of four sampling times (128, 149, 170 and 191 days after planting).



BIOMASS PRODUCTION

In the destructive analysis, the treatment with 3 L of organic fertilization showed higher values of fresh biomass, dry biomass and dehydrated than the treatment with 1 L of organic fertilization, however, these values did not differ statistically (Table 3). The higher biomass value presented in the treatment with 3 L of organic fertilization is associated with the greater supply of nutrients in this treatment and its influence on the soil structure, with increased porosity and greater infiltration and retention of water in the soil (Soares et al., 2014; Costa *et al*., 2008b).

In the study with citronella grass in the State of Tocantins, mentioned above, in the destructive analysis the authors observed that the treatment with organic fertilization presented values of fresh biomass, dry biomass and dehydrated significantly higher than the treatment without organic fertilization (Soares et al., 2014).

In the study by Costa et al. (2008b) with lemongrass, the authors reported that organic fertilization of the plants resulted in a higher production of dry biomass. These authors also mentioned the results observed in the cultivation of mentrasto (*Ageratum conyzoides*), where there was an increase in plant biomass in the treatment with organic fertilizer compared to the treatments using mineral fertilization and liming.

Souza et al. (2014), in Cruz das Almas-BA, observed that rosemary plants grown in full sun obtained greater gains in total plant dry mass than plants grown under shade, reaching 18.99 grams/plant after four months of cultivation.

May et al. (2010) studied the biomass production of rosemary as a function of height and cutting intervals and found a high production of dry biomass of the leaves, 5.90 t $^{ha-1}$, which corresponds to 70 % of the dry biomass production of the aerial part produced, which was 8.39 t $^{ha-1}$. In the same article, the range of annual dry biomass production of rosemary leaves from 1.6 to 2.4 t ha-1 was mentioned.

In the present study, in the treatment with 3 L of organic fertilization, the production of fresh leaf biomass allows us to estimate a yield of approximately 3.90 t $^{ha-1}$ and 1.85 t $^{ha-1}$ of leaf dry biomass. This dry biomass production of the leaves found is within the average range of dry biomass production of the leaves cited in the consulted literature, as previously discussed.

Table 3. Mean values in the variables fresh biomass, dry biomass and dehydrated biomass of R. *officinalis leaves* (1 L and 3 L of organic fertilization).

Organic fertilization	Fresh biomass (g. $^{plant-1}$)	Dry biomass (g. plant $^{-1}$)	Dehydrated biomass (g. $^{plant-1}$)
1 L	241 a	120.5 a	204.9 a
3 L	276.7 a	130.1 a	229.6 a

Means followed by the same letter in the column, in each variable, did not differ from each other according to the Kuskal-Wallis test ($p > 0.05$).

FINAL THOUGHTS

In the present study, no significant influence of the dose of organic fertilization on rosemary cultivation was observed on the variables height, number of branches, stem diameter and vigor.

In the production of rosemary biomass, it was found that the higher dosage of organic fertilization (3 L cova-1) favored the production of biomass, but no statistical difference was observed between the fertilization treatments. The plants of the treatment with 3 L of organic fertilization showed visibly, in all evaluation periods, more vigorous and with a greater number of leaves, which resulted in greater biomass in this treatment.

From the results obtained in the present study, it was found that the production of rosemary presented great potential to be implemented in small urban areas or in the consumers' own homes with the reduction of transportation costs and improvement of the quality of the final product. Rosemary can be used as a condiment in food preparation and provide greater palatability and acceptability of the low-sodium diet by hypertensive people.

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