International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Production of coriander fertilized with a mixture of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*) plus goat manure in a latosol

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International Journal of Science and Research Archive, 2026, 19(02), 005-012

Publication history: Received on 25 March 2026; revised on 28 April 2026; accepted on 01 May 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.19.2.0952

Abstract

The practice of fertilization with spontaneous species from the semiarid region is of great importance for farmers who work in the organic production of vegetables, bringing promising results. In this sense, the objective was to study the production of coriander fertilized with the mixture of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*) plus goat manure in a latosol. The research was conducted at the Rafael Fernandes Experimental Farm, belonging to the Federal Rural University of Semi-Árido (UFERSA), from July to September 2024. The experimental design used was a randomized complete block design, with six treatments and four replicates. The treatments consisted of six amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) with rooter tree (*Calotropis procera*) plus goat manure (0.0; 1.2; 2.4; 3.6; 4.8; 6.0 and 7.2 kg m^{-2} on a dry basis). The coriander cultivar used was "Verdão". The spacing used was 0.1 x 0.05 m with five plants per hole, corresponding to 1000 plants m^2 of area. The characteristics evaluated were: plant height (cm $plant^{-1}$); number of stems ($plant^{-1}$ units); production (g m^{-2} of area), number of bunches (m^{-2} units of area) and dry mass (g m^{-2} of area). The maximum production of coriander and number of bunches was observed in the mixture of spontaneous species with goat manure at doses of 6.72 and 5.6 kg m^{-2}, with values of 767.20 g m^{-2} and 7.77 units of bunches m^{-2}. The mixture of alternative fertilizer sources in vegetable cultivation is extremely important.

Keywords: Spontaneous vegetation; Agriculture; Organic production; Family farming.

1. Introduction

Organic farming is quite widespread among farmers with low levels of technology in the Mossoró region, RN, who lack the resources to provide adequate productivity that guarantees the sustainability of the system, given that the source of fertilizer used by farmers consists exclusively of manure (bovine and veal), generating increased production costs, since the producer does not always have this organic input available on their properties [1].

Coriander (*Coriandrum sativum* L.) is the most widely produced vegetable in the semi-arid region of Mossoró, RN, being cultivated for fresh consumption and sold in markets and commercial centers. In the semi-arid region, plantings of this

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vegetable are carried out in production areas with family farmers, seeking greater food production and environmental sustainability in this activity.

Sowing is carried out in areas with predominantly sandy and clayey soils, either broadcast or in rows, with an average number of plants ranging from 800 to 1000 plants m^{-2} [2]. In these production areas that cultivate using organic systems, the use of manure (bovine, vegan and ovine) in soil fertilization is quite evident; however, the farmer does not always have this resource available on their property, which increases production costs.

The use of plant residues in agriculture promotes an improvement in soil structure, contributing to greater water infiltration, increasing the organic matter content of the soil, favoring the microbiota and making the edaphic environment more suitable for agricultural cultivation. The most commonly used species as green manure are legumes, as they produce very labile quantities of green and dry biomass, which favors a close carbon-nitrogen (C/N) ratio. However, species from other families can be used for this purpose, particularly regarding nutrient cycling compared to introduce species.

In this context, the Brazilian semi-arid region has spontaneous species with potential for use as green manure, such as hairy woodrose (*Merremia aegyptia* L.), which appears during the rainy season, with green and dry phytomass production of approximately 40,000 and 6,000 kg ha^{-1}, respectively, with a nitrogen content of 25.4 g kg and a carbon-nitrogen ratio of 23/1 [3]. Another noteworthy species is the rooster tree (*Calotropis procera*), which is very common in the semi-arid region, presenting the following chemical concentration: 600 g kg^{-1} of carbon (C); 22.5 g kg^{-1} of nitrogen (N); 10.8 g kg-1 of phosphorus (P); 14.0 g kg^{-1} of potassium (K); 9.8 g kg^{-1} of magnesium (Mg); 11.5 g kg^{-1} of calcium (Ca) and a carbon-nitrogen ratio of 27/1 [4].

Aiming at agroecological alternatives, many researchers have been developing studies with farmers who seek sustainable agriculture with diversified systems that use low amounts of chemical inputs [5], which is of great value to farmers working in organic farming systems.

1.1. Objective of the study

Given the importance of seeking alternative fertilization methods within cultivated areas to improve soil fertilization and crop development, the objective was to study the production of coriander using a mixture of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*) plus cattle manure in an Oxisol.

2. Materials and methods

2.1. Characterization of the experimental area

The experiment was conducted at the Rafael Fernandes Experimental Farm, belonging to the Federal Rural University of the Semi-Arid Region (UFERSA) (Figure 1), from June to August 2024, in the semi-arid region of Brazil with geographic coordinates of latitude between 5°03'37"S and longitude between 37°23'50"W Gr, with an altitude above sea level of 72 m (RÊGO et al., 2016), in soil classified as Red-Yellow Latosol Argisolic sandy loam [6].

According to [7] and the Köppen classification, the local climate is type BSwh', dry and very hot, with the dry season typically 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%.

2.2. Soil chemical analysis

Before the experiment was set up, soil samples were taken at a depth of 0-20 cm, which were 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) = 7.0; Ca = 220.8 mg dm^{-3}; Mg = 125.2 mg dm^{-3}; K = 47.56 mg dm^{-3}; Na = 12.9 mg dm^{-3}; P = 88.29 mg dm-3 and O.M. = 1.6 g kg^{-1}.

2.3. Experimental design and treatments

The experimental design used was a randomized complete block design, with six treatments and four replications. The treatments consisted of six amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*) plus cattle manure (0.0; 1.2; 2.4; 3.6; 4.8; 6.0 and 7.2 kg m^{-2} on a dry basis). Each plot consisted of twelve rows of plants spaced 0.1 m x 0.05 m apart, with 5 plants per plot, corresponding to 1000 plants m^{-2} of plot, which corresponds to the economically viable plant population for agronomic exploitation [8].

The total area of the plot was 1.44 m^2 with a usable area of 0.80 m^2, containing 800 plants. The coriander cultivar sown was "Verdão" widely used by farmers, with a very green color and a cycle of 30 to 35 days from sowing to harvest.

Soil preparation consisted of manual weeding, removal of spontaneous vegetation present in the experimental area, and manual raising of the garden beds using a hoe as a tool.

Irrigation was carried out in two shifts (morning and afternoon) to maintain the soil at the field capacity necessary for the full development of the crop. Cultural practices consisted of removing weeds, preventing competition for water and nutrients with the coriander crop.

2.4. Chemical composition of sheep manure

Spontaneous species of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*) were collected within the Federal Rural University of the Semi-Arid Region, in an area of native vegetation, and were cut with a manual tool (machete), sun-dried, and incorporated into the experimental plots. Three samples were taken and sent to the soil fertility laboratory of the jitirana-silk flower mixture at the Center for Agricultural Sciences, where chemical analyses were determined, with the following values: 560 g kg-1 of carbon (C); 22.5 g kg-1 of nitrogen (N); 10.8 g kg-1 of phosphorus (P); 14.0 g kg-1 of potassium (K); 9.8 g kg-1 of magnesium (Mg); 11.5 g kg-1 of calcium (Ca) and a carbon-nitrogen ratio of 27/1 (Figure 1).

A B

Figure 1 Illustration of hairy woodrose (*Merremia aegyptia* L.) (A) and rooster tree (*Calotropis procera*) (B) during flowering period in the semi-arid region. Photo: Researcher PhD Paulo César Ferreira Linhares

Sheep manure was acquired from a producer in the Mossoró-RN region. Chemical analyses were performed in the soil, water, and plant laboratory of the Department of Agricultural and Forestry Sciences of the Center for Agricultural Sciences, with the following chemical concentrations: pH = 7.40; Nitrogen (N) = 9.42 g kg^{-1}; Organic matter (OM) = 110.5 g kg^{-1}; Phosphorus = 320.5 mg dm-3; Potassium (K) = 1,063 mg dm^{-3}; Sodium (Na^+) = 180 mg dm^{-3}; Calcium (Ca^+) = 6.10; Magnesium (Mg^{2+}) = 0.20 mg dm^{-3} and Aluminum (Al^{3+}) = 00 mg dm^{-3}.

2.5. Agronomic characteristics of coriander cultivation

Thinning was carried out ten days after planting, leaving four plants per hole. Thirty-five days after sowing, the experiment was harvested, and the plants were transported to the Post-Harvest Vegetable Laboratory of the Department of Agronomic and Forestry Sciences at UFERSA, where the following characteristics were analyzed: plant height (obtained from a sample of twenty plants per plot in the experimental area, measuring from the base to the apex of the plant with a millimeter ruler and expressed in cm $plant^{-1}$); number of stems (obtained by counting all the stems of a sample of twenty plants, expressed in units $plant^{-1}$); production (measured by the weight of all plants in the useful area of the plot, on a precision scale of 1.0 g, expressed in g m^{-2} of area); Number of bunches (determined by dividing

the m^{-2} productivity by 100 g, the reference weight for a bunch of coriander, expressed in m^{-2} area units) and dry matter mass (obtained by weighing twenty plants from the plot on an electronic scale with 1.0 g precision, followed by drying in a forced-air oven at 65 °C until constant mass).

2.6. Statistical analysis

Statistical analysis was performed according to conventional analysis of variance methods [9], using the statistical software ESTAT [10]. The response curve fitting procedure was performed using the ESTAT software [10], applying regression analysis and conducting hypothesis tests that help the researcher to accept or reject a statistical hypothesis based on experimental results [11]; [12].

3. Results and discussion

The application of spontaneous species in addition to cattle manure contributed significantly to a significant effect at the $p<0.01$ probability level in all evaluated characteristics of the coriander crop (Table 1), demonstrating the effectiveness of the mixture of fertilizers of plant and animal origin in improving soil fertility, which is important for farmers who work in this activity (vegetable production).

Table 1 F values for plant height, expressed in cm $plant^{-1}$ (PH), number of stems, expressed in $plant^{-1}$ units (NS), coriander productivity, expressed in g m-2 (CP), number of bunches, expressed in m-2 units (NB) and dry mass, expressed in g m-2 (DM) of coriander under the mixture of hairy woodrose (*Meremia aegyptia* L.) with cattle manure in an Oxisol.

Causes of Variation	GL	PH	NS	CP	NB	DM
Treatments	6	218.7^{**}	57.30^{**}	26.37^{**}	31.76^{**}	151.4^{**}
Blocos	3	1.2^{ns}	0.4^{ns}	1.79^{ns}	0.55^{ns}	2.09^{ns}
Resíduo	18	----	----	----	----	----
Average	----	11.57	5.92	545.00	5.60	56.6
Coefficient of variation (%)	----	6.39	7.45	18.00	17.88	7.45

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

Plant height is an important characteristic in coriander cultivation for commercial purposes, considering that consumers prefer plants taller than 15 cm (Linhares et al., 2025). For this characteristic, a maximum height point was observed at a dose of 7.2 kg m^{-2}, with a value of 18.26 cm $plant^{-1}$ (Figure 2). Santos et al. (2023), studying the productivity of arugula-coriander intercropping fertilized with a mixture of carnauba straw (*Copernicia prunifera*) and bovine manure, found a plant height of 19.38 cm plant-1 at a rate of 3.0 kg m^{-2}, which is higher than the present study. Similar behavior was observed by [13], studying spontaneous species of the semi-arid region in proportions with bovine manure, where a plant height of 19.04 cm $plant^{-1}$ was observed with the presence of 100% hairy woodrose, which is higher than the present study. This superiority may possibly be related to the type of fertilization, considering that the studies were conducted under the same soil conditions.

Similarly, [1], evaluating the spacing for coriander cultivation fertilized with carnauba straw under the conditions of Mossoró-RN, found 9.0 stems per plant, as did [15], studying the quantities and decomposition times of jitirana in the agronomic performance of coriander, with a value of 22.0 cm per plant, higher than the present research.

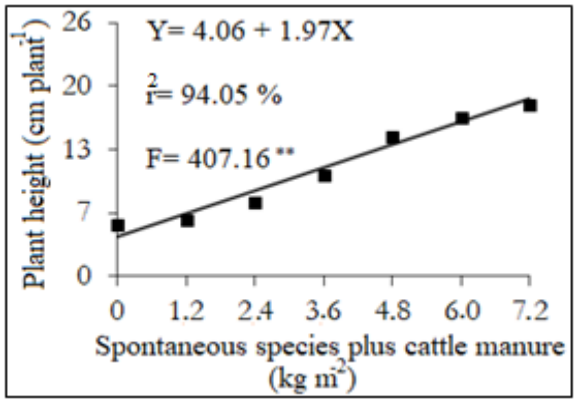

Figure 2 Spontaneous species [hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure incorporated into the soil in plant height in a latosol

The number of stems is a characteristic of paramount importance for producers, since in commercialization, the quantity of leaves becomes appreciable to consumers [1]. The increase in the number of stems constitutes a positive factor for those who work in this activity, being of great relevance [2]. In this characteristic, there was an adjustment of the quadratic equation for the observed data, with a maximum number of stems at a dose of 6.8 kg m^{-2}, corresponding to 7.82 plant^{-1} units (Figure 3). Santos et al. (2023), studying the productivity of arugula-coriander intercropping fertilized with a mixture of carnauba straw (*Copernicia prunifera*) plus bovine manure, found 6.12 stems plant^{-1} at a quantity of 3.0 kg m^{-2}, differing from the present research.

Similar behavior was observed by [14], studying spontaneous species of the semi-arid region in proportions with bovine manure, observing a number of 6.64 stems plant^{-1}, which is lower than the present work. This inferiority may possibly be related to the type of fertilization, considering that the studies were developed under the same edaphic conditions. However, [1], evaluating the spacing for coriander cultivation fertilized with carnauba straw under the conditions of Mossoró-RN, found 9.0 stems per plant, as did [15], studying the quantities and decomposition times of jitirana in the agronomic performance of coriander, with a value of 10.2 stems per plant.

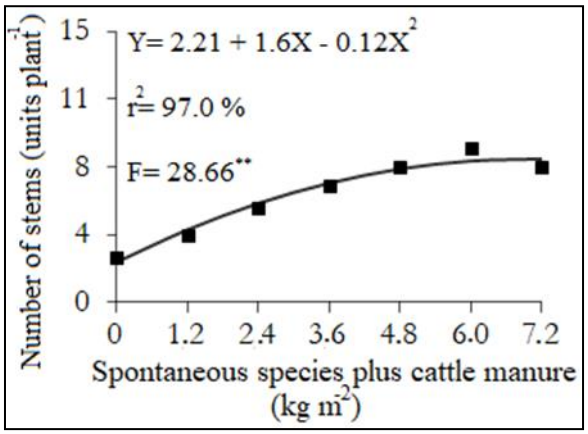

Figure 3 Spontaneous species [hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure incorporated into the soil in number of stems in a latosol

In the characteristics of cilantro production and number of bunches, a maximum production point was observed for both parameters with values of 767.20 g m^{-2} and 7.77 bunches m^{-2} at doses of 6.72 and 5.6 kg m^{-2} of area, respectively (Figures 4A and 4B). [13], studying the productivity of arugula-coriander intercropping fertilized with a mixture of carnauba straw (*Copernicia prunifera*) and bovine manure, found 482.4 g m^{-2} at a dose of 3.0 kg m^{-2}, which is lower than the aforementioned research. Similar behavior was observed by [14], studying spontaneous species of the semi-arid region in proportions with bovine manure, observing a productivity of 587.3 g m^{-2} with the presence of 100% jitirana, which is lower than the present work. This inferiority may possibly be related to the type of fertilization, considering that the studies were developed under the same edaphic conditions.

[16], studying the organic cultivation of coriander in no-till farming using organic compost, obtained an average productivity of 6.5 t ha^{-1}, equivalent to 650 g m^{-2} at a dose of 30.0 t ha^{-1} of organic compost, lower than that of the aforementioned study. [1], evaluating spacing for coriander cultivation fertilized with carnauba straw under the conditions of Mossoró-RN, found a productivity of 1.1 kg m^{-2}, corresponding to 11.0 units of coriander bunches m^{-2}. A similar value was observed by [15] studying the quantities and decomposition times of jitirana in the agronomic performance of coriander, with a productivity of 7,064 kg ha^{-1}, equivalent to 706.4 g m^{-2} in the quantity of 15.6 t ha^{-1}.

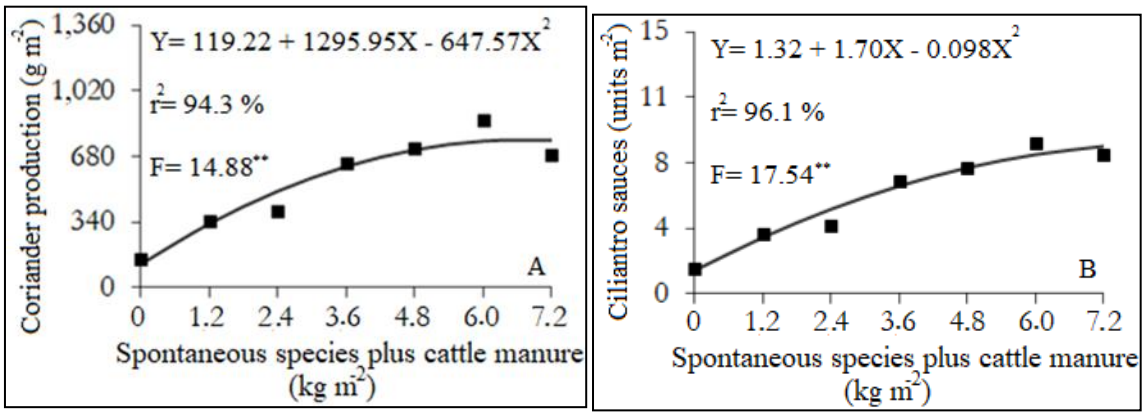

Figure 4 Spontaneous species [hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure incorporated into the soil in coriander production (A) and number of bunches (B) in a Latosol

For dry matter, there was an upward trend as a function of the doses of the mixture of hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure incorporated, with maximum value of 91.70 g m^{-2} at the dose of 7.2 kg m^{-2} (Figure 5). Dry matter mass is a characteristic of paramount importance, as it most directly reflects plant growth, being the most appropriate for growth analysis [17], reflecting the influence of treatments imposed on the crop. Inferior behavior was observed by [18], who, studying different quantities and types of green manures, obtained dry matter mass of coriander of 540, 550, and 480 kg ha^{-1} for (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and pasture killer (*Senna uniflora* L.), equivalent to 54.0, 55.0, and 48.0 g m^{-2}, respectively.

Similarly, [2], evaluating coriander productivity as a function of incorporating green manures with hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*) and pasture killer (*Senna uniflora* L.) in a semi-arid region of Brazil, found dry mass values of 126.6 and 103.8 g m^{-2} for hairy woodrose (*Merremia aegyptia* L.) and rooster tree, respectively, at a quantity of 1.6 kg m^{-2}, values that are higher than those in the present study.

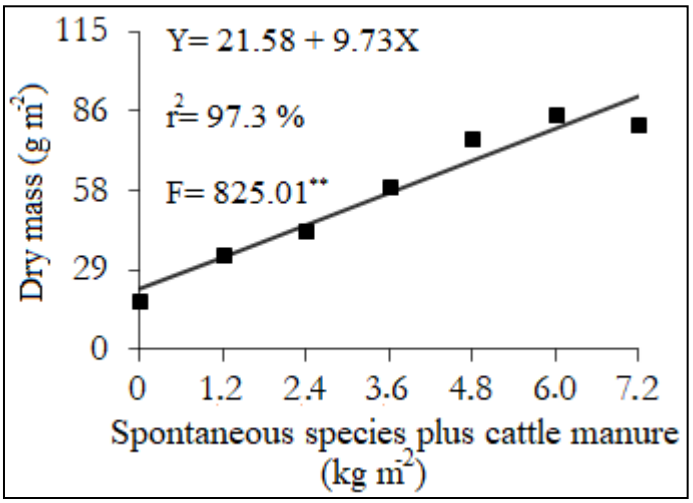

Figure 5 Spontaneous species [hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure incorporated into the soil in the dry mass of coriander dry matter

4. Conclusion

The maximum coriander production and number of bunches was observed in the mixture of spontaneous species [hairy woodrose (*Merremia aegyptia* L.) with rooster tree (*Calotropis procera*)] plus cattle manure at doses of 6.72 and 5.6 kg m^{-2}, with values of 767.20 g m^{-2} and 7.77 bunches m^{-2}. The mixture of alternative fertilization sources in vegetable cultivation is extremely important.

Compliance with ethical standards

Acknowledgments

To the Jitirana Research Group - National Council for Scientific and Technological Development - CNPQ, Brazil, which since 2005 has been developing research with spontaneous species of the semi-arid region [hairy woodrose (*Merremia aegyptia* L.), rooster tree (*Calotropis procera*), pasture killer (*Senna uniflora* and *Senna obtusifolia* L.) and carnauba straw (*Copernicia prunifera*) in the organic production of vegetables] and to UFERSA (Federal Rural University of the Semi-Arid Region), for the physical structure, at the Rafael Fernandes Experimental Farm, for carrying out the scientific work.

Disclosure of conflict of interest

There is no conflict of interest in this research article.

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