Inovações em pesquisas agrárias e ambientais

Volume VI

Alan Mario Zuffo
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| organizadores |

Pantanal Editora

2024

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Volume VI

Pantanal Editora

2024

Editor Chefe: Dr. Alan Mario Zuffo
Editores Executivos: Dr. Jorge González Aguilera e Dr. Bruno Rodrigues de Oliveira

Diagramação: A editora. **Diagramação e Arte:** A editora. **Imagens de capa e contracapa:** Canva.com.
Revisão: O(s) autor(es), organizador(es) e a editora.

Ficha Catalográfica

Catalogação na publicação
Elaborada por Bibliotecária Janaina Ramos – CRB-8/9166

I58

Inovações em pesquisas agrárias e ambientais - Volume VI / Organização de Alan Mario Zuffo, Jorge González Aguilera, Bruno Rodrigues de Oliveira. – Nova Xavantina-MT: Pantanal, 2025.
75p. ; il.

Livro em PDF

ISBN 978-65-85756-50-1
DOI https://doi.org/10.46420/9786585756501

1. Agronomia - Pesquisa. 2. Feijão. 3. Sustentabilidade. I. Zuffo, Alan Mario (Organizador). II. Aguilera, Jorge González (Organizador). III. Oliveira, Bruno Rodrigues de (Organizador). IV. Título.

CDD 630

Índice para catálogo sistemático

I. Agronomia - Pesquisa

Pantanal Editora

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Apresentação

Bem-vindos ao mundo fascinante das pesquisas agrárias e ambientais! É com grande entusiasmo que apresentamos o e-book "Inovações em Pesquisas Agrárias e Ambientais Volume VI".

No decorrer dos capítulos deste e-book, são explorados os seguintes tópicos: estudos Preliminares sobre Evasão Escolar no Instituto Tecnológico Nacional do México, Campus Valle del Yaqui; utilização da agricultura de precisão na produção de plantas medicinais; o potencial da tecnologia de drones na agricultura brasileira; desempenho agronômico do feijão-caupi, cultivar Tumucumaque, em função de densidades de plantio fertilizadas; produção agronômica de rúcula em função de diferentes doses da mistura de *Merremia aegyptia* L. e esterco bovino; produtividade de grãos verdes de feijão-caupi sob mistura de *Merremia aegyptia* L. e esterco bovino; viabilidade agronômica da beterraba fertilizada com a mistura de palha de carnaúba e esterco bovino na região semiárida. Esses capítulos fornecem uma análise prática e detalhada sobre técnicas de manejo de solo, cultivos e monitoramento ambiental em diferentes contextos agrícolas.

Agradecemos aos autores por suas contribuições e esperamos que este e-book seja uma fonte valiosa de conhecimento para estudantes, pesquisadores e profissionais interessados nessas áreas vitais.

Boa leitura!

Os organizadores

Sumário

Chapter 5

Agronomic production of arugula according to different doses of the mixture of hairy woodrose (*Merremia aegyptia* L.) and cattle manure

Recebido em: 21/01/2025
Aceito em: 14/02/2025
10.46420/9786585756501cap5

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INTRODUCTION

Vegetables are grown in a variety of systems, with conventional agriculture dominating most of the global production. However, vegetable production in organic systems has experienced an average annual growth of 20% in recent years, driven by consumers' growing concern about food quality and environmental preservation. This increase is the result of the search for alternatives that reduce dependence on agro-industrial inputs, which have high economic, social and energy costs (Souza & Resende, 2014).

Arugula (*Eruca sativa* Mill.) is characterized by its herbaceous size, annual cycle, and belongs to the Brassicaceae family (Filgueira, 2018). According to Linhares et al. (2024), the species is of great relevance to farmers who work in organic vegetable production, contributing to increased income.

In the context of organic production, the sources of organic fertilizer used by farmers include manure from different sources, such as cattle, goats and poultry. These resources are widely available on rural properties and are used in arugula production to enrich the soil with essential nutrients (Linhares et al., 2014). The use of organic fertilizer is a common practice that not only improves soil fertility but also promotes the sustainability of agricultural production by reducing dependence on inorganic fertilizers (Matos et al., 2016).

In addition to manure, it is of great importance that farmers know and use green manure species that can be incorporated into crop areas. These species help to improve soil characteristics and fertility in a sustainable manner. Among the species with agronomic potential for the semiarid region, the hairy woodrose (*Merremia aegyptia* L.) stands out for its capacity to produce green and dry phytomass, with yields of 42.0 and 6.04 t ha^{-1}, respectively. The hairy woodrose (*Merremia aegyptia* L.) also has a nitrogen concentration of 22.2 g kg^{-1} and a carbon-nitrogen ratio of 17:1 at 104 days after emergence, which makes it an excellent option for green manure (Linhares et al., 2021).

According to Linhares et al. (2021), the use of plant residues in agriculture promotes an improvement in soil structure, contributing to greater water infiltration, increasing the soil's organic matter content, favoring the microbiota and making the soil environment more suitable for agricultural cultivation.

Given the continuous growth in demand for arugula and the need for more sustainable agricultural practices, it is essential to evaluate the impact of different doses of the mixture of hairy woodrose berry and cattle manure on its production. The objective of this study was to analyze the different doses of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure on the agronomic production of arugula.

MATERIAL AND METHODS

Geographical location of the experiment

The scientific research was developed in soil classified as Red Yellow Latosol Argisolic Sandy Franco (Embrapa, 2018), at the Rafael Fernandes Experimental Farm, belonging to the Federal Rural University of Semi-Arid (UFERSA), from July to September 2023, in the semiarid region of Brazil with geographic coordinates of latitude between 5º03'37"S and longitude between 37º23'50"W Gr, with an altitude above sea level of 72 m (Rêgo et al., 2016). According to Kottek et al. (2006) and the Köppen classification, the local climate is of the BSwh' type, dry and very hot, with the dry season normally from June to January and the rainy season from February to May. The average annual precipitation is 673.9 mm and the average relative humidity is 68.9%.

Before the experiment was set up, soil samples were taken at a depth of 0-20 cm, air-dried, sieved through a 2 mm mesh and subsequently analyzed at the Soil Chemistry and Fertility Laboratory of UFERSA. The results were as follows: pH (water 1:2.5) = 6.7; Ca = 1.2 cmol dm^{-3}; Mg = 0.7 cmolc dm^{-3}; K = 30.0 mg dm^{-3}; Na = 10 mg dm^{-3}; P = 32.3 mg dm^{-3} and M.O. = 1.1 g kg^{-1}.

Statistical design and treatments

The experiment was conducted in a completely randomized design with six treatments and four replicates. The treatments consisted of six amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) with cattle manure (0; 1.2; 2.4; 3.6; 4.8 and 6.0 kg m^{-2}). The spacing used was 0.2 x 0.1 m, with four planting lines, with two plants per hole, in plots of 0.8 x 1.2 m, corresponding to an area of 0.96 m^2, with ninety-six plants in the plot. The useful area was 0.4 m^2, with forty plants.

Daily irrigations were carried out (morning and afternoon) in order to maintain the soil at field capacity for the full development of the crop. Cultural treatments were carried out (removal of invasive plants) to prevent competition for water and nutrients with the coriander crop. No chemical pesticides were used to control undesirable plants, and control was done manually.

Hairy woodrose (*Merremia aegyptia* L.), which is widely found in the semiarid region, was used as green manure, with green and dry phytomass production of around 42.0 and 6.04 t ha^{-1}, respectively, with a nitrogen concentration of 22.2 g kg^{-1} and a carbon nitrogen ratio of 17/1 at 104 days after emergence (Linhares et al., 2021).

Chemical analysis of fertilizers used

The hairy woodrose (*Merremia aegyptia* L.) was harvested green on the Rafael Fernandes experimental farm and manually crushed using a hand tool (machete). The weights were quantified for incorporation into the experimental plots. Samples of hairy woodrose jitirana were taken for analysis of carbon (C); nitrogen (N); phosphorus (P); potassium (K^+); calcium (Ca^{2+}); magnesium (Mg^{2+}) and carbon/nitrogen ratio. The values observed were: 560 g kg^{-1} C, 25.0 g kg^{-1} N, 14.2 g kg^{-1} P, 23.3 g kg^{-1} K, 13.4 g kg^{-1} Ca, 15.7 g kg^{-1} Mg and a nitrogen/carbon ratio of 22/1 (Figure 1).

Figure 1. Hairy woodrose (*Merremia aegyptia* L.) inflorescence (A) and area with predominance of the species being harvested mechanically (B). Photo: Researcher D.Sc. Paulo César Ferreira Linhares.

The cattle manure used came from the raising of dairy cows of the Holstein breed from the cattle breeding sector of UFERSA (Figure 3), raised in an intensive system, fed with concentrate and using canarana grass (*Echinocloa polystochya* (Kunth) Hitchc.) as bulk. Three samples were taken and sent to the soil, water and plant laboratory of the Department of Agronomic and Forestry Sciences of the Center of Agricultural Sciences, for determination of the levels of N; pH; EC; Ca; Mg; K; Na; P and M.O (Table 1).

Table 1. Chemical analysis of cattle manure added to the experimental plots.

pH	N	M.O.	P	K^+	Na^+	Ca^{2+}	Mg^{2+}	Al^{3+}
H_20	------ g kg^{-1} ------		--------- mg dm^{-3} ---------			--------- $cmol_c$ dm^{-3} ---------		
7.70	5.42	158.39	622.3	2,177.2	429.9	8.10	0.50	0.0

When the plants were thirty-five days old after planting, they were harvested, and the following characteristics were evaluated (plant height, number of leaves, arugula production, number of bunches and dry mass).

Plant height (this was carried out in the field by measuring twenty plants randomly, measuring from the base to the inflection of the leaves, using a millimeter ruler, expressed in cm $plant^{-1}$); number of leaves (this consisted of measuring a sample of twenty plants, all commercial standard leaves were counted and divided by 20, expressed in $plant^{-1}$ units); arugula production [production was measured by weighing all plants in the useful area (0.4 m-2), on a 1.0 g precision scale, estimating for 1.0 m^{-2}, for this purpose, it was multiplied by a factor of 2.5, expressed in g m^{-2}]; number of bunches (calculated by dividing the arugula production by 100g, corresponding to the weight of a bunch of arugula sold on supermarket shelves, expressed in units m^{-2}).

Statistical analysis

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

RESULTS AND DISCUSSION

A significant effect was observed between the different doses of the mixture of jitirana and cattle manure on the characteristics of plant height, number of leaves, production, number of bunches and dry mass of arugula at the probability level of $p<0.01$ (Table 2).

The mixture of hairy woodrose (*Merremia aegyptia* L.) and cattle manure contributed greatly to the characteristics evaluated, considering that the material added to the soil has nutritional values that contributed to the better development of the crop.

Table 2. F values for plant height, expressed in cm plant^{-1} (AP), number of plants, expressed in plant^{-1} units (NH), arugula production, expressed in g m^{-2} (PD), number of bunches, expressed in m^{-2} units (NM) and dry mass, expressed in g m^{-2} (MS) of arugula as a function of different doses of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure in the semiarid region.

Causes of Variation	GL	AP	NH	PD	NM	MS
Treatments	5	209.7**	60.0**	51.5**	50.7**	52.8**
Blocks	3	2.97^{ns}	1.07^{ns}	0.78^{ns}	0.82^{ns}	1.05^{ns}
Residue	15	----	----	----	----	----
Average	----	12.02	6.3	830.0	8.30	86.66
Standard deviation	----	0.82	0.68	132.9	1.30	12.70
CV (%)	----	6.82	10.8	16.0	15.66	14.65

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

The analysis of the height of arugula plants as a function of the doses of the mixture of hairy woodrose hairy woodrose (*Merremia aegyptia* L.) and cattle manure was adjusted to a linear regression equation (Y=4.20+2.60X), indicating that there was an increase in plant height as a function of the higher dose incorporated into the soil, with a maximum value of 19.83 cm plant^{-1}, at a dose of 6.0 kg m^{-2} (Figure 2). The lowest plant height estimated by the equation was observed at dose 0, that is, in the absence of fertilization, with a value obtained of 4.2 cm plant^{-1}.

According to Salles, Abaker, Ferreira and Martins (2017), analyzing the response of arugula to fertilization with different organic compounds, they observed that the presence of poultry manure promoted larger plants, with a value of 19 cm plant^{-1}, lower than the aforementioned research. Possibly the amount of fertilizer used contributed to better crop performance.

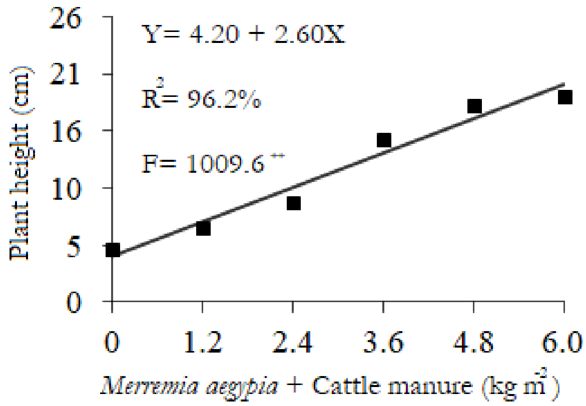

Figure 2. Height of arugula plant as a function of different doses of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure incorporated into the soil.

For the number of leaves characteristic, the data fit a first-degree, linearly increasing equation, with a maximum value of 9.68 plant^{-1} units at a dose of 6.0 kg m^{-2} of the mixture of jitirana and cattle manure, with an increase of 6.9 plant^{-1} units in relation to the lowest dose incorporated into the soil (Figure 3). The number of leaves is of utmost importance, considering that it is the part of the plant that is commercialized. Santos et al. (2023) found 10.8 plant^{-1} units with the addition of 3.0 kg m^{-2} of the mixture of carnauba straw and cattle manure, which is higher than the aforementioned study. This superiority is probably due to the quality of the material used.

Linhares et al. (2024) evaluating the agronomic efficiency of arugula in successive cultivation with lettuce fertilized with spontaneous species from the semiarid region found 12.3 plant^{-1} units in the amount of 11.7 t ha^{-1}, as well as Melo et al. (2024) studying the agronomic efficiency of jitirana as an organic fertilizer in the consortium of mint with arugula and found 11.82 plant^{-1} leaf units higher than the aforementioned research.

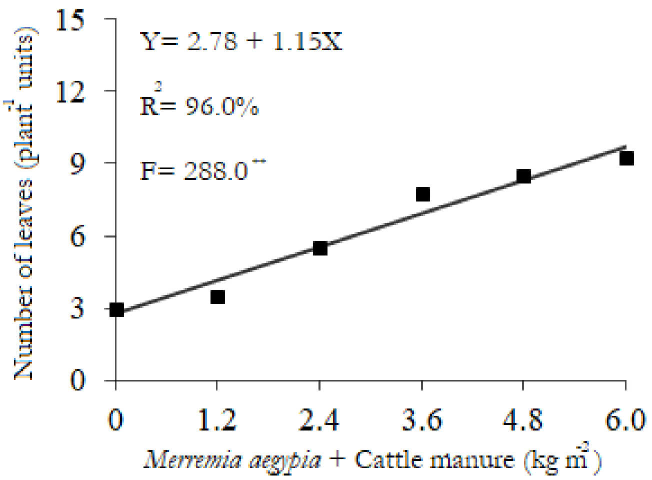

Figure 3. Number of leaves of arugula plant as a function of different doses of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure incorporated into the soil.

For the arugula production characteristic, there was an increase of 1,264.3 g m^{-2} between the absence of fertilization and the dose of 6.0 kg m-2, with a maximum value of 1,462.1 g m^{-2}, corresponding to 14.6 units of bunches (Figures 4A and 4B).

Almeida et al. (2015), studying the agronomic efficiency of the lettuce-arugula intercrop fertilized with silk flower, found arugula production of 37.96 t ha-1, equivalent to 3,796 g m^{-2} with the addition of 35.5 t ha^{-1} of rooster tree (*Calotropis procera*), being higher than the aforementioned research. This superiority is possibly due to the amount of green manure used, providing a greater yield of arugula.

Linhares et al. (2024), evaluating the agronomic efficiency of arugula in successive cultivation with lettuce fertilized with spontaneous species from the semiarid region, found a productivity of 8,190 kg ha^{-1}, equivalent to 819 g m^{-2} with an application of 13.1 t ha^{-1}, lower than the aforementioned research. Probably, the smaller quantity used in this research was what contributed to a production below the aforementioned research. Melo et al. (2024), studying the agronomic efficiency of hairy woodrose (*Merremia aegyptia* L.) as an organic fertilizer in the consortium of mint with arugula, found a production of 150.42 kg 100 m^{-2}, equivalent to 1,500 g m^{-2}, corresponding to 15 bunches m^{-2}, higher than the aforementioned research.

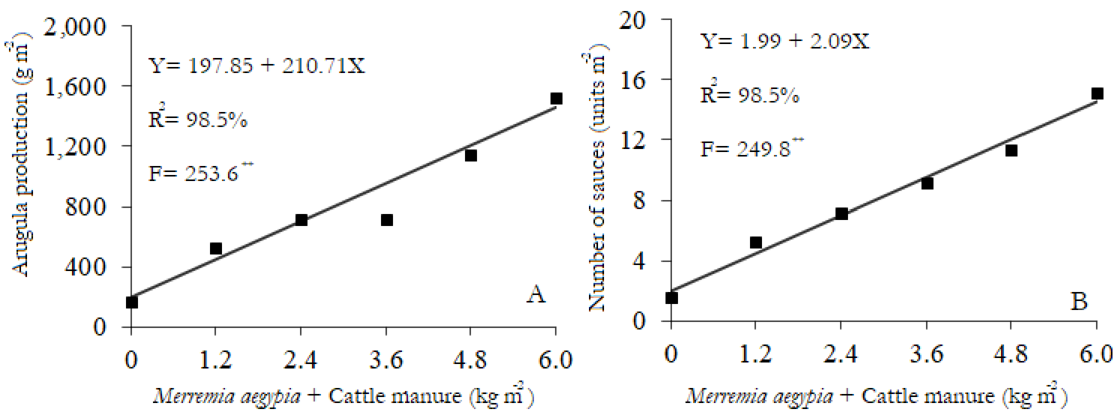

Figure 4. Arugula production (A) and number of arugula bunches (B) as a function of different doses of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure.

For the dry mass characteristic of arugula, there was an increase in function of the different doses of the mixture of hairy woodrose (*Merremia aegyptia* L.) with cattle manure, with a maximum value of 147.7 g m^{-2} at the dose of 6.0 kg m^{-2} (figure 5). Between the highest dose (6.0 g m^{-2}) and the treatment without fertilization, there was an increase of 122.07 g m^{-2} of dry matter. Dry mass is a characteristic of utmost importance in the evaluation of a crop, as it is directly related to plant growth (Taiz and Zeiger, 2017).

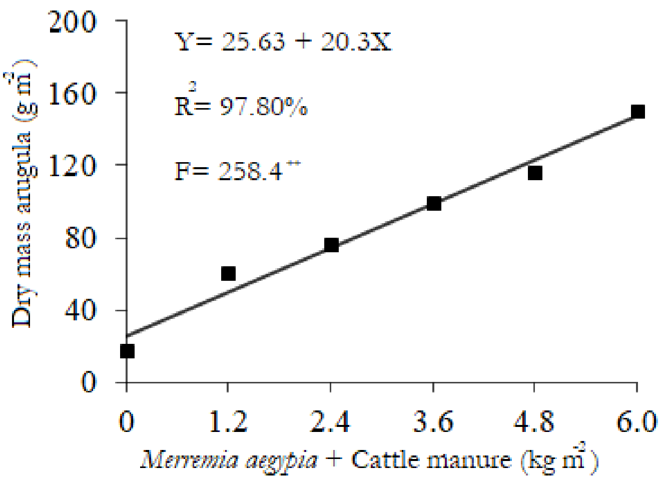

Figure 5. Dry mass of arugula plant as a function of different doses of hairy woodrose (*Merremia aegyptia* L.) plus cattle manure incorporated into the soil.

CONCLUSION

The highest agronomic performance of the arugula crop was observed at a dose of 6.0 kg m^{-2} of jitirana plus cattle manure, with a production of 1,462.14 g m^{-2}, corresponding to 14.56 units of sauces m^{-2}. The equitable mixture of fertilizers of animal and vegetable origin proved to be efficient from an agronomic point of view.

ACKNOWLEDGMENT

To the Jitirana-CNPQ Research Group, since 2005 has been developing research with spontaneous species from the semi-arid region [hairy woodrose (*Merremia aegyptia* L.), roostre 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, for providing space to carry out scientific work.

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9786585756501