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Mixture of hairy woodrose (*Merremia aegyptia* L.) with carnauba straw (*Copernicia prunifera*) in the productivity of lettuce in the semi-arid region of Brazil

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Key words: *Lactuca sativa* L., Agroecological production, Leafy vegetable

Abstract

The use of mixtures of organic fertilizers present in the cultivation areas is of paramount importance for farmers who produce in the family farming system, in this sense, the objective was to study the mixture of hairy woodrose (*Merremia aegyptia* L.) with carnauba straw (*Copernicia prunifera*) in the productivity of lettuce in the semi-arid region from Brazil. The experiment was carried out in a greenhouse in the experimental area of the Department of Agronomic and Forestry Sciences. The experiment was carried out in a completely randomized design in a 5 x 2 factorial scheme, with three replications. The first factor consisted of five amounts of the mixture of jitirana with carnauba straw (0.0; 1.5; 3.0; 4.5 and 6.0kg m^{-2} of area), and the second factor for the forms of application to the soil (embedded and cover). The lettuce cultivar planted was crespa, which is widely sold in the semi-arid region of Brazil. The evaluated characteristics were: Plant height, diameter, number of leaves, lettuce production and dry mass. The research results showed that the amount of 4.5kg m contributed to the increase of the evaluated characteristics, with values of 115 and 11.97g $plant^{-1}$. The use of a mixture of organic fertilizers (hairy woodrose and carnauba straw) was extremely effective in the production of vegetable crops, bringing agronomic advantages to the producer.

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Introduction

Aiming at an agroecological production, many researchers and farmers seek a sustainable and diversified agriculture with systems of use with low chemical inputs (Altiere, 2002). According to Linhares *et al.* (2018) the use of organic sources in the region of Mossoró, RN, Brazil is of great importance for vegetable growers, with manure (beef, goat and poultry) as inputs, however, the dependence on these sources contributes to the increase of production costs, as farmers do not always have these resources available on their properties.

Aiming at agroecological alternatives, many researchers have carried out research with farmers who seek sustainable agriculture with diversified systems with low use of chemical inputs (Altieri, 2002), which is of great value to farmers who work in the organic agriculture system. In these areas, where various vegetables are grown, lettuce (*Lactuca sativum* L.) is an annual herbaceous plant, originating in the Mediterranean, with a small, unbranched stem, to which the leaves attach (Santos *et al.*, 2011) , being the most important leafy vegetable in the diet of the Brazilian people, consumed as a salad (Yuri *et al.*, 2006).

In the semi-arid region, organic fertilization is widely used in the production of lettuce (Linhares *et al.*, 2022). The amount to be used depends on the quality of the available fertilizer and local conditions, soil, climate and management (Freire *et al.*, 2013). However, when green manure is applied to the soil, it provides ideal edaphic conditions for greater vegetable production, given the productive potential of phytomass and nitrogen concentration of spontaneous species from the semi-arid region, compatible with legumes, such as hairy woodrose (*Merremia aegyptia* L.) (Linhares *et al.*, 2021).

This species presents green and dry phytomass production in the order of 40000 and 6000kg ha^{-1}, respectively, with an average nitrogen content of 23.0g kg^{-1} and a carbon-nitrogen ratio of 23/1, being quite prominent during the rainy season in the semi-arid region and found in the cultivation areas of farmers who work in the production of vegetables in an organic system in the region of Mossoró, RN, Brazil (Linhares *et al.*, 2021).

Another species that is important in terms of use as an organic fertilizer is the carnauba tree (*Copernicia prunifera* L.), which occurs in the semi-arid region and is used by farmers in the production of vegetable crops (Linhares *et al.*, 2014).

Several scientific studies have shown the use of alternative organic sources in the semi-arid region to meet the nutritional needs of vegetable crops, such as coriander (Linhares *et al.*, 2018a; Linhares *et al.*, 2018b; Linhares *et al.*, 2014a and Linhares *et al.*, 2012), lettuce (Linhares 2009) carrot (Linhares *et al.*, 2014b) and radish (Linhares *et al.*, 2013).

In this sense, it is extremely important to use alternative organic sources that provide satisfactory edaphic conditions for the development of vegetable crops. Thus, the objective was to evaluate the mixture of hairy woodrose (*Merremia aegyptia* L.) with carnauba straw in the productivity of lettuce in the semi-arid region of Brazil.

Materials and methods

Characterization of the experimental area

The experiment was carried out in a greenhouse of the didactic garden of the Department of Agronomic and Forestry Sciences of the Federal Rural University of the Semi-arid (UFERSA), Mossoró, RN, Brazil, in soil classified quartzarene neosolin (Empraba, 2018). The experiment site was in the municipality of Mossoró, RN, Brazil, located at 5º 11' south latitude and 37º 20' west longitude and altitude of 18 m. According to Thornthwaite, the local climate is DdAa', that is, semi-arid, megathermal with little or no excess of water during the year, and according to Köppen it is BSwh', as dry and very hot, with two seasons: a dry period, which generally covers the period from June to January, and a rainy period, between February and May (Carmo Filho *et al.*, 1991).

The soil was collected in a quartzarene neosol to compose the 0.4 m x 0.32 m containers used for the

development of the research work. Before the installation of the experiment, soil samples were taken at a depth of 0-20cm, which were air-dried and sieved through a 2-mm mesh and subsequently analyzed at the UFERSA Laboratory of Soil Chemistry and Fertility. The results were as follows: pH (water 1:2.5) = 7.6; Ca = 3.4cmol dm^{-3};mg = 1.2cmolc dm^{-3}; K = 32.0mg dm^{-3}; Na = 6.7mg dm^{-3}; P = 33.8mg dm^{-3} and M.O. = 0.4g kg^{-1}.

Statistical delineation and treatments

The experimental design used in the entirely randomized with treatments arranged in a 5 x 2 factorial scheme, with 3 replications. The first factor consisted of five amounts of the mixture of hairy woodrose (*Merremia aegyptia* L) with carnauba straw (*Copernicia prunifera*) (0.0; 1.5; 3.0; 4.5 and 6.0kg m^{-2} of area in dry basis), and the second factor consisting of two forms of application to the soil (incorporated and cover) in single cultivation.

Irrigations were carried out (morning and afternoon) in order to maintain the soil at field capacity for the full development of the crop. Cultural practices were carried out (removal of invasive plants) preventing competition for water and nutrients with the lettuce crop. To compose the mixture of fertilizers in the research, jitirana (*Merremia aegyptia* L.) was used, a spontaneous species from the semi-arid region with production of green and dry phytomass in the order of 42000kg ha^{-1} and 6000kg ha^{-1}, respectively, with nitrogen content of 24.7g kg^{-1} at 104 days after emergence and carbon nitrogen ratio of 23/1 (Linhares *et al.*, 2021) (Fig. 1).

The hairy woodrose (*Merremia aegyptia* L.) was harvested in an area of 3.0 ha in the semi-arid region and crushed in a forage machine, dried in the sun, four samples were taken and sent to the soil fertility and plant nutrition laboratory of the Center for Agricultural Sciences at UFERSA for analysis of carbon (C); nitrogen (N); phosphorus (P); potassium (K+); calcium (Ca2+); magnesium (Mg2+) and carbon/nitrogen ratio, whose values were: 535g kg^{-1} C, 23.5g kg^{-1} N (nitrogen), 10.8g kg^{-1} P (phosphorus), 15.4g kg^{-1} K (potassium), 9.7g kg^{-1} Ca (calcium), 11.7g kg^{-1}mg (magnesium) with a nitrogen/carbon ratio of 23/1.

Fig. 1. Pattern of development of hairy woodrose (*Merremia aegyptia* L.) in full flowering period in the semi-arid region of Mossoró, Brazil. **Photography:** Researcher PhD Paulo César Ferreira Linhares, leader of the Jitirana research group.

Another species used as fertilizer was carnauba straw (*Copernicia prunifera*), which occurs in the semi-arid region, and is used as an organic fertilizer for vegetables (Linhares *et al.*, 2014). The species was collected inside the experimental farm Rafael Fernandes-UFERSA, Brazil, in an area completely occupied with the species, and the straw was crushed in a forage machine to obtain the substrate to be mixed with the jitirana. The chemical composition found in this material was: 19g kg^{-1}N (nitrogen); 12g kg^{-1}P (phosphorus); 9.3g kg^{-1}K (potassium); 8.7g kg^{-1}Ca (Calcium) and 9.6g kg^{-1}Mg (Magnesium) (Fig. 2).

(A)

(B)

Fig. 2. Carnauba straw (*Copernicia prunifera*) in full vegetative development (A) and its organic residue (B) at the UFERSA experimental research farm, Mossoró, Brazil. **Photography:** Agronomy student, member of the Jitirana research group and scientific initiation scholarship holder Maria Elisa da Costa Souza.

The fertilizers were mixed and applied to the soil, with the material remaining for an incubation period of thirty days before planting, as recommended by (Linhares *et al.*, 2012). During the decomposition process of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*) in the soil, irrigations were carried out in all plots up to field capacity, being of fundamental importance in the nitrification process (Meurer, 2007).

Plant height: determined from a sample of five plants, with a millimeter ruler up to the inflection of the leaf, expressed incm plant^{-1}. Diameter: determined from a sample of five plants, measuring the distance between the opposite margins of the leaf disc using a melimetric ruler, expressed incm plant^{-1}.

Number of leaves: determined from a sample of five plants, counting all the leaves and expressing units plant^{-1}. Lettuce production: determined from the fresh mass weight of all plants, weighed on a 1.0g precision scale and expressed in g plant^{-1} and dry mass : Taken from a sample of five plants, in which the dry mass was determined in an oven with forced air circulation at a temperature of 65°C, until constant weight was reached, and expressed in g plant^{-1}.

Statistical analysis was performed according to conventional methods of analysis of variance (Kronka and Banzato 1995), using ESTAT statistical software (Barbosa, Malheiros and Banzatto, 1992). The response curve fitting procedure was performed using the ESTAT Software (Barbosa, Malheiros and Banzatto, 1992).

Results and discussion

There was a significant effect at the probability level $P<0.01$ for all the characteristics evaluated in terms of the different amounts of the mixture of hairy woodrose (*Merremia aegyptia* L.) with carnauba straw (*Copernicia prinufera*) (Table 1).

The increase in the evaluated characteristics of the lettuce crop is probably due to the nitrogen concentration that varied between 19.0 and 23.0g kg^{-1} for carnauba straw and hairy woodrose, respectively, considering that this element is responsible for leaf expansion (Taiz and Zeiger, 2017).

According to Oliveira *et al.* (2010) the organic system in the production of vegetables is of paramount importance, as it influences the physical, chemical and biological properties of the soil, since they have conditioning effects and increase the capacity of the soil to store nutrients necessary for plant development.

Table 1. F values for plant height, expressed incm plant^{-1} (AT), number of stems per plant, expressed in units plant^{-1} (NH), plant diameter, expressed incm plant^{-1} (DA), lettuce production, expressed in grams m^{-2} of area (PL) and dry mass, expressed in grams m^{-2} of area (MSL) of lettuce fertilized mixture of hairy woodrose (*Merremia aegyptia* L.) with carnauba straw (*Copernicia prunifera*) in the semi-arid region of Brazil.

Causes of Variation	GL	AT	NH	DA	PL	MSL
Amounts of mixture of hairy woodrose with carnauba straw (A)	4	23.4**	27.5**	87.1**	41.5**	17.00**
Incorporated and coverage (B)	1	3.3^{ns}	3.3^{ns}	2.1^{ns}	0.25^{ns}	1.9^{ns}
A X B	4	0.5^{ns}	1.2^{ns}	1.4^{ns}	1,8^{ns}	0.8^{ns}
Treatments	9	-------	-------	--------	------	---------
Residue	20	-----	-------	---------	-------	-------
Average	----	13.20	14.00	18.30	87.10	9.30
CV (%)	----	12.20	9.90	6.20	15.80	3.70

** = P <0.01, statistical significance at 1% probability * = P <0.05, statistical significance at 5% probability and ^{ns} = not significant

Regarding the forms of application to the soil of the mixture of jitirana with carnauba straw (incorporated and cover), no statistical difference was observed for plant height, number of leaves, diameter, fresh and dry mass of lettuce, with values of 12.7 and 13.8cm plant^{-1} for plant height, 13.6 and 14.5 units plant^{-1} for number of leaves, 18.6 and 18.1cm plant^{-1} for diameter, 87.2 and 87.8 g plant^{-1} for fresh mass and 9.0 and 9.3 g plant^{-1} for dry mass, respectively (Table 2). Absence of significance between the forms of application to the soil of the mixture of jitirana with carnauba straw, is probably due to the availability of nutrients present in the forms of application, contributing to the development of the crop.

Regarding plant height, there was an increase of 5.45cm plant-1 between the smallest amount (0kg m^{-2}) and the largest (6.0kg m^{-2}), obtaining the highest plant height of 12.86cm plant^{-1} in the amount of 6.0kg m^{-2} of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*) (Fig. 3). Linhares (2009), evaluating the spontaneous vegetation as green manure in the agroeconomic performance of leafy vegetables, found a plant height of 16.0cm, lower than the aforementioned research. Neves *et al.* (2018) evaluating sucessive crops of lettuce fertilized with bivine manure in the presence and absence of bean found a plant height of 12.1cm, lower than that research. According to Oliveira *et al.* (2010) the highlight of the cultivation system on lettuce yield, is probably due to the functions that organic fertilizers have on the physical, chemical and biological properties of the soil, since they have conditioning effects and increase the soil's ability to store nutrients necessary for plant development.

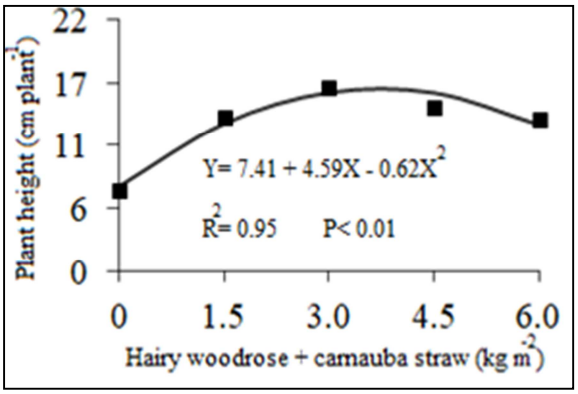

Fig. 3. Lettuce plant height as a function of mixture amounts of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) in a semi-arid region.

In the characteristic number of leaves, the data were adjusted to a quadratic equation, with an inflection of the curve in the amount of 4.5kg m^{-2} of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*), with a maximum number of leaves of 16.43 units plant^{-1} (Figura 4). Neves *et al.* (2018) evaluating sucessive crops of lettuce fertilized with bivine manure in the presence and absence of bean found a number of leaves of 14.0 units plant^{-1}, lower than that research. Linhares (2009), evaluating the spontaneous vegetation as green manure in the agroeconomic performance of leafy vegetables, found a plant height of 16.0cm, lower than the aforementioned research.

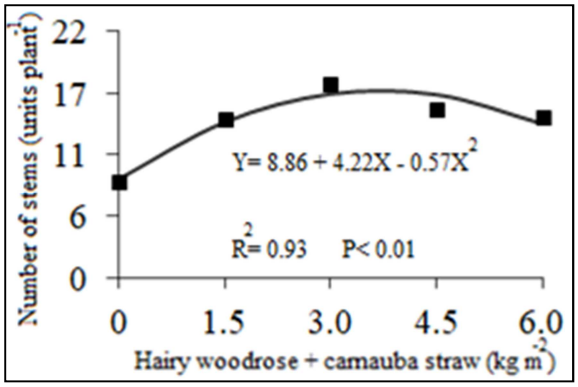

Fig. 4. Number of leaves as a function of mixture amounts of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) in a semi-arid region.

For the characteristic diameter, it was observed that there was an increase in the diameter up to the amount of 4.5kg m^{-2} of area of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*) with a maximum value of 21.7cm $plant^{-1}$, occurring a decrease afterwards referring to the amount of 6.0kg m^{-2} in area, with a value of 18.9cm $plant^{-1}$ (Fig. 5). Neves *et al.* (2018) evaluating successive crops of lettuce fertilized with bivine handling in the presence and absence of bean found a plant height of 20.9cm $plant^{-1}$, lower than that research. Paiva (2016) evaluating the study of lettuce and conetro in consortium and monoculture under different fertilizations in two periods found a diameter of 26.78cm $plant^{-1}$, higher than that research. A similar behavior was observed by Oliveira *et al.* (2010) studying the productivity of lettuce and arugula in an intercropped system, under organic and mineral fertilization, found a diameter of 25.7cm $plant^{-1}$.

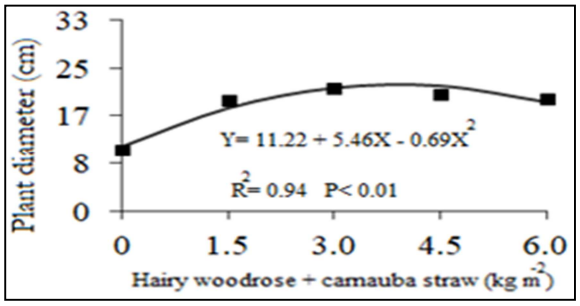

Fig. 5. Diameter of plant of leaves as a function of mixture amounts of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) in a semi-arid region.

The amount of 4.5kg m^{-2} of area of the mixture of hairy woodrose (*Merremia aegyptia* L.) plus carnauba straw (*Copernicia prunifera*) promoted the greatest increase in the green dough and dry mass of lettuce, with maximum values of 115.0 and 11.97g $plant^{-1}$, with a reduction in the later amount, with values of 114.46 and 9.42g $plant^{-1}$ in the amount of 6.0kg m^{-2} of area (Fig. 6 and 7). This characteristic is of paramount importance, considering that this is the form of commercialization in agroecological fairs and supermarkets in the semi-arid region of Brazil. Neves *et al.* (2018) evaluating successive crops of lettuce fertilized with bivine handling in the presence and absence of bean found a green mass of 85.0g $plant^{-1}$, lower than that research. Paiva (2016) evaluating the study of lettuce and conetro in consortium and monoculture under different fertilizations in two periods found a green mass of 53.4g $plant^{-1}$ in first cultivation, below the referred research. Linhares *et al.* (2009) studying the influence of coverage as green manure on the agronomic performance of lettuce, found a green mass of 70g $plant^{-1}$, a value below the referred research.

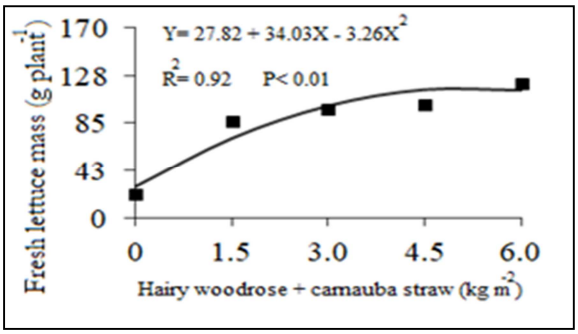

Fig. 6. Fresh lettuce mass as a function of mixture amounts of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) in a semi-arid region.

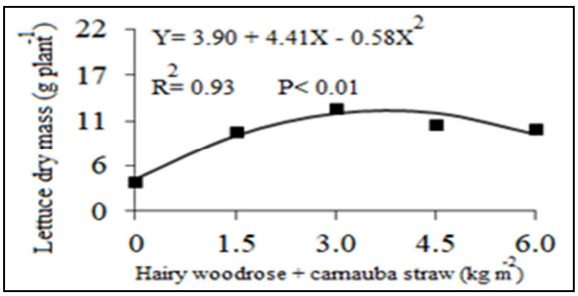

Fig. 7. Dry lettuce mass as a function of mixture amounts of hairy woodrose (*Merremia aegyptia* L.) and carnauba straw (*Copernicia prunifera*) in a semi-arid region.

Table 2. Forms of application of the mixture of jitirana with carnauba straw in the characteristics plant height, expressed incm plant^{-1} (AT), number of stems per plant, expressed in units plant^{-1} (NH), plant diameter, expressed incm plant^{-1} (DA), lettuce production, expressed in grams m^{-2} of area (PL) and dry mass, expressed in grams m^{-2} of area (MSL).

Forms of application in the soil	AT	NH	DA	PL	MSL
Incorporated	12.7 a	11.0 a	18.6 a	87.2 a	9.0 a
Coverage	13.8 a	11.0 a	18.1 a	87.8 a	9.3 a
CV (%)	12.20	9.90	6.20	15.80	3.70

* Means followed by the same letter in the column do not differ by Tukey test at the 5% probability level

Conclusions

The research results showed that the amount of 4.5kg m contributed to the increase of the evaluated characteristics, with values of 115 and 11.97 g plant^{-1}. The use of a mixture of organic fertilizers (hairy woodrose and carnauba straw) was extremely effective in the production of vegetable crops, bringing agronomic advantages to the producer.

Acknowledgements

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