Australian Journal of Crop Science
AJCS
AJCS 17(7):549-555 (2023) ISSN:1835-2707
doi: 10.21475/ajcs.23.17.07.p3801

Organic cultivation of mint under different amounts of hairy woodrose (*Merremia aegyptia* L.) and harvesting times

Paulo César Ferreira Linhares[1*], Alany Moisa Bezerra de Almeida[2], Patricio Borges Maracajá[3], Lunara de Sousa Alves[4], Aline Carla de Medeiros[5], Janilson Pinheiro de Assis[6], Roberto Pequeno de Sousa[6], Joaquim Odilon Pereira[6], Maiele Leandro da Silva[7] Natalia Fernandes de Oliveira Alves[8], Maria Elisa da Costa Souza[8], Domingos Severino de Souza Junior[8], Thiago Jardelino Dias[6], Antônia Vilma de Andrade Ferreira Amâncio and Eudes de Almeida Cardoso[6]**

[1]Federal Rural Semi-Arid University, Department of Agronomic and Forestry Sciences, Leader of the Jitirana Research Group, Mossoró-RN, 59625-900, Brazil
[2]Agroindustrial Systems, member of the jitirana research group, Mossoró-RN, 59625-900, UFERSA, Brazil
[3]Researcher at the National Institute of the Semi-Arid, National Institute of the Semi-Arid, Campina Grande, PB, 58434700, Brazil
[4]Plant Science and member of the Jitirana research group
[5]The Federal University of Campina Grande, PB, Brasil
[6]Federal Rural Semi-Arid University, Department of Agronomic and Forestry Sciences, Leader of the Jitirana Research Group, Mossoró-RN, 59625-900, Brazil
[7]The State University of Mato Grosso do Sul, 79200000 - Aquidauana, MS – Brasil
[8]The Federal Rural Semi-Arid University and member of the Jitirana research group.
[9]Federal University of Paraiba, Campus Areia, Areia-PB, 58397-000, Brazil

***Corresponding author: paulolinhares@ufersa.edu.br**
****Work extracted from the first author's master's thesis**

Abstract

This experiment was conducted to evaluate the possibility of organic cultivation of mint under different amounts of hairy woodrose and harvesting times. The experimental design was randomized complete blocks with the treatments arranged in 4 x 3 factorial scheme with three replicates. The first factor consisted of four amounts of hairy woodrose (0.0, 0.5, 1.0 and 1.5 kg m^{-2} of dry beds) and the second factor, corresponded to three harvest bunches (30; 60 and 90 days after transplanting). The cultivar "*Mentha piperita*" was used as mint crop. The evaluated characteristics were the following: biomass height, biomass production, number of sauces, dry mass, oil content and yield. There was interaction between the factors-treatments for yield, number of bunches and oil content. The best productive performance of the mint was obtained in the amount of 1.0 kg/m^2 of hairy woodrose incorporated into the soil at 60 days after mint transplanting (AMT). Hairy woodrose proved to be efficient as a green manuring in the mint crop.

Keywords: Green manuring; *Mentha piperita* (L.); medicinal plant. agroecological production.
Abbrevations: UFERSA_Federal Rural Semi-Arid University, AMT_after mint transplanting, pH_hydrogen potential, P_phosphorus, K_potassium, Ca_calcium, Mg_magnesium, Na_sodium, M.O._organic matter, N_nitrogen, C/N_carbon/nitrogen.

Introduction

Within genus Mentha which belongs to the family Lamiaceae, *Mentha arvensis* and *Mentha piperita*, are popularly known for the commercial exploitation of essential oil extracted from its aerial part and also for the medicinal use in the combat of stomach disorders, respiratory apparatus and intestinal parasites (Chagas et al., 2011).
In Brazil, the genus Mentha is widely used for medicinal and food purposes (Lorenzi and Matos, 2002). One of the factors that interferes in the production of essential oil is the soil fertility, since the nutritional conditions of the soil are essential for the balance between accumulation of biomass and production of oils in the Mentha culture (Valmorbida and Boaro, 2007).
Veronese et al. (2001) stated that mint and mint oil yield are modified by biotic and abiotic factors. This statement is supported by some agronomic studies recorded in the literature, especially those investigating the influence of fertilization on the development of this species. Organic fertilization represents a nutrient source for plants that helps to improve the physical, chemical and biological structure of the soil in addition to providing adequate nourishment.
In the region of Mossoró-RN, Brazil, the most used fertilizer source is cattle manure. This limits the production, given that the farmer does not always have this resource available, contributing to the increase in production costs (Linhares et

al., 2012 and Linhares et al., 2014). Thus, the use of plant species as green manuring, promotes benefits the whole system. Additionally, it guarantees the farmer success in production and optimization of the resources (Linhares, 2013).

Legumes are the most used plants for green manuring, because they contain a high percentage of phosphorus, potassium, calcium, and mainly nitrogen due to their ability of symbiotic N fixation by the bacteria belonging to the genus Rhizobium that develop in their roots (Tavares Junior et al., 2016). However, species from other families may be used.

Hairy woodrose (*Merremia aegyptia* L.) is a spontaneous species of the caatinga biome in semi-arid region of northeastern Brazil. It is an herbaceous species, belonging to the Convolvulaceae family, with green and dry biomass production of the order of 42000 and 6000 kg ha^{-1}, respectively, an average nitrogen content of 22.2 g kg^{-1} as dry matter, with a carbon/nitrogen ratio of 18/1, making the species feasible for use as a rapid decomposing quantity straw based green manuring usually (Linhares et al., 2021 and Linhares, 2013).

Hairy woodrose (*Merremia aegyptia* L.) has been used as a green manure in vegetable crops, such as coriander (Linhares et al., 2018; Linhares 2009a; Linhares et al., 2009b; Linhares et al., 2012a; Linhares et al., 2012b; Linhares et al., 2012c; Linhares et al., 2011a); arugula (Linhares, 2007 and Linhares et al., 2008a); radish (Linhares et al., 2013; Linhares et al., 2010) and carrot (Linhares et al., 2014).

Studies have shown that spontaneous species of the Caatinga biome may present the same performances of leguminosae as green manuring (Linhares et al., 2021; Linhares et al., 2011b and Linhares et al., 2009b).

Therefore, this study aims to evaluate the possibility of organic cultivation of mint under different amounts of hairy woodrose and harvesting times.

Results and Discussion

There was a significant interaction between the amounts of hairy woodrose and harvest times on the characteristics such as productivity, number of bunches and oil content of mint (Table 1).

The biomass height was not statistically different for the hairy woodrose amounts, with a mean value of 34.6 cm. For the harvesting times (30, 60 and 90 days AMT), there was a statistical difference at the level of ($p < 0.01$) probability, with a value of 47.61 cm at 90 days AMT (Figure 1). Vicente, Maia and D' Oliveira (2008), evaluated the production of medicinal plants with filter cake and reached a greater average height of 45 cm for mint, being a superior result to that achieved in this study. This greater average height is probably due to an extended time in the field for the species which was evaluated at 240 days after planting, and a different parameter for this study, which was measured at 90 days AMT.

Productivity of mint under amounts of hairy woodrose incorporated into the soil in the time of 30 days AMT is shown in (Figure 2), whereas we observed a significance in 30 days with a yield of 129.4 kg 100 m^{-2}. For the harvest seasons, there was a breakdown within the quantities of with yields of 332.7, 338.7, 366.50 and 386.25 kg 100 m^{-2} at 60 days after transplanting mint in amounts of 0.0, 0.5, 1.0 and 1.5 kg m^{-2} at the time of 60 days AMT, respectively (Figure 3A; 3B; 3C and 3D).

The increase in these characteristics is due to application of this green manuring affecting the chemical and physical attributes of the soil, among them the ion exchange capacity, which is responsible for the nutrient exchanges of the solid phase with the liquid phase (in the soil solution). Penteado (2007) emphasizes that the plant material, when returned to the soil, represents the return of 40 to 50% of the nutrients extracted by the production.

Cunha et al. (2018) evaluated agronomic efficiency of different quantities of jitirana {*Merremia aegyptia* (L.) Urb.} mixed with cattle manure in the intercropping of coriander with mint and reported a green mass of 56.4 kg 100 m^{-2} in the quantity of 3.0 kg m^{-2}, lower than the present study.

The number of mint bunches reached a mean value of 1316.38 units at the amounts of 1.5 kg m^{-2} of hairy woodrose when applied at 30 days period (Figure 4). In times of harvest, the average values of mint units were 3326.7, 3259.7, 3445.1 and 2998.7 100 m^{-2}, referring to the amounts 0.0; 0.5; 1.0 and 1.5 kg m^{-2} of hairy woodrose, when applied at 60 days AMT, respectively (Figure 5A; 5B; 5C and 5D).

Vicente et al. (2008), studied production of medicinal plants with filter cake. They reported 400 g m^{-2} of green biomass production of mint, equivalent to four bunches, which is inferior to the results of the above referenced research. This inferiority is due to the mint being measured at 240 days after sowing, which in turn causes the senescence of the basal leaves which later decrease the green mass foliage growth of the plant, since it is basically made up of leaves.

There was no significance of the amounts of hairy woodrose (*Merremia aegyptia* (L.) in the dry mass, with an average value of 35.7 kg 100 m^{-2}. For the harvesting times, there was a maximum yield point, with a value of 59.0 kg 100 m^{-2} in the 60 days season (Figure 6). The dry mass is a characteristic that reflects the growth of the vegetable (Taiz and Zeiger, 2009). Cunha et al. (2018) reported agronomic efficiency of different quantities of jitirana mixed with cattle manure in an intercropping system of coriander with mint and reached a dry mass of 6.56 kg 100 m^{-2} in the quantity of 3.0 kg m^{-2}, lower than the present study.

In the oil content, there was a maximum point of 1.17 and 1.23 g kg^{-1} at the amounts of 0.0 and 1.0 kg m^{-2} of hairy woodrose, at the times of 30 and 60 days AMT, respectively (Figure 7a and 7b). There was no curve fit for the harvesting times factor. Linhares et al. (2008b) stated that the increase in the production of phytomass results from a decrease in the nitrogen content through the dilution process, which possibly occurred in the present research. The essential oil content is a genetic characteristic and is independent of the amount of biomass produced by the plant. The essential oil content is a genetic characteristic and independent of the amount of biomass produced by the plant, making it more difficult to change when comparing the yield of essential oil (Oliveira, 2011).

There was no statistical impact of presence or hairy woodrose amounts on oil yield of mint, with an average value of 187.8 g 100 m^{-2}. For harvesting times, we observed maximum production of 335.0 g 100 m^{-2} at 60 days AMT (Figure 8). Cunha et al. (2018) studied agronomic efficiency of different quantities of jitirana mixed with cattle manure in the intercropping system of coriander with mint and reached an oil yield of 57.4 g 100 m^{-2} in the quantity of 3.0 kg m^{-2}, lower than the present study.

Table 1. F-values for biomass height, productivity of mint, number of bunches, dry mass, oil content and oil yield of mint fertilized with different amounts of hairy woodrose and times of harvest.

Causes of variation	GL	BH	PM	NB	DM	OC	OY
Amounts (A)	3	0.4 ns	0.5 ns	1.3 ns	2.2 ns	13.2 **	1.8 ns
Harvest times (B)	2	86.3 **	169.1 **	166.2 **	113.1 **	2.7 ns	125.3 **
A x B	6	2.1 ns	3.0 *	3.8 **	1.9 ns	15.6 **	2.0 ns
Treatments	11	-------	-------	-------	-------	-------	-------
Blocks	2	4.3 *	0.2 ns	0.5 ns	1.3 ns	0.5 ns	1.2 ns
Residue	22	------	-------	------	------	-------	-------
CV (%)	----	9.5	14.7	14.6	17.9	17.1	17.8
Average Overall	----	34.6	205.4	2081.9	35.7	0.9	187.8

** = P <0.01, statistical significance at 1% probability * = P <0.05, statistical significance at 5% probability and ns = not significant. BH= biomass height; PM= productivity of mint; NB= number of bunches; DM= dry mass; OC= oil content and OY= oil yield.

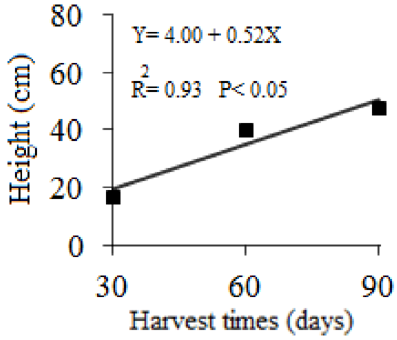

Fig 1. Biomass height at different harvesting times.

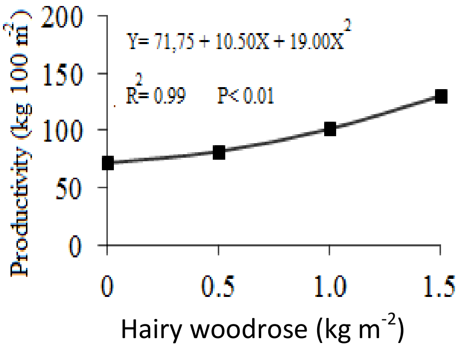

Fig 2. Productivity of mint under amounts of hairy woodrose incorporated into the soil in the time of 30 days AMT.

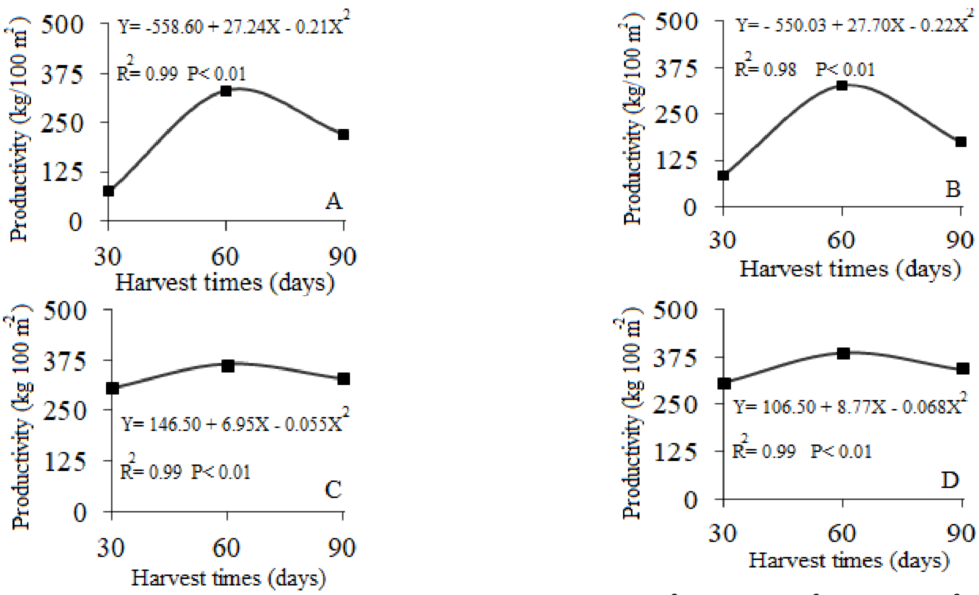

Fig 3. Mint production as a function of harvest times within the amounts of 0.0 kg m^{-2} (A); 0.5 kg m^{-2} (B); 1.0 kg m^{-2} (C) and 1.5 kg m^{-2} (D) of hairy woodrose incorporated into the soil.

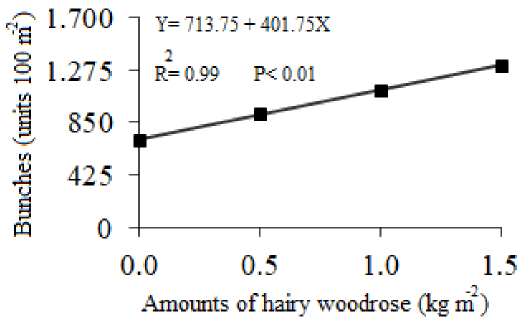

Fig 4. Number of bunches of mint under different amounts of hairy woodrose at 30 days AMT.

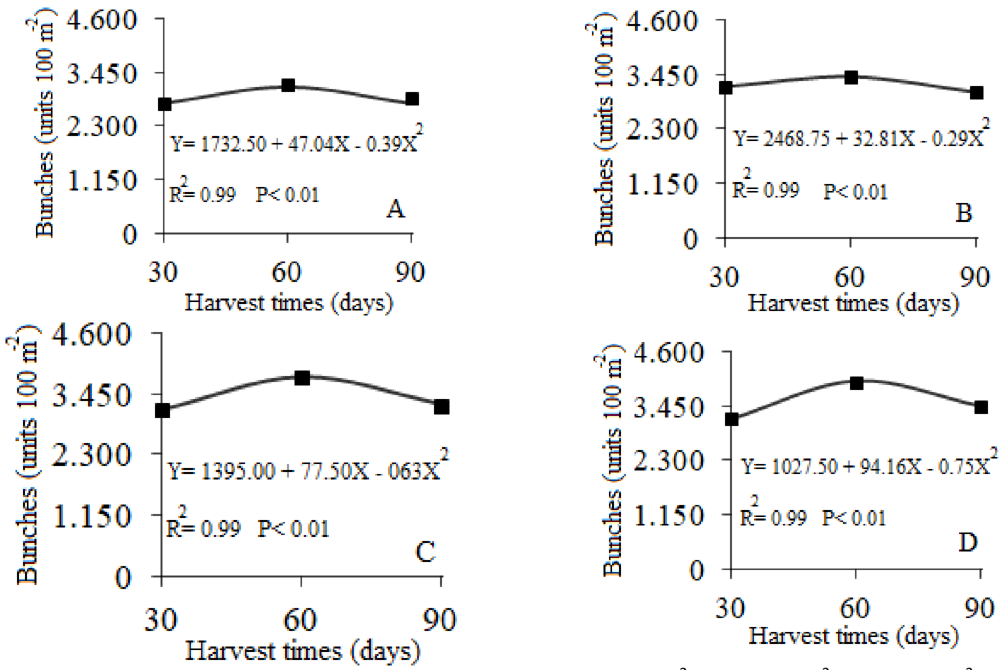

Fig 5. Number of bunches of mint as a function of the amounts of 0.0 kg/m^2 (a); 0.5 kg/m^2 (b); 1.0 kg/m^2 (c) and 1.5 kg/m^2 (d) of hairy woodrose at the time of 60 days AMT.

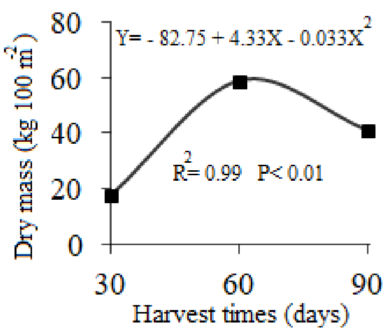

Fig 6. Dry mass of mint as a function of the harvest times AMT.

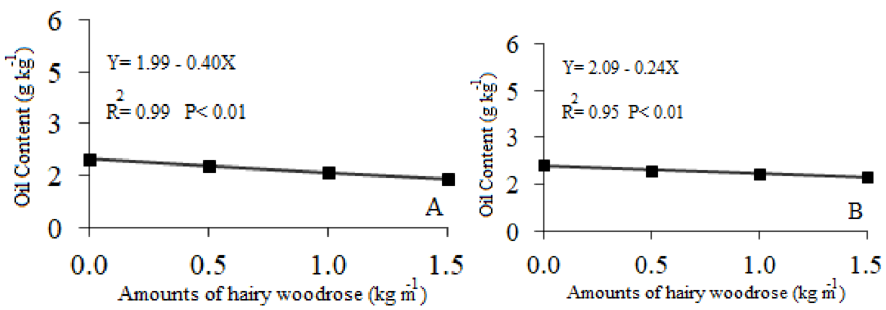

Fig 7. Oil content of mint as a function of the amounts of 0.0 kg m^{-2} at 30 days (A) and 1.0 kg m^{-2} at 60 days AMT (B) of hairy woodrose.

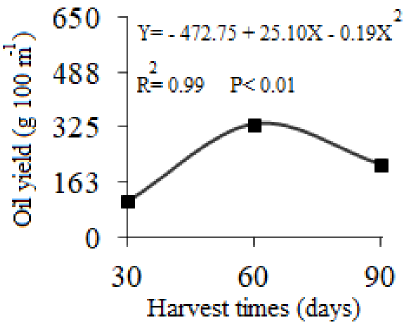

Fig 8. Oil yield of mint as a function of the harvest times AMT.

Fig. 9. Development of the hairy woodrose (*Merremia aegyptia* L.) 120 days after emergence under field conditions in the semiarid region. Mossoró, RN, Brazil. **Photo:** PhD researcher Paulo César Ferreira Linhares.

Materials and Methods

The study was conducted in the research area of the Rafael Fernandes Experimental Farm of the Federal Rural Semi-Arid University (UFERSA), located in the Alagoinha district, 20 km from the Mossoró-RN, Brazil, municipality (5º 03′ 37" S and 37º 23′ 50" W, 70 m altitude). The farm comprises of some 400 hectares (Rêgo et al., 2016). According to Carmo Filho et al. (1995) and the classification of Köppen, the local climate is BSwh ' dry and very hot. The dry season is normally from June to January, and a rainy season being from February to May. The average annual rainfall is 673.9 mm and the average relative humidity is 68.9%. The soil of the research area was classified as sandy loam Argisol Yellow Red Latosol (Embrapa, 2006).

Before the installation of the field experiment, soil samples were collected to a 0-20 cm layer and then sent to be processed and analyzed in the UFERSA Water, Soil and Plant Analysis Laboratory, providing the following results: pH (water 1:2,5) = 6.64; exchangeable cations Ca = 1.30cmol$_c$ dm^{-3}; Mg = 0.60 cmol$_c$ dm^{-3}; K = 34.5 mg dm^{-3}; Na = 10.7 mg dm^{-3}; P (Mehlich) = 1.80 mg dm^{-3} and organic matter = 2.48 g kg^{-1}.

The experiment design was randomized complete blocks with treatments arranged in a 4 x 3 factorial scheme with three replications. The first factor consisted of four amounts of hairy woodrose (0.0, 0.5, 1.0 and 1.5 kg m^{-2} of dry beds) and the second factor, corresponding to three harvest times (30; 60 and 90 days after mint transplanting- AMT). All the experimental plots were incorporated into the amount of 1.0 kg m^{-2} bovine manure, corresponding to 19.6 g of nitrogen m^2. The hairy woodrose was decomposed in the soil for a period of 30 days before transplanting the mint (Linhares et al., 2012a).

The preparation of the soil consisted of the harrowing and preparing of the seedling beds. During the study, manual weeding was performed to keep the crop free from spontaneous weed growth. Before sowing, irrigation was performed to maintain ideal soil moisture conditions for the mineralization process (Novais, 2007).

Each block was 17.0 m in length by 1.4 m in width. The study plots were 1.4 m x 1.4 m, with a total area of 1.96 m^2, with 40 plants in each of the single crop and intercropping with coriander, spaced 0.35 mx 0.2 m respectively. The yielding area with six plants was therefore 1.26 m^2 with 18 plants.

The propagation of the seedlings was carried out by clipping the apical buds, picked from select *Mentha piperita* plants and cultivated in expanded polystyrene trays of 128 cells which contained a commercially available vermiculite substrate. The seedlings were transplanted after being grown in a greenhouse for 15 days, with 50% shading, and until they reached approximately 10 cm in height.

The hairy woodrose (*Merremia aegyptia* L.) used was collected from the native vegetation in the vicinity of the campus of UFERSA during the flowering season. It is at this time that the plant has the maximum concentration of nutrients and chemical properties of: 570 g kg^{-1} C; 25.0 g kg^{-1} N; 12.5 g kg^{-1} P; 18.0 g kg^{-1} K; 12.0 g kg^{-1} Ca; 16.0 g kg^{-1} Mg, with carbon/nitrogen ratio of 23:1 (Linhares et a., 2021) (Figure 9).

The cattle manure used was stabilized and sourced from the heifers of the UFERSA cattle herd, which are raised in an intensive system, fed with corn-based concentrate, soy bean and wheat bran, and having as bulk Canarian grass (*Echinocloa polystochya*), which has a chemical concentration of: pH (water 1: 2.5) = 8.06; and the total contents of 17.6 g kg^{-1} of N; 0.667 g kg^{-1} of P; 5.827 g kg^{-1} of K^+; 1.849 g kg^{-1} of Na^+; 0.197 g kg^{-1} of Ca^{2+} and 0.037 g kg^{-1} of Mg^{2+}).

The harvest was performed according to the cutting season of the mint. The crops were harvested at 30 days, 60 days and 90 days, AMT, cutting all the plants of the useful area. After harvesting, plants were transported to the Post-Harvest of Vegetables Laboratory at the Department of Plant Sciences at UFERSA where they were analyzed.

For the mint crop, the following differences were evaluated: biomass height (was measured in the field, in centimeters using millimeter ruler, ten plants per plot), green mass (was obtained by cutting above ground, was weighed on a precision scale of 1.0 g and expressed as 100 m^{-2}, corresponding to family farmers cultivating areas in the region of Mossoró-RN, Brazil), number of bunches (was determined by dividing the fresh mass in an area of 100 m^2 per 100 g, comparable to the weight of a mint bunches sold at the local agroecological fair and on the supermarket shelves in Mossoró-RN and measured in units 100 m^{-2}), dry mass (was obtained from a forced-air heating oven at 65 °C, to constant mass and expressed in g 100 m^{-2}), oil content (%) and oil yield (g 100 m^{-2}).

In determining the essential oil content and yield, the Simões et al. (2003) methodology was used. Samples of the above ground part of the dried plants were subjected to hydro distillation in a modified Clevenger apparatus for 1.5 h, using 600 mL of distilled water in 1 L distillation flask. The oil content was defined as the ratio between the mass, in grams of essential oil, and the mass of dried leaves, inserted into the distillation flask x 100, expressed in g kg^{-1} and the oil yield (the oil content (%) x the dry matter (in kg 100 m^{-2}) of the area portion divided by 100 was determined.

A univariate analysis of variance for randomized block design with treatments arranged in a factorial design was performed on each feature of mint, through the application ESTAT (Kronka and Banzato, 1995). The procedure for adjusting the response curve was performed using the Table Curve (Jandel Scientific, 1991) application.

Conclusions

The best productive performance of the mint was obtained in the amount of 1.0 kg/m^2 of hairy woodrose incorporated into the soil at 60 days AMT. Hairy woodrose proved to be efficient as a green manuring in the mint crop.

References

Carmo Filho F and Oliveira OF (1995) Mossoró: um município do semiárido nordestino, caracterização climática e aspecto florístico. Mossoró: ESAM, (Coleção Mossoroense, Série B) 62p.

Chagas JH, Pinto JEBP, Bertolucci SKV, Santos FM, Botrel PP and PINTO LBB (2011) Production of Japanese mint in relation to organic fertilization during planting and cover (Produção da hortelã-japonesa em função da adubação orgânica no plantio e em cobertura). Horticultura Brasileira, 29(3): 412-417.

Cunha LMM, Linhares PCF, Neves APM, Almeida AMB, Pereira MFD, Assis JP, Sousa RP and Alves LS (2018) Agronomic efficiency of different quantitys of jitirana wixed with cattle manure in the intercropping of Coriander with mint. International Journal of Development Research, 8(2): 18786 – 18792.

Empresa Brasileira De Pesquisa Agropecuária – Embrapa, (2006) Brazilian system of soil classification (Sistema brasileiro de classificação de solos). 2.ed. Rio de Janeiro: Embrapa, 306p.

Jandel Scientific 1991. Table Curve: Curve Fitting Software: *Jandel Scientific*, 280 p.

Kronka SN and Banzato DA. Estat (1995) system for statistical analysis (Estat: sistema para análise estatística. Versão). 2. 3.ed. Jaboticabal: Funep, 243 p.

Linhares PCF, Maracajá PB, Liberalino Filho J, Assis JP, Sousa RP, Medeiros AC (2021) Jitirana (*Merremia aegyptia* L. Urban) [livro eletrônico]: Potencialidade de uso como espécie espontânea do semiárido na adubação verde de hortaliças. In: Linhares PCF, Cunha LMM, Silva NV, Neves AM, Medeiros BBM and Paiva AC. Fitomassa verde e seca, teores e acúmulo de macronutrientes da jitirana (*Merremia aegyptia* L. Urban) em diferentes estádios fenológicos– Nova Xavantina, MT: Ed. Pantanal. 96p. Cap. 2, p.24-45.

Linhares PCF, Assis JP, Sousa RP, SÁ JR, Pereira MFS, Ramalho WB, Silva RIG, Silva RA and Pereira KLV (2018) Optimized amount of hairy woodrose (*Merremia aegyptia* L.) in the productivity of coriander cultivars. Bulgarian journal of Agricultural Science. 24(4): 654-659.

Linhares PCF, Maracajá PBM, Pereira FS, Assis JP and Sousa RP (2014) Roostertree (*Calotropis procera*) under different amounts and periods of incorporation on yield of coriander. Revista Verde de Agroecologia e Desenvolvimento Sustentável, 9(3): 07-12.

Linhares PCF (2013) Adubação verde como condicionadora do solo. Revista Campo e negócios. 11(127): 22-23.

Linhares PCF, Pereira MFS, Assis JP and Bezerra AKH (2012ª) Quantidades e tempos de decomposição da jitirana no desempenho agronômico do coentro. Ciência Rural. 42(2): 243-248.

Linhares PCF, Sousa AJP, Pereira MFS, Alves RF and Maracajá PB (2012b) Proporções de jitirana (*Merremia aegyptia* L.) com flor-de-seda (*Calotropis procera*) no rendimento de coentro. Agropecuária cientifica no Semi-árido. 8(4): 44-48.

Linhares PCF, Pereira MFS, Dias MAV, Holanda AKB and Moreira JC (2012c) Rendimento de coentro (*Coriandrum sativum* L.) em sistema de adubação verde com a planta jitirana (*Merremia aegyptia* L.). Revista Brasileira Plantas Medicinais. 14(5): 143-148.

Linhares PCF, Silva MLS, Pereira MFS, Bezerra AKH and Paiva ACC (2011) Quantidades e tempos de decomposição da flor-de-seda no desempenho agronômico do rabanete. Revista Verde de Agroecologia e Desenvolvimento Sustentável. 6(1): 168-173.

Linhares PCF, Pereira MFS, Oliveira BS, Henriques GPSA and Maracajá PB (2010) Produtividade de rabanete em sistema orgânico de produção. Revista verde, 5(5): 94-101.

Linhares PCF (2009ª) Vegetação espontânea com adubo verde no desempenho agroeconômico de hortaliças folhosas. Departamento de Ciências Agronômicas e Florestais da Universidade Federal Rural do Semi-Árido (Tese), Mossoró. 109p.

Linhares PCF, Silva ML, Bezerra AKH, Silva JS and Silva UL (2009b) Avaliação da decomposição da jitirana em cobertura no desempenho agronômico de rúcula. Revista Caatinga. 22(3): 1983 -2125.

Linhares PCF, Lima GKL, Madalena JAS, Maracajá PB and Fernandes PLO (2008ª) Adição de jitirana ao solo no desempenho de rúcula cv. Folha Larga. Revista Caatinga. 21(5): 89-94.

Linhares PCF, Bezerra Neto F, Maracajá PB, Duda GP and Sá JR (2008b) Produção de fitomassa e teores de macronutrientes em jitirana em diferentes estágios fenológicos. Caatinga, 21(4): 72-78.

Lorenzi H and Matos FJA (2002) Medicinal Plants in Brazil native and exotic. Plantas Medicinais no Brasil nativas e exóticas. *Ed. Instituto Plantarum*, Nova Odessa: 250 – 251.

Novais, R. F. Fertilidade do solo. In: E. J. Meurer (2007) Fatores que influenciam o crescimento e o desenvolvimento das plantas. Viçosa: SBCS, p. 65-90.

Oliveira ARMF (2011) Produção de óleo essencial de mentha x piperita var. citrata sob diferentes condições de manejo. Dissertação (Mestrado em Produção vegetal) Universidade Estadual de Santa Cruz. Ilhéus-BA, p.83.

Penteado SR (2007) Adubação orgânica: Compostos Orgânicos e Biofertilizantes. Campinas: *SP*. 162 p.

Rêgo LGS, Martins CM, Silva EF, Silva JJA and Lima RNS (2016) Pedogênese e classificação de solos de uma fazenda experimental em Mossoró, Rio Grande do Norte, Brasil. Revista Caatinga. 29(4):1036-1042.

Simões CMO, Shenkel EP, Gosmann G, Mello JCP, Mentz LA and Petrovick PR (2003) Farmacognosia: da planta ao medicamento. 5.ed. Porto Alegre/Florianópolis: Editora da UFRGS/Editora da UFSC: 615-656.

Taiz L and Zeiger E (2009) Plant Physiology, 3. ed. Porto Alegre: Artmed, 719 p.

Tavares Júnior JB (2016) Produção de fabáceas para adubação verde no município de Lagoa Seca, PB. Trabalho de conclusão de curso (Graduação em Agroecologia)- Universidade Estadual da Paraíba, Centro de Ciências Agrárias e Ambientais, 24p.

Valmorbida J, and Boaro CSF (2007) Growth and development of Mentha piperita L. in nutrient solution as affected by rates of potassium. Brazilian Archives of Biology and Technology, 50 (3): 379-384.

Veronese P, Li X, Niu X, Weller SC, Bressan RA and Hasegava PM (2001) Bioengineering mint crop improvement. Plant cell, Tessue and Organ Culture. 64(2): 133-144.

Vicente EC, Maia E and Oliveira PS (2008) Production of medicinal plants fertilized with filter cake. (Produção de plantas medicinais adubadas com torta de filtro). Iniciação Científica CESUMAR. 10(1): 07-12.